INTEGRATION OF ETHNOMATHEMATICS IN THE TEACHING OF PROBABILITY IN SECONDARY SCHOOL MATHEMATICS IN ZIMBABWE.

BY

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Topic: Integration of ethnomathematics in secondary school mathematics in Zimbabwe.

I declare that the above thesis is my own work and that the sources I have used or quoted have been indicated and acknowledged by means of complete references

I further declare that I submitted the originality checking software and that it falls within the accepted requirement for originality

I further declare that I have not previously submitted this work or part of it for examination at Unisa for another qualification or at any other educational institution.

23 May 2022

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SUMMARY OF THE THESIS IN ENGLISH

Approved title for the thesis: Integration of ethnomathematics in the secondary school mathematics in Zimbabwe.

SUMMARY

The main purpose of this study was to develop a policy framework for facilitating the integration of ethno-mathematics in secondary school mathematics in the teaching of probability in Zimbabwe.

The study focused on the following objectives: it sought to identify the mathematics teachers' difficulties in integrating ethno-mathematics in the secondary school mathematics when teaching probability, explore the rural Shona learners' out of school mathematical practices that can be integrated in the teaching of probability, explore the integration of ethno-mathematics in the form of the rural Shona learners' out of school activities in the teaching of probability, and to determine the impact of integration of ethno-mathematics in the secondary school mathematics in the teaching of probability in the secondary school.

Literature review revealed that studies on integration of ethnomathematics which were carried out in Zimbabwe focused on mathematising the cultural activities without guiding the mathematics teachers on how to integrate them in the mathematics classroom.

The study was underpinned by the Social Constructivist Theory and the postmodern philosophy. The study used participatory action research [PAR] as a research design. Three mathematics teachers teaching at a rural secondary school in Zimbabwe together with their Form three learners were purposely selected to participate in this study. At the beginning of the PAR the participants wrote narratives about themselves regarding their teaching experiences as some aspects regarding teaching and learning of mathematics. Also, data was collected using semi-structured interviews at the beginning and at the end of the study as well as using lesson observation. After every lesson a post lesson reflection interview was conducted with the participants. The gathered data was qualitative in nature, was transcribed and coded for emerging themes.

The study developed an ethnomathematics instructional model which I conclude that when implemented properly improves mathematics teachers' ability to integrate ethnomathematics in the teaching of probability. The findings in this study highlight the significance of implementing the ethnomathematics instructional model in this study in schools. It is also advisable to undertake further studies to find out how the ethnomathematics instruction model can be used in other topics in mathematics.

KEY TERMS DESCRIBING THE TOPIC OF THE THESIS: mathematising, cultural activities, ethnomathematics instructional model, cultural activities, rural secondary school, mathematics, probability concept, social constructivism, Participatory action research, integrating ethnomathematics, mathematics teacher, rural secondary school learners

DEDICATION

I dedicate this thesis to my wife, Jacqueline, my children, Sudden, Yvet, Channon, Chandler, Ibide and Millichamp as well as my mother Muzvireki who passed on while I was writing this thesis

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- My uncle Zebron Chari for assisting in proof reading of my work
- The three mathematics teachers for taking part in data collection
- The Form Three learners at the school where data collection took place.

Abstract

Underpinned by the social constructivism theory and the praxis of integrating ethnomathematics in the teaching of probability, this PAR developed a policy framework for facilitating the integration of ethno-mathematics in secondary school mathematics in the teaching of probability in Zimbabwe. A qualitative method approach was used in a case study of one rural secondary school. The study targeted rural secondary school mathematics teachers who were teaching Form Three classes. The school was purposively selected and so were the three form three mathematics teachers and the form three learners at that school who participated in this study. The study triangulated the research instruments which included semi-structured interviews, lesson observation schedules and post-lesson reflection interviews. The study developed an ethnomathematics instructional model which was found to successfully guide the participants to integrate ethnomathematics in the teaching of probability. Thematic analysis was used to analyse data which was wholly qualitative. Findings of this study reveal that the use of the ethnomathematics instructional models helped the participants to integrate ethnomathematics in the teaching of probability effectively. Teaching probability concepts using the ethnomathematics instructional model was also found to trigger improvements in the learners' performance in probability. The two theories namely, Determination of Randomness Theory and Determination of Independent Outcome Theory which emerged from this study can guide mathematics teachers when incorporating cultural games in the teaching of probability concepts. Based on the findings of this study I conclude that the ethnomathematics instructional model when implemented properly improves the mathematics teachers' ability to integrate ethnomathematics in the teaching of probability. The findings in this study have the potential to inform mathematics teachers, policy makers, and curriculum developers on the significance of implementing the ethnomathematics instructional model used in this study in schools. It is also advisable to carry out further studies to find out how the ethnomathematics instruction model can be used in other topics in mathematics.

KEY CONCEPTS: Rural secondary school teachers, ethnomathematics, cultural activities, ethnomathematics instructional model, probability concepts.

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ACRONYMES

AR- Action Research

BSPZ-Better School Programme of Zimbabwe

CRPT-Culturally Relevant Pedagogy Theory

CED-Collins English Dictionary

EIM-Ethnomathematics Instructional model

MOPSE-Ministry of Primary and Secondary Education

OL-Ordinary Level

PAR-Participatory Action Research

SCT-Socio-cultural Theory

ZCFPE-Zimbabwe Curriculum Framework for Primary and Secondary School Education.

ZIMSEC-Zimbabwe School Examination Council

ZSECS-Zimbabwe School Examination Council Syllabus

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1.Introduction

The significance of mathematics in a developing country like Zimbabwe cannot be overemphasised. According to Chirume and Chikasha (2014), mathematics is viewed as a natural human activity which is important as a tool for solving everyday problems. The strand of mathematics whose importance has grown significantly is probability. The worldwide demand for probability in the secondary school curriculum has been highlighted since the 1980s, (Gal, 2005; Jones, 2000). According to Pratt (2005), the reasons for inclusion of probability in the secondary curriculum are related to the growth of its usefulness in daily life. Probability plays an instrumental role in other disciplines, and its importance in decision making should not be underestimated in this modern technological world where large volumes of data are generated and processed to make decisions. Despite the importance of probability in the daily lives of people, mathematics teachers continue to struggle to link the teaching of probability to the learners' out-of-school mathematics activities as a way of making the learners understand probability concepts. This problem is common in rural areas where teachers use textbooks with examples whose context is far detached from what the learners are familiar with (Chikodzi & Nyota, 2010).

The teaching methods used by the rural mathematics teachers in Zimbabwe have been of late castigated by some researchers, (Chikodzi & Nyota, 2010; Mupa, 2015) due to their failure to link mathematics and the learners' out of school mathematics practices. The lack of connectivity between school mathematics and real life had earlier on been echoed by (Masingila, 1993), who affirms that the present curriculum is so divorced from the learners' out-of-school experience that it makes it difficult for learners to connect their context mathematics to school mathematics. According to Cheung, Lam, Siu, and Wong (1986), probability has by far the closest direct link with daily life as compared to other strands of mathematics. Pale (2016) mentioned that probability related examples are usually not used in the mathematics classroom resulting in learners playing a passive role in learning probability.

In addition, researchers (Chirume & Chikasha, 2014; Adamu and Sadiq, (2014) assert that learners do not perform well in mathematics due to a negative attitude towards mathematics. In most cases, learners develop a negative attitude towards mathematics because mathematics taught at school is not connected to the learners' real-life situations. According to Chikodzi and Nyota (2010), mathematics taught in secondary schools in Zimbabwe is irrelevant to learners who live in rural areas. A rural area is defined in this study as a geographical area which is outside town where people mostly depend on peasant farming as a way of livelihood. Also, Cheung, Lam, Siu, and Wong (1986) point out that in the teaching of probability too many examples given are related to gambling using dice and coins, giving the learners lopsided impression of the subject.

In addition, researchers, Makgato and Mji (2006), Chikasha and Chirume (2014), Chikodzi and Nyota (2010), Tachie and Chireshe (2013), Adam and Sadiq (2014), Chirume and Chikasha (2014), Mapolisa and Tshabalala (2014), and Jameel and Ali (2016), have continued to search for the lasting solution to the challenges experienced by mathematics in rural secondary schools. Some scholars (Chikodzi & Nyota, 2010; Madusise, 2014) attribute the poor performance to lack of link between school mathematics and the learners' out of school mathematical practices. Those researchers argued that mathematics teachers teach mathematics as though mathematics resides in the textbooks without any link to the learners' real life. The mathematics teachers put undue emphasis on syllabus coverage at the expense of meaningful learning of mathematics concepts. Masingila (1993) observes that mathematics teachers place too much emphasis on the transmission of syntax (procedures) rather than on the teaching of semantics (meaning) and this discourages learners from bringing their intuitions to bear on school learning tasks. Moreover, Cheung *et al*. (1986) point out that when teaching probability mathematics teachers put more emphasis on computational techniques at the expense of conceptual understanding. For example, learners can be able to calculate the probability that the seed will germinate is 80%, but still think that the prediction is wrong when the seed fails to germinate because teachers may not be teaching the interpretation of probability concepts.

Lack of connectivity between learners' culture and school mathematics is also highlighted by Bansilal, James, and Naidoo (2010) who assert that the failure rate in mathematics has been exacerbated by the fact that learners fail to see the utility of school mathematics. Also, Tachie and Chireshe (2013) in their investigation of the causes of high failure rate in Mathematics Examination in rural senior secondary schools in the Eastern Cape Province of South Africa cite poor method of teaching as one of the causes of poor performance in mathematics in rural secondary schools. In support of this point, Aikpitanyi and Eraikhuemen (2017), in their study to find the extent to which mathematics teachers use ethnomathematics in the Edo State of Nigeria, also cited poor teaching methods as the major cause of poor performance in mathematics. This implies that poor teaching methods are some of the leading factors that contribute to poor performance in mathematics examinations in many countries. In support of this view, Jameel and Ali (2016) also assert that some methods teachers use in mathematics do not help learners to develop conceptual understanding of mathematics. Furthermore, Chikodzi and Nyota (2010) observe that the rural secondary school learners are further disadvantaged using English language as a medium of instruction thereby making mathematics more alien. When teaching probability Batanero, Chernoff, Angle, Lee, and Sanches (2016) are of the opinion that mathematics teachers should not rush to engage learners in computation of probability because probability in the learners out of school mathematical practices is not enumerated but only expressed in words. Mathematics teachers are supposed to utilise the manner in which learners express probability concepts outside school as the springboard to get into academic probability.

According to Rosa and Orey (2011, p38), mathematics teachers should know that "…mathematical skills that learners learn in school are not logically constructed based on abstract cognitive structures, but rather forged out of a combination of previously acquired knowledge and skills and new cultural inputs". This implies that the mathematics teachers should find the compatibility of the secondary school mathematics and the learners' home-based mathematical practice. The failure of Zimbabwean teachers to see the link between secondary school mathematics and the learners' out of school mathematics practice is affirmed by Mtetwa and Jaji (2006) who point out that secondary school mathematics teachers believe that the rural Shona people's mathematical practices and activities are too preliminary to be integrated into the secondary school mathematics. Also, Alivarez and Oliveras (2014), in their paper presented at the Fifth Conference on Ethnomathematics in Maputo, hint of the existence of an obstacle between ethnomathematics and school mathematics, because teachers doubt the mathematical value of ethnomathematics. Ethnomathematics is defined as the mathematical practices of identifiable cultural groups such as national tribal societies, labour groups, children of certain age brackets and so on, and may be regarded as mathematical ideas found in any culture (D'Ambrosio, 1985). These ethno mathematical ideas can be used to make connection between school mathematics and the learners' out-of-school mathematical practices (D'Ambrosio, 2001). However, the teaching approaches which mathematics teachers treat school mathematics as if it is completely unrelated to the learners' out-of-school mathematical experience. This is supported by Masingila (1989), who says that school mathematics leave the impression that there is only one way to do a given task. Some techniques used at school are like non-standard techniques used by the learner outside the school which the teacher may not know. When teaching probability, Batanero *et al.* (2016) assert that learners have intuitive ideas about chance and probability which they use in qualitative expressions such as 'probable', 'likely' and 'unlikely' which they use to express their degree of belief. Mathematics teachers should utilise these intuitive ideas to help the learner link probability concepts as taught at school to the out of school probabilistic experience. Also, Chikodzi and Nyota (2010) found that some of the rural Shona people' activities can be used to form connections between the rural learners' understanding of probability and probability as taught in the mathematics classroom although they do not go into details. For example, fishing activity as practiced in the Shona culture can be used to illustrate the concept of probability.

Nevertheless, some scholars have suggested an effective instructional strategy that can maximise learners' performance in mathematics. The use of culturally relevant pedagogy, (Gay, 2000 & Ladson Billing, 1995) may enhance understanding and efficient learning resulting in higher performance of learners in mathematics. A culturally relevant pedagogy is a pedagogy that advocates for making connections between the learners' culture and school mathematics. When pedagogy incorporates the learners' culture to the teaching of mathematics, ethnomathematics is said to be integrated in the school mathematics. The ethno-mathematical ideas differ from culture to culture as Borba (1990) and Rosa and Orey (2011) reveal that every culture does mathematics although the mathematics is expressed in the way unique to that culture. For example, Emaegwali and Shiza (2016) point out that in the Shona culture time is not measured exactly but it is given within the range of time whereas the Western perspective gives time precisely. This implies that when teaching mathematics concepts teachers should begin from the learners' perspective and then move on to other perspectives.

This study utilised the mathematical concepts found in the rural Shona learners' culture in coming up with culturally relevant pedagogy for the teaching of probability. Moreso, Charleston (2005), identified use of real-world context for teaching mathematics as a way of maintaining learners' focus on mathematics ideas. D'Ambrosio (2001) advocates for the inclusion of cultural characteristics of the learners' invention in school mathematics for the learners to perform better in mathematics. According to Rosa and Orey (2011), teaching mathematics through cultural relevance and personal experience helps learners to understand more about reality, culture, society, environmental issues, and themselves by providing them with mathematical content and approaches which enable them to successfully master academic mathematics. For example, the mathematics teacher can use the learners' diaries which show the learners' activities daily for a period exceeding two months to develop some mathematical concepts and problems. Apart from understanding mathematical concepts from the use of diaries, the learners also develop a clear picture of themselves (Fasheh, 1982), the meaning of being a boy or a girl in their culture and how to interact with their environment as members of a given society. Integration of ethnomathematics in the school mathematics for the teaching of probability in secondary schools in Zimbabwe requires an analysis of some traditional mathematics activities in Shona people's daily lives and finding ways to incorporate them into the pedagogy. Balamurugani (2015) suggests that ethnomathematics can be integrated in the school mathematics by broadening mathematics content to include history of mathematics and multicultural application of mathematics such as indigenous games, and artefacts. Balamurugani goes on to say mathematics teachers can also use any other cultural activity that can promote the learning of mathematics in the school as a way of integrating ethnomathematics with the school mathematics. In this study, the probabilistic activities found in the daily lives of the rural Shona people's culture were incorporated into the pedagogy for teaching probability. This study therefore explores the integrating of ethnomathematics in the form of the rural Shona learners' home based mathematics practices in the secondary school mathematics for the teaching of probability at Ordinary Level [OL], which is the final certification for secondary school to be taken at the fourth year of secondary school at approximately at the age of 16 in Zimbabwe.

1.2.Background to the Study

As a mathematics teacher with a Bachelor of Education from the University of Zimbabwe, I was very enthusiastic about helping members of the community in mathematics. I started some a tutorial centre where I could help some learners at a small fee during the evening after work and on Saturdays. This tutorial centre attracted learners from four surrounding secondary schools all of which had rural settings. When I started that program, it did not take me long to realise that probability caused a lot of problems to rural secondary school learners and the methods used by mathematics were not effective. Teachers could not make the learners understand probability concepts. This period coincided with my tenure as the District Chairman for the Mathematics Association. At one point, the Better School Program in Zimbabwe [BSPZ] (2011) carried out a survey with 138 rural mathematics secondary school learners to find out the volatility of OL mathematics topics and it emerged that 86 per cent of the learners indicated that probability was the most volatile topic the learners could easily forget probability concepts after being taught. The second survey the BSPZ (2014) carried out was on the teaching and learning aids that the mathematics teachers used when teaching probability and found that it was only dice, balls, coins and playing cards that were being used in the teaching of probability. That is when I realised that the teaching of probability in rural secondary schools is not linked to the learners' out of school mathematics practice as pointed out by Chikodzi and Nyota (2010).

I found that probability is one of the topics that mathematics teachers experience the challenge of contextualising within secondary school mathematics. Also, in a survey conducted by the [BSPZ] (2014), it was found that mathematics teachers regarded probability as one of the topics which they found difficult to teach for easy understanding by the learners. Both the mathematics teachers and OL learners wished the topic to be removed from the syllabus. The BSPZ is an educational program that was initiated by the Ministry of Education of Zimbabwe and the Sweden Government in the year 2000. The sole responsibility of BSPZ is to assist schools and teachers to improve the quality of education through funding teachers' workshops. It was during one of those workshops in 2014 when one of the participating OL mathematics teachers said:

I am failing to help my students on some probability questions which are in the New General Mathematics book 3. The question talks about dominoes yet even me I do not know what dominoes are. I asked one of my colleagues to assist and he managed to arrive at the correct answer given in the answer book but all the same he failed to explain to my students what dominoes are for the learners to understand the concepts. It is not this question alone, but there are some questions about tetrahedral dice, the student does not know what these are as a result *it becomes very difficult to explain to the students about these things that even me do not know. The problem with probability is that it is abstract ….*

This except made me develop interest in probability, I started to have a clear picture of how the teaching of probability was causing problems amongst members of my profession. Earlier, the Zimbabwe School Examination Council [ZIMSEC] Mathematics 4008/4028 Examination Report (2013) had revealed that OL learners did not perform well in probability questions, showing that learners were not equipped adequately to meet the demands of probability questions in the OL Examinations. In 2015, there was a workshop at the BSPZ for helping teachers to prepare their students for the impending examinations. At that workshop one of the OL mathematics teachers had this to say:

I have stopped teaching my students probability because it scares my students into dropping mathematics. I tried to reteach the topic several times, but it does not help, and I found that probability is not like any other topics in the syllabus it is very abstract. Also, it is very difficult to find suitable teaching learning aids for this topic and every question in the examination comes with a new situation, it cannot be mastered.

I recall when some of my classmates dropped mathematics in Form 3, some three decades ago, when they failed to understand when we were being taught about probability. I found that the problem of dropping mathematics was still there to stay even though mathematics was regarded as a compulsory subject. Garfield and Ahlgren (1988) suspected that many students develop distaste for probability through having been exposed to its study in a highly abstract and formal way. This distaste in the Zimbabwean classroom may be caused by the mathematics teachers who rely on textbooks for conceptual development and questions which make it difficult for the learners to understand probability. One may wonder how the mathematics teachers expected the OL learners to understand probability when the terminology and concepts used are culturally irrelevant to the learners.

Fischbein (1975), Steinbring (1991) and Pratt (2005) highlight the need for instruction to build on learners' existing notion of probability, whether they are mature intuition or more formal understanding. According to Garfield and Ahlgren (1988), learners appear to have difficulties develop correct intuition about fundamental ideas of probability because probability ideas as presented in the mathematics classroom often appear to conflict with learners' experience and how they view the world. For example, probability in the Shona culture has only three points of reference, either the event is a failure or it a success or it is half-half, yet the probabilities calculated at school have other points such as the probability of one-fifth. They go on to say that some concepts that are presented by the teachers in probability lessons are unlike anything the learners have thought of before. Pratt (2005) advocates for teachers to design tasks that incorporate purpose and utility. That means the designed tasks should have a meaningful outcome for the learner and enable the learners to appreciate the applicability of the concept.

When I was the chairman of the District Mathematics Association in Zimbabwe from the year 2009 to 2011, I found that every year probability always topped the list when it comes to problem areas for both teachers and learners. The OL learners' challenges in probability are also highlighted in [ZIMSEC] Mathematics 4008/4028 Examination Report (2018). The report revealed that few candidates attempted to answer probability questions and majority of those who attempted to answer those questions did not perform well. I also realised that the game of tossing coins which most teachers used in teaching probability is not encouraged. The Shona people believe that it grooms children to become thieves and robbers hence the learners may not cooperate when such methods are used. This is controversial to the Shona culture of upbringing.

The learners' cultural background usually affects how they learn mathematics at school. Amir and William (1999) point out that learners bring informal knowledge acquired in daily life from their culture which might interfere with the learning of probability. For example, culturally the learners normally think that luck and God interfere with some probabilistic events hence the concept of fairness does not exist. Amir and William (1999) assert superstition, religiousness, personal experience with games and interpretation of language used to describe probabilistic occurrence as some of the cultural influences that affects probabilistic thinking that the teacher should not just choose to ignore. Sharma (2016) advocates for meaningful context and drawing on learners' experiences and probabilistic understanding as a way of enhancing learners' understanding of probability concepts. It is through this background that I came to realise that the teaching of probability needs to take new dimensions to make the learners understand probability concepts.

1.3. Motivation

I was motivated by several events to carry out this research. This includes the continuous underperformance of rural learners in mathematics examination in rural secondary schools, (Chikodzi & Nyota, 2010) and the desire to come up with an effective Ethnomathematics instructional model [EIM] for teaching probability. My motivation was not only academic but arose out of my own context of experience, my passion for my profession as a mathematics teacher and my desire to reflect on my past as a rural secondary school learner. Probability occupied approximately 8% of the OL mathematics curriculum. In the OL examinations, probability questions can appear in both papers, Paper 1 and Paper 2. The biggest challenge was that probability concepts could be integrated in other areas such as statistics, mensuration sets or any other topic that the examiner might find fit. When it was on its own it was mostly found in Section B of Paper 2 carrying 12% of the marks. Any learner who could go into the mathematics examination without mastering probability concepts was likely to be shocked when it could be found that probability aspects had been integrated into a topic one thought had mastered such as mensuration for example. Under such situations, the learner might panic and may not perform well in mathematics. My desire to find ways in which the mathematics teachers may make the learners master probability concepts motivated me to embark on this study.

1.4. Statement of the Problem

The way in which the Mathematics Curriculum is presented in Zimbabwe Curriculum Framework for Primary and Secondary Education [ZCFPE] (2015-2022) policy documents may sound perfect. However, quiet often there are disparities between what is documented in the policy document and what is implemented in the mathematics classroom (Pagana, Nyikahadzoyi, Mutambara & Chagwiza, 2015). According to Chikodzi and Nyota (2010), teaching of mathematics in Zimbabwe lacks the desired interconnection between mathematics and culture which is a prerequisite for the learner to see the utility and the social value of mathematics. The failure of the mathematics teacher to form a link between secondary school mathematics and the learners' culture implies that the learners do not understand what the teachers will be teaching.

The Zimbabwe School Examination Council Syllabus [ZSECS] [4008/4028] (2018) clearly articulates the need to link the teaching of mathematics to the learners' out-of-school mathematics practices but in most cases this link is usually missing in the mathematics classroom. According to the [ZCFPSE] (2015), one of its aims is to develop people who are aware of their environment, however, such awareness can only be realised if the learners see the utility and relevance of the subjects being taught. The learners can only see the relevance of mathematics when there is connection between school mathematics and the learners' out of school mathematics practices.

The problem is that the mathematics teachers do not seem to see the connection between some secondary school mathematics topics and the learners' out-of-school mathematics practice (Sunzuma & Maharaj, 2019). Also, the mathematics teachers seem to lack the skills required to form a meaningful connection between mathematics and the learners' real-life context (Madusise, 2015). The mathematics teachers lack the prerequisite knowledge required to extract mathematical concepts from the rural secondary school learners' out of school activities and utilise them as context for teaching some topics in secondary school mathematics (Madusise, 2015, Sunzuna & Maharaj, 2019). The integration of ethnomathematics in teaching of some topics in secondary school mathematics has been overlooked. It is against this background that this study sought to develop an ethnomathematical framework to facilitate the integration of ethnomathematics in the teaching of probability as a strand of secondary school mathematics.

1.5.The aims of the study

This study aims to integrate ethnomathematics in Zimbabwe secondary school mathematics for the teaching of probability.

1.5.1. Objectives of the study

The study seeks to:

- explore the rural Shona learners' out of school mathematical practices that can be integrated in the teaching in the teaching of probability;
- explore the integration of ethnomathematics in the form of the rural Shona learners' out of school activities in the teaching of probability;

- determine the impact of integration of ethnomathematics in secondary school mathematics in the teaching of probability in the secondary school.
- identify the mathematics teachers' difficulties in integrating ethnomathematics in secondary school mathematics when teaching probability;
- To develop a policy framework for facilitating the integration of ethno-mathematics in secondary school mathematics in the teaching of probability

1.6. Research Questions

The major question which this study sought to explore was: How can ethnomathematics be integrated in secondary school mathematics in the teaching of probability in Zimbabwe?

1.6.1. Sub questions

- Which mathematical concepts found in the rural Shona learners' out of school mathematical practices can be integrated in the teaching of probability?
- How can the mathematical concepts in the rural learners' daily activities be integrated in the secondary school mathematics for the teaching of probability?
- How can the integration of ethnomathematics in secondary school mathematics improve on the cultural relevance of the pedagogy in the mathematics classroom?
- What are the difficulties faced by mathematics teachers in integrating ethnomathematics when teaching probability?
- What should a policy framework for facilitating the integration of ethno-mathematics in secondary school mathematics in the teaching of probability look like?

1.7. Rationale of the study

The need for integrating ethnomathematics in school mathematics curriculum has been called for by several studies including (Rosa & Orey, 2010; D' Ambrosio, 2001, Madusise, 2014; & Nyoni, 2014). Although some studies were carried out, Chikodzi and Nyota (2010), Nyaumwe (2006) and Sunzuma, Zezekwa, Zinyeka & Chinyoke (2013) on integration of ethnomathematics in Zimbabwe, none of them focused on the teaching and learning of probability. Also, these studies assumed that all cultural mathematics practices can readily fit into the school mathematics, the assumption which is disputed by (Borba, 1990) who indicated that different cultural groups know mathematics in a way which is different from school mathematics. Chikodzi and Nyota (2010) only identify the rural Shona activities which are mathematical in nature, but they did not integrate the rural Shona people's activities into the teaching of mathematics. Hence this study investigates how ethnomathematics in the form of rural Shona learners' culture can be used to develop a policy framework for facilitating the integration of ethno-mathematics in secondary school mathematics in the teaching of probability in Zimbabwe.

1.8. Development of EIM to facilitate the integration of ethnomathematics in the teaching of probability

The integration of ethnomathematics in the teaching of probability in Zimbabwe is not guided by any framework hence this study is the ideal opportunity to address this by developing such a framework. One alternative strategy available is to encourage the teachers to use the EIM to guide them on how to integrate ethnomathematics in the teaching of probability. The EIM is likely to guide mathematics teachers on how to sequence lesson activities during integration of ethnomathematics in a way that makes learners to understand probability concepts better. The EIM enables mathematics teachers to analyse cultural activities and come up with culturally relevant problems that are posed as introductions to the lessons. An EIM is necessary to avoid a situation whereby mathematics teachers integrate ethnomathematics in the teaching of mathematics without being guided by any framework. An EIM framework that guides teachers in the integration of mathematics step by step has been overdue. The implementation of the EIM has very high potentials of contributing towards the effective integration of ethnomathematics in the teaching of probability.

1.9. Significance of the Study

The study makes an innovative contribution to ethnomathematics by developing developing a policy framework for facilitating the integration of ethno-mathematics in secondary school mathematics in the teaching of probability in Zimbabwe. It confronts many of the questions that arise when mathematics teachers try to incorporate the learners' culture in the teaching of mathematics in their classrooms or when curriculum developers try to develop mathematics curriculum which is relevant to the learners. This research addresses a significant problem of integrating ethnomathematics in the curriculum since scarcity in literature in ethnomathematics in Zimbabwe is enough evidence to show that ethnomathematics is understudied in Zimbabwe. Ethnomathematics studies in Zimbabwe were only carried out by Mtetwa and Jaji (2006), Nyaumwe (2006), Chikodzi and Nyota (2010), Sunzuma and Maharaj (2019) and few others. Also, to the best of the researcher's knowledge, the experience of rural secondary school mathematics teachers integrating ethnomathematics for the teaching of probability has never been documented before. This study also adds to the increasing literature on the transformative possibilities of the probability pedagogy. Mathematics educators benefitted from this study through its timeliness since current global educational trends emphasise on the need to improve mathematics instruction for the benefit of programs such as STEM. This study provided the mathematics teachers, who took part in this study to examine their experiences of teaching probability, reflect on them and determine their own efficiency and improve in their instructional practices. Finally, it is hoped that this study will act as a starting point in terms of engaging practising mathematics teachers who experience problems in forming a link between the teaching of probability and the learners' culture. It cannot be overemphasised that teaching in the context of the learner is a cornerstone for improving the students' performance in mathematics. A study of how to integrate ethnomathematics in secondary school mathematics in the teaching of probability may impact on the long-term improved performance in mathematics in the rural secondary schools in Zimbabwe.

1.10. Research Philosophy

In this study, I used the postmodern philosophy. A postmodern philosophy challenges the existence of universal and absolute truth which is used in most cases as a major cause for maintaining the status quo that only Western Mathematics is mathematics. Postmodern philosophy helped me "to view postmodernity as a vital opportunity that gave a chance to the alternative", (Tamirepi, 2013) that every culture has its own mathematics contrary to the view that mathematics is universal. In the research journey, the participants as teachers teaching in the rural areas by first thinking that probability is difficult to contextualise in the rural Shona learners' context, they later acknowledge the existence of cultural activities that can be used to teach probability to rural learners to make it understandable. There was revitalisation of "cultural activities" as neglected resources which could be used as context for teaching probability to rural learners. In this research journey, my interest was to find out how mathematics teachers could use the rural Shona culture as context for teaching probability in secondary school without an inferiority complex as it were before when everything cultural and rural was regarded as inferior. The post-modern framework to teaching mathematics in this study required critical stance towards knowledge including the learners' cultural activities which were local and contextual. More details of the theoretical framework are given in Chapter 3.

1.11. Conceptual framework

For the past three decades, scholars, D'Ambrosio (1985), Masingila (1993), Gerdes (1994), Ladson Billing (1995), Gay (2000), and Rosa and Orey (2003) have documented the need for mathematics teachers to integrate ethnomathematics into school mathematics through a theory of culturally relevant pedagogy. Integration of ethnomathematics in the school mathematics results in the mathematics teachers creating a culturally relevant pedagogy which has proved in other instances to be an effective approach to teaching for understanding because it gives the learners tools to be critical participants in the classroom (Rosa & Orey, 2010). Ethnomathematics is said to be integrated into the school mathematics when the teacher incorporates the learners' out-of-school mathematical practice into the pedagogy. In integrating ethnomathematics into the school mathematics, I was guided by theories which are discussed fully in the theoretical framework (Chapter 3). For example, Socio Cultural Theory [SCT], Culturally Relevant Pedagogy Theory [CRPT] and Social Constructivism Theory [SCT]. This study was underpinned mainly by the SCT whose proponents Vygotsky (1978) and Wenger (1998) suggest that learning should be considered more as a product of social, cultural, and political influence and less as an individual activity. I therefore put into consideration the learners' out-of-school experiences, beliefs, religion, superstitions, interpretation of language and the learners' probability intuition in coming up with a culturally relevant pedagogy for the teaching of probability, the details of which are presented in Chapter 3.

I was also guided by postmodern philosophical ideas as an epistemology in this study due to its stance that there is no objective, there exist multiple realities and that knowledge is contextual. In this study, what constitutes mathematical knowledge, how is it generated and for whom form the pillars of the epistemological framework of this study. It is through postmodernity that I visualised the second assumption that different cultural groups know mathematics in a way that is different from school mathematics. Carraher, Carraher and Schliemann (1985), Bandeira and Lucena (2004), Chieus (2004) and D'Ambrosio (2006) contrasted mathematics practice in school with mathematics practice in everyday situations and revealed that there is a difference. Using this assumption, the teachers who participated in this study used some mathematical concepts found in the rural Shona learners' out-of-school activities to come up with a model that could be used in teaching probability. With these two assumptions in mind, the teacher manages to engage in a culturally responsive pedagogy, a pedagogy which takes the learner's culture into consideration.

In this study, I subscribed to an ethnomathematical approach in which the lived experience of rural mathematics teachers became central. Ladson-Billing (1995) described how pedagogy can benefit from cultural analysis as an approach that can be used to come up with a culturally relevant approach. Instead of focusing on the learners, in this study, I opted to hear the voices of the rural mathematics teachers and their experience in linking the teaching of probability and culture. D' Ambrosio (1985) affirmed that the experience of learners outside the school is a source from which to teach mathematics. I took cognisance of this fact as I integrated ethnomathematics into the school mathematics with the participants. To that end, it was necessary that the teaching of probability begins with how the rural learners understand probability in their out-of-school. A more detailed conceptual framework of this study is presented in Chapter 3.

1.12. Methodology

In this study, I used the interpretive paradigm. According to Cohen and Crabtree (2006, p.1) a paradigm is a framework that is derived from a world view or belief system about the nature of knowledge and existence. Literature review reveals that in education research there are two opposing models, namely, the positivist and the anti- positivist normally known as the interpretive or ethnographic model (Hullet 1992). Hichcock and Hughes (1989) describe a positivist as a researcher who follows methods and procedures employed in natural sciences and as a result employ quantitative method. On the other hand, Hitchcock and Hughes (1989) refer to interpretative as a paradigm that enables researchers to learn first-hand about the social world, they are investigating by means of involvement and participation in the world through a focus upon what individual actors say and do. Borrego, Douglas and Amelink, (2009) posit that the interpretivists view human beings as capable of thinking and reflect, hence argue that positivist methods are inappropriate for studying the society. I used this qualitative approach because I wanted to "explore" (Elkatawneh, 2016, p.2) how the rural secondary school mathematics teachers integrate ethnomathematics in the teaching of probability. In this qualitative research, the data that were collected from the participants were mainly in words unlike in positivism where the data is mainly in figures, (Moore, 2016). Mohajan (2018) affirms that the objective of data collection in an interpretive inquiry is to create comprehensive records of participants' words and action. With a qualitative research approach interviews and observations prove to be suitable instruments for this study as they enable the researcher to understand the phenomenon under consideration from the insiders' point of view (Trigueros, p.1-2). In this study, to understand how the rural Shona learners, use probability concepts outside the school, I needed to be close to observe the learners to create comprehensive records of how probability concepts are used in the rural Shona people community. Borrego, Douglas and Amelink (2009) state that interpretive research enables the researcher to see how meanings are constructed and negotiated by the participants. The interpretive approach is in line with my guiding philosophy of postmodernity which emphasises contextual knowledge.

1.13. Research Design

This study follows a Participatory Action Research [PAR] design. A PAR seeks to understand and improve the world by changing it through changing the practices of the participants who take part in it (Baum, MacDougall, & Smith, 2006). I chose to be guided by PAR in this study because this study sought to change the practice of the rural secondary school mathematics teachers who participated in this study. Meyer (2000) affirms that PAR enables the participants to reflect on and try to find the best action that should be taken to improve their practice. Carr and Kemmis (1986) add that PAR is collective, self-reflective that both the researcher and the participants collaborate to comprehend and improve upon the practices of participants. In this study, I intended to collaborate with the rural secondary school mathematics teachers to find ways in which they can effectively integrate ethnomathematics in the teaching of probability in OL mathematics. I wanted to do research with them so that they would become part of the team that generates solutions to their problem and improve their practices. One key aspect of PAR is that those directly affected by the problem, the researched should be involved in the research process actively (O'Connor, Greene & Anderson, 2006). Meyer (1986) describes AR as "doing research with and for people rather than undertaking research on them". In a PAR reflection is a process which is directly linked to action (Baum, MacDougall, & Smith, 2006, p.854). In using the PAR, I wanted to generate a solution which is local, contextual, and guided by the postmodern philosophy. Stringer (2008) points out that action research aims to "find appropriate solutions for the particular dynamics at work in a local situation". MacDonald (2012, p.36) affirms that PAR differs from the less dynamic approaches in that PAR does not remove data and information from their contexts. Finally, I opted for PAR in this study because I felt that a general solution arising from a less dynamic approach may not fit the context of the selected school.

1.13.1. Sample and Sampling procedure

The school was purposely selected because it is one of the schools in the district where the problem of integrating ethnomathematics for the teaching of probability was being experienced. Purposeful sampling is a sampling technique which involves the researcher's engagement of a deliberate choice of a participant due to certain qualities that participants possess, such as ideal proximity to the study area (Choongwa, 2018). The researcher formed a research team of three mathematics teachers who are teaching OL mathematics at the purposely selected school. The teachers were also purposely selected because they are teaching in the district in which the problem of integrating ethnomathematics in the school mathematics was being experienced. Also, I considered the relationship that will be created between me as a researcher and the teachers. Montero (2004) notes that the relationship between the researcher and the participants is key to successful PAR.

I did not anticipate any problem in negotiating access to the site and finding volunteers amongst the teachers. I was teaching at the neighbouring school to the selected school some years ago. Since I left the school, I have been visiting that school frequently, so the teachers at the school take the researcher as their colleague.

1.13.2. Instruments

After a thorough survey of related literature, I found that semi-structured interviews and lesson observations were the best instruments for this study. Gall, Borg, and Gall (1996) and Creswell

(2007) describe how interviews promote verbatim recording of responses that provides immediate feedback and give room for probing and clarification of issues, and this allows the researcher to cross-check data for authenticity. Cohen and Crabtree (2006) are of the view that observation allows the researcher to see phenomena about a situation which those involved may take for granted. In this study, observation of cultural activities journalised while lesson observations and interviews journalised, and audio recorded. With the statement of the problem in mind the instruments for this study were developed from 7 open ended interview questions. The observations were used to collect data on the probability concepts in the rural Shona learners' out-of-school probability concepts and to collect data during lesson delivery. The interviews were used to collect data from the OL mathematics teachers.

1.13.3. Data analysis

Tuckman and Harper (2012) post that in a qualitative study data collection and data analysis are inseparable because data analysis guides the researcher build coherent data hence qualitative data analysis starts with preliminary analysis conducted in the field. The researcher began transcribing interview and post lesson meetings during the data collection period, and this helped the researcher in identifying some new strategies for collecting new data. Doing data analysis from the onset of data collection helps to inform the researcher to cycle back and forth between thinking about the already collected data and generating new ideas for collecting improved data (Thorne, 2008). The interviews and meetings analysis followed the following stages: transcribing, coding, restructuring and saturation of data. The researcher and the participants had a data analysis meeting. In this meeting the researcher and the participant compared data from the journals, meetings, and the participants, interviews, and reflections.

1.13.3.1. Coding

I was responsible for coding emerging themes (Linneberg & Korsgaard, 2019) from the journals during analysis meetings. The codes were created with the aspect to be analysed in mind guided by the research questions. Additional codes were created as transcribing was going on to cater for some new aspects which might arise. Cope (2010) posits that the researcher should create codes for emerging themes might not have thought about before. The researcher also created codes for aspects which came up but unrelated to the integration of ethnomathematics in teaching mathematics.

1.13.3.2. Restructuring

Open interviews normally result in some issues not being taken in the same order (Griffee, 2005) and, some issue may be focused more than once. Under such situations, the researcher had to reorganise the transcripts. The researcher re-read the interview scripts to ensure that all words spoken and everything that observed during the lesson were subjected to analysis**.**

1.13.3.3. Data verification

Re-reading of all interviews, meeting and lesson observations was done to ensure that all words uttered by the interviewees regarding integration of ethnomathematics were considered for analysis.

1.14. Ethical Consideration

The researcher got a clearance letter from the Research Ethics Review Committee, (RERC) before getting into the field for data collection. The researcher took the clearance letter from RERC to the District Education Officer of the district where the research was going to be carried for him to be allowed to carry out this study in that district. The researcher wrote a letter to explain the purpose of the research to participants. Also, the participants took part in the research on a voluntary basis and made informed and non-coerced consent. The participants expressed their consent by signing a consent form. The researcher ensured that no one was going to be harmed in any way during this research. This form explained the purpose of the research and the way the information was going to be used and the confidentiality of the information that was collected**.** For ethical consideration in this research no real names of the participants were used, pseudo codes were used in place of names and the recorded audio tapes were kept safe and not disclosed to the third party. Participants were also informed that they had the right to withdraw without being prejudiced.

1.15. Limitation and delimitation of study

According to Creswell (2011), delimitation is defined as the boundary of the study in terms of the time frame, location, and the sample all of which are under the control of the researcher. In this study, several reasons influenced my decision to use PAR and focus on the rural secondary school. The first reason is when I commenced this study, I was teaching Research Methodology as a block release lecturer at one of the universities in which I was responsible for teaching Action Research. I had developed interest in PAR and believed in its power in the improvement of the teachers' instructional effectiveness. The number of mathematics teachers who were committed to see this study completed delimited this study. The study focused on a single rural secondary school and the three mathematics teachers who teach OL mathematics at that school. When PAR is used the purpose is to guide people in a particular problem to realise that the solution of their problem comes from within them hence randomness is not the aim of AR.

The experiences of mathematics teachers of this current research cannot be generalised within schools in other areas in Zimbabwe. The unique cultural and social environment of the study makes it difficult to draw conclusions about similar populations in another school. The lack of recent literature relevant to the Zimbabwean set up will be a limitation on its own. Thus, the study was mainly based on literature from other countries in the same situation as Zimbabwe.

This study was carried out at one selected rural day secondary school in Bikita District in Masvingo Province of Zimbabwe. The district under consideration has 57 secondary schools of which 54 are rural day secondary schools. The chosen secondary school is in the area where most adult people are former employees of a certain cattle range. The focus of the study was to integrate ethnomathematics in the teaching of probability in secondary schools in Zimbabwe. The study was based on interviews for the teachers, lesson observations and meetings.

1.16. Definition of key concepts

In this section, I present conceptual definitions of some key concepts used in this study. These concepts are further explained in the discussion of theoretical framework.

1.16.1. Integrate: To connect or combine the two things together so that they form an effective unit or system (Macmillan English Dictionary for advanced learners, 2000).

1.16.2. Rural Shona people: The people who speak Shona language in Zimbabwe whose cultural practices has unique mathematical practices and concepts which are different from those used in school mathematics.

1.16.3. School mathematics: This is synonymous to academic mathematics being taught in schools. This is mathematics as shown in the school curriculum which is taught at schools.

1.16.4. Mathematical practices: This is how mathematics is used knowingly or unknowingly in the day-to-day activities of the people living together as a society.

1.16.5. Ethnomathematics: Ethnomathematics is a pedagogy in which the learners' home mathematical practices are put into consideration. D'Ambrosio (1980) defined ethnomathematics as the way different cultural groups use mathematics.

1.16.6. Culturally relevant pedagogy: Using cultural knowledge, prior experiences frame of reference, and performance style of ethnically diverse students to make learning encountered more relevant and effective for the learners (Gay 2000).

1.16.7. Ethnomathematical approach: It is a teaching approach in which mathematics teachers take into consideration the cultural and linguistic background of their students in the pedagogy. In other words, ethnomathematical approach is when the teacher uses the culturally relevant pedagogy.

1.17. Overview of this study

Chapter 1 was about introduction, problem statement, and background to the study, motivation, research aims and objectives, research questions, methodology of study of the study, purpose of study, rationale, and significance of study. It also looked at limitations, delimitation of the study and finally defined the key concepts used in the study. Chapter 2 focused on literature review. The third chapter presents the theoretical framework of the study. In Chapter 4, I present the methodological considerations for the study. In the fifth chapter, I present the participants who took part in this study. The sixth chapter presents the pilot study and the findings of this study. In the seventh chapter, I present the findings of this study. Finally, the eighth chapter presents the conclusion and the recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

The chapter presents the context in which learning takes place in the rural areas of Zimbabwe where this study was conducted. The context under consideration covers the availability of infrastructure, availability of learning material, availability of qualified teachers, the rural learners, and the problems they encounter at home and at school. The chapter goes on to look at the concept of ethnomathematics, how it came about and how it has evolved up to the present day. The chapter also discusses the integration of ethnomathematics, what it means to integrate ethnomathematics and the benefits of integrating ethnomathematics in the teaching of mathematics. It also focuses on the traditional mathematics classroom where it has been revealed that the teaching of mathematics disregards the learners' culture thereby making it difficult for the learners to see the connection between culture and school mathematics. The chapter highlights the weak connection between the teaching of mathematics and the learners' culture currently witnessed in the mathematics classroom and how it disadvantages the learners. The pedagogical challenges faced by mathematics teachers in the teaching of probability are and also how integration of ethnomathematics. can alleviated those challenges is discussed Finally, the chapter discusses the gap left by the studies which were carried out in Zimbabwe on the integration of ethnomathematics in the teaching of mathematics.

2.2.1. The context in which learning of mathematics takes place in rural areas in Zimbabwe

Ethnomathematics is still a new study area in Zimbabwe, therefore the literature on ethnomathematics is still scarce. This is confirmed by Sunzuma and Maharaj (2019) who found that teachers in Zimbabwe were not trained to use ethnomathematics approach in teachers' training colleges. This study utilised that little literature available and what has been studied elsewhere since there are some similarities in ethnomathematics studies. The literature is not exhaustive. However, the synthesis of this literature clarifies concepts and made me understand what has been done as far as integration of ethnomathematics in the school mathematics is concerned in Zimbabwe and in other countries.

2.2.2. The rural areas

In this study, the concept of a rural area is understood through its geographical characteristics and the activities that people carry out in those areas. According to Acker and Gasperini (2009, p.10), a rural area is a place where most people engage in agriculture to produce their own food or work for very low compensation. The major activities that take place in the rural area in which this study was carried out are cattle rearing and subsistence crop production. The area under consideration was previously a cattle range farm of a white man and the area is dry and has infertile soils. Peresu, Nhundu and Makoni (1999) described Zimbabwe rural areas as characterised by large tracks of infertile land for farming and grazing. In addition to these two main activities people in rural areas also practise handcraft and hunting of small games and river fishing (Acker & Gasperini, 2009). It is around those activities that the rural Shona people's culture is coined and hence the integration of ethnomathematics into the secondary school mathematics sought to utilise some of those activities. There are also some subcultures which emerge from those activities which were considered in this study. Polygamy is one such subculture which arises from the desire to have many wives and children to provide labour in the field and other activities. Baloyi (2013) affirms that one of the causes of polygamy in an African society is to share responsibilities in taking care of livestock and ploughing the field.

2.2.3. Infrastructure in rural secondary schools

The teaching of mathematics in Zimbabwe rural secondary schools is mired with problems. According to Mutale (2015), one of the major challenges faced by rural secondary schools is lack of infrastructure. In addition, the Newsday of 4th September 2014 after surveying the infrastructural challenges faced by rural schools reported that most rural areas have schools which are not adequately supported with facilities that will make education attainable to many. Most of the rural secondary schools in Zimbabwe do not have enough classrooms, toilets and even teachers' cottages. The infrastructure problem in some schools is so pathetic that one may wonder how the learners are expected to learn under such situations. Mutale (2015) goes further to say poor infrastructure reduces learners' concentration leading to poor performance in mathematics. In addition, Mandina (2012) also observed that lack of classrooms results in overcrowded classes hence the teacher-pupil ratio becomes unreasonably high to the extent that teachers find it difficult to effectively deliver their lessons. Also, many rural schools lack the essential infrastructure to enable them to function as safe, efficient, and effective schools.

2.2.4. Availability of qualified mathematics teachers in rural areas

Another challenge faced by rural secondary schools is scarcity of qualified teachers especially in Science and Mathematics (Gomba, 2015). There is high turnover of science and mathematics teachers because the government of Zimbabwe has for some years failed to adequately remunerate teachers. Due to poor remuneration the teachers have become the laughingstock in the communities in which they work. According to Gomba (2015), poor remuneration leads to lack of respect for teachers by both parents and learners, as a result, qualified teachers leave the rural areas for greener pastures. Apart from poor remuneration, Mandina (2012) opines that rural areas do not attract teachers because of limited resources. The Ministry of Education (2008) Report reveals that teachers' emigration from the rural areas was felt in the Science and Mathematics subjects. Most of those migrated to countries such as South Africa and Botswana where they were in demand and highly remunerated.

Despite the demotivating working conditions in the rural areas, there are some qualified teachers who serve in the rural areas. According to Gomba (2012), some of the reasons why some teachers do not intend to leave the rural areas is being close to their families, and love of their work. Some also want the job security provided by the government, hence they choose to soldier on despite working in those dehumanising conditions. Whatever their reason for staying, Mandina (2012, p.770) maintains that those teachers are forced to find additional income which usually impacts negatively on their performance in the classroom. In the rural area in which this study took place, teachers supplemented their income by practising crop farming and animal husbandry when they had free time. The unique unfavourable conditions faced by the rural secondary teachers is further expressed by Eppley (2009) who states that being a successful teacher in rural school is different from being a successful teacher in other settings. This is so because rural school conditions are not conducive for both the teachers and the learners. Effective teaching in mathematics requires that mathematics teachers plan their work, gather learning and teaching aids, but due to the demotivating rural situations usually some teachers teach from the textbook without adequate preparation. However, some of the teachers are dedicated to their work and they are in constant search of solutions to the problems affecting their lesson delivery. Hence it is against that background that some of them volunteered to participate in this study to improve their practice.

2.2.5. The rural secondary school learners in Zimbabwe

The rural secondary school learners are the most disadvantaged group of learners in Zimbabwe (Chikodzi & Nyota, 2010). Some of the learners walk very long distances of more than fifteen kilometres to the nearest secondary school, a situation that has proved to be counterproductive and retrogressive in terms of preparing the learners for the future (Newsday, September 2014). The learners reach the school very tired such that they cannot concentrate on the schoolwork. The rural learners in Zimbabwe like in any other developing countries provide unpaid agricultural and domestic labour to the family. Before they go to school, they must do some domestic chores and after school they go to the field and herd cattle. According to Admassie (2003), it is common for rural learners to combine domestic chores and school attendance. Besides combining school and household chores, most of the rural secondary school learners come from economically marginalised families (Ncube, 2014). Due to these factors the learners are likely to be demotivated to learn especially when the teaching of mathematics seems irrelevant to their environment. Since the learners are preoccupied with the domestic chores and agricultural activities, the mathematics teacher should try to capitalise on this situation by including these activities as context for teaching mathematics. In addition to that, Ncube (2014) found that Zimbabwe rural secondary school students lack exposure to modern technology hence the use of local ideas and resources in teaching mathematics can improve the participation and performance of the learners in mathematics. Utilising the local environment and activities in the teaching of mathematics can enhance learners' understanding of mathematics concepts (Jojo 2015). Those activities in which the rural learners are engaged out of school can be used to make connections between culture and learning of mathematics.

In support of this view, Bush (2005) affirms that the rural areas activities have potential to disclose interesting and useful insights relating to the connections that exist between culture and school mathematics. This study utilised those activities to develop culturally relevant pedagogy for the teaching of probability in rural secondary schools. In addition, Tatira, Mutambara and Chagwiza

(2012) affirm that rural communities have well-knitted and immortal cultural activities which possess intricate and diverse mathematical concepts which can be used for the benefit of the pedagogy. Apart from activities connected to agricultural activities and domestic responsibility, the rural learners engage in many more other activities. For example, they play games, swim in the rivers, fetch water from the wells, and fetch firewood from the forest. All those activities can be used as the starting points when integrating ethnomathematics in the teaching of probability concepts.

2.2.6. Scarcity of teaching and learning resources in rural secondary schools

People who live in the rural areas in Zimbabwe are mostly peasant farmers who cannot finance the education of their children adequately. Their schools usually depend on government funding for textbooks and equipment, but the government funding is also inadequate. The rural secondary schools are poorly funded, and they are characterised by lack of textbooks and other learning materials. Mandina (2012) affirms that the social-economic realities of rural secondary schools put the learners at a disadvantage as they usually do not have textbooks that they need. The few textbooks are shared, or they may not be there at all. So instead of looking forward to finding textbooks which may not be forthcoming, the mathematics teachers ought to find ways of teaching without textbooks but still get the learners to understand mathematics. This is supported by Mukeredzi (2013) who pointed out that apart from lacking facilities, the schools are also under-resourced in terms of textbooks and equipment such that even mathematics teachers must improvise on such things as mathematical instruments. Mukeredzi (2013) goes further to say that improvising with limited resources prompts in teachers an ability to think creatively. Even where some few textbooks may be available, they have proved to be irrelevant because they present the context which is far detached from the context familiar to rural learners. Moreover, Chikodzi and

Nyota (2010) affirm that the few mathematics textbooks which are available in the schools have most examples detached from the rural learners' context. For example, the probability problems found in those textbooks are not familiar to rural learners. The rural learners therefore need support in the form of the pedagogy that can make them understand mathematics.

2.3.1. Understanding the concept ethnomathematics

This section focuses on the meaning of the term ethnomathematics. My views and understanding of ethnomathematics were influenced by the ideas of D'Ambrosio (1985) and Borba (1990). The general idea of ethnomathematics is based on the point that mathematics is practised by every culture, and it is practised in different ways in dealing with problems that arise in people's daily lives. Ethnomathematics can be viewed as a field of knowledge intrinsically linked to a cultural group and its interest and is tightly linked to the group's reality and expressed in a language different from the one used in school mathematics (Borba, 1987). According to Borba (1990, p.40), ethnomathematics is mathematics knowledge expressed in the language code of a given social cultural group. Borba (1990) asserts that every culture does mathematics, although the mathematics is expressed in ways unique to that culture. This study analysed the probabilistic concepts in the day-to-day activities of the rural Shona people, to see how those concepts are used and how they can be incorporated into the teaching of probability in secondary schools. Based on these definitions people can only understand mathematics of another cultural group different from theirs through being socialised into that culture. Borba goes on to say that mathematics is regarded as a language whose code can only be understood by people who have participated in a common experience.

To ensure that the participants in the study would be able to understand the ethnomathematics found in the activities of the rural Shona learners, I deliberately chose mathematics teachers who were fluent in the Shona language. This made it possible for them to identify and incorporate the rural Shona learners' understanding of probability concepts into their pedagogy. Thus, ethnomathematics cannot be detached from the language of the cultural group, and anyone who may need to understand ethnomathematics needs to understand the language of the social group involved.

According to D' Ambrosio (1985), ethnomathematics is the mathematics practised by different cultural groups, such as urban and rural communities, groups of workers, professional classes, children in any given age group, indigenous societies and so many other groups. The groups are identified by their objectives and traditions common to the members of those groups. This study focuses on the rural Shona secondary school learners as a cultural group which has its own ethnomathematics that has its roots in their problem-solving activities by virtue of their common age group and being secondary school learners. Borba (1990) used "social group" in the definition of ethnomathematics, while D'Ambrosio (1985, p36) used "cultural group". These terms are synonymous, they include any subgroup that can be a subset of the main social groups such as headmen, children who play a certain game for example and any other group sharing the same experience and practice mathematics to solve problems encountered by that particular group. Learners in a certain grade are a subset of the main social group therefore it is possible to find ethnomathematics practised by such a subgroup. This study therefore treated the rural secondary school learners as a subgroup whose ethnomathematics could be found and integrated in the school mathematics.

Bishop (1988) regards mathematics as a cultural product which develops because of various activities. However, this contrasts with Joseph (1987) who views mathematics as independent from culture. Joseph's (1987) perspective sounds ambiguous when he says mathematics is culture free because mathematics has histories and that "the histories have come from different cultures" (Bishop, 1988, p.180). Mathematics has history of its origin as well as how it was practised, therefore there is no way mathematics can be regarded as being culture free. D'Ambrosio (1985) corroborated that mathematics is not independent from culture and defined ethnomathematics as the relationship between culture and mathematics.

Pais (2013) adds that mathematics is any form of cultural knowledge or social activity characteristic of a social group that can be recognised by other groups but not necessarily by the group of origin as mathematical knowledge. According to this opinion the cultural group on its own cannot ascertain whether what it is doing is mathematics or not. Furthermore, their aims are not to do mathematics but to solve their problems. However, this understanding of ethnomathematics subjects all other ethnomathematics to be evaluated by school mathematics because other mathematics cannot make such determination. In the integration of ethnomathematics the mathematics teachers by virtue of their knowledge of school mathematics have the mandate to mathematise the learners' out-of-school mathematics practices. Even the so called ethnomathematicians likewise bank on their strength of school mathematical knowledge to identify some mathematical concepts in cultural activities. The participants in this study depended on their understanding of probability concepts from the school perspective of probability to identify some probability concepts in the rural Shona learners' activities. However, in carrying out these activities, the rural Shona learners might not know that what they were doing is probability, since their intention is not to do probability. Pais' argument is consistent with Borba (1990, p.41) who says, "Every cultural group practice mathematics but the intention is not to do mathematics" in the same way learners do mathematics at school, but to solve real life problems they encounter as they move on with their lives.

Gerdes (1994) also affirms the relationship between mathematics and culture when he defined ethnomathematics as the cultural anthropology of mathematics, showing that the two cannot be separated. Cultural anthropology of mathematics refers to how social groups develop, practice, and transmit mathematics ideas from one generation to the other. The strength of the bond between mathematics and culture can be traced to Borba (1987, p.38) who says ethnomathematics is knowledge "intrinsically linked to cultural groups…" Citing the strong connection between mathematics and culture, when integrating ethnomathematics in the school mathematics the mathematics teachers should not prune ethnomathematics of its context because the learners may not see the connection between school mathematics and their cultures. In Zimbabwe, the problem is that mathematics teachers teach mathematics as though mathematics is culture free, and as a result, learners fail to understand mathematics concepts being taught. Some mathematics teachers do not understand the relationship between mathematics and culture. Muzangwa and Chindanya (2014) studied the in-service teachers' views on culture and mathematics education in Zimbabwe in which 27 teachers participated. They found that 21 of the teachers believed that mathematics is a culture free subject. Such a perception is not unique to mathematics teachers in Zimbabwe only.

2.3.2. Uniqueness of ethnomathematics

Ethnomathematics has two assumptions (see Section 1.10). In this section, I discuss one of the assumptions which is based on "the epistemological nature of mathematics" (Cimen, 2014, p.524). According to D'Ambrosio (1995), cultural mathematics is unique. The uniqueness of ethnomathematics is also asserted by Gerdes (1994) and D'Ambrosio (1994) who state that historically some cultures created their own mathematics.

According to Rosa and Orey (2010), ethnomathematics is a way in which people from a particular culture use mathematical ideas and concepts in dealing with quantitative, relational, and spatial aspects of their lives. The uniqueness of the mathematics found in different cultures is emphasised by the use of the possessive pronoun "their" in this definition. Rosa and Orey (2010) further note that mathematics is a tool used by different cultural groups in dealing but with problems they encounter daily. The problem the cultural groups may be facing may be the same but being solved differently resulting in using different mathematics. For example, two cultural groups faced with the problem of catching fish from the river, one cultural group developed skills to mix herbs that may kill the fish without making them poisonous to eat, while another developed skills to construct fish nets for catching the fish. Cimen (2014) describes how two different cultural groups confronted with the problem of crossing the river can solve the problem differently due to their different environments which will in turn give rise to different mathematics.

School mathematics is different from ethnomathematics in that it is done for its own sake whereas ethnomathematics is problem-solving oriented in that it is "linked to the obstacle that was encountered by the cultural group in the past", (Barba, 1990, p.41). For example, most of the mathematical problems solved in the classroom are pseudo problems. Ethnomathematics is mathematics that arise from a solution of real-life problems of a particular cultural group. However, not all solutions to the cultural group problems are regarded as ethnomathematics, only solutions to the cultural group's problems which contribute to the development of ethnomathematics of that particular culture when it involves some mathematical treatments (Borba, 1990). When integrating ethnomathematics it should be noted that each identifiable subgroup found in the main cultural group has its own unique ethnomathematics which is different from that of the main group by virtue of encountering and solving different problems as a subgroup. For example, the young people herding cattle have their own probabilistic ideas different from the probabilistic ideas used by girls when using clay to mould clay pots which the participants used when integrating ethnomathematics in classes with both boys and girls. Also, when integrating ethnomathematics in the teaching of probability, the participants had to find out how the concept originated in the cultural group and the circumstances under which it is used outside the school. They had to find out what problem the activities intended to solve and their original context.

Bandera and Lucena (2004) and Duarte (2004) reveal that mathematical concepts and skills are also acquired outside the structured system of mathematics learning such as schools. In most cases, the mathematics skills acquired outside school are quite different from those acquired at school. For example, Prediger (2008, p.1) identified that when solving probability tasks, learners perceived a strong gap between the conceptions demanded in probability classrooms and their individual conceptions. Difference in conception is brought about by the difference between school mathematics and mathematics practised outside the school. For example, in the Shona culture of Zimbabwe, probability statements such as I think it will rain tonight are given without any calculation required, whereas in the school conception of probability one is required to go further to find the degree of accuracy of such statements by giving numerical value of the probability. The rural Shona learners acquire some probability concepts in their day-to-day activities such as games (Chikodzi & Nyota, 2010) but those probability concepts may not be the same as those acquired from school because the intention is not to do mathematics but to play the game. Those probability concepts need to be mathematised for them to determine how best they can be incorporated into the mathematics classroom.

Orey (2000) regards ethnomathematics as a tool developed by a cultural group to act in the world. Different cultures act differently to a given situation, consequently each cultural group develops different tools to solve the problems, and this results in different mathematics for different cultural groups. For example, the Ndau people who occupy the eastern part of Zimbabwe protect their maize from weevils by exposing it to all weather elements throughout the year while some Karanga people of Masvingo put the maize in the granaries and seal the granaries so that the maize is not exposed to weather elements. It is therefore clear that those two groups of people had developed two different approaches to dealing with probability of weevils attacking their maize, therefore giving rise to unique mathematics.

The uniqueness of mathematics was further affirmed by Bandera and Lucena (2004) whose study established that mathematics used by farmers in the North Region of Brazil for producing, harvesting, and marketing their vegetables was different from mathematical knowledge acquired in the school setting. This implies that the farmers use mathematics concepts developed by their culture which serve the same purpose as school mathematics. Hence it is possible to link ethnomathematics of any cultural group such as the rural Shona learners' ethno-probability concepts to school mathematics. For example, in the Shona culture if a pregnant woman appears to be hating her husband during her pregnancy, she is most likely to give birth to a baby boy. It has become apparent that the rural Shona people has a lot of probability concepts which can be connected to school mathematics. Balamurugani (2015) affirms that ethnomathematics is about mathematical ideas that were created and perfected by indigenous societies and which are inherently embedded in the social practices and daily rituals. Furthermore, every cultural group has developed a unique and often distinct way to mathematise their own reality (D'Ambrosio, 1990). For example, to determine whether in a particular year there would be adequate rainfall, the Shona people of Zimbabwe determine by how the *muswati* tree flowers bloom during spring. It is believed that if the flowers of *muswati* tree are very white, there will be enough rain for the crops that year, but if the flowers are yellowish in colour, it signifies drought. In integrating ethnomathematics in the school mathematics the researcher had to dig in on the daily rituals of that cultural group under consideration especially the reason behind those rituals.

In the integration of ethnomathematics, some mathematical concepts found in cultural activities do not always match those found in school mathematics because the two were developed by different cultural groups. Ethnomathematics is coded in the language, symbols, and myth of that cultural group (Rosa & Orey, 2013) thus making ethnomathematics unique for each cultural group. For example, in the Shona culture, prediction is based on belief and myth while in the Western culture it is based on randomness. This implies that there does not exist a fair die in the Shona culture. However, there exist people who are naturally gifted that when they toss a die for example it is likely to favour them by showing the outcome they desire. This aspect of ethnomathematics has been overlooked by many researchers when integrating ethnomathematics in the teaching of mathematics they assume a one-to-one relationship between ethnomathematics and school mathematics. For some few studies which were carried out in Zimbabwe there is no in-depth analysis of ethnomathematics to show that although there are some mathematical concepts in the cultural activities, they cannot fit exactly in the school mathematics.

Chikodzi and Nyota (2010), in their study of the interplay of culture and mathematics, list cultural activities found in the Shona culture such as making beads, fetching of water, swimming, herding cattle just to mention a few and their corresponding uses in the mathematics classroom. By just mentioning the classroom use of these activities without considering how and why these activities are carried out in the Shona culture they disregard the values and beliefs associated with these activities thereby pruning ethnomathematics of its context. In the integration of ethnomathematics, teachers can frame a task based on the learners' values and beliefs. For example, there is no need to insist on the fair coin and fair dice when such a concept does not exist in the mind of the learners. The teacher needs to start with a coin or die which favours a certain individual then move on to the fair coin or die. Also, Mpofu and Mpofu (2019) in their study of the mathematics embedded in the indigenous games of the Karanga people of Zimbabwe focused on the school mathematics such as sequences, probability law and projectiles just to mention a few. They did not give the cultural aspects of those games, which includes their cultural significance. Apart from that, the mathematics derived from those games is beyond the scope of the age groups that plays the games and there is neither cultural attribute nor any uniqueness to show that the games were drawn from the Karanga people of Zimbabwe.

2.3.3. The dual aspect of mathematics

In the previous section, I highlighted the uniqueness of ethnomathematics generated by Karanga people of Masvingo Region of Zimbabwe and the Ndau people who occupy the Eastern part of Zimbabwe. In this section, I explain the dual aspects of mathematics, regarding when mathematics can be said to be a cultural product and when it is said to be universal. D' Ambrosio (1985a) asserts that before they go to school, all children in the world become "matherate". They can use numbers for counting, make pattern inference the process of which arises through the process of cultural socialisation. For example, if a Zulu child and a Shona child are given five counters to count in the way they do in their own culture and language, both can count successfully. In this case, we cannot argue that their mathematics is different, the difference is in terms of the languages and probably the methods of counting but the mathematics inherent there is enumeration which gives the same result for the two cultures. The probability ideas like any other mathematical concept are found in all cultures but it is only the symbolisation that varies. This is affirmed by Cimen (2014) that different cultures use different symbolisation to express their mathematical ideas. All cultures for example deal with concepts of area, volume and time, it is the representation that varies from culture to culture but the reality about those variables is shared across cultures (Turugari, 2008).

Going back to the example of the two children, if we take the symbolisation or representations used as the mathematics, then one can say mathematics produced by the two cultures is different and unique. However, if we take enumeration as the mathematics then their mathematics is the same. This argument gives rise to the question of whether mathematics refers to the problem being solved or to the method being used to solve the problem. By referring to ethnomathematics as a tool, Rosa and Orey (2000) mean that mathematics is the method or technique used to solve problems. Hence since different cultures use different techniques then mathematics found in different cultures are unique. When integrating ethnomathematics in the teaching of probability the symbols used by the learners outside the school should be the starting point. This implies that by evoking an ethnomathematics approach it is desired that the mathematics teachers begin from the representation familiar to the learners. This is confirmed by Borba (1990) that the process of education should have ethnomathematics as the starting point for the learner to understand school mathematics. Mathematics should not be removed from its context if the learners are to benefit from integration of ethnomathematics. Also, when integrating ethnomathematics in the teaching of mathematics teachers need to show appreciation of the learners' culture. (See 3.6.4).

The studies which were carried out on ethnomathematics rushed to identify the mathematical concepts similar to those found in school mathematics in the culture activities and ignored the cultural explanation of those activities which may help the teacher to develop challenging tasks for the learners. For example, Chikodzi and Nyota (2010) rush to say that there are probability concepts in a game played by the rural Shona children called *zairakaora* and ignore the reason why the game is not culturally played to teach probability but alertness which the study did not even mention. In a study carried out by Abiam, Abonyi, Ugama and Okafor (2016) on the effect of ethnomathematics based instructional approach in Nigeria the researchers asked learners to name the cultural artefacts in their environment and measure their dimensions. Naming artefacts alone is not enough to constitute an ethnomathematics approach although one can argue that it is because the teacher used the artefacts found in the learners' culture. However, it could be necessary for the teacher to include how the artefacts are used and how their sizes are measured in that culture. After that then the teacher may go on to ask how they are measured at school. It seems some researchers (Abiam *et al.,* 2016; Chikodzi & Nyota, 2010) only analyse the culture to find the mathematics inherent in them but no analysis to find out why things are done in that way in that particular culture. Chikodzi and Nyota (2010) explain how some mathematics concepts found in some games played by some Zimbabwean children such as *nhodo, pada* and *mahumbwe* can be used in a mathematics classroom. However, they ignore the reasons why those games are played in the first place, thereby ignoring the myths and beliefs associated with playing games in the Shona culture. For example, it is not allowed in the Shona culture to play some games such as *hwai-hwai* during the daylight. While the boys and girls would be playing games that linked to their gender roles during the day, some games that are played during the night because they appeal to gender roles of both boys and girls in the Shona culture. *Hwai-hwai* is meant to show how safe the children are when they are close to their parents and no matter how difficult it may be one should always go home. When playing *hwai-hwai*, the players divide themselves into three groups who act as parents, children, and hyenas. The parents and the children should be at least five metres away and the hyenas halfway that distance but hiding on the sides. A line is drawn closer to the group representing the parents and the line marks the safe zone beyond which the hyenas cannot attack the children. The parents call their children to come home, and the children say they do not want to come home because they are afraid of hyenas but the parents shout that there are no more hyenas. As they say that the children run all at the same time aiming to go and cross the safe zone before being caught by the hyenas. The game is repeated until no more child is left then they start all over again changing the parents, children, and hyenas' roles.

Also, before taking those games into the mathematics classroom the teacher needs to understand the aspect of life the game aims to teach the children and develop the pedagogy around that aspect. For example, the teacher should understand why children playing *zairakaora* sit in a circle and not in a straight line. *Zairakaora* means a rotten egg. This game of rotten egg is played during the night by both boys and girls. All the players sit in a circle except one who is chosen to run around the seated players with what is a pebble in his/her hand that is assumed to be a rotten egg. As he/she runs around the other players he/she is supposed to stealthily place the pebble behind any one of the seated players. Having placed the pebble, he/she is supposed to make one complete revolution back to the person where the pebble had been placed before the person realises the pebble has been placed behind him/her. If the person realises that the pebble has been placed behind, he/she quickly picks the pebble and stands up and follows the one who had placed the pebble and sings *zairakaora*. The one who had dropped the pebble then goes and sits on the place left by the one who now has the pebble. If one fails to see that the pebble has been dropped behind him/her until the one who had put the pebble comes back to that point, they are removed from the circle for they are assumed to be rotten eggs who can spoil them. This continues until there is one person left for the whole group to start again. Although the game can be used to teach randomness in the sense that any of them can become a rotten egg, the game is meant to teach the young people not to associate with bad people of any sort because they will also end up being bad. Hence through understanding this cultural motive of the *zairakaora* conditional probability can be taught. For example, if Tapiwa and Tinashe are friends, and it is known that Tapiwa is a thief the probability that Tinashe is also a thief is one. Failure to understand these cultural aspects, the teacher may ignore symbolism used in that culture and concentrate on the Western mathematics aspect found in the games.

2.3.4. Evolution of ethnomathematics

Ethnomathematics as a way of knowing at its inception emerged in response to a long-standing history disclosing a deliberate devaluation of the mathematics developed and expanded by non-European civilisation (Chahine, 2013). At that time, it was believed that mathematics knowledge could only be acquired through Western civilisation and that was the only way of knowing mathematics. Ethnomathematics emerged to counter the perspective where the contributions of other cultures to mathematics development were side lined in favour of Western mathematics. Some ethnomathematicians such as Powell and Frankenstein (1987), Bishop (1990), Frankenstein (1997), and D' Ambrosio (1999), describe how Western mathematics was being used as one of the most powerful weapons in imposing the Western culture. When ethnomathematics was suggested for the first time in the 1970s and 1980s as a new field in mathematics education, it was seen as something new and exotic. The idea of observing mathematics in other cultures which were not of the Western origin and using the findings in everyday classes sounded very strange for the mathematics teachers. The only way they thought ethnomathematics could be used was as an enrichment to the Western mathematics. According to Shirley (2001), when ethnomathematics emerged in the 1970s, it was a way of looking at the mathematics found in other cultures without an intention of using it in the mathematics classroom but just to show that mathematics is not culture free.

Also, at that time it was difficult to convince the mathematics educators that mathematics is not culture free because mathematics educators at that time had confidence in the wisdom of the Western educators who advocated for cultural matheracy. According to Bishop (1988), the Western mathematician's perspective mathematics was culture free knowledge, and its ideas were decontextualised and abstracted in such a way that they could apply anywhere. This perception of mathematics originated from the externalist philosophers who believed that mathematical knowledge was not a human construct and was culture free. As a result of this view, the teaching of mathematics was constant without any issue of the learners' culture except that mathematics has some sociological aspects (Shirley, 2001). In this context sociological aspects refer to the application of mathematics in the society when D'Ambrosio (1984) first introduced ethnomathematics in the Fifth Congress of Mathematics, in a paper titled "The Basis for the Socio-cultural Instruction of Math", the audience was shocked by its reference to social and cultural issues in mathematics and no discussion took place about it. Social and cultural issues in mathematics refers to how social and cultural factors such as socio-economic, cultural background, beliefs and values affect how the learner understands what is taught in the mathematics classroom (Clarkson, 2015). The flabbergasted audience did not want to discuss the cultural aspects of mathematics because by then it was believed that mathematics was confined to European mathematics. European mathematics in this context refers to mathematics that was taught in schools as a neutral subject that involved teaching of universally accepted facts, concepts, and content (Rosa & Orey, 2011).

Until the early 1980s, ethnomathematics was regarded as mathematics for the non-literate or the primitive people (Francois, 2010), and it did not have any place in the classroom except for enrichment purposes. In many parts of the world, the instruction of mathematics relied solely on the European content model, structure, and algorithms. This means that mathematics taught in many parts of the world follows the European curriculum format which consists of a body of knowledge of facts with fixed procedures for obtaining the correct answers, axioms and theorems all of which were regarded as universal. Powell and Frankensteitn (1997) cautioned that the cultural mathematics practice might only be used as examples to ‘real’ mathematics. In this context, cultural mathematics refers to mathematics used by cultural groups in their day-to-day activities, while real mathematics refers to mathematics taught at school. As a result of those developments, there was then agreement that there was mathematics in cultural activities, however, this mathematics did not have a place in the mathematics classroom.

Later on, some scholars such as D’ Ambrosio (1985), Bishop (1988), Stinger and Barnes (1988) continued to push the ethnomathematics agenda further by exposing how the West uses mathematics to further its colonialism agenda. D’ Ambrosio (1990) explains the role played by mathematics in the building of democratic and just society and its impact on developing self-identity. Modern knowledge depends on mathematics, and therefore mathematics education is viewed as something that prepares people for future jobs, hence mathematics is used as a filter. This implies that teaching mathematics for every learner to understand mathematics capacitates learners to become citizens who are less likely to be cheated by those in power and as a result leads to a just society whose people are proud to identify with their community. Bishop (1990) also narrates the dominating influence of mathematics and how it perpetuates the dominance of Western culture. For example, these contexts could also be used to expand learners' general knowledge and widen their horizons

In the studies cited above it is agreed that mathematics can be used as a tool for domination by those cultural groups which want to oppress others. It is in light of these revelations that Knijnik (1993) studied how Brazilian sugar cane farmers could be politically and economically armed with mathematical knowledge to the realisation that possession of mathematics knowledge is a liberating tool. For example, the Brazilian sugar cane farmers armed themselves with mathematical knowledge of measuring the land in their communities and estimating volume of tree trunks without depending on academic mathematics and hence liberated themselves. For some time, mathematics educators did not understand what ethnomathematics means and this resulted in its proponents like D'Ambrosio to continue refining its meaning. D'Ambrosio (1990) in his quest to make some educators understand the term ethnomathematics broke it into three components. The first component was 'ethno' which he says refers to social cultural context which includes language jargon and codes of behaviour, myths, and symbols. This means that ethnomathematics like school mathematics also has some special words that are used by members of the particular cultural group in their own language. Also, in communicating mathematics ideas each culture has conversational principles and expectations which are considered binding by members of the cultural group. Ethnomathematics also uses symbols to represent something else by means of association in a way like how symbols are used in school mathematics.

However, ethnomathematics is characterised by the existence of the sacred being. For example, in the Shona culture of Zimbabwe when children are going to look for wild fruits, they should not run because it is believed that running for food is a sign of being greedy and God will make the fruits disappear. The next component was '*mathema*' which he says it means to explain, to know, to understand and to do activities such as measuring, classifying, inferring, and modelling Finally, the word 'tics' is derived from tech and has the same root as the techniques. Up to that time only Western mathematics was regarded as mathematics, the mathematics found in the non-Western cultures was never regarded as mathematics. Francois (2009) reveals that originally diversity was considered as practice of the "other", the exotic, and it had no place in the Westernised mathematics classroom. In this context, the "other" was used to refer to some non-Western cultures. Also, the extensions of the term 'ethno' leads to mathematical inquiry of traditions such as sand drawing, weaving and many other activities which the ethnomathematics researchers deemed were mathematical by then. Ambrosio (1990) regards ethnomathematics as a teaching methodology designed to fit the school culture of the learners as the basis for helping them to understand themselves and their peers, develop and structure social interactions. Moreover, Rosa and Orey (2011) add that ethnomathematics is a programme that includes curriculum relevance and builds knowledge around the local interest, needs and culture of the students. This continuous effort to reshape ethnomathematics resulted in its inclusion in the Westernised mathematics classroom.

By the mid of the 1980s research evidence from anthropological and cross-cultural studies had emerged and demonstrated convincingly that mathematics is a culturally bound phenomenon and every culture practising mathematics in their own way is worth recognising (Bishop, 1990). Although there was a general agreement on the benefits to be derived by the learners through integrating ethnomathematics into the school mathematics, there were challenges of how this could be incorporated in mainstream academic mathematics. The situation was made more complex by the change in cultural diversity in the mathematics classroom. There emerged approximately as many cultures as there were learners in the mathematics classroom which militated against the teachers' efforts to cope with this cultural diversity in the mathematics classroom. In response to this situation, some studies came up with different suggestions. At the beginning, educators called for school curricula and teacher instruction to undergo reforms which could cater for cultural diversity (Emit, 2018). To say that the school curricula and the way the teachers teach should be changed without clarifying what exactly was supposed to be done did not make sense leading to some researchers (Cohen, 1987; Cohen & Lotan, 1997; Cohen, Lotan, Scarloss & Arelleno, 1999;

Cese, 2009; Francois, 2009) to shed more light on how they expected curricula or teacher instruction to change.

Cohen and Lotan (1997) suggested the use of complex instruction as a way of dealing with cultural diversity in the mathematics classroom. Complex instruction is an instructional approach which aims to increase participation and learning for every child (Cohen, Lotan, Scarloss & Arelleno, 1999, p.80). A complex instruction approach promotes interaction amongst the learners through putting them in small groups hence it caters for cultural diversity among learners. Another method which was touted to cater for the cultural diversity included “child centred learning” Francois (2009, p.1519) in which the learners’ interests are catered for. Cohen (1987) and Ceser (2009) advocate for an interactive approach as the best didactic approach in an ethnomathematics classroom. Since the inception of ethnomathematics, the search for ways of integrating ethnomathematics in the mathematics classroom which happens to be the purpose of the current study is still an ongoing process. Different ethnomathematics models have been developed which explain how ethnomathematics can be integrated in the mathematics curriculum.

Up to the present day, some educators’ views towards ethnomathematics have changed favourably that it is now regarded as a guiding philosophy of mathematics education where mathematics literacy is a basic right of all pupils (Francois, 2009). Ethnomathematics is now used to deal with equality in education amongst the learners. Equity is afforded to all learners by dealing with pupils’ everyday mathematical practices as the starting point of mathematics pedagogy. According to Powel and Frankenstein (1987), ethnomathematics acts as an emancipatory tool in which learners are taught to develop a critical attitude that liberates them. When the ethnomathematics approach is used, learners from all cultural origins may be led to realise the significance of their culture in the development of mathematical knowledge hence mathematics can no longer be used to perpetuate cultural dominance of the elite class. Some of the school curricula now require that mathematics be taught in context to create equal chance for all learners which happens to be the central value of ethnomathematics (Francois, 2009). However, in other countries that have Mathematics Literacy in the secondary schools such as South Africa, it is Mathematical Literacy that prescribes that the requirements that the subject be taught in context. The ethnomathematical approach has developed more significantly in the past two decades and has spread more widely than before. It has become a more used, routine approach, which is implemented in curricula by educators around the world, (Emit, 2018. p.5). The advancement of ethnomathematics since the beginning of the 20^{th} century is evident by several studies directed towards integrating ethnomathematics in institutions of higher learning at various levels from diploma level to post graduate degrees.

2.2.6. Ethnomathematics as a programme

Ethnomathematics developed from the combination of mathematics and mathematics education to develop a pedagogy that recognises the mathematical thinking of various cultural groups (ICEM5, 2014). We can understand how learners from different cultural groups learn mathematics and the nature of their mathematics through the study of ethnomathematics. According to D'Ambrosio (2001), ethnomathematics takes into consideration the nature of mathematical knowledge and how different cultural groups transmit mathematical knowledge. People from different cultures learn mathematics in different ways. This implies that mathematics teachers need to understand how people in the community from which the learners come from learn mathematics for them to become effective teachers. Integration of ethnomathematics does not only refer to the incorporation of the mathematical aspects of the learners into the pedagogy, but also includes the use of the methodology understood by learners of different cultural origins. For example, one method that can be used for teaching mathematics to the rural Shona learners is storytelling.

Integration of ethnomathematics into secondary school mathematics in Zimbabwe for the teaching of probability requires that the mathematics teachers understand how Shona people of Zimbabwe interpret probability concepts. An ethnomathematics approach starts by describing the nature of mathematics knowledge then goes on to find out how different cultures develop mathematical knowledge and the effective way in which this knowledge is disseminated to the members of the cultural group. In an ethnomathematics program, the questions of what to teach and how to teach form the cornerstones of integration of ethnomathematics in the school mathematics. However, Chikodzi and Nyota (2010) put emphasis on didactics when they state that the focus is on a methodology that takes the rural cultural environment into consideration to make mathematics relevant. Ernest (1989) defined pedagogy as the way of presenting the subject knowledge that makes it understandable to the learner. Pedagogy in this case includes both the methodology used by the teacher such as discovery learning for example, and the content of the subject matter. Therefore, Chikodzi and Nyota (2010) in their study seem to underplay the role of curriculum content in the integration of ethnomathematics and focus on the methodology. This approach to integration of ethnomathematics may not be effective because ethnomathematics utilises the learners' environment as the foundation of subject matter to be taught to the learners.

In dealing with ethnomathematics there is no 'one size fits all' approach as far as curriculum content and methodology are concerned. Each cultural group has relevant curriculum contents and methodology that fits it. In both the curriculum content and the methodology cultural aspects of the cultural group under consideration should be embedded. Ensign (2003) describes the culturally related techniques of teaching problems that helped to mediate the difficulties that learners faced in understanding mathematical concepts. Ensign created mathematics problems which were connected to the learners' lives. Also, the learners used journals in which they wrote to connect mathematics situations to their own experience, and this led to the improvement in the performance of the learners in mathematics. The incorporation of the rural Shona learners' probability concepts in the learning of probability improved the learners' understanding of probability. Ensign (2003) also shows that the learners' interest in mathematics is raised when the learners are solving their own problems rather than those found in their textbooks. Chikodzi and Nyota (2010) in their study of the interplay between culture and mathematics in Zimbabwe found that examples which are used in the textbooks are far detached from the rural learners' context. Therefore, in the integration of ethnomathematics in the teaching of mathematics, the teacher should develop tasks that are related to the learners' lives as a way of motivating the learners. For example, when teaching probability concepts to the rural Shona learners of Zimbabwe, the mathematics teacher developed tasks related to the daily activities of the rural Shona learners.

Chahine (2013) describes ethnomathematics as an organic model of communal learning and mathematics identity building which emphasises the role of the free classroom with freedom of expression by both the learners and the teachers towards the pursuit of the truth. This implies that learning in the mathematics classroom should reflect what takes place in the learners' community in terms of the willingness of the learners to learn. When integrating ethnomathematics in the teaching of mathematics issues such as age of the learners, language, ethnicity, and many other culturally related aspects should also be put into consideration. Ethnomathematics as a program goes down to dictate the environment and the atmosphere under which the learners learn for them to get maximum benefit from what goes on in the mathematics classroom. For example, it dictates that the learners should be taught using the learner centred approach where the learners are free to try their own ideas without being afraid of being criticised. Although some studies, Gerdes (2009) and Joseph (2011) extended the concept of ethnomathematics to include how it affects the political wellbeing of the learner in the society, this study only focuses on how integration of ethnomathematics in the secondary school mathematics can improve the teaching and learning of probability concepts in secondary schools in Zimbabwe.

2.2.6. Ethnomathematics and the teacher

The daunting task faced by mathematics teachers who teach in rural secondary schools in Zimbabwe is to reframe mathematical instruction to be culturally relevant for the rural learners. According to Chikodzi and Nyota (2010), the teaching of mathematics in Zimbabwe secondary schools is mostly irrelevant to the learners who live in rural areas. Also, (D'Ambrosio, 2001; Madusise, 2014) point out that traditionally in the mathematics classrooms, the relevance of culture has been strangely absent from content and instructions. The situation is made worse by the textbooks that the teachers use which do not have tasks that deal with the learners' out-of-school mathematics experiences. Also, the methodology used by the teacher treats mathematics concepts as if they are biblical revelations without any link to the learners' prior knowledge. When teachers talk about teaching from the known to the unknown, they are referring only to prior taught concepts in the mathematics classroom and disregarding the knowledge that the learners bring to school (Turugari, 2008). This is supported by Matthews (2008) who witnesses instructional choices of several teachers focus on strict adherence to textbook tasks with little or no potential to make connections to students' culture.

According to Matthew *et al.* (2013), as mathematics teachers strive to use a cultural approach to improve the learners' performance in mathematics, they should re-engineer mathematics classroom content and classroom instruction to support a culturally relevant approach. Integrating ethnomathematics into the school mathematics is therefore the responsibility of the mathematics teachers who should work on the content and instruction to make them relevant to the learners. When integrating ethnomathematics in the teaching of mathematics, the mathematics teachers should design tasks which appear to be building relationships and utilise mathematics tasks from which learners can read cultural information, (Matthew, 2008). For example, the mathematics teacher can develop a task centred on herding cattle such as when you are heading cattle which one of your cattle has the highest probability of escaping and go back to the kraal? In this type of task, the learners can reflect on their cattle herding experiences which were rich in cultural activities such as milking cows. For the teacher to come up with culturally relevant tasks, the mathematics teachers need to familiarise themselves with the learners' out-of-school mathematical activities. An alternative approach of creating a culturally relevant pedagogy was used by Leonard and Guba (2002) who used the students' neighbourhood as a source of mathematical tasks. This approach can enable the learner to be critical about the effects of mathematics in their daily lives and view their neighbourhood through a mathematical lens.

However, mathematics teachers in Zimbabwe seem to have little skills of integrating ethnomathematics in the teaching of mathematics. According to some studies (Mtetwa & Jaji, 2006; Sunzuma *et al.*, 2013; Nyaumwe, 2006) who carried out studies on the integration of the Shona people's cultural mathematics practices, mathematics teachers view mathematics found in the Shona cultural activities as either too simple or too complex to be incorporated in the secondary school mathematics. For example, Mtetwa and Jaji (2006) in their study of school mathematics and out of school mathematics and Zimbabwe youngsters conclude that mathematics teachers in Zimbabwe regard ethnomathematics as the foundation upon which school mathematics can be built, however, it does not have any place in the secondary school mathematics. It is likely that at the time at which Mtetwa and Jaji carried out their study, ethnomathematics was still a new area of study in Zimbabwe or that the teachers who participated in that study did not have a clear understanding of ethnomathematics. However, there is evidence to support that even few years ago mathematics teachers lacked a clear understanding of ethnomathematics as Alverez and Oliveraz (2014) hint that there is an obstacle between ethnomathematics and school mathematics because teachers doubted the mathematical value of ethnomathematics mathematics. When mathematics teachers do not see the connection between mathematics and ethnomathematics it implies that they do not understand what ethnomathematics is about.

Therefore, before researchers involve teachers in some studies which require the teachers to make judgement about the effectiveness of ethnomathematics the researchers should ensure that the mathematics teachers understand what ethnomathematics is. For example, Chahine (2013) in the study of how the teachers can gain adequate knowledge of mathematics found in the indigenous knowledge system, mathematics teachers were immersed into the indigenous knowledge systems and structures which included indigenous music, architecture, mural decoration, indigenous games, bead work, weaving, cultural artefacts and other social systems and activities. When the teachers are interviewed after such an exposure, they are likely to give informed responses which can guide further research. It is against this background that the participants in this study were exposed to the rural Shona learners' cultural activities so that they could be able to integrate ethnomathematics in the teaching of probability.

Teachers' training colleges should equip mathematics teachers with ethnomathematics skills. However, in Zimbabwe, teachers' training colleges do not teach ethnomathematics as a course to equip mathematics teachers with skills to deal effectively with its issues in the mathematics classroom. This is confirmed by Sunzuma, Zezekwa, Zinyeka and Chinyoke (2013) in their study of incorporating religious mathematics in the teaching and learning of formal geometry in Zimbabwe who went on to recommend the introduction of ethnomathematics at teachers' colleges in Zimbabwe. Their recommendation might have emanated from the fact that they realised that mathematics teachers who had not been trained in ethnomathematics were not able to mathematise the learners' out-of-school mathematical activities and integrate them in the teaching of mathematics. Therefore, teachers' training colleges should include courses in ethnomathematics if it is to be effectively integrated in secondary school mathematics. In addition, Nyaumwe (2006) studied the geometry in the construction of the Great Zimbabwe monuments which took place between the twelfth and the fourteenth centuries and recommended the introduction of ethnomathematics in schools. The statement that ethnomathematics should be introduced does not lead anywhere since it lacks precision of exactly what should be done to address the problem. It is generally agreed by the above-mentioned studies that there are mathematical concepts in the learners' cultural activities and practices, and that mathematics teachers lack the skills to extract mathematical concepts from those activities for incorporation into the pedagogy. It is against this background that this study involved mathematics teachers in a Participatory action research (PAR) to assist them to extract probability concepts from the rural Shona learners of Zimbabwe's cultural activities and integrate them into the teaching of probability.

2.2.7. Ethnomathematics and the traditional mathematics classroom

Mathematics taught in the traditional mathematics classrooms has been castigated by some researchers (D'Ambrosio 1985; Bishop, 1988; Madusise, 2014) because the subject is taught as if it is about the rules and procedures to be followed without any connection to the learners' real-life situations. Also, D'Ambrosio (2001, p.308) affirms that mathematics in many classrooms has practically nothing to do with the world that the learners are experiencing. This results in both the learners and the teacher thinking that there is no connection between mathematics and culture. According to Borba (1990, p.269), mathematics teachers should have a particular ability and responsibility to help learners to find the intersection between their realms of meaning and those of the teacher. In addition to that Begg (2001) says that in the mathematics classroom, the teacher should strive to link mathematics with everyday life, with prior knowledge, with familiar contexts within school and outside, with other topics within mathematics and with the past and the likely future. Traditional mathematics classrooms are characterised by use of formulas without bothering how these formulas are derived resulting in the learners memorising the formulas without understanding the concepts. Due to this view, (Shirley, 1988) adds that school mathematics lessons leave an impression that there is only one way to perform a given task. The teaching of mathematics does not give room to the learners to create mathematics but to take mathematics as a finished product. This is affirmed by Begg (2001) who points out that in the teaching of mathematics there often prevails a situation of admiring the practice of academic mathematicians in recycling the finished product of mathematics instead of emulating the process of creating mathematics.

Therefore, learners cannot apply school mathematics in their out-of-school lives because they are given school mathematics as a finished product. The formation of links helps the learners to understand mathematics better. To make a connection between school mathematics and the learners' out-of-school mathematical activities, Boutte, Kelly, Johnson (2010) state that the teachers must take time to learn from their learners the information about the communities they live by engaging in some form of micro-ethnographies. Lack of connection between culture mathematics and school mathematics results in learners failing to understand mathematics and this gives rise to conflicts that the learner fails to know which of the two approaches is correct. For example, at school, they talk of a fair coin when playing games yet outside school they use elements of luck or intervention of God, hence there is nothing like a fair coin. This is supported by De Abrem, Bishop and Pompen (1992) who point out that learners' experience conflict in terms of contradiction in understanding caused by their participation in two different mathematics cultures, one at school and the other connected to their out-of-school mathematics practices.

Lack of connection between the school mathematics and the out of school mathematics seriously affects learners in rural areas as Bishop (1994, p.16) narrated on how learners experience dissonance between the cultural tradition and that presented in school mathematics. In most cases, the way problems are solved at home is different from the way they are solved at school. Most often, the use of English in mathematics creates conflict in that the way the words are used in mathematics at school sometimes differs completely from the way the words are in the learners' out-of-school mathematics practice. For example, in its everyday use outside the school by the rural Shona learners the word half, laterally means not full or incomplete whereas in the school context it is used technically to mean fifty percent. Therefore, the learners are likely not to perform well in mathematics because they are made to operate in no man's land between everyday culture and the school mathematics culture of thinking (Prediger, 2004). In addition, Madusise (2014) also affirms the teachers' failure to connect out-of-school mathematics practices and school mathematics in their mathematics classrooms, and she also points out that the teachers' knowledge of indigenous knowledge is shallow. This is supported by Bonoto (2001) who says, "In the mathematics classroom the relationship between reality and mathematics is not defined and the learners do not know whether it is permissible to solve problems utilising the methods they use outside school." As a result of the missing link between the approaches used to solve problems at school in the mathematics classroom and the approaches the learners use outside school, the learners are likely to switch between the two approaches without attempting to reconcile them. For example, in their daily activities outside the school the rural Shona learners use the concept of luck to determine the outcome of random events while in the mathematics classroom the concept of luck is not put into consideration in determining the outcomes of probability events.

The following studies on ethnomathematics in Zimbabwe have failed to realise that ethnomathematics like academic mathematics is stratified; there is both simple and complex mathematics in ethnomathematics as outlined by Powell and Frankenstein (1997). This means that mathematics teachers who pointed out that ethnomathematics is too simple to be included in secondary school mathematics as revealed by Mtetwa and Jaji (2006) might not have adequately mathematised the out-of-school activities of the learners to identify complex mathematics inherent in them. On the other hand, by indicating that on the construction of Great Zimbabwe monument there are some geometric concepts which most of the secondary school learners may find to be difficult, Nyaumwe (2006) might have failed to realise that those geometrical concepts may not be for school level but for university level mathematics. Therefore, the weakness of ethnomathematics studies in Zimbabwe is that they assume that ethnomathematics is limited to mathematics taught in primary and secondary schools, yet some ethnomathematics concepts are for higher levels.

This section has revealed that mathematics teachers fail to link mathematics and culture in the mathematics classroom. It has also been noted that some attempt to make a connection between the learners' out-of-school mathematics practices of the learner and school mathematics is hindered by failure on the part of the teacher to realise that ethnomathematics is stratified from simple to complex mathematics. This results in ethnomathematics regarded as being too simple or too complex for the school learners. Also, there is a lack of skill on the part of the teacher to identify and select ethnomathematics for the intended level. This study was only focused on ethnomathematics that can be integrated in the teaching of probability concepts in secondary schools' mathematics.

2.2.8. Challenges of teaching probability

Before the learners go to school, they already have developed some probability concepts although these ideas may be spontaneous. For example, learners can confidently say what they are going to do the following day hence, learners have dealt with various situations that involve certainty and uncertainty. In most cases, mathematics teachers rarely put into consideration the learners' spontaneous ideas and hence it is not surprising that mathematics teachers find difficulties in teaching probability concepts (Garfield & Ahgren, 1988). Garfield and Ahgren (1988) found that some probability concepts are difficult to learn because they are different from anything the learners have thought of before and other concepts are counter to the intuitive ideas that the learners already developed. For example, experimental probability seems to conflict with theoretical probability. Suppose a coin is flipped five times and it has already shown four tails in the first four flips, the probability of getting five tails is one sixth which is counter intuitive since this is not the probability of getting a tail when a coin is flipped. According to Garfield and Ahlgren (1988), at any level, learners appear to have difficulties developing correct intuition about fundamental ideas of probability because probability ideas taught at the school often appear to conflict with students' experience and how the learners view the world.

Some studies, (Fischbein, 1975; Steinbring, 1991), advocate for instructions to build on the learners' existing notion of probability whether they be immature intuitions or more formal understanding. This is in line with the ethnomathematics approach that requires the teaching of mathematics to begin with the concepts familiar to the learners. In support of this view, Jones

(2003, p.4) emphasises the need for the teachers to make a link between instruction and the learners' pre-instruction probability conception. Moreover, Shaughnessy (2003) points out that probability questions in the context of real data based on the learners' out of school probability experiences supersedes approaches to probability that started with counting problems.

In most cases, the learners deal with statistics outside school in their daily activities therefore the importance of maintaining an ongoing connection between statistics and probability may help the learners in understanding probability concepts (Shaughnessy, 2003). In addition, Pratt (2005) advocates for the design of probability tasks that incorporate purpose and utility of probability. The literature reveals that learners find difficulties in understanding probability because mathematics teachers do not form a link between probability taught at school and that the learners practise out of school.

2.2.8. Integrating ethnomathematics in the teaching of mathematics

Some researchers (D'Ambrosio, 1985; Barton, 1996; Eglash, 1997; Rosa & Orey 2010) advocate for the integration of ethnomathematics in the school mathematics, however, this should not be regarded as an easy task for the teachers. This is a difficult task for the teacher because although every culture practise mathematics, the purpose of the practice is not to do mathematics, but to solve problems as they carry on with their day-to-day routine (Borba 1990). As a result, the mathematical concepts found in those activities are hidden, and hence they must be mathematised before they are incorporated into the school mathematics. Seepe (2000) points out that the challenge is to locate and identify the scientific skills, knowledge and process embedded in the cultural practices of the African majority. However, Masingila (1993) identifies three aspects in ethnomathematics that could be targeted when integrating ethnomathematics in the school mathematics namely, mathematics curriculum content, didactics, and research in mathematics education. However, this study targets curriculum contents and didactics in its pursuit to integrate ethnomathematics in the teaching of probability.

Also, Begg (2001) gives three reasons for integrating ethnomathematics into the school mathematics based on the simple notion about education. The first reason is that learning needs to start from where the learner is and assumes that the learner is more likely to be more familiar with mathematics from their culture than mathematics from outside. The second reason is for the learning to begin with the interest of the learners with the assumption that the learners will also be interested in what comes from other cultures. By targeting activities that the learners do outside the school or do at school in their free time, the learners are likely to be interested in activities and hence in mathematics. Finally, Begg argues for giving mathematics a "human face" by using mathematics ideas from the learners' immediate environment and from their history. Giving mathematics a "human face" means making mathematics connected to human activities. Giving mathematics a human face is likely to result in learners' interest that promotes learning. Integration of ethnomathematics into the school mathematics consequently leads to the understanding of the connection between mathematics and culture thereby giving a human face to mathematics.

Ethnomathematics like school mathematics also consists of both simple mathematics and complex mathematics. It is therefore possible to integrate ethnomathematics into academic mathematics at any level in the formal education system. When integrating ethnomathematics in the school mathematics, all levels of mathematics can be found starting from simple calculations to more complex mathematics. Powel and Frankenstein (1997) refer to ethnomathematics as a broader cluster of ideas ranging from distinct numerical and mathematical systems to multicultural education. This description of ethnomathematics highlights the stratification of ethnomathematics. This implies that integrating the cultural activities of the learners into school mathematics can be achieved at all levels. In doing so, mathematical tasks should be in the context of the learners and the techniques which are employed in solving the tasks should be familiar to the learners. When integrating ethnomathematics in school mathematics at times it might be necessary to use the language that the learners use when dealing with these problems outside the school. Nyoni (2014), in his study of integrating ethnomathematics in teaching of differentiation, found that differentiation concepts can be understood better by the learners when they are presented in the language that the learners use outside school. Also, the other components of ethnomathematics which should be integrated into the school curriculum includes the activities, the technique which the learners experience outside the school

The philosophy guiding ethnomathematics approach is based on the idea that linking school mathematics to the learners' out-of-school mathematical experiences promotes better understanding of mathematical concepts by the learner. Chahine (2013) asserts that the myth that mathematics can be taught effectively without relating it to students' culture has been widely destabilised and dispelled.

Ethnomathematics can be incorporated in the school mathematics in different ways. Powel and Frankenstein (1997) also suggest that the first stage in integrating ethnomathematics should be to find space in the school traditional curriculum where the out-of-school mathematics practices of the learner can be introduced. This study used the rural Shona learners' out-of-school probability practices as mathematics content which resulted in learners understanding probability concepts. Kim (2000) proposed two ways of integrating ethnomathematics into the mathematics classroom. The first one is the use of inventive ideas inspired from one's own culture and the second is to explore mathematical ideas in other cultures. However, exploring mathematics ideas from other cultures may not motivate the learners since the learners may not be familiar with them. Powel and

Temple (2001) in their study of the *oware* a game played by Akan-speaking people of Ghana used the cultural games as a way of incorporating cultural activities in the mathematics classroom. They argued that games make learners develop skills in mathematical investigation such as arrangement and probability and chances. Also, Fouze and Amit (2017) studied the games played by the Negev Bedouin people of Israel and explained how the games include mathematical values and how they help learners to think mathematically. In Zimbabwe, there are many games played by the rural Shona children that can be used to teach probability concepts as a way of integrating ethnomathematics into the teaching of mathematics.

Based on the approaches of integrating ethnomathematics given above, integration of ethnomathematics in the school mathematics has two agents, namely, the mathematics teacher and the curriculum content. Some view the mathematics teacher as the sole agent of integration of ethnomathematics while others view both the teacher and the content as the vehicle by which ethnomathematics can be integrated in the school mathematics. For example, researchers (Mtetwa & Jaji, 2006; Nyaumwe, 2006) when they carried out their studies to find how some mathematical concepts in the daily lives of the Shona people of Zimbabwe can be of use in the mathematics classroom, their focus was on the teacher as the sole vehicle by which those mathematical concepts could be made available to the learner. In contrast, Madusise (2014) in her study of a cultural village as a context for mediating culture and mathematics education in the South African curriculum points out that the mathematics curriculum in schools lacks content and specific strategies that enable the pedagogy to connect mathematics and culture. Also, D'Ambrosio (2001) hints that in mathematics classrooms traditionally, relevance of culture has been absent from the content and instruction. These studies suggest that integration of ethnomathematics in the school mathematics is three dimensional. The integration of ethnomathematics can be in the form of instructions or contents or both. The current study utilised both contents and instruction in integrating ethnomathematics into the teaching of probability.

Lack of compatibility between the secondary school mathematics and the learners' out-of-school mathematical practices has been evident in many countries. Madusise and Mwakapenda (2015) in their study of using mathematics to understand cultural activities in South Africa highlighted lack of connection between school mathematics and culture and went on to assist mathematics teachers on how to use their mathematical knowledge to mathematise activities of the cultural village and artefacts to develop mathematical models which could be used as context in the mathematics classroom. In addition, Johnson (2017) also created ethnomathematics word problems which were used in the Republic of Maldives and concluded that the learners performed better in them than in routine word problems. This implies that learners tend to perform better in mathematics when they are familiar with the concepts being taught from their cultural mathematics perspective.

Mathematics found in cultural activities is mathematics in application, it is hidden and to reveal the mathematics in the cultural activities one must mathematise the cultural activities. Rosa and Orey (2011) indicate that cultural mathematical practices can be related to the conventional mathematics system through mathematical thinking. Therefore, integration of ethnomathematics in the school mathematics does not only focus on creating familiar contexts, but it also derives formal mathematics from the cultural activities through mathematisation. Integration of ethnomathematics in the teaching of mathematics is a cornerstone for improving the learners' performance in mathematics, however its success hinges on the mathematics teachers' ability to investigate and mathematise their learners' cultural mathematical activities. Through investigating the learners' out of school mathematics practices, the teacher can identify some anomalies and inconsistencies that are inherent in the learners' out-of-school mathematical practices. Viewing mathematical concepts from two different points may help the learners to understand mathematics better by comparing the school-based understanding and the out of school mathematics practice. Rosa and Orey (2011) assert that by considering the effects of culture on mathematical knowledge and working with the learners to uncover the distorted and hidden history of the mathematical knowledge, the teacher will be empowering the students to understand mathematics. In this study, the mathematics teachers first acknowledged the existence of some probabilistic ideas in the out-of-school mathematics activities of the Zimbabwe rural Shona secondary school learners. The ideal process of integrating ethnomathematics in the teaching of mathematics involves dialogue between the teacher and the learners in which the two parties should open up to each other on how they understand the concept under consideration, and in that process, the teacher can understand the learners' conception while the learners also understand the teacher's views on the mathematical aspect involved. Under such situations, the role of the teacher is to help the learners to find "the intersection between their realms of meaning and the teachers' realm," (Borba, 1990, p.41).

Integration of ethnomathematics is more effective when implemented at school level than at national level because this process uses the local environment and the local culture which is different from school to school. Every school has a distinct environment and unique culture which the mathematics teachers may consider when integrating ethnomathematics. Rosa and Orey (2011, p.48) state,

> In this context, there have been many discussions about changing mathematics curriculum in the schools. The purpose of these is to implement or restructure mathematics curriculum in making connections between mathematical content and students' daily life. In the proposed curriculum mathematics content is articulated with students' life experience…

When implementing an ethnomathematics curriculum there is a need to come up with either content or methodology or both which articulate the learners' out of school mathematical experiences. An ethnomathematics curriculum implies that schools no longer use a centralised mathematics curriculum unit as far as content is concerned although the objectives of the curriculum should be centralised. It is evident that the centralised mathematics contents cannot cater for diversified learners' experiences and cultures. Ethnomathematics can only be effectively implemented at school level. Horsthemke and Schafer (2014) also support the view that ethnomathematics can give better results when implemented at school level when they say that "ethnomathematics can be meaningful only in a very narrow and localised context." This study integrated ethnomathematics in the teaching of probability at a selected rural secondary school in Zimbabwe and utilised the local environment and culture to teach probability concepts.

Zimbabwe has four types of schools, namely, government schools, private schools, urban or rural boarding schools and rural day schools. In the four types of schools, integration of ethnomathematics in Zimbabwe can be achieved more effectively in rural day secondary schools where learners' experiences are not very diverse, the learners come from the same area around the school unlike in other types of schools such as boarding schools which attract learners from too diverse cultural backgrounds even with some of the students being foreigners. In the study of using the cultural village as context mediating in teaching mathematics carried out by Madusise (2014), both the teachers and the pupils were familiar with the activities found in the cultural village which helped in the integration of ethnomathematics in the teaching of mathematics in South Africa. Hence integration of ethnomathematics may prove to be easier to implement where learners share a common culture than when there are diverse cultures because when there are different cultures the teacher is required to appeal to all the diverse cultures which may not yield the expected results.

When ethnomathematics is integrated in the teaching of mathematics, the content, the method, and the context should be culturally relevant to the learner. According to Matthew *et al*. (2013), in a culturally relevant pedagogy, cultural knowledge is a deliberate primary source of informal knowledge that can be used to build learners' mathematical ideas and that experience should shape mathematics as a way of thinking critically about the society, its structure and knowledge. This implies that integration of ethnomathematics in the teaching of mathematics should not only use the learners' environment but should result in the learners to be critical of their environment to see how things can be done differently. The environment of the learners becomes the source of the mathematical problems. Where there is change in the curriculum content to reflect the learners' cultural mathematics experience, the implementation of ethnomathematics is completed when the pedagogy also incorporates the learners' out-of-school mathematical practices. This perspective is shared with D'Ambrosio (1990) who affirms that the role of ethnomathematics in the school mathematics is to provide the pedagogical tools to connect the learners' diverse way of knowing and learning that are culturally embedded with school mathematics.

2.2.9. Culturally relevant pedagogy versus culturally specific pedagogy

When integrating ethnomathematics in the teaching of mathematics, the mathematics teachers create culturally relevant pedagogy in that process. This implies that integrating ethnomathematics in the teaching of mathematics and creation of culturally relevant pedagogy are two sides of the same coin. However, culturally relevant pedagogy has a broad context because culture encompasses many variables which include age, sex ethnicity, language, beliefs, myths and many other variables. At times, it is necessary for pedagogy to be "culturally specific" (Mathew, Jones & Parker, 2013 p.237). In culturally specific pedagogy, the teacher deals with these cultural variables as they apply to the specific group of learners under consideration. Leonard (2008, p.9) defined culturally specific pedagogy as "intentional behaviour by the teacher to use gestures, language, history, literature and other cultural aspects of a particular race, ethnic or gender group to engage students belonging to that group in authentic learner- centred learning." In developing a culturally specific pedagogy, the teachers use the learners' immediate environment as well as historical facts. When integrating ethnomathematics in the school mathematics, this study utilised probability activities in which learners engage in outside the school putting into consideration the context and the language specifically employed when the learners are carrying out these activities in their daily lives. At times, it became necessary to group the class into females and males in order to create a culturally specific pedagogy since some of the activities that were incorporated into the pedagogy were specific to one gender or to a particular learner. For example, cattle herding is a male dominated role in the culture of the Shona people of Zimbabwe, while firewood fetching is dominated by females, hence it was necessary for the class to describe the activity clearly before it was used in the probability tasks (see 3.6.2). Connecting the learners' out-of-school experience specifically for a selected group helps the learners to mathematise their out-of-school activities and as a result see the utility of mathematics.

Matthew (2013) asserts that culturally specific tasks that cause learners to critique the world around them lead to better decision making and cause learners to place more thought and meaning into a process. Culturally specific pedagogy becomes more effective as a way of integrating ethnomathematics when it puts the students' prior knowledge and issues the learners face in their communities into consideration. It may go even as far as looking into the learners' families as a source of mathematical tasks. When integrating ethnomathematics in the teaching of mathematics in Zimbabwe, issues such as polygamy, farming, fishing, games, and many other activities were used in this study as source of probability content.

2.2.10. Benefits of integrating ethnomathematics into the teaching of mathematics

The integration of ethnomathematics enables the learner to understand mathematics through seeing the application of mathematics. In other words, integrating ethnomathematics helps the learner to be mathematically literate. Horsthemke and Schafer (2014) point out that learners taught using an ethnomathematical approach can contribute and participate in society in which they live with confidence. This may be since ethnomathematics helps the learners to understand their environment and activities which the teacher mathematises in the mathematics lesson. For example, when the mathematics teacher uses natural phenomena such as the relationship of the position of the moon during the month to determine the possibility of receiving rainfall, the learners can advise their parents and members of the community on when to plant the crops with confidence. Moreover, Seepe (2000) suggests that inclusion of the African knowledge system into the curriculum may enable many students to access mathematics. Seepe further says that when students see part of their daily mathematical practices in the curriculum they may be motivated to do better in mathematics. In addition, Chahine (2013) asserts that purposeful engagement in existential experiences that unfold culturally embedded mathematical competences can inspire learners to question enforced imminent boundaries and discover the joy and excitement in making transformation real and possible. For example, when learners are taught about how probability concepts are used in their daily lives, they are likely to be able to identify unfairness in some activities such as games and demand the change of some rules of the games. Ladson–Billing (1994) also adds that the three goals which are supported by a culturally relevant pedagogy include academic success, cultural competence, and the ability to critique social order. This implies that culturally relevant pedagogy makes the learners to perform better in their academic work, to understand their culture and become capable of questioning the norms of their society in pursuit of justice.

Integration of ethnomathematics in the teaching of probability results in the cultural characteristics of the learner, invention, experience, and application of probability being realised and helps learners to be critical in nature since the learners understand what the teacher will be teaching. The learners even develop the courage to question the teachers' probability understanding and methods. According to D' Ambrosio (2001), when ethnomathematics is integrated into the school mathematics, learners are helped to construct their own personal mathematics understanding and have alternative ways to explain their work that may be different from that of the teacher. For example, in this study through integration of ethnomathematics in the teaching of probability the learners were courageous enough to explain how their own methods worked.

Despite those advantages emanating from integration of ethnomathematics, the current situation in the mathematics classroom puts more emphasis on procedures and number operations without giving reason as to why those operations are necessary (Kline, 1990). In such a setup, a good mathematics learner is one who gets the correct answer to mathematical problems using the laid-out procedures. Therefore, it becomes apparent that the objective of teaching mathematics in this case is aimed at the learners to develop literacy and procedural competency. However, an ideal situation in the teaching of mathematics should aim to develop matheracy in the learners. D' Ambrosio (1990, p.369) defined matheracy as the capability of inferring, proposing hypotheses and drawing conclusions from the data. Hence development of matheracy by the learners can be achieved through integration of ethnomathematics in the curriculum through exposing the learners to real life problems. For example, through listening to the stories of the local farmers who were called by the teacher to narrate their stories about the crops they have been growing in their areas over a period, the learners were able to come up with a reasonable probability of success of different types of crops grown in their area. D' Ambrosio (2001) asserts that although the school mathematics curriculum has some aspects such as problem solving, and modelling, the mathematics teachers give precedence to mathematics procedures. In fact, the mathematics teachers concentrate on teaching the learners how to get the correct answers without making the learner develop problem solving skills that are needed to deal with new situations in the future. This type of teaching may end up denying the learners the opportunity to invent their own meaningfully personalised understanding of mathematics. In addition to that, Francois and Kekhove (2010, p.123) point out that traditional mathematics lessons are characterised by drills where learners are required to follow given procedures without understanding the concepts being taught. Learning mathematics in this way may result in the learners failing to see the relevance of learning mathematics. For example, if the learners are drilled on probability concepts, the learner will not be able to make connections between probability concepts taught at school and those they experience in their daily life, hence they are likely to quickly forget what they had been taught. Kline (1990) also argues that "mathematics taught in the schools is detached from its rich intellectual setting in the culture of our civilisation and is reduced to a series of techniques and has been grossly distorted." This means that the mathematics taught in the schools lacks connection with real life mathematics found in the learners' culture, and it is nothing more than sequenced techniques and it is quite distorted type of mathematics that the learners can hardly recognise as mathematics. Matthew, Jones and Parker (2013) suggest the teaching of mathematics shifts from traditional approaches which view mathematics as a static set of isolated facts and procedures taught with little connection to the concepts. In this traditional approach of teaching mathematics, the mathematics teachers have the role of controlling the learners by not affording them chances to criticise both the teacher and the concepts. The teachers regard themselves as transmitters of knowledge while they regard learners as empty vessels waiting to be filled.

Moreover, Bonoto (2001) hints that local strategies developed in practices are more effective than the algorithm approaches used in schools. Local strategies refer to the strategies used by people in their daily lives in dealing with problems of a mathematical nature. Integration of ethnomathematics into the teaching of mathematics utilises the local strategies which can enable the teachers to link the learners' spontaneous ideas to the school mathematics and in the process assists the learners to understand school mathematics. The teachers' role in an ethnomathematics approach is to narrow the gap between the learners' spontaneous ideas and school mathematics by creating a classroom situation which links the out-of-school mathematics ideas with the school mathematics. The learners may be motivated to do well in mathematics when they see their out-of-school mathematics practices in the classroom.

Integration of ethnomathematics in the teaching of mathematics can encourage learners to construct personal mathematical understanding and be able to explain their work. Instead of memorising some mathematics formulas and procedures, the learners can understand mathematical concepts and be able to justify and apply their knowledge. The learners can also help each other during the mathematics lesson because each one of them has their own way of understanding the mathematical concepts that will be under consideration. Matthew, Jones, and Parker (2013) assert that culturally relevant mathematics pedagogy makes mathematics meaningful. They go further to say that if the mathematics tasks are made meaningful, this may impact on the learners' understanding of mathematical concepts and hence improve their achievement. This implies that mathematical tasks become meaningful when they relate to the real world in which the learners live. Apart from making mathematics understandable and interesting to the learners, culturally relevant mathematics teaching enables the learners to participate in the society in which they live meaningfully. The role of motivation should be on the centre stage when developing a culturally relevant pedagogy. However, this motivation should be brought about through making the learners realise the importance of mathematics in their daily life. Bracey (2013) affirms that a culturally relevant pedagogical approach positively affects engagement, motivation and mathematical performance, for the poor underperforming children. According to (Gay, 2010), culturally relevant pedagogical approaches are teaching approaches that put into consideration the learners' cultural knowledge, prior experiences, frames of references and performance style of ethnically diverse learners to make learning encountered more relevant and effective to them. According to Ezeife (2002), when the learners' out-of-school mathematic activities are incorporated in the school mathematics learners develop self-confidence which makes them improve their participation in class as well as performance.

2.2.11. The role of ethnomathematics in the mathematics classroom

Researchers (Gerdes, 1991; Eglash, 1999; D'Amboise, 2001; Ascher, 2002; Rosa & Orey, 2013) assert that the role of ethnomathematics in the mathematics classroom is to form a link between school mathematics and the learners' cultural activities. In addition, Francois (2007, p.32) argues that the use of culture in the mathematics classroom is to include the learners' personal experience to make the learning of mathematics more effective for the learners. Also, insiginificant connection between school mathematics and out-of-school mathematics usually leads to disequilibrium in the mind of the learner which may result in the learner failing to understand mathematics as taught at school. For example, a mathematics teacher may want the learners to follow mathematics procedures without explaining to them how the topic itself is linked to their real-life situation. Failure to make connections between mathematics and real-life situations may result in the learners losing interest in mathematics. In emphasising this view, Bishop (1994) asserts that, when the out-of-school mathematical practices of the learners are ignored in the mathematics classroom this leads to learners experiencing dissonance arising from the cultural difference between cultural traditions represented outside the school and the culture represented inside the school.

One major purpose of ethnomathematics is to teach mathematics literacy to the learners, (Frankenstein, 1987; 1990; Skovsmose, 1984, D'Ambrosio, 2001). Francois (2007) defines mathematics literacy as an individual's ability to identify and understand the role played by mathematics in the world around them and use mathematics in the way that meets their needs in life. This implies that the integration of ethnomathematics in the teaching of mathematics a high potential to promotes the learners' mathematics literacy by exposing the learners to the mathematical problems found in their daily lives. Apart from being exposed to their own cultural mathematics practices, the learners also become aware of mathematics practices in other cultures. In addition, Vithal and Skovsmose (1997) assert that integration of ethnomathematics helps the mathematics teachers to deal with diversity in the mathematics classroom. Moreover, Alangui (2017) affirms that integration of ethnomathematics in the mathematics classroom enables the learners to become aware of how people in their culture and other cultures mathematise. For example, in a multicultural mathematics class the learners can learn about how other cultures mathematise when the teacher makes connections between mathematics and the diverse cultures found in the class. The learners also become aware of the connection between the out-of-school mathematics practices and conventional mathematics through integration of ethnomathematics in the teaching of mathematics.

2.2.12 Challenges in the integration of ethnomathematics into school mathematics

Although proponents of ethnomathematics demand the linking of mathematics teaching to learners' indigenous mathematical practices, it has been mentioned before that there is no one-to-one relationship between cultural mathematics and academic mathematics. All those cultural mathematical practices may need mathematising before they can be integrated into the school mathematics. This is also affirmed by Rosa and Orey (2000) who refer to ethnomathematics as a form of mathematics that varies because of being embedded in cultural activities. By virtue of being embedded in cultural activities it means that it is not an easy task to extract mathematics from the cultural activities. Bandeira and Lucena (2004) studied mathematics used by Brazilian farmers and found that they were different from school mathematics. This situation highlights the challenges associated with extracting ethnomathematics from cultural activities to integrate them into secondary school mathematics. Francois (2009) asserts that integrating ethnomathematics starts with curriculum contents and teachers are mandated with the implementation of the curriculum in the classroom. However, their task of implementing the curriculum is made difficult if there is no connection between curriculum contents and the culture of the learners.

The line separating mathematical activities and non-mathematical activities when both are subjected to mathematisation is so thin, they can all be linked to some mathematical concepts (Alangui, 2017). This implies that when people think mathematically about every human activity it is found that there is a mathematical concept that can be linked to it. For example, cracks found on the ridge of soil where sweet potatoes were grown can lead to probability concepts about the readiness of the potatoes for harvest. Chikodzi and Nyota (2010) found mathematics in all the activities mathematised and as a result all the cultural games in the rural Shona people of Zimbabwe would be included in the mathematics curriculum. This challenge was also raised by

(Begg, 2001, p.71) who posits that the most challenging thing in this ethnomathematics debate is to identify elements of knowledge from the learner's cultural knowledge that can be classified as mathematics. Therefore, in this study any of the cultural activities of the learner could be used as the starting point of integration of ethnomathematics in the teaching of probability.

The strong relationship between mathematics and other subjects need not be under-estimated; the integration of ethnomathematics may not be comprehensive if the mathematics concepts that stretch into other areas are ignored. Else (2001) notes that if we wish to make connections with aspects of learners' background and culture then it is not mathematics only that we should look at, but we should also look at other subjects in the curriculum since they have their shares of the learners' culture. Focusing on mathematics and neglecting some non-mathematical areas does not fully address the integration of ethnomathematics in the teaching of mathematics. In addition, Alangui (2017) argues that all cultural activities including non-mathematical activities can be used as a start-up point in the teaching of mathematics. The challenge of most ethnomathematics studies is that they rush to identify some aspects of conventional mathematics found in those cultural activities as though the purpose of those activities is to do mathematics. For example, Achor, Imoko and Uloko (2019) used the thatched roofs of the people of Benue State of Nigeria to teach locus in mathematics. In that study, the learners were taken out of the class to do the thatching practically and measured sizes of arcs, angles, radius and diameter but nothing was said about the beliefs and values of the people of Benue about those round roofs.

The challenges associated with identifying mathematics in other cultures other than the Western cultures remains subjective in that the mathematics in those cultural activities should be matched with similar concepts in Western mathematics, for them to be recognised as mathematics (Dowling, 2001). For example, it may be said that there is some mathematics in playing a certain traditional game, but those mathematical concepts can only be articulated in terms of Western mathematics when communicated to others. In other words, it is only those people with academic mathematical knowledge who can identify mathematics in those cultural activities. The supremacy of Western mathematics is maintained because the cultural mathematics should be able to utilise mathematical symbols used by Western mathematics. Moreover, Furuto (2014) says that a lot of cultural mathematics evades notice because they lack similar Western mathematics counterparts. This implies that the emancipation argument fronted by ethnomathematics advocates that Western mathematics is imposed on other cultures cannot be justified. In support of this argument, Rosa and Orey (2011) affirm that cultural mathematical practices can be related to conventional mathematical systems and vice versa through mathematical thinking. The use of the word conventional maintains the supremacy of Western mathematics although proponents of ethnomathematics want everyone to believe that conventional mathematics and ethnomathematics are equal. While ethnomathematicians advocate for the inclusion of some cultural aspects in the mathematics classroom, the learners may regard some aspects as old fashioned, the practice they may not want to be associated with (Horsthemike & Schafar, 2014). Therefore, when integrating ethnomathematics in the teaching of mathematics, learners may regard what was practised by their ancestors as primitive and backwards thereby becoming a serious obstacle to the integration of ethnomathematics. For example, when the teacher gave a task involving the rural Shona men of Zimbabwe who when travelling on foot with their wives were not allowed to help their wives by carry anything, the learners did not want to be associated with that cultural practice citing that it was old fashioned.

2.2.13. The gap that was not filled by other researchers

In the light of the above discussion, it is acknowledged that there are some mathematical concepts that can be harnessed in the learners' cultures. Also, there is evidence to suggest that integration of ethnomathematics in the teaching of probability in secondary school mathematics was partially addressed by the previous researchers. The studies that were carried out in Zimbabwe on the integration of ethnomathematics in the teaching of probability in secondary school mathematics (Chikodzi & Nyota, 2010; Mpofu & Mpofu, 2019) only go as far as identifying mathematics concepts in the cultural activities of the learners and do not go further to integrate these concepts in the pedagogy. These studies seemed not to have adopted any theory of action or a mental model that guides how they design the learning experience for the learners in the integration of ethnomathematics. The recognition by the policy makers and educators that integration of ethnomathematics in the teaching of mathematics is essential to improve the learners understanding of mathematical concepts implies that it has to be done holistically and hence it should not be left to individual mathematics teachers to decide how they integrate ethnomathematics, but a guiding framework should be provided. In this regard, my argument for conducting this study was that ethnomathematics can be integrated in the teaching of probability more effectively when there exists an instructional model that guides mathematics teachers on how to apply such a model. According to Hubbel and Goodwin (2019), an instructional model assists mathematics teachers understand how to design learning opportunities for the learners effectively.

My contention was that although there are some ethnomathematics models (Adam, 2004; Alangui, 2017) that were developed to integrate ethnomathematics in the curriculum, they do not assist the teacher in any way because they just leave the mathematics teacher to mathematise the learners' cultural activities and make connection to conventional mathematics. Leaving mathematics teachers to mathematise mathematical concepts in the learners' cultural activities without caring about how the mathematising should be done and how the cultural mathematical concepts are going to be integrated in their pedagogy is a gap that needed to be filled. In my attempt to fill this gap, the present study quested for an Ethnomathematics Instructional Model [EIM] that guides the mathematics teachers how to mathematise the learners' cultural activities and after mathematising the teachers are further guided on how to integrate the mathematical concept found in the culture in the teaching of probability in secondary mathematics. The instructional model developed in the current study does not give supremacy to the conventional approach of solving probability problems like the case in the previously developed models, rather it takes the ethnomathematical approach of solving problems as the first point of call when solving mathematics problems in the mathematics classroom. Also, the ethnomathematics instructional model that came in my mind was a circular ethnomathematical instructional model that helps the learners to apply what they have learnt in the mathematics classroom to transform their out-of-school mathematics practice. The difference between the ethnomathematics model developed in this study and the other models that were developed before is that this model dwells on how the secondary school mathematics teachers can assist learners to reflect on their ethnomathematics practices as a way of improving their understanding of ethnomathematics outside school and probability concepts in the learning of mathematics at school. The ethnomathematics instructional model that was developed in the current study is a step further than the models which were developed in the previous studies because it gives the mathematics teachers step by step guidance on how to integrate ethnomathematics in the teaching of probability in secondary school mathematics. The focus of the current study shifted from identifying mathematics concepts in cultural activities of the learners which was the focus of the previous researchers in Zimbabwe, (Chikodzi & Nyota, 2010; Sunzuma *et al*. 2013; Dewah & Van Wyk, 2014; Mpofu & Mpofu, 2019: Sunzuma & Majaraj, 2019), to integrate ethnomathematics into the probability pedagogy in secondary school mathematics in Zimbabwe. To find how the ethnomathematics instructional model impacts on the relevance of probability pedagogy in the mathematics classroom, I positioned the rural secondary school mathematics teachers as the "knower" or expert in their own practices. Those teachers became participants throughout this study and collaboratively explored the possibilities of integrating ethnomathematics in the teaching of probability in secondary schools' mathematics and together the participants and I co-created an ethnomathematical instructional model that is used to guide mathematics teachers in the integration of ethnomathematics in the teaching of probability in secondary schools in Zimbabwe. It is envisaged that use of an ethnomathematics instructional model to guide mathematics teachers in the integration of ethnomathematics in the teaching of probability can go a long way in improving the mathematics teachers' instructional practice as well as improving the learners' understanding of probability concepts. The research also suggests and demonstrates the advantages to mathematics teachers and policy makers of the ethnomathematics instructional model, its effectiveness in improving the learners' performance in probability and in mathematics in general as well as its adaptability to different mathematical topics.

2.3.1 Conclusion

The chapter concludes by focussing on the obstacles to integration of ethnomathematics and how this study overcame such obstacles. Finally, it looks at the gap that exists and has not been filled by the other research which were done in Zimbabwe. This chapter acknowledges that if ever a similar study was done anywhere else other than Zimbabwe, the unique context of the Zimbabwe rural secondary schools justifies why this study was supposed to be done. It reveals that the studies that were previously done in this area did not go as far as integrating ethnomathematics in the school mathematics, a gap that this study sought to fill. The next chapter is going to focus on the theoretical frame of this study. I look at ethnomathematics as a theoretical framework to guide how the learners' culture can be incorporated into the pedagogy. Adams (2004) and Alangui's (2017) ethnomathematical models and a proposed model for integrating ethnomathematics which guided the integration of ethnomathematics in the teaching of probability in this study will be discussed in the next chapter.

CHAPTER THREE

THEORETICAL FRAMEWORK

3.1. Introduction

This chapter focuses on the theoretical framework underpinning this study. The study sought to explore the integration of ethnomathematics into the teaching of probability in secondary school mathematics. The chapter also explains how this study is connected to the Socio-cultural Theory, Social Constructivism Theory, and the Culturally Relevant Pedagogy Theory. Finally, the chapter discusses the ethnomathematics models, and the proposed framework for integrating ethnomathematics in the teaching of probability.

3.2. Socio-Cultural Theory

Most of the work on Sociocultural Theories [SCT] emanated from the work of Vygotsky (1896-1934). Other theoreticians who furthered Vygotsky's socio-cultural theories include Crawford (1996), Hay and Barab (2001) and Wertsch (1985). The SCT is a theory of mental development that recognises the central role played by social relationships and culturally constructed artefacts in "organising uniquely human form of thinking", (Lantolf, 2004, p.30-1). Although the SCT was developed based on language development, its major findings have been successfully applied in other disciplines of education such as Physical Education (Peers & McClendont, 2002) and Information Science (Wang, 2006). In the same way, it can also be used as a theoretical framework for integrating ethnomathematics in secondary school mathematics.

According to Peers and McClendont (2002, p.136), social interaction plays a fundamental role in the improvement of learning. In this regard learning is viewed as embedded in social and cultural contexts. Social context refers to how people's surroundings influence how they view and interpret things, whereas cultural context refers to the environmental situation relevant to the beliefs, values and practices of a given culture (Savard & Mizoguchi, 2019). In other words, cultural context refers to the social expectations that may be considered normal for the particular time, place and event where it takes place. Social context reflects how the event occurring affects one's action and attitude at the time and place of its occurrence. The major assertion of SCT is that learning, thinking, and knowing are relations among people in activity with, and arising from the socially and culturally structured world (Wang, 2006).

The main ideas of the Vygotsky's SCT on cognitive (mental) development as given in Zubaidi (2015, p.11) includes:

- Internalisation: Internalisation is absorption of new knowledge that the learner has observed in social cultural context. That new knowledge can only be known to the learner social social exposure. Internalisation always take place in the language that is used in the social context in which the new knowledge originated.
- Zone of Proximal Development (ZPD): The ZPD emphasizes that allowing the learner to be assisted by an adult or working with other peers can lead to the learner improving in problem solving. The difference between what the learner can do alone and what he/she can do with assistance is what refered to as ZPD.
- Scaffolding: Competant assistance usually provided through mediation of the environment by either a parent or teacher by which cognitive, socio-emotional and behavioural forms of development are facilitated. Scaffolding means that the learner should first do the task with peers

and feedback is given, eventually the learner will be able to solve the problem on his/her own without assistance.

- Meditation: Learner’s contact with the world is not direct but it is mediated by signs which are refered to as tools. The tools are made up of psychological tools and social tools. These two types of tools together constitute the cultural tools.
- Dynamic Assessment: It highlights the point that what the learner can do with assistance of the teacher or parent better reflect intelligence than what the learner can do alone. Dynamic assessment can help the teacher to determine how much support the learner needs in order to solve the problem alone.

Of paramount importance of these ideas to this study is the ZPD, which Vygotsky (1978) define as the distance between the actual development level of problem solving that the learner achieves independently and the potential development under the guidance of the teacher or parent or in collaboration with a more capable peer. For example, when teaching probability, the learners may do well in simple probability, however, they may need assistance from others or the teacher when it comes to some high-level concepts such as conditional probability.

According to the Valsiner (1987) model of learning, all learning takes place in two stages, at social level and then inside the learner. The first stage is important in that it creates the context of the knowledge. This implies that when teaching probability, the teacher should first resort back to the contexts in which the learners encounter probability concepts outside the school and form a contextual link between probability concepts found outside the school and probability taught in the classroom. The formation of this link may help the learners to understand how probability taught at school is connected to real life situations.

Some proponents of SCT (Woolfolf, 2010; Lee 2015; Zubaidi, 2015) argue that learning is enhanced when knowledge is shaped by the activities and the perspectives of the group. They argue that collaborative learning creates a sense of a community in which the learners can be moved from Vygotsky's first level of learning (guided learning) to the second level (independent learning). According to SCT, learning happens through social interaction and is situated in specific cultural environments (Berry & Williams, 2004). In addition to this, SCT advocates for learner-centred approaches in which the teacher is only a facilitator of learning. In support of this view Phan(2012) states that SCT put into consideration the important role that social relations, community and culture play in cognitive learning. This implies that the mathematics teachers need to properly design activities such as games which the learners should play. Also, they should employ group work in order for the learners to help each other since group work can make the learners understand concepts better.

Socio-cultural learning theories regard learning as a product of social interaction and cultural context. This view is supported by Amineh and Asl (2015) who point out that in a socio-cultural perspective reality is not something that individuals can discover because it does not pre-exist prior to its social invention. This implies that learners take part in creation of the social reality through participating in the communities in which they live. The learners are not observers in the society they live but they are active participants, and it is through social participation that shapes the way they understand reality. Although learning may involve the learner's mind, SCT argues that learning is highly dependent on the learner's interaction with other members in the community. According to Wang (2006), SCT takes into consideration social and cultural aspects of acquiring knowledge. This implies that under SCT, knowledge construction by the learner is not independent of the social and cultural context. Basing on this perspective, the role of the teacher is to elicit and understand the prior instruction knowledge of the learners to help learners to construct new knowledge and connect it with what they already know. For example, in this study, the mathematics teachers could elicit from the learners how the probability concepts were used in the learners' out-of-school mathematical experience in order to help them to construct new probability knowledge.

However, Vygotsky could not explain how the SCT could be used in the learning of mathematics since the theory was solely developed for the learning of languages. Moreso, Lambert and Clyde (2000) argue that the SCT presents restricted view of the learning process that reduce the learners to be passive and become dependent upon an adult. Due to these shortcomings of the SCT, I had to consider another theory.

3.3. Culturally Relevant Pedagogy Theory

The Culturally Relevant Pedagogy Theory [CRPT] was developed by anthropologists who intended to develop the teaching approach that accounted for both learners' home culture and the school (Ladson-Billing, 2001). The culturally relevant pedagogy [CRP] is the term first used by Ladson-Billing to define a teaching approach that incorporates the learners' out of school experience relevant in assisting the learners to improve their performance intellectually, socially, and emotionally. Gay (2010) used the term culturally responsive pedagogy to refer to the pedagogy that uses the learners' cultural knowledge and their prior experiences as frame of reference when teaching the learners. The CRPT attempts to find how the learners' out of school experiences can be utilised by the teacher to the benefit of the learners. The CRPT was initially used by some sociolinguistics who identified that when learners' home language is incorporated into the classroom instructions students are more likely to succeed academically (Au & Jordan, 1981; Mohatt & Erickson, 1981). However, since then the CRPT has been successfully used in other areas such as mathematics. For example, Madusise (2014) utilised the CRPT framework when she incorporated the activities of the cultural village as a context for teaching mathematics at Grade Nine level in South Africa.

The main idea of the CRPT is to improve pedagogy, hence this resulted in reconceptualisation of pedagogy. Scholars such as Bartolome (1994) advocate for humanising the pedagogy so that the pedagogy uses the reality, history, and the perspective of learners as an integral part of pedagogical practices. Apart from those aspects Shulman (1987) decomposes pedagogy into three components, namely, subject matter knowledge, pedagogical knowledge and pedagogical content knowledge as focal points upon which the pedagogy can be improved. According to Pretage and Perk (1999), subject matter knowledge is defined as the body of knowledge and information about the subject that the teacher and the learners are expected to learn. Therefore, the subject matter knowledge for mathematics includes the structure, the concepts, facts, skills, and definitions as well as methods of justifying and proving theorems and axioms. Pedagogical knowledge refers to the specialised knowledge of the teacher that makes them able to create and effectively facilitate teaching and learning environments for learners independent of subject matter. In addition, Shulman (1987) defines pedagogical content knowledge as a body of knowledge that represents the blending of content knowledge and pedagogy into an understanding of how particular topics, problems or issues are organised, represented, and adapted to meet diverse interests and ability of learners and presented for instruction. When using CRPT, the teachers identify the learners' strengths to use them for the learners to improve the performance. In this study, the activities in which the rural Shona learners engaged in outside the school such as heading cattle, fishing and hunting were incorporated into the probability pedagogy. Also, the mathematics teachers endeavoured to value the skills and competencies possessed by the rural Shona learners and used them in a way that benefited the learners in solving probability problems.

By using the learners' culture, the mathematics teachers made the learners to critically engage the world in which they live and solve real life problems that involve probability. When using culturally relevant teaching, the utility of mathematics becomes apparent to the learners. For example, using probability challenges that the learners confront in their daily lives makes the learners see mathematics at play and as a result learners are keen to solve the problems both for academic excellence and for the need for survival. Although the learners' culture was used as a cornerstone for obtaining new knowledge in this study, the teacher also presented alternative knowledge from other cultures such as Western culture to enable the learner to develop multiple perspectives in dealing with probability problems.

However, the CRPT is more focused on the teacher than the learner, yet in this study I was also interested in how the rural Shona learners understand probability concepts as they are used in their culture. Furthermore, Byrd (2016) points out that CRPT assumes monoculture in the mathematics classroom yet in fact a mathematics class consists of many different cultures which makes it challenging for the teacher to implement CRPT. The CRPT also treats the learners as cultural reality takers who do not have any contribution on how cultural reality is created, hence I had to find a theory which articulates how the learners themselves contribute to the creation of cultural reality.

3.4. Social Constructivism

Amineh and Asl (2015) notes that Social Constructivism is a theory of knowledge in sociology and communication that focuses on the knowledge and understanding of the world that people develop jointly as a society. Social Constructivism assumes that understanding, and meanings are the product of social interaction of people who live together in the society (Fraise & Brooks, 2015, p.16). According to Amineh and Asl (2015), the most important elements in the social constructivism theory are the assumptions that human beings rationalise their experience by creating a model of the social world and the way that it functions, and that people understand reality using language. For example, learners can understand probability questions better at school if they can be able to form the images of things involved in the question and they can represent them in their language. In some cases, when learners fail to understand a question, it is likely that they have failed to find the meaning of some words in the question. For example, when rural Shona secondary school learners are given a probability question involving tetrahedral dice, they are likely to fail to answer the question properly because in their culture such dice do not exist hence, they cannot form its image in their minds. In addition to this, (Kim 2001, p.2) points out that social constructivism emphasises the importance of culture and context in understanding what occurs in society and constructing knowledge based on this understanding. According to Social constructivism, individual knowledge originates from social interaction of individuals with other people and their environment and then the individuals internalise that knowledge. In support of this view, Gergen (1994) also affirms that in the social construction perspective, explanations of reality are not based on what exist but they have their origins in people interactions. This means that people only come to know about the world around them through interacting with other people in different social relationships. For example, it is through interaction with other members of the community that the rural Shona learners came to know about the probability concepts in their culture. Those concepts did not exist in their minds until society created them and gave them those names.

According to Kim (2001) Social Constructivism is based on specific assumptions about reality, knowledge, and learning. In this context reality refers to the independent existence of being affected by ideas that concern reality while knowledge arises from psychological effects of perception, learning and reasoning. Learning refers to acquisition of skills and knowledge. It is therefore important to understand the reasons behind those assumptions to apply models of instruction that are connected to the perspectives of the social constructivists. Kim goes on to say that in the social constructivist perspective, reality does not come before the mind, it cannot be discovered: it does not exist prior to its social invention. By saying that knowledge is a social invention it implies that members of a given society must collectively create their new reality through interaction with each other in the society. To consolidate this view, Kim further says that reality is constructed through human activities. For example, in the Shona culture activities such as fishing, fruit gathering, herding cattle, hunting, and playing games contribute a very important role in creating the reality of the Shona people. According to the Shona culture reality, it is believed that if one carries money when going fishing or hunting the probability that one catches fishes or kills the animal is very low. This could be since cultural activities such as hunting are associated with the purity of the ancestral spirits while money is associated with evil of the modern world hence the two do not mix. In addition to that, Amineh and Asl (2015, p.13) says, "social constructivists believe that since reality is not made before social invention, it is not something that can be discovered by individuals." Gergen (1994) explains social constructivism as a theory of epistemology and not an ontological theory which does not make claims about the nature of private experience of physical reality but about the process of expressing and making sense of private experience with physical reality. More so, social constructivists' view on knowledge is that it is socially and culturally created, hence individuals create meaning through interactions with each other and with the environment they live in, Kim (2001). For example, the theory assumes that a learner can only fully understand a probability question that involves polygamy provided in their society there exists a concept of polygamy. The social constructivist assumption on learning is that it is a social process that occurs meaningfully when individuals are engaged in social activities. Social activities include activities such as playing games, field work, festive events and traditional dances. Social constructivists are of the opinion that no amount of external force can bring about learning of new knowledge in an individual. This view is supported by Gergen (2003) who says that from the constructivists position the process of understanding is not natural, but is the result of an active community participation. Therefore, in this study the rural Shona learners did not understand probability concepts as used in their culture naturally or passively, rather they were active participants in the communities in which the meanings of those probability concepts were being negotiated and created. This implies that, for the learners to understand the probability concept as used in the mathematics classroom the learners also needed to be active participants in the mathematics class as the teacher together with the learners created the probability concepts through connecting them with the learners' cultural probability concepts. Also, Amineh and Asl (2015) affirm that social constructivists are of the opinion that meaningful learning occurs when individuals are engaged in social activities such as interaction and collaboration with others.

Moreover, Amineh and Asl (2015, p.13) said, "…knowledge is a human construction that is socially and culturally constructed." This implies that people living in a society have their own unique interpretation of the world and give rise to reality, which is contextual, subjective, localised and suit their own context. For example, in the rural Shona reality, there is no fair coin, a coin can show a head or a tail depending on the person who is tossing it, and there is a belief that the coins are biased in favour of any lucky person who may be tossing them. Therefore, in this study the way in which the probability concepts and activities were presented in the rural Shona learners' activities represented their probability reality. The mathematics teachers had to respect that reality and took it as the starting point when integrating ethnomathematics in secondary school mathematics.

Since I have laid out the theoretical framework, it is now possible to see the implications of social constructivism for this research. In this study I used Social Constructivism as a lens for knowledge which I employed throughout my research journey of exploring the integration of ethnomathematics in the secondary school mathematics for the teaching of probability. According to Gergen and Gergen (2003), Social constructionists accept subjective and locally claimed realities since they are expected and honoured, The locally claimed probability realities of rural Shona secondary school learners and mathematics teachers who participated in this research journey in their different capacities as teachers and learners were honoured by allowing them to be heard in this academic discourse.

In this research journey, I became interested in understanding how participants made connections between the rural Shona learners' understanding of probability concepts and classroom understanding of those concepts. Particularly, I became interested in how the participants used the rural Shona learners' out of school activities in the teaching of probability concepts. In this Social constructivism inquiry, I was basically concerned about how the participants come to describe, understand and explain the probability world in which the rural Shona learners live and how it can be used in the mathematics classroom. The way in which the rural Shona secondary school learners understand probability concepts should be put into consideration when integrating ethnomathematics in the teaching of probability.

According to de Boer, Thompson, Ravignani, and Boeckx (2020), people change their own languages with time and create their intersubjective meanings regarding their daily experiences. Intersubjective meanings are subjective meanings constructed by people as they interact with each other and used as an everyday resource for interpreting the meaning of elements of social and cultural life. Intersubjective meanings arise where people share common sense, and this results in them sharing definition of the situations. In that same way, the rural Shona learners generate meanings surrounding their probability activities. Using a social construction perspective and the postmodern philosophy, the rural learners' probability concepts are socially and culturally constructed through interaction and communication with the other members in their society. In the integration of ethnomathematics using the social constructivism perspective language plays a very fundamental role in that participants were required to understand words associated with probability in the rural learners out of school activities. In support of this narrative Tamirepi (2013) emphasised the role of language and relationships in the constructions of meaning in a social constructivism. For example, the participants would be required at some moments to ask the rural learners the meanings of some probability concepts as they are used in the Shona culture to incorporate them in probability pedagogy.

The use of probability concepts differs across contexts and culture, hence in this study I wanted among other things to explore the integration of ethnomathematics in the form of the rural Shona learners' out of school mathematics practices in the teaching of probability in secondary schools in Zimbabwe.

3.5 An Ethnomathematics Instructional Model [EIM]

This study sought to explore the integration of ethnomathematics in the teaching of mathematics in secondary schools. Specifically, the study sought to utilise the rural Shona learners' cultural activities as context for teaching probability in secondary school mathematics in Zimbabwe. Integration of ethnomathematics in the teaching of mathematics for the teaching of probability requires an EIM that can guide mathematics teachers on how it should be done. Integration of ethnomathematics in the teaching of mathematics is a challenging task for most mathematics teachers that without proper guidance on how to do it the mathematics teachers are likely not to succeed. Also, like I have mentioned before, ethnomathematics is still a very new field in Zimbabwe and teachers' colleges do not train mathematics teachers in the integration of ethnomathematics in the teaching of mathematics. Therefore, development of an EIM to guide mathematics teachers in the integration of ethnomathematics in the teaching of mathematics can go a long way in helping mathematics teachers to create culturally relevant lessons. Some ethnomathematics models such as those developed by Adam (2004) and Alangui (2017) only guide mathematics teachers on the contents to include in the mathematics curriculum and leave the mathematics teachers to make their own discretion on what to do in the classroom. The type of models which guide the mathematics teacher steps by step are instructional ethnomathematics models. This study sought to develop an EIM that can be used to guide mathematics teachers in the integration of ethnomathematics in Zimbabwe because currently there is no model for integrating ethnomathematics in the teaching of probability in secondary school mathematics in Zimbabwe.

3.6.1. Development of an EIM

Developing an EIM that guides mathematics teachers in the mathematics classroom to integrate ethnomathematics in the teaching of probability can be done in two ways. The first alternative is to develop the model from scratch, whereas the second alternative is to improve the already available models. Once the EIM is developed, the framework should be continuously tested and refined to ensure that it remains suitable for guiding mathematics teachers in the integration of ethnomathematics in the teaching of mathematics. For example, Adams (2004) model of integrating ethnomathematics in the school curriculum was modified by Alangui (2017) by adding an arrow linking conventional mathematics to the students' world activities citing that some conventional mathematics may be the same as they are practised by the learners outside school.

This study developed a proposed EIM that can be used to guide mathematics teachers in the integration of an ethnomathematics in the teaching of probability after considering the weaknesses of Alangui's (2017) model**. Figure 3.1** below shows Alangui's (2017) framework for an ethnomathematical curriculum model which was developed in the Philippines. The model was developed to help mathematics teachers to develop culturally relevant lessons because teachers who were teaching mathematics to the indigenous people of the Philippines had challenges in developing culturally relevant mathematics lessons. Also, it was found that ethnomathematics was found to be a useful framework for developing culturally relevant mathematics education in the Philippines.

The model was originally developed as an improvement to Adam (2004) model. This existing model had a narrow scope of the activities that could be linked to the teaching of mathematics, whereas Alangui's (2017) model widened the scope of the activities that could be subjected to mathematics thinking. In this improved model the sources of mathematics thinking were expanded to include all the cultural activities. In Alangui's model, cultural activities need not to be mathematical to be included in the model, instead all cultural activities are subjected to mathematical analysis.

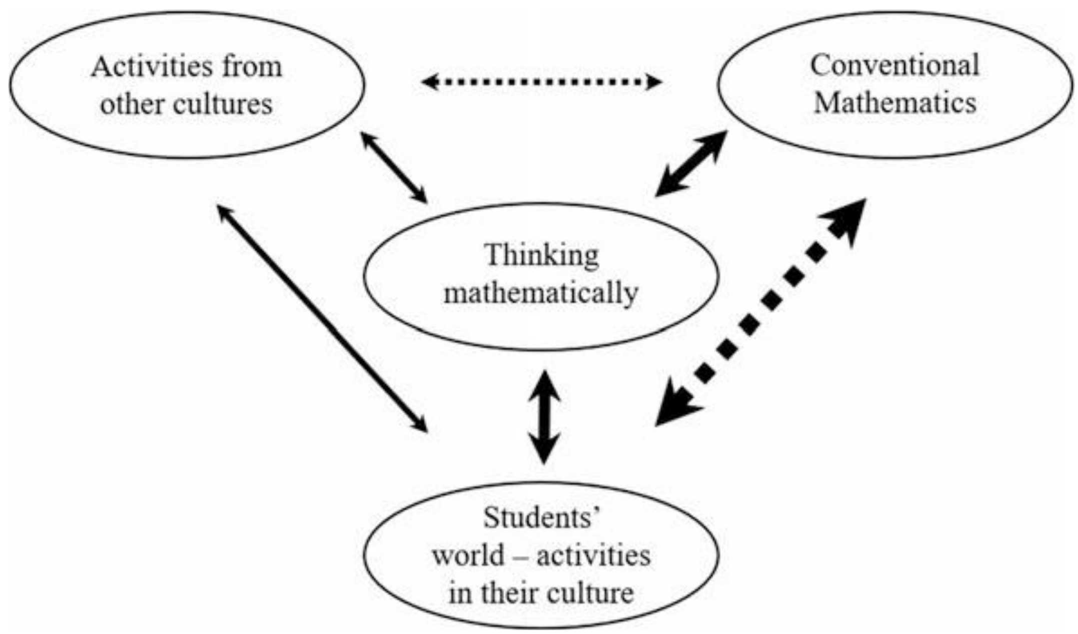


Figure 3.1 Framework for an ethnomathematical curriculum model (Alangui, 2017, p. 202)

Alangui's framework begins with the students' world consisting of the activities in students' culture as the starting point of mathematical ideas. In this model cultural activities are expressed

8imathematically, and those ideas are eventually connected to conventional mathematics. In this context conventional mathematics refers to mathematics taught in schools. Some of the cultural activities used in this model are not mathematical in nature. The connection between the conventional mathematics and the learners' cultural activities is not represented by a solid arrow but by broken arrows. According to **Figure 3. 1**, the broken arrows mean that connection of the mathematical activities in the culture to conventional mathematics is not straightforward. This is also the same with the connection between cultural activities from other cultures and conventional mathematics; they are not straight forward. The thicker lines in the model signify mathematical connection and action because of student context.

3.6.2. Weaknesses of Alangui (2017) ethnomathematics model

Alangui's (2017) model was developed to guide mathematics teachers in the Philippines to integrate ethnomathematics in the mathematics curriculum as outlined in their school syllabi. However, the model leaves it to the mathematics teacher to implement the ethnomathematics curriculum in the classroom in ways they deem fit without giving mathematics teachers guidelines on how to do it in the mathematics classroom. Alangui's model uses mathematisation of the learners' cultural activities as the key aspect in the integration of ethnomathematics in the school curriculum, identifying some mathematical aspects in the learners' cultural activities that the teachers should incorporate in the pedagogy. According to the Colin English Dictionary (CED) (2019), mathematisation refers to the process of interpreting or expressing concepts mathematically. For example, cattle herders can identify cows which are likely to produce more milk by merely looking at the sizes of their udders when they came from the pastures. The bigger the cow's udder the more the milk the cow is likely to produce. Alangui's framework only helps the mathematics teachers to choose content that can be integrated in the teaching of mathematics but leaves the mathematics teacher to determine how to integrate it. The process of mathematising in this model only leads to the identification of mathematical concepts in the learners' culture and it is silent on the teacher-learner activities in the classroom. The model lacks illustration of what should be done in the mathematics classroom except to help in content identification. Furthermore, it does not put the teacher and the learners' activities into consideration yet those are the most important factors in determining what takes place in the mathematics classroom. The model also ignores the learners' pre-instruction conception which implies that the teaching does not begin from what the learners already know. In addition, the model lacks continuity in that after mathematising the teacher starts to introduce the topic of the day. The framework uses the term mathematise as the only activity that should be done, but very few mathematics teachers may understand what it means to mathematise. According to Peregrin (2012), mathematisation involves extraction of the structures of the phenomenon in the form of mathematics. Mathematisation is ambiguous because given a cultural activity such as herding cattle any two mathematics teachers can mathematise in a different way especially for activities which are non-mathematical.

3.6.3. The proposed ethnomathematics instructional model [EIM]

The proposed instructional model that guided mathematics teachers in integrating ethnomathematics in the teaching of probability was developed after considering the shortcomings of Alangui's (2017) ethnomathematics model. The proposed ethnomathematics model was meant to guide mathematics teachers in the integration of ethnomathematics in the teaching of probability in secondary schools in Zimbabwe. It avoids the use of the term mathematise since it is a general term that may not adequately guide the mathematics teachers on how to integrate ethnomathematics in the teaching of mathematics. Instead of using the term mathematising, the proposed model decomposed mathematising into problem posing, problem solving and dialogue because the three stages help the mathematics teacher to unpack the process of mathematising. The proposed model also includes the reflection phase and the application phase for the learners to reflect on the concepts learnt and apply them to different contexts.

In addition to the five phases give above, there are other two phases in the proposed model (not given in chronological order) which are:

1. Description of cultural activity phase.

2. Conventional mathematics phase.

Although the model was developed specifically for integrating ethnomathematics in the teaching of probability, it may also be found useful for integrating ethnomathematics in the teaching of any other mathematics topic. The phases of the proposed EIM are diagrammatically presented in

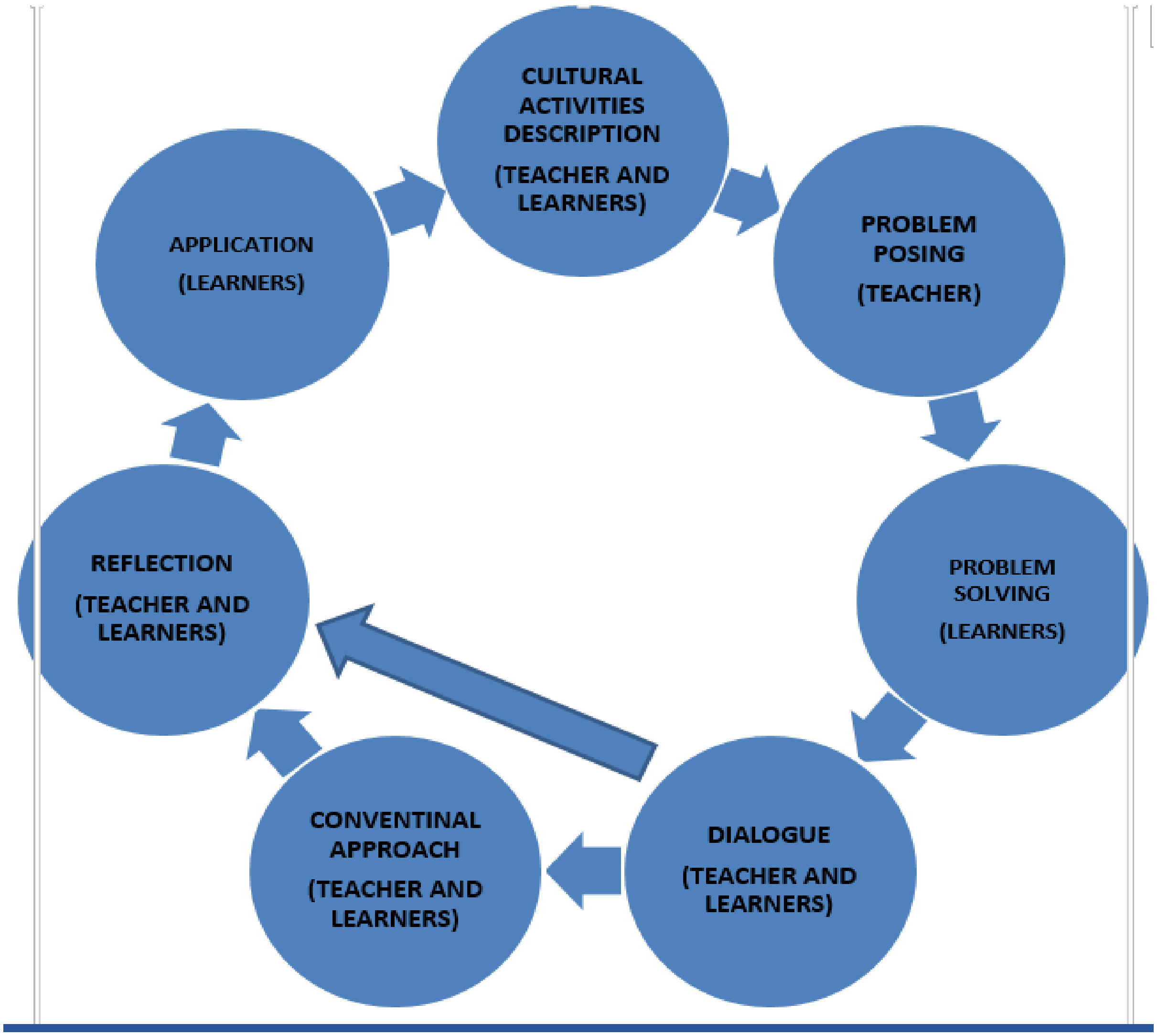


Figure 3. 2: The proposed EIM

3.6.4. The Features of the proposed model

The proposed EIM is different from the available models in several ways. Firstly, the proposed model is cyclic in nature. Also, the activities from other cultures are included in the cultural activities. The cultural activities from other cultures are catered for through cultural diversity found in the mathematics class. Hence cultural activities from other cultures are not found separately on the model. The proposed model provides more details than those found in the available models. Presented below is an outline of the phases in the proposed model.

3.6.4.1. Description of Cultural Activities phase

The mathematics teacher states the topic of the lesson as the starting point of investigation assignment by the learners. Prior to the teaching of the lessons the mathematics teachers went into the communities where the learners live to observe the activities that the learners engaged in outside school. The teachers got into some form of mini ethnographic studies in which they sought to understand the cultural activities of the learners. The mathematics teachers analysed the learners' cultural activities and decided which activities could be incorporated in the teaching of probability in the mathematics lesson. The mathematics teacher had to be very clear of the mathematics curriculum objectives to integrate the cultural activities in the teaching of mathematics lessons. For example, the Zimbabwe Mathematics Syllabus Form 1-4, Section 7.14 prescribes that the learners should be able to compute probabilities of single events. The mathematics teacher could use the role played by boys and girls in a family to teach this concept. For example, they could use the number of boys and girls in the families of the learners to find the probability of members who were responsible for fetching water or herding cattle. Also, understanding of the cultural activities of the learners enabled mathematics teachers to incorporate some activities that appeared non-probabilistic at the beginning, but which end up connected to probability concepts. For example, the role played by the members of the family given above does not seem probabilistic at the beginning. The purpose of taking such activities is to give the teacher the chance to verbally approve the learners' culture as a way of motivating the learners. In the example of the roles played by boys and girls in a family the teacher emphasised to the learners why people should play different roles and why those roles are appropriate for each gender. The mathematics teacher identified an activity that was familiar to the learners such as herding cattle for example and the learners described the activity as a class. The descriptions are meant to make everyone in the class understand the activity. In the cattle herding example, all learners in the class knew everything concerning cattle herding such as when the cattle are taken to the pastures, who is responsible for herding cattle, number of people who can herd cattle together, the activities that cattle herders do when herding cattle and many more things about cattle herding.

3.6.4.2. Situational Problem Development and posing phase

The mathematics teacher came up with a problem(s) arising from the activity described in the first phase. For example, in the cattle herding activity the problem could be: When the cattle herders settle down and start playing games some cattle may begin to stray in different directions. The problem was who would be responsible for driving the cattle back when the other herders relaxed or were enjoying playing the games. The cattle herders might decide to use rotational turns or to use any other method that they deemed fit. Those questions for example could be:

1. How do cattle herders choose the method to be used to decide on who has the turn to drive back the cattle when they stray?

2. Cattle herders at times use *mapuza* (a random method in which one cattle herder after driving back the stray cattle secretly put tree leaves between his fingers with one of the leaves bitten on one end and close his hand to make a fist. The other cattle herders pick one leaf one after the other. The one who picks the leaf with a bitten end is the one who has the turn to drive the cattle back next when they stray) Explain why you think *mapuza* a fair game to all cattle herders who may be involved?

3. If *mapuza* is used, who has the higher chances of picking the bitten leaf between the one who picks first and the one who picks next?

The number of questions the teacher could ask depended on the complexity of the activity under consideration. The teacher’s conception of ethnomathematics is a key aspect that affects task development. For example, the teacher might perceive integration of ethnomathematics as time wasting, hence may rush to tasks which are likely to come in the examination. In most cases, the teacher's conception is shaped by their experience of teaching a particular topic (Superfine, 2008, p.17). When developing problems for integrating ethnomathematics the mathematics teacher may be required to overcome their conception and be prepared to learn something new from their learners as they describe the activity in phase one. The mathematics teachers laid the groundwork for the lesson clearly identifying how to develop the problem for it to be culturally relevant as well as meeting the intended objectives of the curriculum. In the suggested example of cattle herders, the problem was culturally relevant to the learners since cattle herding was part of the learners’ culture. The cattle herders’ example met the objectives of the school curriculum (Ministry of Primary and Secondary Education [MoPSE] 2015) that requires the learners to be able to calculate the probability of simple events. The mathematics teachers decided at this stage on the probabilistic ideas that the learners should learn through the task accomplishment. Also, the mathematics teachers decided on how to get feedback from the learners. For example, the teacher makes up his mind whether the learners are going to write the work or whether they presented it orally in groups or individually. However, for the purpose of this study the learners worked collaboratively. The purpose of designing mathematics tasks for the lesson is to ensure that the mathematics teachers do not lose direction of what was to be achieved (Ball, 1993). The problem might be decomposed into several questions that the learners should answer. Some of the questions of the task should deliberately involve calculations to expose the weaknesses of some informal methods that the learners might use and give way to the introduction of conventional mathematics and mathematics formulae.

3.6.4.3. Problem solving strategies phase

During this phase the learners solve the problems in the task assigned by the teacher in groups or in pairs. In this study, most of the tasks were carried out in groups. This stage involved the learners attempting to solve the problem the way they solved the problem outside the school. In those groups, the learners shared different approaches therefore considering diverse methods used by different cultures brought about by the diversity of learners in the class. The solutions to the problems might not necessarily need to be written, for example question one to three in the example given (see 3.6.4.2), the learners are required to first work in groups and then discuss as a class. Also, the solution to those problems might not need to be numbers but might be given in words. The teacher's role at this stage was to observe and see what the learners were doing. In that observation, the teacher came to identify the pre-instruction conceptions of the learners without interfering with what the learners were doing. For example, on question three about *mapuza* the learners' perception was that if one picked the leaf first, they were likely to pick the leaf that was bitten on one end, and it became their turn to drive the cattle back. However, the one who picks the leaf first has lower chances of picking that leaf since there is a high number of leaves whose ends are not bitten. However, there were cases whereby some unscrupulous herders would manipulate outcomes by biting the ends of four leaves and leave only one unbitten.

3.6.4.4. Dialogue and Further Problem phase

The learners gave feedback to the class and the teacher analysed the learners' answers with the motive of understanding their pre-instruction conceptions. The teacher also got clarification on the learners' pre-instruction conceptions and discussed their appropriateness to the given task with the learners. The learners on the other hand tried to justify their approaches in the face of potential criticism that might arise from other learners or from the teacher. In this phase, the mathematics teacher also gave alternative examples from other cultures. For example, instead of *mapuza* some cultures use *chifemberwa*. *Chifemberwa* also uses the concept of randomness where the person who had just brought back the cattle puts a tiny object such as a small stone in his palm and closes both palms and asks the other cattle herders one by one to guess which hand holds the object. If one fails to locate the object, it becomes his turn to drive the cattle back when they stray. The dialogue concluded when both the teacher and the learners agreed on the solutions presented. The teacher finally summarised the learners' answers and went on to pose further questions of probabilistic nature that involved calculations. For example, the follow-up question for this example could be: If Taurai, Fungai, Chiuya, Farai, Tino, and Tapera are herding cattle and Farai brings *mapuza* for the other five cattle herders, to pick what the probability is that;

a) Chiuya is the next to drive back the cattle when they stray?

b) Taurai is the next to drive back the cattle when they stray?

c) Tino is the next to drive back the cattle when they stray?

In answering the follow-up questions above the teacher did not prescribe the method to be used, learners could use the methods they use outside school if available.

3.6.4.5. Conventional mathematics strategy phase

When the method used by the learners to answer follow-up questions could give answers which were acceptable to conventional approach, then there was no need to teach the learners using the conventional approach on the same aspect, hence conventional phase is skipped for that particular aspect. (**See Figure 3.1**). If for example the learners fail to get answers acceptable to conventional mathematics on follow-up questions the mathematics teacher could guide the learners through the conventional mathematics approach in doing the same task. After guiding the learners through the conventional approach, the teacher should give the learners similar questions for the teacher to ensure that the learners had mastered the method. When the learners were working using the conventional approach the teacher observed what the learners were doing. It was also an opportunity for the teacher to analyse the learners' conception and how they affected the learners' understanding of the concepts. The teacher could assist those learners who might be at stake in the process and give further work to those learners who had done well.

3.6.4.6. Reflection phase

The reflective stage proposed in the model helps the teacher to assess the progress made towards the set objectives of the lesson. The teacher finds out how the learners had shifted from the pre-instruction conception to the post-instruction conception. The teacher could do this by questioning the learners. According to Prediger (2007), another approach to reflection is through questioning for sense making. For example, in the picking of *mapuza* the learners believed that the one who picks first is likely to pick the leaf bitten on one end. For the learners to reflect on the situation, the teacher entered the following dialogue with the learners.

Teacher: If the person has five leaves of *mapuza* on his hand, and Taurai picks the first leaf and the leaf is not replaced, what fraction of the total number of leaves was picked?

Learners: It is one fifth.

Teacher: Good

Teacher: Chiuya picked another leaf. What fraction of the remaining leaves was picked?

Learners: One quarter.

Teacher: Simbarashe picked another leaf. What fraction of the remaining leaves was picked?

Learners: One third.

Teacher: Compare the fractions 1/3, ¼ and 1/5 to find out who has higher chances of getting the bitten leaf between the one who first picked the leaf and the one who picks last.

Teacher: Suppose the leaves were secretly replaced after every draw so that they remain five a before, how does this affect the chances of drawing the leaf bitten on one end by the consecutive drawers?

Also, it became necessary for the teacher to test for some prior identified misconceptions with respect to the concept as illustrated by this pilot interview. Neubrand (2000) points out that although reflection is always a personal task for the learner, but the teacher can provide an opportunity and the stimulation of reflection. Therefore, the teachers ensured that the way the tasks were developed and presented stimulated reflection. In this regard, learners who may need further assistance and those ready for more advanced problems can be identified.

3.6.4.7. Application phase

The teacher assigned some work in different contexts to the learner to determine the level to which the learners could generalise the acquired knowledge. The questions which were used to test the learners' ability to apply their knowledge were sourced from the textbooks and some real-life situations where the knowledge gained was to be applied were also used. For example, the teacher could find whether the learners could identify other activities that used the same concept as *mapuza* where the chance of occurrence increased with each subsequent draw and calculated their probabilities. Finally, the learners were given more abstract questions on the same concept found in the textbooks to solve. The learners' ability to solve those problems determined the development of new tasks that would be given to the learners.

3.7. How the proposed ethnomathematics model differs from the others.

Apart from the differences between the available models and the proposed model given in Section 3.6.3 there are also the other differences as outlined below.

- The proposed model properly defines what takes place in the classroom by identifying the teacher and the learners' roles.
- The proposed model has seven phases instead of the four found in the available models.
- The available model aims to take the learners to conventional mathematics and end there while the proposed model is cyclic in nature.
- The concepts that the learners had mastered are applied in changing the way the learners practise their daily activities.
- The proposed model targets to understand the learners' pre-instruction conception and aims to change it or develop it using dialogue.
- When using the proposed model some ethnomathematical solutions given by the learners may be the same as those which are obtained using conventional methods, under such circumstances the conventional approach stage is skipped and goes straight to reflection (see Figure.2)

3.8 The superiority of the proposed model over the available models.

The proposed model addresses problems which the available models failed to address. Firstly, the available models use ethnomathematics as an introduction leading to conventional mathematics, while the proposed model treats conventional approach as an alternative ethnomathematical approach that the learners must know. This implies that in the proposed model mathematics formulae are used when the ethnomathematics approach fails to reach a correct answer. According to Fischbein (1982), mathematics teachers fail to get rid of the learners' powerful probabilistic pre-instruction intuition because they use probabilistic formulae without the learners knowing how these formulae connect to their out-of-school probabilistic practices. In the proposed model formulae were introduced when the ethnomathematics approach failed to give the correct answer, therefore the learners understood the need for using formulae. The proposed EIM allowed learners to use the ethnomathematical approach they use in their daily lives to solve probability problems in the mathematics classroom. Allowing learners to use informal methods in the classroom helped the mathematics teachers to identify the learners' pre-instruction conceptions thereby assisting the mathematics teacher to close the gap between probability concepts found in the learners' out of school activities and those found in the classroom. Some of the informal methods used were approximation and guessing.

The proposed model also addressed the concern raised by Pedigree (2008) who asserts that when solving probability tasks, learners perceived a strong gap between the conceptions demanded in probability classrooms and their individual conceptions. The concepts demanded in probability at school for example include randomness and causality while the learner's concepts are God's interference and luck. The proposed model enables the learners to use the methods that the learners use out of school. In that way, it is acknowledged that mathematics that the learners use outside the school is acceptable in the mathematics classroom. For example, the learners could use representative heuristic where the probability of the sample could be estimated by noting the level of similarity between the sample and the population from which the sample is drawn. Through accepting the method used by the learner outside the classroom the proposed model closes the gap between school mathematics and out of school mathematics. The existence of the gap between school probability concepts and out of school probability concepts was echoed by Shaughnessy (1992) who notes that learners who successfully solve probability problems in school mathematics do not use those conventional approaches in their everyday life. The proposed model closes this gap, by not imposing conventional mathematics on the learners, rather it makes the learners contrast the ethnomathematics approach and the conventional approach and use the one that gives the correct answer for a particular purpose. The proposed model does not treat the conventional mathematics approach as superior to the ethnomathematical approach; rather, it promotes both approaches and give the learner freedom of choice to choose between the two in the light of the nature of the solution required.

3.9 Conclusion

The theoretical framework in this chapter provided insight for moving on to the next stage of this study. The socio-cultural theories discussed in this chapter reveal how the integration of ethnomathematics in the school mathematics for the teaching of probability can be handled. The theoretical framework revealed some ethnomathematics models and how they do not provide enough guidance to the mathematics teacher in the mathematics classroom on how to integrate ethnomathematics, their weaknesses in this regard are unveiled. Their shortcomings prompted the development of the instructional model to support them. The next chapter presents the methodology, instruments used in the study to assess the effectiveness of the theoretical framework in guiding the integration of ethnomathematics into the teaching of probability.

CHAPTER FOUR

RESEARCH DESIGN AND METHODOLOGY

4.1. Introduction

The first chapter of this thesis chronicles the background to my research journey highlighting why I embarked on this study. In Chapter 2, I presented the literature review and gave the context in which the research was carried out together with the concept of ethnomathematics and its evolution and the gap that was filled by this study in the integrating of ethnomathematics in secondary school mathematics. In Chapter 3, I presented the theoretical framework of this study that informed the development of an ethnomathematics model that was used in the integration of ethnomathematics in school mathematics for the teaching of probability. The ethnomathematics model was developed after identifying shortcomings of the other ethnomathematical models which are currently in use. This chapter articulates the methodology which was used in this study focusing on how ethnomathematics was integrated in secondary school mathematics for the teaching of probability. It also dwells on the research design that was used, research setting, and selection of the research team, data collection and analysis. The chapter concludes by discussing the ethical considerations of this study.

4.2. Restating the purpose of the study and the research questions

The purpose of the study was to explore the integration of ethnomathematics in the teaching of probability as a strand of secondary school mathematics. The research study was guided by the following research questions.

- What are the difficulties faced by mathematics teachers in integrating ethnomathematics when teaching probability?

- Which mathematical concepts found in the rural Shona learners' out of school mathematics practices can be integrated in the teaching of probability?
- How can the probability concepts in the rural learners' daily activities be integrated in the secondary school mathematics for the teaching of probability?
- How can the integration of ethnomathematics in secondary school mathematics improve on the cultural relevance of the pedagogy in the mathematics classroom?
- What should a policy framework for facilitating the integration of ethnomathematics in secondary school mathematics in the teaching of probability look like?

4.3 Mind map of the study

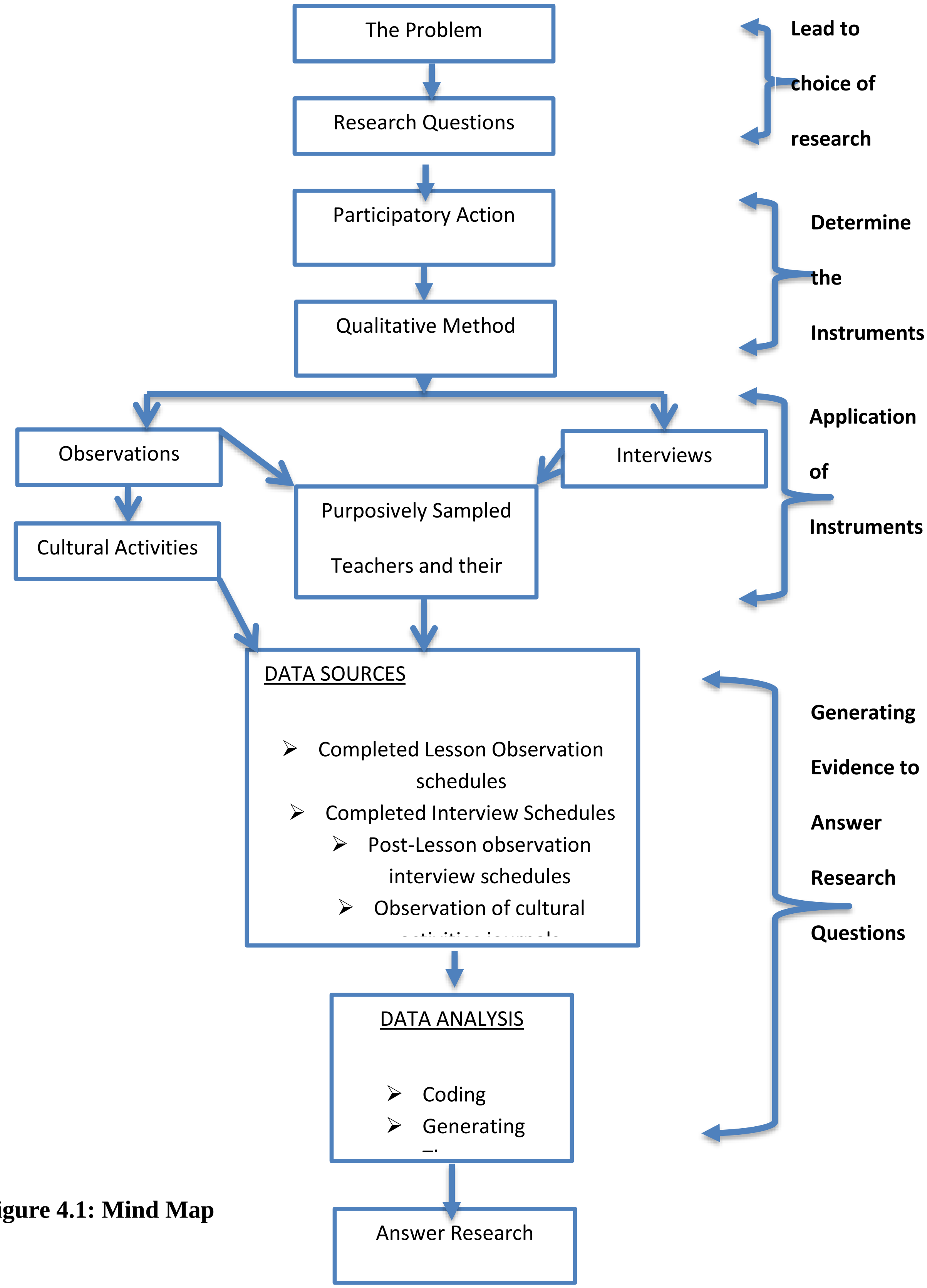


Figure 4.1: Mind Map

Figure 4.1 shows the researcher's mind map of this study from the point of research problem identification up to the answering of research questions. It shows how the research study unveils itself in my mind and how one stage led to the next.

4.5. Ground-breaking and familiarisation

I travelled to the school where the study was to take place, and this marked the beginning of my study journey. The development of relationships between me and the participants was smooth. The participants and I collectively brainstormed on the problem that was to be studied and how the data collection and analysis was going to be done. Initially, the participants and I intended to go and observe the rural learners' cultural activities in the community every day when the participants finished work from Monday to Friday, but the participants indicated that they would be very tired after the day's work, so we decided to do the observations on Saturdays when the participants were not at work. During that time, I was familiarising with the participants. I requested participants to write narratives about their teaching experience, their understanding of the nature of mathematics and their views about teaching in the rural areas. Those narratives constitute Chapter 5 of this study. I wanted the narratives because the narratives would assist in revealing some aspects about about participants which might not be revealed by interviews. Also, those narratives could help the readers of this study to understand the context in which the conclusion of this study was reached. Initially, the participants and I had agreed that lesson observations would commence during the vacation school of June-July 2021 since the Form 3s would not be taking part in the vacation school. However, this did not happen because of the COVID-19, because no one was allowed to be at school that time. The schools were opened for the first term on the 15th of March 2021 and were closed on the 4th of June 2021 under COVID-19 lockdown, so we had to postpone it until schools opened in September 2021.

The COVID-19 impacted negatively on this study. It resulted in the suspension of lesson observations to early November 2021 because all the schools in Zimbabwe were closed and the people's movements were restricted, people were required to stay at home. Even when the schools were opened in September 2021 visitors were not welcome in schools, I was only allowed to get into the school early October 2021. Also, at some point during that COVID-19 lockdown in March 2020 my laptop charger broke down and I had nowhere to buy another one because only essential services such as pharmacies, grocery shops and other few service providers were allowed to operate under the COVID-19 regulations here in Eswatini where I am domiciled. I could not work on my research project for almost two months because I did not have a laptop charger, and I only had my laptop charger replaced when the lockdown was partially lifted. The remaining part of data collection was done after the Form 3 classes in Zimbabwe were allowed back to classes and when visitors could be welcome in schools, (see Table 4.1).

4.6. Preparation of the lesson plans

The holding of the feedback meeting on the 30th of October 2021 marked the resumption of data collection process after it was suspended on the 30th of May 2021 due to the impact of COVID-19. Lesson observations began on the 11th of November 2021. The researcher and the participants jointly prepared lesson plans that could be used by the participants to teach lessons which covered the probability concepts taught at Form 3 Level to their classes. Also, the lesson plans were prepared in such a way that they were guided by the stages outlined in the instructional ethnomathematics model (see Section 3.6.2). The format of the lesson plans that were prepared is given in **Annexure O.** During lesson planning the participants were free to use introductions of their own, decide how they were going to pose the problem. However, they were supposed to share it with me and the other participants at this stage. The phases of the lesson plans had to be the same except the conclusion and evaluation which varied with each individual lesson. Also, the participants were at liberty to decide on the class organisation whether the learners were to work in pairs or in groups in solving the problems, and such decisions were to be reflected on the individual participant's lesson plans. During lesson planning it was ensured that the participants understood properly how the selected cultural activities embedded in the lesson plan were carried out.

4.7. Research Paradigm

The term paradigm is used to describe the world view of the researcher, (Sefotso, 2015). According to Kivunja and Kuyini (2017), the world view is the "perspective, or thinking, or school of thought, or set of shared beliefs that inform the meaning or interpretation of research data." In other words, the research paradigm reflects the researcher's view about the world that he/she lives. This view is also shared by Creswell and Creswell (2014) who see worldview as a general philosophical orientation about the world which affects the nature of the research that the researcher brings to a study. This implies that the researcher's paradigm has some bearings on how he/she carries out his/her study. The extent to which the research paradigm affects the researcher is highlighted by Kivunja and Kuyini (2017) who say that a paradigm is the lens through which the researcher views the world. Also, Rehman and Alharthi (2016, p.51) view the paradigm as the "researcher's set of beliefs that guide the researcher in conducting the investigations." The significance of the research paradigm is that it reveals the researcher's beliefs and dictates the phenomenon that should be investigated and how it should be investigated as well as directing how the results of the study should be interpreted. Therefore, the choice of a research paradigm influences the researcher's methodology, and how meanings are constructed from the data that the researcher collects.

According to Cohen, Manion and Morrison (2018, p.8), educational research have absorbed several competing views of social science all of which can be categorised either as scientific view or interpretive view. This is also echoed by Choongwa (2018) who asserts that in research there are two contrasting paradigms namely the positivist paradigm and the interpretive paradigm. Although Creswell and Creswell (2018) identify four mostly discussed worldviews in the literature, namely positivist, interpretive, transformative, and pragmatism, they can still be dichotomised into scientific perspective and interpretive perspective. Also, Perera (2016) presents sixteen more paradigms that can be adopted by the researcher and again they can be classified as inclined more to either positivism or interpretivism. Rehman and Alharthi (2016) defined positivist paradigm as the world view to research which is grounded in research method as scientific method of investigation, and it assumes that reality exists independent of human mind. On the other extreme the interpretivists believe in socially constructed multiple realities (Rehman & Alharthi, 2016). The interpretive paradigm tries to understand the contextual and subjective world views of human experience.

In this study, I used the postmodern paradigm which is more inclined to interpretivism than to positivism. Cohen, Manion, and Morrison (2018) posit that postmodernism supports interpretive paradigm in one sense or the other. According to Creswell (2009), the key concept of postmodernism is that knowledge claims must be within the conditions of the world today and in multiple perspectives of different groups. In addition to that among other things, postmodern philosophies reject objectivity, absolute facts, and traditional epistemology, (Hossieni & Khalili, 2011). I used the postmodern paradigm in this study because the study of how the rural secondary school mathematics teachers integrate ethnomathematics in the teaching of probability generated subjective knowledge which depended on how the researcher and the participants understood it. The assumption of subjectivist epistemology that underpins the postmodern paradigm implied that as a researcher I constructed meaning of the data that I collected about how rural secondary school mathematics teachers integrated ethnomathematics in the teaching of probability. I constructed meanings of the data through my own thinking and cognitive processing of the data informed by my interaction with the participants and their learners. The use of the postmodern paradigm in this study enabled me and the participants to use our experience to create knowledge of how the rural Shona learners' out of school mathematics can be integrated in the teaching of probability. According to Cohen, Manion, and Morrison (2018), it is understood that the researchers who use a postmodern paradigm construct knowledge socially because of their personal experiences of the real life in the natural setting that they investigate since researchers are part of the world they are researching. Postmodern paradigm enabled me to understand how the integration of ethnomathematics can improve the learners' understanding of probability concepts. I could only understand how the learners' understanding of probability concepts by intermingling with both the rural school mathematics teachers and the rural secondary school learners in their classrooms and make my own judgement basing on my experience as an experienced mathematics educator, an aspect which might not be accommodated when one is using the positivist paradigm.

According to Weinblatt and Avrech-Bar (2011), postmodern philosophies hold reality to be plural and relative and depend to a larger extent on who the interested parties in those realities are and the nature of their interest. Therefore, as an advocate of the postmodern paradigm I believe in relativist ontology whereby the phenomenon being studied had multiple realities. I had to explore and construct meaning of probability concepts found in the rural Shona learners' cultural activities through interaction with the rural secondary school mathematics teachers and the learners in their natural setup. Relativism rather than absolutism in making decisions of what constitutes knowledge, is one of the distinguished hallmarks of postmodern philosophies, (Cohen, Manion & Morrison, 2018). I chose postmodernism as the paradigm to underpin this study because I used the naturalist methodology where I utilise data which I collected from the participants through interviews and observations in which I was a participant observer. Rehman and Alharthi (2016), point out that the decision of choosing a paradigm to investigate a phenomenon should be guided by the necessities and requirements of the research study rather than just an insistence to adhere to one particular paradigm to the exclusion of the others. In choosing postmodern as my paradigm, I considered that it has a very high emancipating potential of recognising individual views, values, perspectives and interpretations. Therefore, this study reflects my values and those of the participants as we tried to present a contextual balanced report of the findings. I also put contextual factors into consideration in my pursuit of understanding how the rural Shona learners' out-of-school probability can be integrated in the teaching of probability in secondary schools in Zimbabwe. Therefore, postmodern became the most appropriate paradigm for this study because my goal in this study was not to generate context free knowledge and truth but to try to create contextual knowledge of how the rural secondary school mathematics teachers' interpretation of rural Shona learners' cultural probability concepts and how they can be integrated in the teaching of probability in the mathematics classroom.

4.8. Research methodology

Qualitative research is a broad umbrella term used to refer to a research approach dealing with people's experiences, behaviours and social context (Linton & Mowat, 2006). The approach that one chooses depends on one's assumptions on the nature of knowledge, the relationship between the researcher and what she/he is researching, the role played by value in research and finally the language that will be employed in the research (Creswell, 2003). In this research, I employed a qualitative research approach because I found that the phenomenon, I was studying could best be investigated using a qualitative methodology.

This study was carried out in two stages, the first stage focused on observing how probability concepts are practised in the culture of the rural Shona secondary school learners of Zimbabwe. Secondly, it involved how the rural secondary school mathematics teachers can integrate those probability concepts in the teaching of probability in the school mathematics. From this background, the knowledge sought in this study was unique and subjective because the study focused on the rural Shona learners of Zimbabwe, and the way they practise probability activities. The way they practise probability activities is different from the way other cultures practise them. Cohen and Manion (1994, p.6) point out that in an interpretive research knowledge is regarded "as personal, subjective and unique". The uniqueness and subjectivity also appeared when I was studying the rural secondary school mathematics teachers in their schools to have first-hand information about how they integrate ethnomathematics in the teaching of probability. This coincides with Willig (2001) who points out that qualitative researcher's study people in their own territory, within their natural occurrences. In conformity to the requirements of a qualitative research this research was conducted with rural secondary school mathematics teachers teaching their allocated classes in their natural environment. Willig (2001, p.10) affirms that qualitative researchers tend to be concerned with the quality and texture of the experience rather than with the identification of the cause-effect relationship. Based on the arguments given for the qualitative approach, I was convinced that a qualitative approach was the most appropriate for this study. My concern was on how the rural secondary school mathematics teachers form connections between the rural Shona learners' culture and the teaching of probability concepts in school mathematics.

In using the qualitative approach in this study, I regard the secondary school mathematics teachers as people who can think about their own problems and are able to change the world in which they live and that they are social beings whose ideas of the truth are through social consensus. This perspective also helped me to learn from first-hand experiences how the Shona learners of Zimbabwe shape probability concepts as well as how the secondary school teachers teach probability concepts. Hitchcock and Hughes (1989) pointed out that in a qualitative perspective, human beings are capable of thinking, they have the capacity to make choices and can act upon the world they live to change it in line with their needs.

4.9. Research Design

Cohen, Manion and Morrison (2018) define a research design as a strategy that is drawn up by the researcher to organise his/her research to make it practicable so that research questions can be answered based on evidence and warrants. The need to have research questions answered as one of the key purposes of research design is also highlighted by Choongwa (2018) who defines a research design as a specific guide about how the research will be conducted in answering the research questions. This implies that the research design should show the details of the nature of data to be collected and how it is going to be analysed to provide evidence to answer research questions. Labaree (2013) on the other hand views a research design as a blueprint that integrates all the different parts of the study coherently and logically to ensure that the research problem is addressed. According to Cohen, Manion, and Morrison (2018) there are so many ways of designing the research, however, the purpose and the nature of the study determine the research design. In this study I found PAR as the most appropriate design because the knowledge that was supposed to be generated was required to change the pedagogical practices of the participants. According to Cohen, Manion, and Morrison (2018), PAR promotes both understanding and change. In this study, I treat PAR as a subset of action research [AR] since it is impossible for one to talk about PAR in exclusion of AR because the concepts are entwined (Munn Giddings, 2012). Mohajan (2018) defines AR as a type of qualitative research that seeks action to improve practice and it also studies the effects of the action that would have been taken due to its cyclic nature. This study by virtue of being a PAR sought to improve the pedagogical practices of participants in teaching probability.

To understand the challenges associated with the integration of ethnomathematics in the teaching of probability, I used a PAR. PAR as defined by Gillis and Jackson (2002) is considered a subset of action research which is the “systematic collection and analysis of data for the purpose of taking action and making change” by generating practical knowledge. The use of PAR as a research design is justifiable in the Zimbabwe secondary school context because not many schools in Zimbabwe have school based professional development programmes, they usually depend on people from outside school such as education officers to evaluate the effectiveness of their teachers' practices. The school authorities in most cases send teachers for workshops to the Better School Program in Zimbabwe (BSPZ) centres where some district resource people, who are deemed to be more knowledgeable but who might not be familiar with the unique problems faced by individual schools and prescribe some general solutions to the imagined problems. It is only after members of the department in a school realise that the solutions to their problems are with them and not with the more knowledgeable outsiders that they can team up in search of a lasting solution to their problems through participatory action research (PAR). The PAR design helped them in reflecting their mathematics teaching practices by identifying shortfalls of their own practices and they began to dialogue about how integration of ethnomathematics into the teaching of probability in secondary school mathematics can be improved.

PAR gave the participants an opportunity to be involved in research as experts on their own experience as mathematics teachers. PAR involves creating knowledge through participatory processes in the context of human relationships (Maguire, 1987). The participants became masters of their own destiny in objective interpretation of data rather than depending on outsiders to do that for them; as a result, they came up with a solution that is local and contextual. Baum, MacDougall, and Smith (2004) assert that the contrast of PAR with less dynamic approaches is that data and information is not removed from its context. Moreover, Wakeford and Rodriguez (2018) argue that PAR is a more superior type of research in that the participation of those directly affected by the problem under study in the research process "facilitate a more accurate and authentic analysis of social reality."

PAR became the most appropriate design in this study because I wanted to share skills and knowledge with the participants taking them as full partners and as a result participants came up with a solution to the problem which affects them. This relationship in PAR is affirmed by Baum *et al.* (2004) when they say the researched cease to be objects and become partners in the whole research process. Also, since the people involved in PAR are familiar with each other, questions are asked freely and anything that needs clarification on the problem being studied is brought to the attention of the researcher and the participants to discuss.

In using PAR as a research design, I wanted the participants to benefit from the transformative power in PAR for both individuals and society through social investigation, education, and action in order to share knowledge creation with those whose voice is usually ignored. Maguire (1987) points out that the aim of PAR is to develop critical consciousness and to improve the lives of those involved in the PAR process. The transformation of relationships through participation in this study made participants realise that taking part in a PAR can address their problem, through collaboration to analyse findings and plan their future action (Pain, Whitman & Milledge 2010).

PAR can employ many different methods hence the researcher and the participants had several options to choose from. In fact, a PAR uses “a set of hybrid practices suited to the circumstances” (Wakeford & Rodriguez, 2018) in which the organisation finds itself. This study utilised interviews, observations and meetings which motivated the participants to add their voices to the research process. The use of hybrid methods resulted in the inclusion of voices which are usually ignored in conventional approaches like the voice of rural secondary mathematics teachers. Therefore, PAR was the best approach to solve this problem since the problem demanded that the participants come up with a solution that suited their context. In addition, PAR gives everyone a chance to be heard (William & Brydon-Miller, 2004) unlike other forms of design where the marginalised groups such as rural schoolteachers and learners are usually ignored. To highlight how the disadvantaged groups are ignored under other types of research designs Maguire (1987, p.37) says:

> Given this framework, ordinary people are rarely considered knowledgeable, in the scientific sense, or capable of knowing about their own reality. They are excluded from the increasingly more specialised research industry, barred by requirements of the "scientific method," and by intimidating concepts and jargon, money, time, skills, and experience. In addition to being excluded from meaningful participation in knowledge creation processes, oppressed and ordinary people are subjected to research processes which treat them as objects and things.

A PAR approach to integration of ethnomathematics into secondary school mathematics, "addresses the immediate needs of the people in a specific setting'' (Herr & Anderson, 2005, p.5). This PAR sought to address the challenges associated with integration of ethnomathematics in the teaching of probability. From the theoretical framework of this study the use of PAR approach in the integration of ethnomathematics in the school mathematics is connected to the idea of contextual social constructivism and postmodernism. Social constructivism emphasises that "learning should be an activity in context", (Magashao, 2014, p.53) and postmodern approach emphasises "subjectivity and local facts" (Hossieni & Khalili, 2011) which formed the cornerstone for this PAR. By engaging the rural secondary school mathematics teachers in a PAR as participants I wanted them to come up with a solution to their problem which was within their local context the integration of the rural Shona learner' culture in the teaching of probability. According to Herr and Anderson (2005), PAR is best done in collaboration with others, who have a stake in the problem under consideration. The rural secondary school mathematics teachers are the stakeholders in this problem of integrating ethnomathematics in the teaching of probability. I was collaborating with them as an outsider who has the skills. I provided professional guidance as I am a seasoned educator in mathematics education. However, the rural secondary school mathematics teachers did not depend on me entirely as we co-created the culturally relevant pedagogy for the teaching of probability. In this study the objective was to co-produce knowledge directly useful to the rural secondary school mathematics teachers hence the use of PAR was inevitable.

4.10. Population

The research population consisted of 73 qualified mathematics teachers who have both pedagogical and mathematics content knowledge who were teaching OL mathematics in rural day secondary schools in Bikita District of Masvingo Province in Zimbabwe. Bikita District has 25 rural day secondary schools all of which have qualified mathematics teachers teaching OL classes. In Zimbabwe, qualified mathematics teachers have three categories. The first category is made up of teachers who have a Diploma in Education. These teachers teach up to OL, they have both pedagogical and mathematics content knowledge to teach up to that level. The second group of qualified mathematics teachers are graduate teachers with both pedagogical and mathematics content knowledge to teach up to Form 6 and they are also qualified to teach mathematics at teachers' colleges. Another category consists of mathematics teachers who have degrees in mathematics, but they do not have mathematics pedagogical knowledge, they are recognised as mathematics qualified teachers, and they are allowed to teach mathematics up to Form 6. Due to the nature of the phenomenon that was being studied, it could not be possible to investigate all 25 secondary schools and the entire teacher population of 73 qualified mathematics teachers, hence the sample was required from the population.

4.11. Sample and Sampling procedure

The school in which the study was conducted was purposely selected because it is one of the schools in the district where the problem of integrating ethnomathematics in the teaching probability was being experienced. According to Choongwa (2018), purposeful sampling is a sampling technique which involves the researcher's engagement of a deliberate choice of a participant due to certain qualities that participants possess, such as ideal proximity to the study area. I selected this school because of its proximity to where I was teaching. I formed a research team composed of three mathematics teachers who were teaching OL mathematics at the purposively selected school. Also purposively sampled were 127 Form 3 learners who were enrolled for the OL classes at the selected school. As a precautionary measure I also negotiated with the other three mathematics teachers at the neighbouring secondary school in the same locality for them to agree to take part in the pilot study. The teachers were also purposely selected because they were at a purposively selected school where the problem of integrating ethnomathematics in the school mathematics was experienced. This is supported by Creswell (2011) who asserts that purposive sampling is to "intentionally select individuals and sites to learn or understand the central phenomenon".

Another reason why I purposely selected this school was that I did not anticipate any problem in negotiating access to the site and finding volunteers amongst the teachers. I was teaching at the neighbouring school for ten years and since I left the school, I had been a frequent visitor to that area so the teachers at the selected school were familiar with the searcher and regarded him as their colleague. The step-by-step procedures I followed to get access to the teachers are explained at the end of this chapter under ethical consideration.

4.12. Data Collection Instruments

Guided by the insight developed from literature review I used the following instruments to answer the research questions a) Semi-structured interviews (at the beginning of the study and at the end of the study), b) Observations (observation of cultural activities and lesson observations), c) Post-lesson reflection interviews (Reflection on the lesson and lesson evaluation), and e) Final reflection (written by the participants on exiting the study and final reflection meeting).

4.13. Data sources and their purposes

The instruments used in this study were designed in such a way that they provide data which serves particular purposes and contribute towards answering research questions. **Table 4.1** below shows how data sources contribute to this study for research questions to be answered. However, more details of purposes of the data sources will be discussed in detail later in this chapter.

Table 4.1: Data sources and their purposes

Phase 1

Source of Data	Purpose of the data
Initial Interviews	Determine the participants' perspective of how to integrate ethnomathematics at the beginning of the PAR
Phase 2	
Observations of cultural activities Lesson observations Participants journals	Identify the cultural activities that can be integrated in the teaching of probability Collect information on how the participants integrated ethnomathematics in the teaching of probability and how they engage learners
Phase 3	
Final interview Final Reflection	Document changes that took place in the participants' practice of integration of ethnomathematics due to their participation in the PAR

4.14. Data Generation Process

The first stage of the data collection process consisted of semi-structured interviews. According to Magaldi and Berler (2020) semi-structured interviews are based on a guide and that it is typically focused on the main topic that provide the general pattern. The three participants who were interviewed individually, and the interviews lasted at least fifty minutes each. The interviews guide started with seven semi-structured questions, however, due to probing some more questions emerged. The interviews were followed by observations of cultural activities of the rural Shona learners. Some of the cultural activities which were of probabilistic nature were embedded in the lesson plans which were used to teach probability concepts to Form 3 learners. I audio recorded the lessons observations as well as writing the narrative report of the lessons.

After every lesson, I conducted post-lesson reflection interviews in which the researcher and the participants reflected on the lesson that had been taught.

4.14.1. Cyclical and spiral nature of the data generation process

The data collection process of this study was cyclical and spiral in nature. It was cyclical in that similar steps recurred in a similar sequence. At the same time, it became spiral because the increased understanding that emerged from the critical reflection from the prior cycle were used as inputs in designing the later cycle. Those cycles continued until the data collected could inform our PAR and this was when the participants and I were satisfied that the data that was collected had reached saturation point. That is to say the cycle and spirals came to a halt when the data collected informed the PAR. I chose this design because I wanted to empower the participants so that they would be able to continue on their own in future should any problem arise. According to Loewenson *et al.* (2014), the cyclical and the spiral process of the PAR has an advantage of providing the participants with the starting point should any new issue emerge in the future at the station from reflecting on and reflecting on action.

The data collection process began when the participants and I collected data on the participants' practices of integrating ethnomathematics in the teaching of probability and critique what was happening. The next step involved the observation which analysed and reflected on the probability concepts found in the learners' cultural activities. This was followed by lesson planning when alternative ways of integrating ethnomathematics in the probability pedagogy were considered. The fourth stage of the cycle was lesson observations in which the consequences of using the instructional ethnomathematical model was analysed. The final stage of the cycle was reflection. Reflection is the crucial stage in each cycle which is very critical because it designs the first stage of the new cycle. The advantage of the cyclical and spiral data collection process is that planning is not separated from other activities, it is embedded in the action and reflection cycles giving enough room for greater rigour to be achieved in the process.

In this study, the reflection on action for some cycles revealed that the cultural activities which had been used were not appropriate for those concepts and other cultural activities were selected and the cycle began again. In some cases, the cultural activities that had been embedded might be appropriate, but they might have been wrongly embedded in the lesson plans, other lesson plans would be developed, and the lesson would be taught again, or the lesson plans might be fine but the participants failed to use them properly then the same lesson plans were used to teach the lessons again with the participants making the deemed corrections. Finally, a final reflection meeting was held, and the participants had already written their final reflections. **Figure 6.1** below shows the cyclic and spiral process of this participatory action research. The first cycle on this diagram is represented by the bottom loop of the diagram and the second cycle represented by the upper loop on the diagram. In this PAR a complete cycle consists of activities numbered from one to five as follows, analysis of participants' experience of teaching probability, observation of cultural events, lesson planning, lesson observations and reflection respectively.

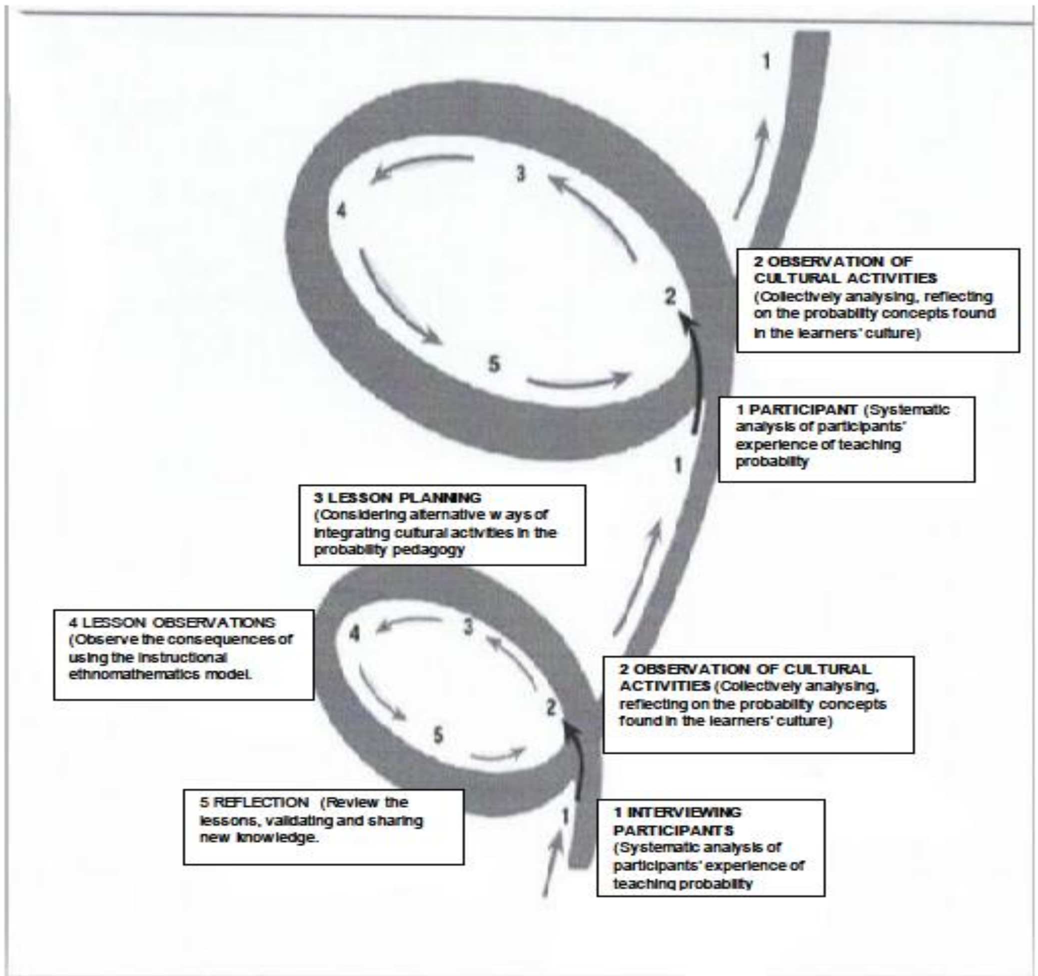


Figure 3.2: The cyclic and spiral process of PAR (Loewenson, D'Ambruoso, & Shroff, 2014, p.13)

4.14.2 Interviews

The study used semi-structured face-to-face interviews to collect data from the participants. When I used semi-structured interviews, I ensured that I did not make assumptions about what the interviewees were thinking about the integration of ethnomathematics in the teaching of probability, I depended on what the participants said. One advantage of face-to-face interview is that the researcher could pick some non-verbal clues which may not be possible when other forms of interviews are used (Rosenthal, 2016). Berg (2007) asserts that interviews do not only collect informative data, but they enable the interviewees to speak in their own voice and express their thought and feeling. Furthermore Owuegbuzie, Leech, and Collins (2010, p.699) add that "although the voice of the interviewee is central in all interviews, nonverbal communications are also important for attaining a deeper shared meaning in which both the interviewer and the interviewee increase their awareness of the contextual nature of the voice". In those interviews, the participants were provided with an opportunity to express themselves, concerning the challenges they face in integrating ethnomathematics in secondary school mathematics in their own words.

I engaged the participants in two major semi-structured interviews. The first interview was carried out on the commencement of the study while the final interview was done at the end of the study. In between the two major interviews post-lesson reflection interviews were held after every lesson. I audio taped the interviews proceedings as well as journalising them so that I had two sources of references when I was transcribing the conversations. In the following Section 1 give the details of the two interviews and the post-lesson reflection interviews.

4.14.3. Initial interview

After getting permission to carry out my study at the selected school from the headmaster, the participants, and the learners I spend three weeks socialising with the participants and the whole school community at large. However, in those three weeks, I did not go down to the research issue but just wanted to familiarise myself with the participants and build trust. The first interview marked the beginning of the formalisation of the research process. I decided to use face-to-face semi-structured interviews instead of questionnaires, to avoid a possible misinterpretation by the participants because using a questionnaire would have appeared as if I was testing the mathematics teachers' ethnomathematical knowledge. I anticipated that it would lead to lack of cooperation from the teachers. Apart from that there are other advantages of interviews over questionnaires which were worth considering in this study. For example, Alshenqueet (2014) is of the opinion that interviews are more powerful in eliciting narrative data that allows the researcher to investigate the interviewees' views in greater depth. Using interviews in the first encounter with the participants also enabled me to create personal relationships with the participants, I intentionally reduced the first interviews close to conversations about integrating ethnomathematics in the school mathematics to create a good rapport with the participants.

The purpose of the first interview was to examine how the mathematics teachers perceive contextualising the teaching of mathematics using the learners' home-based mathematical practices prior to the research. I wanted to know the participants' teaching experience in probability and how they connect the teaching of probability to the learners' out of school mathematics practices. Furthermore, those interviews were necessary because they revealed the challenges faced by the participants in the integration of ethnomathematics in the teaching of probability. I also wanted to know their opinion on whether they thought there was any difference between teaching probability in rural areas and in other schools such as boarding schools or urban schools. This agrees with Rosenthal (2016) who identifies the purpose of the interview as to obtain an in-depth understanding of the participants' experience, perception, and knowledge. The participants had different backgrounds in terms of institutions they attended for teacher's training and work experience, therefore it was necessary to interview them before the commencement of the research to establish whether those differences had any bearing in the integration of ethnomathematics in the teaching of probability. In short, the purpose of the first interview was to construct the participants' prior knowledge about how they were using the learners' home-based mathematical practices in teaching of probability in general and in teaching of probability in particular. Finally, the first interview helped me to develop an EIM that capitalized on the teachers' understanding of how to link the teaching of probability to the out of school mathematics practices of the learners.

The first interview took place on the 30th of April 2021 in the office of the school's Head of Mathematics department. All three participants Amos, Amon and Messey (not their real names) were interviewed on that date. The participants were interviewed individually in turns because I wanted to document the individual participants' understanding of ethnomathematics prior to the PAR so that I would be able to see how they evolved during PAR and after the PAR. The place was quiet and there was no one else who could overhear the conversation between me and the participants for I made sure there was no one in the next room and nearby outside that office.

4.14.4. Observation

This study also used observation as one of the methods of data collection. According to Marshall and Rossman (1989) observation is the systematic description of the events, behaviour and artefacts of a social setting. Using observation as a data collection method that enables the participants and I to get the knowledge of the researched phenomenon through making observations of the phenomenon as and when it occurs, (Kawulich, 2009). Therefore, in order to get the knowledge of how the rural Shona learners' out-of-schools probabilistic activities are carried out, the participants and I needed to observe those activities as they were being carried out in their natural context. Observations were found suitable as a means of collecting data in this study because it enabled the participants to access those aspects of a social setting that might not be visible to the actors themselves, such as the inherent probabilistic concepts in those activities. In support of this view Bernard (1994) asserts that observation gives the researcher a better understanding of what is happening in the culture and lends credence to the observer's interpretations of the observations. By using observation as a data collection instrument, the participants and I came to understand how the rural Shona people of Zimbabwe present and understand probability concepts. In this study observations were used to collect data for two purposes which I am going to explain.

4.14.4. 1 Observation of cultural activities

The observations aimed at identifying the probability concepts as they occur in the rural Shona learners' cultural activities. The participants and I observed the rural Shona learners' out-of-school activities to get a clear idea of how those cultural activities were carried out in their natural setting. Although the participants and I were familiar with the rural Shona learner's out-of-school activities by virtue of us being Shona-speaking people, they did not want to assume but to observe what takes place in those activities at the local level. At the same time, I wanted the participants to begin at the same footing on how these activities are carried out so that they could be able to incorporate them into their pedagogy. According to Walshe, Ewing and Griffiths (2011), observation facilitates understanding of what people do and how it can alter in responses to situations and over time. Using observation as a data collection method at this level helped the participants to understand how the probability concepts are presented in the day-to-day life of the rural Shona learners. The activities were grouped as follows: Animal rearing activities, crop production activities, games, and domestic chores. The participants also focused on demographic issues and artefacts found in the community to identify how probability concepts are at play in those artefacts. The participants documented how the activities were carried out individually. When all were satisfied with how the activities were carried out and had identified the probability concepts in them, the participants and I came together for a post-observation meeting. In those meetings, the participants shared the probability concepts found in the cultural activities of the learners. Initially, we had agreed that those observations would take place during Saturdays, however, this changed because the schools were closed due to COVID-19 lockdown. Since I was locked out in Eswatini, the participants did the observations of cultural activities and kept their observations in their journals. The participants and I could share some of their cultural activities' observations, but due to COVID-19 lockdown it became impossible to have a face-to-face feedback meeting hence the meeting was finally held on the zoom platform meanwhile the participants had to perfect their observations.

4.14.4.2. Lesson observations

One of the objectives of the participant lesson observations in this study was to assess holistically how the EIM could be successfully used in integrating ethnomathematics in the teaching of probability. DeWalt and DeWalt (2002) concur with this arrangement when they say that the goal for designing the research using participant observation as a method is to develop a holistic understanding of the phenomenon under study that is as "objective and accurate as possible given the limitations of the methods." This began by finding out if the problems posed by the participants appealed to the rural Shona learners' real-life situation. Since the problems which were posed by the participants were drawn from the learners' daily lives the observation was also aimed to assess the ability of the learners to solve the problems on their own using the methods they use outside school. The classes in which this study was carried out were multicultural although they were dominated by learners with Shona culture origin. It was in my interest to find how the minority cultures in the classes solved the problem differently. In that scenario the participants should be able to manage diversity by approving those different approaches used by the learners and reconcile them. The observation also sought to find out if the participants could identify the learners' pre-instruction conceptions and how they modified them. Learning is normally effective when the learners can reflect on their knowledge and be able to apply it in new contexts. Hence by observing the lessons I could find out how the participants guided the learners to reflect on their knowledge and apply the newly acquired knowledge to the new situations.

The lesson observations were recorded in narrative form to capture everything that transpired during the lessons including the learners' responses to the teachers' questions. This is in line with Griffee (2005) who asserts that using predetermined categories for recording observations narrows the attention of the observer causing them to miss some important details. When it was possible, the learners would be asked to go out of the classroom to see the activity that the teacher would be teaching about taking place.

4.14.5. Post-lessons reflection interviews

After every lesson, I conducted post-lesson reflective interviews with the participants to assess the effectiveness of the lesson [**see Section 4.2**]. If the lesson plan failed to give the desired outcome another lesson plan would be prepared. This process could continue until we made a lesson plan that delivered the desired outcome. The interviews aimed at the participants to reflect on their lessons. Post-lesson reflection interviews were done every time after the lessons had been taught. This was done so that the participants gave feedback while they still precisely remembered what transpired during the lessons. Before the interviews, the participants were required to write their lesson self-evaluation on the lesson plans. I used self-evaluation because I wanted to trace changes that took place in the participants after every lesson they taught. The purposes of the post-lesson reflection interviews were for the participants to evaluate the lesson in general and to evaluate the effectiveness of the instructional ethnomathematics model. The focus would be on how the learners showed an understanding of the probability concepts during the lesson and how the teacher successfully implemented the instructional ethnomathematics model by following the lesson plan. The interviews took place in the mathematics department library that was allocated to me for that purpose in case the Head of Mathematics Department of the school was working in his office at the time I wanted to conduct the interviews.

4.14.6. Final interviews

The final interviews involved all the three participants whose pseudo names for the sake of confidentiality were Amos and Amon and Messey. Amos and Amon were interviewed on the 6th of December 2020. Messey was not interviewed because he was not at school on that day. The interview took place in the office of the Head of Department of Mathematics of the school. Confidentiality was maintained by ensuring that no one was around the office as per my request that people keep away from this office when I had meetings or interviews with the participants. I had to go back to interview Messey on the 8th of December 2021 and after which the participants and I set the date for the final reflection meeting which was held on the 17th of December 2021.

Messey was interviewed in the car parked in the open space in the school sports field where it was quiet, and no one could hear the conversation between Messey and I. I chose this venue because the keys to the office of the Head of the Mathematics Department who was not present that day could not be found.

There were several reasons for holding the final interviews. The final interviews were focussed on tracing changes that took place in the participants from the beginning of the PAR to the end. I wanted to find at the end of the study whether the participants had realised that there are some mathematical concepts in the cultural activities of the learner that can be used in the teaching of probability. Another reason was to determine if the participants found the incorporation of the cultural activities in the teaching of probability helpful. I was also expecting to get the summative evaluation of the lessons which were taught during this PAR from the participants. Also, the participants were expected to evaluate the effectiveness of the EIM which was used to integrate ethnomathematics in the teaching of probability during the PAR. The final interviews helped me to analyse how the participants' involvement in the PAR would have enhanced their ability to integrate ethnomathematics in the teaching of probability. Also, I wanted to find whether the participation in the PAR by the participants would lead to a change in their practices of teaching probability.

4.14.7. Final reflection

At the end of the research period all participants wrote self-final reflections that were also used to evaluate the EIM process based on the attainment of its objectives and their general experience. According to Maeots, Siiman, Kori, Eelmets, Pedaste and Anjewierden (1992), reflection is a cognitive process carried out to learn from experience through individual inquiry in collaboration with others. In the final reflection, the participants revealed how the EIM helped them in understanding how to integrate ethnomathematics in the teaching of probability. Also, some snapshots of how the learners think their challenges of learning probability were alleviated through taking part in this study were revealed. The final reflection showed how the experiences of participation in the PAR had transformed the participants as far as the ability to integrate ethnomathematics in the teaching of probability was concerned.

4.15. Data Analysis

The data analysis started as soon as data was collected. According to Mlanga and Shumba (2014), qualitative data analysis starts with preliminary analysis conducted in the field during data collection and continues off the field. I started analysing data when I was doing the first interviews. Doing early data analysis helped me to cycle back and forth between thinking about existing data and generating new strategies for collecting improved data. In this study I was guided by Creswell and Creswell (2018) who urge researchers to look at qualitative data analysis as a process guided by sequential steps. When the researcher was satisfied that the collected data was enough to inform this study, the participants and I held data analysis meetings. In those meetings, the participants and I compared data from the journals, some correspondence between the participants and I, and post-lessons reflections interviews. Data analysis for this study was divided into two, the analysis of interviews and all data from other sources of data such as journals, final reflection, and observation of cultural activities, and the analysis of lesson observations.

4.15.1. Analysis of interviews and data from other sources

The analysis of the data collected by interviews, journals, meetings was subjected to coding for emerging themes based on the research questions. The detailed account of the data analysis from transcription to the generation of themes is shown below.

4.15.1.1. Transcribing

I ensured that the classrooms and the rooms in which interviews were conducted were quiet so that I would manage to transcribe the lessons and the interviews word by word as well as enhancing confidentiality for each participant. This was done by replaying the audio player several times to ensure that every word uttered by the participants had been noted. When transcribing I was writing exactly what the participant said. This method of transcribing is consistent with what Konieczny (2019) described as sociological transcription in which exactly what was said by the interviewee is transcribed without modification or correcting language as well as highlighting the non-verbal clues. Lesson observations were written in narrative form, writing exactly what was said and what was observed during the lesson observations.

4.15.1.2. Data organisation

Interviews normally result in some issues not being taken in the same order, also, some issues could surface more than once due to follow up questions. Data pieces had to be rearranged several times before the reassembled pieces emerged into a coherent pattern. As a result, there was a need to reorganise the transcripts checking aspects that had been repeated. I would re-read the interview scripts and replay the audio player to ensure that all words spoken had been subjected to analysis.

4.15.1.3. Reading all transcripts and data saturation

According to Sandelowski (2008, p.825), saturation in qualitative research is the point in continuous data collection that signals little need to continue because additional data will serve only to confirm an emerging understanding. Re-reading of all interviews, lesson reflection transcripts and lesson observations journals were done to ensure that all words uttered by the interviewees regarding the integration of ethnomathematics were considered for analysis. Also, Rosenthal (2016) adds that data saturation occurs when no more new information is being generated. This implied that the re-reading of transcripts, lesson observation journals and lesson reflection transcripts would stop when the re-reading no longer generated new information.

4.15.1.4. Coding

I was responsible for coding emerging themes from interviews, the journals and post-lesson reflection interviews during the data analysis meetings based on the research questions. Codes enable me to handle data more easily. This is in line with Mile and Hurberman (1994, p.65) who affirmed that codes promote data handling efficiency, data labelling and data retrieval also empower and speed up data analysis. The codes were created with the aspect to be analysed in mind and guided by the research questions. Gibson (2003) asserts that after identifying words and phrases used frequently as well as ideas coming from how interviewees had expressed themselves the researcher has to organise those ideas into codes categories. Additional codes would be created as transcription went on to cater for some new aspects which might arise. I also created codes for aspects that might arise but are unrelated to the integration of ethnomathematics in the teaching of probability.

4.16.1.4.1. Development of codes, categories, and themes

After identifying the codes, the categories were developed and finally the themes.

Figure 4.3. below illustrates the schematic process leading to theme development.

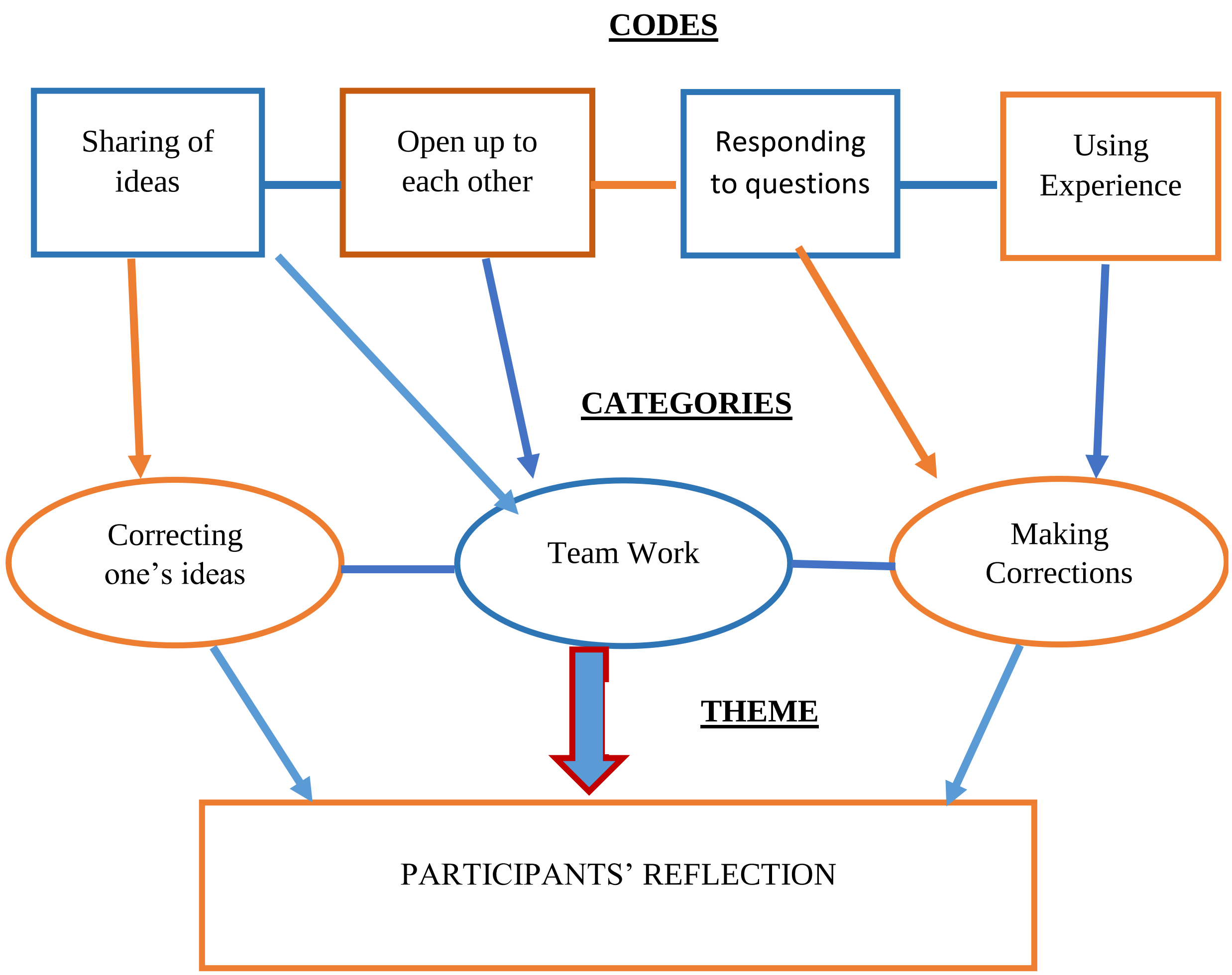


Figure 4.3: Data analysis Process

The codes, categories and themes which emerged out of this analysis and were connected to the integration of ethnomathematics in the teaching of probability in the secondary school mathematics are in **Table 6.1.**

4.16. Pilot Study

The pilot study was carried out with two mathematics teachers who were teaching at a neighbouring secondary school of the purposely selected school where this study took place.

According to Malmqvist, Hellberg, Mollas, Rose and Shevlin (2019), one of the purposes of pilot study is to try out a particular research instrument. In this study, the purpose of the pilot study was not simply to show that it was done, but to identify the weaknesses of the interview questions and modify them. Also, the pilot study targeted to improve the validity of the interview questions as Chenail (2011) points out that issues that may be addressed during piloting a qualitative interview include instrumentation rigor and management of bias.

During the pilot study some of the unnecessary and ambiguous questions were discarded while other new questions emerged and added. The mathematics teachers who took part in the pilot study were given enough information about this research study including details about the purpose of the pilot study and how it was related to the main study. I informed the teachers that they were required to provide critical information on the interviews and interview techniques that I employed. I made it apparently clear that the information they provided would be used to improve the research instruments. In that pilot study, the interviews were audio recorded and two meetings were held to discuss the interview questions and the responses that were given and how the interview questions could be improved. In those meetings I asked the mathematics teachers who took part in the pilot study to identify ambiguities in the difficult interview questions.

4.17. Trustworthiness

According to Maxwell (1996), trustworthiness of a qualitative research is measured by its credibility of description, conclusion, explanation and interpretation or any other form of account. In this study I adopted Sandelowski (1993) who presented criteria for evaluation of trustworthiness as credibility, transferability, dependability and conformability.

Gunawan (2015) defines credibility as the extent to which the results of the study approximate reality. In order to enhance credibility I audio-recorded the interviews and transcribed the verbatim to ensure accurate recording of all words uttered by the participants which were related to integration of ethnomathematics in the teaching of probability. Also, the use of lesson observation, interviews and post-lesson reflection interviews allowed triangulation since data was collected using different methods from the same participants. This study was carried over a period of more than a month in which the researcher was interacting with the participants and this led the participants to feel free to communicate whatever they wanted regarding their challenges of integrating ethnomathematics in the teaching of probability.

Transferability means that specific knowledge gained from the study conducted with small numbers of participants is transferable by the reader to other similar settings (Ncube, 2014). In this study the sample was carefully selected to typically represent the rural secondary school teachers and the rural secondary school learners in Zimbabwe. This can enable other researchers to relate the findings of this study to their own settings

Conformability of the study requires the researcher to indicate in the early stages of the study how conformability is going to be attained or demonstrated at the end of the study, hence it was necessary to outline in the early stage of the this study the expected outcomes (Gunawan, 2015). In this study I clearly outlined the aims and the objectives of the study at the beginning of the study. The research question to be answered were clearly articulated as a way of assisting conformability of the study

Dependability is the stability of data over time and over conditions (Guawan, 2015). Dependability involves participants' involvement in evaluation of the finding, interpretation and recommendation of the study. In this study depenadability was enhanced through verification of all data elements with the participants to ensure that data was capturerd accuratly. The participants were also involved in data analysis although the researcher was responsible for developing the codes, however, the the participants had to cofirm that the codes and the emerging sub-themes and finally the themes were consistant with what has been said by the participants. The provision of naratives by the participants on their understanding of ethnomathematics also built on dependability of this study since it helps the readers of this study to inderstand under what contexts the conclusion of the study was reached.

4.18. Ethical Considerations

The first thing I did before I went into the field to collect data was to get a clearance letter from The Research Ethics Review Committee (RERC) of the University of South Africa (UNISA). I took the clearance letter from RERC to the District Education Officer (DEO) of Bikita District where the research was carried out for me to be allowed to conduct this study in that district. In addition to the RERC clearance, I wrote a letter to the DEO asking for permission, explaining the purpose of my study, how it was funded, who was expected to participate, the participants' rights and the risks associated with participation in this study. The DEO permitted me to go to the selected school where I asked for permission from the headmaster to carry out my study at his school. After being granted permission by the headmaster he introduced me to the head of the department of mathematics of the school who in turn introduced me to the mathematics teachers in his department. I explained my intention to all mathematics teachers who volunteered to participate. The head of the mathematics department also happened to be the senior master at the school. I asked him for permission to address the Form 3 learners because I wanted them to take part in the study. I explained to the Form 3 learners that participation in the study was voluntary, and they had the right to withdraw at any point of the study if they were no longer interested without them being prejudiced in any way. Also, the results of the study would not be used to progress the learners to the next levels.

I wrote consent letters to the participants explaining the purpose and the methodology of the research as well as letters of assent to the guardians of learners who were below the age of eighteen to sign them to indicate that they allow them to take part in this study sign. The willing participants and guardians signed the consent letter and assent letters respectively to indicate that they would participate in the study voluntarily. The consent letters also explained the confidentiality of the information that would be collected**.** However, some of the learners who were involved in this study wanted their names to appear in the thesis citing that there was nothing bad about what they were going to say which they might want to be hidden. I explained to them the need for maintaining confidentiality in research which they came to understand and agreed to be treated anonymously. Therefore, for ethical reasons in this study, no real names of the participants were used, pseudo names were used in place of names of the participants. The recorded audio was kept safely and not accessible to the third party.

4.19 Conclusion

This chapter has explained the methodology, the research design, data collection and analysis, ethical considerations and validity and reliability of the study. The next chapter (Chapter 5) presents the research team. Chapter 6 presents the findings of the current study. Chapter 7 presents the discussion of the findings and Chapter 8 presents the conclusion and recommendation of this study.

CHAPTER FIVE

NARRATIVES FROM THE PARTICIPANTS

5.1. Introduction

This chapter presents the findings of the initial interview, observations, and final interviews. The initial interviews were carried out to determine the participants' understanding of integration of ethnomathematics prior to the PAR. In a PAR it is necessary to understand the researcher and the participants because it may help the reader of the study report to understand the context in which the findings and the conclusion of the study were reached. Each of the participants were requested to submit in writing their own narratives. By writing their own narratives about themselves, I reduced authorial bias to minimum, and, enabled the participants to position

themselves within the context of the PAR. The narratives also assisted me to modify questions before conducting the final interview. The participants were given subheadings to guide them on how to write the narratives. Among the aspects which were considered in these narratives were the participants' teaching experiences, and their beliefs about mathematics education, their relationship with the learners, and their opinion on why learners fail mathematics at OL. After presenting the narratives I go on to present the findings, analysis and discussion of the initial interviews. Pseudo names for all the participants were used.

5.2. Participants' narrative

5.2.1 Amon's teaching Experience

I started teaching at this school four years ago and this is my sixth year of teaching in the rural areas. Before I came to this school, I had taught at three other schools in this province. At one of *the schools which I taught before I came here, transport was a serious challenge. If one wanted to travel to town, he/she had to be at the bus stop by one o'clock in the morning because there was only one bus which passed by the school on its way to town around that time and passed by the school on its way back around eight o'clock in the evening. Another challenge at that school was accommodation; there were three houses to accommodate ten teachers. To make matters worse the headmaster did not want to share the house; he wanted to live alone with his family in one of the houses. I was sharing a room with another teacher and that set up affected how I worked as a mathematics teacher*

Also, there were very few mathematics textbooks for each class, a class had a maximum of three textbooks. The sizes of the classes ranged from forty-five to sixty students and the students had no financial capacity to buy textbooks for themselves. Since I was sharing a room with another teacher it was not possible to make learning aids to support learning before the other teacher went to sleep because it would disturb him. I could wake up as early as three o'clock to prepare job cards for the class because there was no way I could use three mathematics textbooks for the entire class without worksheets. That set up made me resourceful; I could make a variety of learning material to close the gap created by shortage of textbooks. To reduce pressure on myself I could assign the students to make or collect some learning aids for themselves where possible. I did it often after I realised that the students enjoy using the learning aids, they make themselves. For example, those with good handwriting could help me to copy questions from one job card to the other job cards. However, it was my responsibility to buy manila sheets for making job cards and charts although I could assign the students to do part of the job. For instance, I provided the manila while the student brought the ropes for making the number lines. The school could buy manila, but it could rarely be enough because some teachers were not using it economically since *some teachers wanted to make chats out of them. They could also go to the township after school to collect empty boxes and anything that would have been thrown away by shop owners such as tins and bottle tops which I could use in teaching mathematics.*

The third school I taught was a mission boarding school, but I was there for only three months. The school got overstaffed, since I was the last person to join that station I was forced to transfer to this school where I am teaching now. Teaching mathematics at a boarding school was the most exciting experience I have ever had in my teaching profession. The students were bright, they worked hard, the textbooks were in abundance, and the students could follow textbook examples on their own and go on to attempt the questions hence my work was the simplest ever. Generally I do not want to teach in the rural secondary school because it is difficult to teach without resources and the students do not have time to study. The students travel very long distances to school. When they arrive at school, they are too tired to concentrate to learn and when they get home from school they are too tired to study. I think the high failure rate in mathematics in the rural areas is attributed to this factor.

5.2.2. Amon's perception of students

My perception of the students depends to a larger extent on how they perform in mathematics. I do not put all the learners in one group, I think they should be treated according to how they do their work. I am a very tough teacher. I do not want students who do not work hard. When I deal with students, I put myself in the position of the parents that I encourage them to work hard in mathematics citing that the subject is very difficult. At the same time, I understand that these students come from different backgrounds, some of them come to school hungry and some of them are orphans and all those differences. Therefore, I study my students so that I know how to deal with them differently. I can see some students have potential to do well but they may be playing. I *put such students under immense pressure so that they can put more effort into their work. However, the challenges I face with these students is that the moment I try to understand them they give me problems, so I am usually tough on them. I think the students are not doing what it takes for them to pass mathematics. I do not want to hear any excuse for not doing work. In short, I can say we have a mixed bag of students, some have the potential while others cannot be redeemed at all. The teachers should identify these two groups of students and guide them accordingly.*

5.2.3. Amon's teaching strategies

When I am teaching mathematics, I normally employ group work because I think the students can benefit from helping each other. Thus, with well-prepared worksheets for the group work the textbook deficit was less felt by the learners. I make the groups more permanent so that each student is given a chance to represent the group in presentation when required. I prefer mixed ability groups so that all the tasks assigned to the groups are attempted. However, I find that some students do not participate actively when they were in these types of groups.

I feel pity for the students in the rural schools like this one because they do not have enough resources, yet they write the same examinations with those students who are in boarding schools and urban schools who have abundant resources. I think such gaps can be closed through employing strategies such as project methods. I also require the students to write down notes when I am teaching because in the absence of textbooks the students use the notes, I give them for revision. The notes I give them comprise of all the worked examples in the textbook so that they can use them in place of textbooks. Another approach I used is project methods, but it does not work properly for the rural secondary students who travel long distances to school. I later realised that project approach is time wasting, it takes a long time to complete a single topic. In most cases *students do not complete the projects giving excuses that they do not have time to do the project since they come from far. I stopped giving homework because it is rarely done. Also, due to lack of resources such as textbooks at the school I normally use the chalkboard as a teaching aid, and this enables me to cover a lot of work during the lesson.*

5.2.4 Mathematics topics which Amon find challenging

In mathematics topics are challenging in two ways. Some topics are challenging to the students while others are challenging to the teacher. The topics that I think are challenging to the students are indices, probability, transformation, and linear programming. Law of indices and probability are very abstract, the teachers say that the students can only master them through memorizing their rules. On the other hand, transformation combines a number of concepts that the students should master before they do transformation and this makes it difficult for most students.

There are some topics that the teacher finds difficult to teach. Such topics include probability and indices again. The teacher when teaching these topics depends on drilling of the learners because these topics do not have visible applications in real life of the learners. There is nothing tangible that the teacher can show to illustrate these concepts. What the teacher can use as illustrations is not different from the abstract situations found in the textbooks. Worse still in our Shona language there is no word that has the same meaning as probability that the teacher can use to help the students to understand the concepts.

5.2.5. Amon's understanding of mathematical knowledge.

The main challenge we face as teachers especially in the rural secondary schools is that the students are not serious with their work, once the mathematics teacher leaves the class the students do nothing on their own. Mathematics is a very difficult subject for most students because it is very abstract. It requires that the students work on their own to revise the work that has been covered *by the teacher. In the rural areas the students do not have time to revise work because when they get home after school, they will be tired by walking. Mathematics can only be understood by the students if the teacher makes them memorise the formulae. There is no way the students can understand mathematics without memorising the formulas they are supposed to use in solving the problems. For example, even on simple topics such as areas if the student does not know the formula to be used, he/she cannot solve the problem. Like I have said before, the students should master the worked examples in their textbooks for them to pass mathematics.*

5.3.1. Amos's teaching Experience

When I came to this school, I taught a Form Two class and that class was the largest class I have ever taught, it had sixty-six students. The classroom had not enough chairs, some of the students would learn while sitting on the floor. By that time the school had five classrooms only for the six classes which were there, hence one of the Form One classes had no classroom the learners learnt outside under a tree. The following year when my Form Two Class proceeded to Form Three the majority of the students dropped Mathematics and I remained with only thirteen students who were still doing Mathematics. As if that was not enough, when they proceeded to Form Four the following year more students dropped Mathematics and I remained with seven students. I tried to convince the students to continue doing mathematics, but they all refused. I had never felt so bad like that in my teaching profession before. I remember one day the headmaster called me to his office so that we could find ways of persuading the Form Three students to continue doing mathematics but to no avail. The system of students dropping mathematics happened for several years until some few years ago when mathematics was made a compulsory subject for all OL full time students. However, the majority of students could register for mathematics examinations to avoid consequences, but they did not write it in the examinations. The students preferred to be *absent during the examinations than to get F ungraded when they fail. However, things have changed, all the students now write mathematics examinations although the pass rate remains low at a one-digit percentage figure except in the year 2017 when it hopped from six percent the previous year to eleven percent. Despite all those challenges I remained one of the most respected teachers at the school because the students know that mathematics is a difficult subject and they know that I am a very hardworking mathematics teacher. However, as a rural secondary school teacher, I used to have an inferiority complex when I met colleagues who teach in boarding schools and urban schools because our students underperform in mathematics. We used to look up to boarding school teachers to provide solutions to teaching problems faced by mathematics teachers, but I came to realise that, as rural secondary schools we face different problems as rural secondary school teachers which we can solve using our own home grown solutions. I enjoy teaching in the rural areas because food is not expensive here. During the harvesting season we receive crops from the parents of our students because the parents appreciate the good work we are doing although some students fail the examinations.*

I went to study for a Bachelor of Education in 2007 at the University of Zimbabwe. When I went to the university, I thought that when I come back from the university, I would be more effective as far as teaching mathematics to OL learners was concerned, however, at the university we were focusing more on contents than on methodology, as a result that did not help me much in improving my lesson delivery in the OL classroom. In other words, the program prepared us to teach Advanced Level Mathematics with little emphasis on OL teaching.

5.3.2. Amos's perception about the students

Since I came to this school I have been working very well with my students. Generally, I sympathise with my students because some of them walk very long distances to school and when they arrive *at school, they will be extremely tired, and they hardly concentrate on schoolwork. However, I believe the students do not do their best because most of the time the students will be playing here at school instead of helping each other in the mathematics home. Also, I do not believe that the students who attend day schools are dull, but they are only poor in that their parents cannot afford sending them to be boarding schools. Given enough support in terms of mathematics textbooks these learners have the capacity to produce excellent results in mathematics. I think in most mathematics classrooms the Labelling Theory is at play, instead of encouraging the students and giving them confidence that they can do well in mathematics, the teachers in most cases are busy discouraging them by comparing their performance with those who are at boarding schools. The learners need everyone's support for them to do well in mathematics. What is needed is to acquire past examination booklets with answers and give them time to concentrate on past examination question papers and on the other hand the teachers should be drilling them so that they internalise questions which frequently come in the examination. In other words, we as teachers lack examination strategies, we waste a lot of time on things which do not come in the examinations.*

5.3.3. Amos's teaching strategies

When I was at college we were taught to teach from the known to the unknown. This principle governs how teachers should teach mathematics; one cannot teach simultaneous equations before teaching linear equations. Teaching of mathematics should follow chronological order from the simple to the complex. Each topic in mathematics has its base which the teacher should begin with. That is the approach I use even now, and I have been finding it very rewarding because when I came to this school fewer than five students would pass mathematics at OL but now, we are talking of 15 students passing mathematics out of 80 students. Although as a school we are doing our best *mathematics remains behind on the pass rate. I use drilling as my strategy of teaching to improve the pass rate in OL mathematics.*

As I got more classroom experience as a mathematics teacher, I realised that in my early days of teaching instead of guiding the learners I showed off my mathematics content knowledge to the learners. I could solve as many problems as I could on the chalkboard with learners contributing nothing. I later realised that mathematics teaching requires more than mathematics contents. When I reflected on the method my father was using when he taught me, I realised that my father had mathematics content knowledge but he lacked mathematics pedagogical knowledge. He tried his best to make me understand but I could not. I came to see the difference between my father's and my OL teacher's approach. My OL teacher tried to link his teaching of mathematics to the learner's previous knowledge. He became my inspiration that even when I became a teacher, I imitated the way he taught us.

5.3.4. Mathematics topics that Amos finds challenging.

Although I find the teaching approach, I have just explained paying dividends, I believe there are some difficult topics which cannot be understood by the learners, even when the learner is given enough time to do them. Some mathematics topics which I find very difficult to teach include transformation, indices, probability, and vectors. Transformation is a very long topic that by the time the topic is completed the students would have forgotten what they were taught at the beginning of the first topic. Indices are very challenging to the students because they are too abstract, there is nowhere one can show the learners in real life situations where indices are at play. On the other hand, probability is confusing because even most of the teachers are not confident with the answers they get in probability questions, one cannot prove that his/her answer is correct. Vectors are easy at the introductory stages when one goes deeper it becomes very *challenging and abstract that one cannot find suitable learning aids to teach them. I am still trying to find ways to overcome my weakness in teaching these topics.*

5.3.5. Amos's understanding of the nature of mathematics knowledge

According to me mathematics is one of the most difficult subjects, it is very abstract. Even during our day as a school passing mathematics was not for everyone only few people could pass mathematics. Mathematics is based on formulas which the students should master in order for them to pass it. You can see that as one goes higher in mathematics formulas are provided for in the examinations but still people fail the examination with those formulas.

Students need to be drilled because what is important is for the students to get the correct ans5ers in the examinations. If you try to teach mathematics for understanding you can only teach one topic the whole term because students need a lot of time to understand mathematical concepts. Some people say one should use teaching and learning aids for students to understand mathematics ideas, yes it helps but some concepts in mathematics cannot be brought physically into the mathematics classroom. For example, mathematics consists of symbols and operations that the learner should master but these symbols cannot be found physically; they only exist in the mathematics textbooks. Some mathematics concepts are better memorised than trying to waste time explaining. For example, the symbol pie is first used in mathematics in Grade five but you cannot explain its meaning even to the majority of secondary school students to understand it. Since I started teaching, I have noted that mathematics is one of the subjects with the least pass rate in the OL Examinations in many schools. To my surprise, mathematics teachers have accepted responsibility for the students' failure when it is the nature of the subject that contributes to this high failure rate.

5.4.1. Messey's teaching Experience

My first deployment after completing college training was in Chipinge District where I was teaching at a newly established school. I was teaching Mathematics and Science in all the five classes. Form one and Form two had two classes each while form three had one class and there were only five teachers at that school. When I was deployed at that school the school was only three years old there were only Form One up to Form Three. Only Form Three class was at the school's new site, Form One and Form Two were accommodated at the nearby primary school which was two kilometres down the dust road that joined the two schools. Since I was teaching all the classes at the school I could go up and down the dust road two or three times per day to teach my classes. The textbook situation was dire with each class having one textbook in each subject. The first group of students to sit for OL at the school got seven credit passes in mathematics out of thirty-three students who had sat for the examinations.

Four year later I moved to another school in the district which was one of the biggest schools in the district, each form had five streams. Teaching was easier at that school because I was teaching mathematics to Form Three classes only. That school was better equipped than the one I was teaching before. There was a good number of mathematics textbooks per class and the school management was very responsive to the teachers' demands of teaching material. For the five years I was teaching at this school mathematics was one of the subjects in which the students performed badly. The pass rate in mathematics was always below thirty-seven but was rated one of the best results in the district. Everything was tried to improve performance of students such as giving financial incentives to the teachers, which included paying the teachers for every credit symbol the teacher got but that did not change anything in the performance of students in mathematics significantly.

From Chipinge District I was transferred to this school because I wanted to come closer to my wife who is teaching at the neighbouring school. However, I could not take up my post immediately because I had been given study leave to pursue a Bachelor of Education in Mathematics for two years. After the two years I came back to this school, and I was teaching Form One classes. The classes were very large, the class sizes ranged from forty-five to fifty-five students. Although the management at this school is very supportive, the resources are limited and there are hardly enough textbooks for such large classes. Also, preference for textbook acquisition is given to Form Three and Form Four classes. I think this practice is disadvantageous to the students in that they do not develop a strong mathematical background when they are in lower forms since they do not have enough learning material when they begin their secondary education.

5.4.2. Massey's perception of the students

Since I started teaching, I have seen that the majority of students who live in rural areas are lazy, if you give them homework for example, they do not do that homework, in most cases they give excuses for not doing homework. The homework is either not done or it is incomplete so there is no way such students who do not do homework can pass mathematics. Although I sympathise with the rural students about their learning condition with little resources, I feel that the students are not playing their part in mitigating these situations. At times I stay with students who help me with domestic chores while I pay for their school fees and provide them with textbooks, but I found that the moment they get settled at my place they forget that they are students. They can even go to bed without doing my homework while I am still on the table marking exercise books.

I normally engage parents when the students whom I believe can do better underperform so that I can give advice on how the parents can help in that situation. This arrangement has made me to *be respected by both parents and the students. Through this practice I have managed to reduce indiscipline in my subject because the students know that if they misbehave, I call their parents and in some cases the parents beat up their children in front of me. Although the students might be doing their homework fearing that I could call their parents in most cases it falls short of the expected standards. Some could do very good work, however, they do not retain that knowledge for long because when I give the same question in the revision test the students fail as if they had not seen the problem before. Therefore, the problem with mathematics is not with the methods used by the teacher but with the learners who fail to retain the knowledge that has been taught to them due to lack of revision.*

5.4.3. Messey's teaching strategies

I usually go through the syllabus so fast that there is enough time for me to drill the students on areas which usually come in the examinations. I have seen that this approach works because we usually find areas that I would have drilled in the examination. I study the examination papers, especially Paper Two. I now know the pattern of the examination questions, the questions that are usually alternated in Section B. This approach is the one that was used on us by our mathematics teacher when I was doing Form Three and Form Four. We completed the syllabus when we were in Form Three. The whole of Form Four we were being drilled as we were doing revision. Although the syllabus that we followed was more difficult than the current syllabus, several students could get a credit pass. I have also been using this trick for some years. It is paying dividends because I have never got a zero-pass rate in mathematics since I started teaching mathematics. I make sure that when students write the Mid-Year Examinations in Form Three the syllabus for Form Four should have been finished, and from there I will be drilling them on the topics I think are coming *in the examinations. Also, I give them a lot of work in the form of weekly tests which we revise thoroughly.*

5.4.4. Most challenging topics in mathematics

The difficulty of the topic depends on the level being taught, in fact every grade or form has its own challenging topics. In Form One the most difficult topic for both the teachers and the learners is Directed numbers. When teaching Directed numbers, the teacher device methods of making the learners understand the concept but in most cases without success because all the methods around teaching of Directed Numbers are just a matter of drilling the learners that a plus and a negative gives a negative but it is not constant with all addition and subtraction although the rule is constant with multiplication and division. In most cases some learners go as far as Form Four without mastering the operation of Directed Numbers.

Form Two also has its share of difficult topics such as bearing. This topic is very technical. Instead of demanding a mathematics mind it demands a technical mind. Most concepts found in bearing at Form two level are challenging, imagine talking about a ship in the sea to a learner who has never been to the sea. Or any aeroplane flying at a given bearing for example, it demands the level of technicality and abstraction beyond the Form Two learners' level of reasoning.

For the Form three I single out Probability as one of the most difficult topics. Probability is something that the learners experience in their real-life situation, however, there seems to be a contrast between the probability found in real life and probability that is taught in schools. All those real-life situations that the learner sees in the real life does not in any way help the learners to solve probability problems in the mathematics classroom. In short probability although prevalent in the lives of the learners it remains abstract making it difficult for the teacher to make learners understand its concepts. While learners in most cases can develop insight as the move up *with education, in probability it seems that insight never develops because student teachers in teachers' college in most cases are asked similar questions with those found at Form Three level and still struggle with them.*

5.4.5. Messey's understanding of mathematics

I think mathematics is the most difficult subject because it is very abstract. Although it is possible for some topics to be done practically, other topics are generally difficult for both the students and the teacher. Linear Programming for example, there is no way the teacher can concretely show the students its practicality because it involves graphs. Also, probability is one such topic which is very abstract, and it is very difficult to prove that the answer is correct or wrong. Although there are activities which are probabilistic in nature which the students use daily there is no connection between mathematics and these activities. Some people say games can be used to teach probability but if one asks the students to play the game then what? It is just a waste of time because that will not be found in the examinations. Students in urban areas are at an advantage because the games they play such as playing cards come in the examination. Since I started school, I have never witnessed games played in the rural areas in the examination paper, but there is either a coin or playing cards. Therefore, many students in rural areas cannot pass mathematics.

5.5. Conclusion

This chapter presented the research participants' narratives and their backgrounds. It also presents the participants' understanding of mathematical knowledge, their teaching experience, and their perception of their learners. The following chapter presents the findings of this study.

CHAPTER SIX

FINDING OF THE STUDY

6.1. Introduction

This chapter presents the pilot study and the findings of this study. The aim of this study was to integrate ethnomathematics in Zimbabwe secondary school mathematics for the teaching of probability. To achieve this aim, the interviews and the lesson observations were intended to answer the research questions. (**See Section 1.6**)

The PAR in this study consisted of a small-scale pilot study and the main study. The pilot study was completed in one complete cycle. Two participants P1 and P2 took part in the pilot study. The two participants together with me prepared the lesson plan which was used by the two participants P1 and P2 to teach probability lessons with each participant teaching one lesson. After the lessons and post-lesson reflection interviews the participants and I held a focus group discussion to assess the effectiveness of the cultural activities and the general procedure which was followed in that cycle. Also, of interest in that discussion was to assess the validity of the interview questions which the participant responded to prior to the lesson observation and how the entire process could be improved.

6.2 Pilot study

This section focuses on the pilot study. The main purpose of the pilot study was to examine the feasibility of the approach that I intended to use in the main study. Although the research timetable was seriously affected by Covid-19 as I articulated in chapter four, the timetable allowed for the conducting of the pilot study. Also, the piloting process did not allow for proper analysis of the data generated from the pilot study, however, the instruments and the procedures were thoroughly scrutinised to ensure that anything that could be learnt from the pilot study was absorbed. In the next section I present the location of the pilot study, the participants, its benefits, and the intervention arising from its outcome.

6.2.1 Site of the pilot study and the participants

The pilot study took place in Bikita District in Masvingo Province of Zimbabwe in a school neighbouring to the one where the main study took place. I selected the neighbouring school because I wanted the school where the pilot study would take place to share the same cultural characteristics and environment with the school where the main study was going to take place since the study was based on the incorporation of cultural activities of the learners in the probability pedagogy. Two mathematics teachers volunteered to participate in the pilot study hence they were purposively selected. Also, twenty-one form three learners taught by one of the participants and twenty-three form four learners from the other participant's class were willing to participate in the pilot study. Hence the learners were also purposely selected to participate.

6.2.2. Pilot Testing

Pilot testing began as soon as I got permission from the school authority to proceed with the study. Initially I conducted a short meeting with the two participants in which I explained the purpose of the pilot study and what was expected from them in the study. I also asked them to be very critical of all the proceedings of the study. I made an appointment with the participants so that I would interview them. The two participants were interviewed on the same day and the duration of the interviews were one hour three minutes and one hour five minutes long respectively. Their responses were digitally recorded and those recorded verbatim were transcribed. In the interviews I noted that the participants were keen to share their experiences of teaching probability and their struggle to integrate ethnomathematics in the teaching of the concepts.

In the pilot study I used semi-structured open-ended questions to gather data from the two participants and each participant taught one lesson which I observed, journalised and audio recorded. I transcribed both the interviews and the lesson observation recordings. The interview questions were designed to elicit qualitative responses from the participants on the integration of ethnomathematics in the teaching of probability. After the interview I had a meeting with the participants in which we discussed how the interview questions were suitable for the intended purpose in terms of the language used and understanding. I wanted to find out whether those responses from the interview questions adequately addressed the research questions. Also, after each lesson we met for post-lesson reflection discussion to assess how the lesson would have met the objectives and how it would be improved.

6.2.3. Benefits from the pilot study

From the pilot study several things were identified as follows:

6.2.3.1. Gaining Access: The pilot study enabled me to be familiar with the procedures of gaining access and building rapport with the participants and getting their consent to participate in the study. I realised that although some of the learners had already attained majority age there was a need to seek further consent from the guardian. I also noted that some guardians signed assent letters for their underage dependents or children which the learners took to them. However, there was a need to ask the headmaster to call a parent meeting if the situation permitted so that I could talk to them face to face about the benefits of the study. Also, I found that the protocol of accessing the venue was not wholly formal once one has been cleared by the ministry. It could be easier when it is first facilitated at a social level outside the workplace such as at township and then it is formalised.

6.2.3.2 Interview questions: The analysis of the participants' responses and the discussions with the participants during the pilot study helped me to review the interview questions, resulting in two questions being modified. I noted that Question Three which was not clear to the participants in that it contained words which the participants were not familiar with, “integrating ethnomathematics” hence I replaced those words by “incorporating cultural activities related to mathematics”. Also, Question Four was found to be unclear,” This question was ambiguous, the participants took some time to respond to it. It sounded like it was asking for the time of the day at which the participants incorporated cultural activities in the teaching of probability, yet it was intended to find how the participants incorporated cultural activities in the teaching of probability.

Question Three originally read: *Is it always possible to integrate ethnomathematics in the teaching of probability?* The question was modified so that the wording became familiar to the participants as follows: *Is it always possible to incorporate cultural activities in the teaching of probability? Give reason for your answer? Explain your answer.*

Question Four which originally read: “*When do you incorporate cultural activities in the teaching of probability?* The question was modified so that it became clear to the participant, and it reads as follows: *How do you incorporate cultural activities in the teaching of probability?*

6.2.3.3. Lesson observations: I noted that during the pilot study while one of the participants was teaching the other participant would be observing the lesson with me. When it became the turn of the participant who had been observing the other participant to teach, they could correct the mistakes that had been made by the other participant thereby failing to reveal their challenges of integrating ethnomathematics in the teaching of probability. I revised this procedure so that I could be the only one observing the lessons so that the participants could not copy what the other participant had done or correct the mistakes that would have been made by the other participants in their lessons.

6.2.3.4. Estimated time of the interviews: It is through the pilot study that I realised that the 50 minutes I had allocated for the interview per participant was not adequate. If the participants were probed to clarify their views, it could be at one hour.

6.2.3.5. Some findings from the pilot study: Some of the findings which I thought are worth getting note of are given hereunder:

The first question I asked the participants was on their challenges of teaching probability.

MT: *Do you have any challenge in teaching probability?*

Both participants mentioned that teaching probability created challenges for them. Their responses are shown below.

P2: *I do have serious problems with this topic. The learners take a long time to grasp the probability concepts. I do not know how I can make the learners understand these concepts faster. On average a mathematics topic found at OL requires an average of ten day to complete, but when teaching probability, it can take up to four weeks to complete the topic. Worse still the learners do not develop a clear idea of the probability concepts, it is not surprising to find learners give a negative number as a probability.*

P1: *Probability is one of the topics which I fear most amongst all the topics in the OL syllabus. There are some concepts which I cannot explain to the learners clearly because I memorised those things when I was a learner myself. I now see that gap, but I find it difficult to fill it. I think I am not the only one with this challenge but even all my colleagues at this school may have that same challenge, because they have failed to clarify these things to me.*

When I probed him to give an example, he said that:

P1: *For example, the use of multiplication for the word 'and' and addition for the word 'or' none of my colleagues had given me an explanation that I can satisfactorily give to the learners.*

The following findings are with respect to the following question.

MT: *Is it possible to find matching cultural activities for all probability concepts taught in school mathematics?*

Participants mentioned that cultural activities do not have some of the probability concepts found in school mathematics. Their responses are:

P1: *Most of the probability concepts which we teach in OL mathematics are not found in the cultural activities. In cultural activities there are some simple probability concepts which even a primary school child can understand.*

P2: *Probability concepts in cultural activities lack the depth that is required in OL probability they can be used at primary school level. In the school probability concepts there are various techniques which are employed in solving probability concepts which cannot be found in cultural activities.*

When I asked the following question to the participants:

MT: *Do you find your participation in this PAR implementation of EIM beneficial to you as far as your ability to deliver a probability lesson is concerned?*

The two participants P1 and P2 responded as follows:

P1: I have learnt a lot about incorporation of cultural activity in the teaching of probability. For the first time I have realised that probability concepts can be presented to the learners in a manner that makes sense to them.

P2: *I learnt how to facilitate learning during the lesson, I have seen that my role in the mathematics classroom is to help learners to express their ideas and help them to correct them if they depart from the desired direction. The EIM helped me to sequence activities in a manner that learners find easy to understand probability concepts.*

He went further to explain his desire to have more members of the department joining the PAR.

P2: *I wish all our colleagues were part of us in this PAR because I have learnt a lot on how probability can be taught easily through incorporation of cultural activities. Furthermore, it promotes sharing of ideas openly without anyone being dominant, both the learners and the teachers participate freely*

To compare the EIM and any other strategy of teaching probability I asked the following question.

MT: *Do you think the EIM makes a difference in helping mathematics teachers to incorporate cultural activities in the teaching of probability?*

The following were the responses of the two participants.

P1: *The EIM makes a difference in assisting mathematics teachers to incorporate cultural activities in the teaching of probability because it clearly outlines how the activities should be incorporated. The sequencing of activities on the EIM makes learning easy for the learners especially on the fact that the lesson begins from the problems which originate from the learners' cultural activities.*

P2: *The EIM help the teacher to follow certain stages hence make it easy*

for me to make learners understand probability concepts. It helps the teacher to understand how cultural activities can be connected to conventional mathematics. Without such a model teachers can only use cultural activities as examples instead of using them meaningfully.

To find out if the participants found it was possible to use the EIM to teach all the concepts in probability, I asked the following question.

MT: *In your opinion is it possible to teach all probability concepts using the EIM?*

The following were the responses given by the two participants P1 and P2 respectively.

P1*: The EIM is a guideline of how to integrate ethnomathematics in the teaching of probability. I think all the concepts can be taught using the EIM because it is a form of planning of a lesson outlining how the cultural activities should be incorporated and how the activities are to be sequenced. What matters in the use of the EIM is the teacher's ability to think of the cultural activities to incorporate in the lesson and once the activity has been found everything goes smoothly.*

P2; I think it is very possible although it may be a challenge for the teacher to pose a relevant problem as required by the EIM. But one can find that if teachers share ideas all concepts can be taught using the EIM. Also, the EIM can be used to teach all concepts if the teacher work with the learners effectively. The learners know their culture very well; if the teacher works closely with the learners the use of the EIM can be much easier.

When I required the participants to compare the learners' participation during the lesson where the EIM was used and in other lessons where other strategies were used, I asked the following question.

MT: *Do you think the use of the EIM has any impact on the learners' performance during the lesson?*

Both participants commented on how the learners' participation is triggered by starting the lesson by problem posing which they said generates a lot of motivation for the learners.

P1: *The use of the EIM motivated the learners to participate because they wanted to show that they knew the activities which had been incorporated. That motivation was triggered by the way in which the cultural activities were incorporated. Starting with the problem which they were familiar with which generally pushed the learners to be active trying to solve that problem.*

P2*: I see the EIM as designed to motivate the learners to participate because it starts by creating problems for learners to solve. In other words, it creates a disequilibrium in the learner and challenges them to solve the problem. The problem posing is when properly done automatically leads the learners to be active during the lesson especially when they are allowed to work in groups or in pairs and allowed to use vernacular language to. explain their points*

He continued by saying.

P2: *I think problem posing and solving part of the EIM is the key element in that model if properly done it pushes the learners into participation. When the problem is familiar to the learners like it is supposed to be, learners become interested in showing the other students how the problem is solved in their culture*.

The participants pointed out that participating in the implementation of the EIM empowered them in some ways that they thought was going to help them to improve the way they teach probability. To get their opinions on how their participation in the implementation of the EIM was of benefit to them I asked the following question.

MT: *Can you explain how you have benefited from participating in the implementation of the EIM?*

One of the participants P2 explained how participation in the implementation of the EIM enhanced his probability teaching skills while P1 narrated how the use of the EIM helped him develop problem posing skills and help the learners to reflect on their probability concepts as follows.

P2: *The way we were sharing ideas on how to incorporate cultural activities made me understand how to create and pose a problem. Also, there are some concepts in probability which I thought were very difficult to teach. I have seen that with the use of the EIM that we implemented here teaching probability becomes easy.*

P1: *The use of EIM helped me to develop problem posing skills. I did not have a clear idea of how to pose a problem. Problem posing skill as required in the EIM helped me to know what type of the problem must be posed. I used to pose problems in my class but unfortunately the learners could not participate, and I did not know the reason. I now know that learners could not solve the problems because the problems were not relevant to them.*

Although the pilot study was carried out over a very short period and with fewer participants and fewer learners it was a worthwhile and valuable lesson. It gave a very thorough overview of how the shortcomings revealed in the pilot study would be improved in the main study. It also came to my attention that findings from the pilot study show the same pattern with those found in the main study. This similarity was of interest to me as a qualitative researcher because it reveals the validity of the interview questions and observation schedules.

6.3. The Main Study

The main study consisted of 14 complete cycles. One complete cycle consisted of the following activities, identifying cultural activities, making lesson plans lesson observations, post-lesson reflection interview, and lesson improvement. Lessons which failed to meet the desired objective were taught again either with the same cultural activity and lesson plan or with the new lesson plan altogether. The probability topic was scheduled to be completed in ten lessons. Amon and Amos taught 12 lessons each while Messey taught 14 lessons, and these include those which were taught for the second time as outlined above. No lesson was taught more than two times.

The source of data for the finding of the main study were gathered from the transcript of semi-structured initial interviews with the participants, lessons observations, post-lesson reflection interviews, self-reflection journals final reflection interviews, participants journals and the final interviews conducted with the three participants Amon, Amos and Messey. Lesson observations were done over a period of three weeks running from the 11th November 2020 to 5th December 2020 excluding weekends. In all the interviews the participants were interviewed individually, and the duration of the interview ranged from one hour to one hour ten minutes.

Doing early data analysis helped me to cycle back and forth between thinking about existing data and generating new strategies for collecting improved data.

When I was satisfied that the collected data was enough to inform this study, the participants and I held data analysis meetings. In those meetings, the participants and I compared data from the journals, lesson observation schedules, interview schedules, and post-lessons reflections interviews. After that I started developing the codes of which 120 codes were identified but I then dropped the other codes which I found not useful in answering research questions of this study and remained with 70-90 codes. I then divided the remaining codes into major code from which categories, subthemes and themes were developed. There were four main themes each with several subthemes corresponding to the identified categories. The following themes were identified from data analysis.

- Hindrance to incorporation of cultural activities in the teaching of probability.

- Failure to make connections.
- The change.
- Participants' reflection.

In **Table 6.** I present all the final codes, categories and themes which emerged from the analysis.

Table 6.1: List of codes, categories, subthemes, and major themes

Codes Employed	**Matching categories**	**Summarised subthemes**	**Themes**

EXPLANING, CONCEPTS, EXPERIENCING, CHALLENGES, LACK OF KNOWLEDGE, NOT CONSISTENT, DIFFICULT TO UNDERSTAND, DIFFERENT FROM DAILY USE, EASILY FORGOTTEN, DIFFICULT, NOT UNDERSTOOD, REACHER'S ROLE, FACILITATING, NOT CHANGING, USED AS EXAMPLES, METHODOLOGY UNCHANGING, REGARDING AS SHALLOW, IGNORING LEARNERS' EXPERIENCE, METHODOLOGY NEGLECTED, INCORPORATING	• Challenges • Inconsistency of probability language. • Volatility of probability concepts. • Difficulties of concept to understand. • Pedagogical stagnancy • Lack of mastery	• Lack of probability subject matter knowledge. • Lack of knowledge of cultural activities • Trivialising probability concepts found in cultural activities.	Hindrance to incorporation of cultural activities in the probability pedagogy.

CULTURE, PROBABILITY LANGUAGE, NOT EASILY UNDERSTOOD, FAILURE TO INCORPORATE, CONCEPTUAL VS PHYSICAL, IGNORANT OF CULTURAL ACTIVITIES, IGNORING LEARNERS, NOT MATCHING, LEARNERS' EXPERIENCE, GAMES, IMPROVED PERFOMANCE , NOT FAMILIAR WITH, CULTURAL GAMES RULES, UNDERUTILISING, THE CULTURAL ACTIVITY, LEARNING FROM LEARNERS, JUSTIFYING ANSWERS, NOT MANAGING DIVERSITY, UNDERSTAND, MASTERED THE	• Incorporation of cultural activities • Facilitating role, • Lesson development, • Respecting the learners • Managing classroom dialogue	• Underutilisation of the incorporated cultural activities. • The participants' cultural incompetency	Failure to make connections

ART, IMPRESSED BY PERFORMANCE, WORKING TOGETHER, LEARNERS' VIEWS, MISCONCEPTIONS, TEACH FROM KNOWN TO UNKNOWN, PROBLEM SOLVING SKILLS, PROBLEM SOLVING, PROBLEM POSING, INITIAL MISCONCEPTION, FAMILIAR, WORKING TOGETHER, ANALYSE, REFLECTION, ENJOYED, ANALYTICAL EYE, PROBABILITY EYE, ABLE TO ANALYSE, JUSTIFY ANSWERS, DEFENDING ANSWERS, GAINED SKILLS, INCORPORATING LANGUAGE, PROBABILITY THINKING, PROBABILISTIC IN NATURE, IMPORTANCE OF LEARNERS' INPUT, DEVELOPED FOCUS, EYE OPENER, REALISED, INCORPORATING GAMES AND OTHER ACTIVITIES, ABRUPT	• Improvement in learners' performance • Improved pedagogical practice. • justification of their probability thinking • Team work • Creativity	• Mathematization and problematizing of cultural activities. • Shift in pedagogical perspective and understanding of cultural activities	The change
	• Experience • Pedagogical reflection • Respect of the learner • Team work • Creativity	• Reflecting on the impact of EIM on the learners' performance.' • Reflecting on the impact of participating in the PAR.	Participants' reflection.

DROPPING, TOGETHERNESS, LIBERATING EXPERIENCE, OPENNESS, NO HIERARCHY, SHARE IDEAS			

6.3. Themes and subthemes

6.3.1. Hindrances to incorporation of cultural activities in probability pedagogy.

The first theme was generated from data that was collected from initial interviews, lesson observations and post-lesson reflection interviews. The PAR provided the participants with an opportunity to identify challenges in their practices of teaching probability. The participants targeted their attention on how they could tackle the obstacles to the incorporation of cultural activities in the probability pedagogy. Although the participants might have challenges in other topics, they chose to focus on a single topic of probability. In carrying out a PAR it is normally believed that the people who are experiencing the problem that is being researched have the solution to the problems but they might not know that. This happened to be the case with the three participants who took part in this study. The three participants by joining this PAR had challenges of incorporating cultural activities in the probability pedagogy which they experienced as mathematics teachers teaching in the rural areas of Zimbabwe. The participants collaborated with me as a researcher in this PAR. As a team the hindrances to the effective incorporation of cultural activities in probability pedagogy were identified. The PAR enabled the participants to learn in the process of generating a solution to their problem of overcoming the hindrance to effective incorporation of cultural activities in the teaching of probability. The participants had an opportunity to share ideas freely which enabled them to find a lasting solution to their problem through collecting data, analysing, and reflecting on it. Therefore, the subthemes which were identified in this theme were: (1) Lack of probability subject matter knowledge. (2) Lack of knowledge of cultural activities. (3) Trivializing probability concept found in cultural activities.

6.3.1.1 Lack of probability subject matter knowledge.

During the initial interview the participants mentioned the pedagogical challenges emanating from lack of subject matter knowledge. These aspects were also revealed during the lesson observations either in the participants' journal or as contributions made by the learners during the lesson of some sort.

When I asked the participants the following question:

MT: *What challenges do you have in teaching probability?*

One of the issues that emerged from the participants' responses to this question was the inconsistency and technicality of probability language. The participants revealed that they were not able to explain some of the language that is used in probability because the way it is used in probability is quite different from the way it is used in the day-to-day life of the learners. Their responses were

Messey: *I have challenges with explaining some probability concepts to the learners because the way the probability language is used in the mathematics classroom is different from the way it is used in the learners' daily lives. For instance, in its everyday use the word 'or' means one of but when used in probability it means both. This makes it difficult for me to explain such words to the learners for them to understand.*

Amon: *One of my challenges is to explain to the learners why the word 'or' translates to addition and the word 'and' translates to multiplication. These words are used differently in the everyday life of the learners. This inconsistency makes it difficult for me to teach probability effectively.*

The failure of the participants to deal with probability words which are used differently in the learners' daily lives was witnessed in all the three participants when they were teaching about probability events in which replacement took place after withdrawal. The following questions were given to the learners to answer. Learners were expected to classify the statement whether they involve probability with replacement or not.

1. State with reason whether the following statements involve concept of probability with replacement or not

a) Giving birth to a baby boy by a chosen woman who is pregnant for the fourth time.

b) Yoking one of the oxen for tilling the land every day in a cattle kraal with five oxen.

2. What is the difference if any between independent events and probability with replacement?

During the lesson delivery in Amos's class Amos failed to explain how the concept of probability with replacement is involved and the learners did not understand what he was saying with respect to the word replacement. The excerpt bellow reveals how Amos failed to convince the learners of the context in which the word replacement was used in the questions.

Amos: *Giving birth to a baby boy by a chosen woman who is pregnant for the fourth time involves concepts of probability with replacement. It is because the probability of giving birth to a baby boy is half. The woman can only give birth to a boy or a girl, so there are only two possible outcomes.*

Learner B1: How can it involve probability with replacement when the children who are born do not go back to the mother's womb? In the example we used you showed us that you were returning the fruit back in the basket and draw again but in this one it is not possible to return the children who were born back in to their mother's womb so that they have a chance of being born again

I recorded the following in Amos' lesson.

MT: *The questions were challenging and appropriate for the concept which was being taught. The learners were very reasonable, their arguments were very clear although they seemed to fail to abstract the concept of replacement. The explanation given by Amos was not convincing for the learners to understand the context in which the word replacement has been used.*

The learners' interpretation of the word replacement as a physical exercise rather than a mental concept was also observed in Messey and Amon's classes as well, with both of them trying in vain to make the learners treat replacement as a mental process rather than a physical one. Probability with replacement should be explained in terms of constant probability. The probability of an event is constant in the current and next observations.

In their post-lesson interviews, I asked the following question.

MT: *What learners' misconceptions arose during your lesson which you need to pay attention to if the lesson must be taught again.*

The participants responded as follows.

Amon: *I had a challenge with that statement of a pregnant woman because the learners did not see the replacement, they expected to see it taking place. According to the learners the word replacement means something physical which should be witnessed by a naked eye so I lost it completely on that question.*

Messey: *The learners' misconception reigned with the word replacement. I thought the learners could understand when I gave an example that the probability that the sun rises the following day is one because it is known that another day is coming, but it did not help.*

The three participants did not realise that the explanation they were using was not consistent with how the word 'replacement' was used in the out of school mathematics practices of the learners. Further work that was assigned to the learners in the participants' classes testing the same concept of withdrawal with replacement but this time around the learners were required to calculate the probability

2 Mr Makaye has three brown cows, four black cows, and three black and white cows. The cows are milked every day in any order. Find the probability that on a particular day

a) The black cow is milked first.

b) The brown cow is milked first.

c) The black and white cow is milked first.

d. Do the probabilities you have calculated in number a-c above represent probability with replacement or not?

I observed and recorded the following:

MT: *The questions were proper representation of probability with replacement. The learners managed to answer the first three questions correctly, however, Amos failed to convince the learners that there was withdrawal and replacement.*

The learners argued that in question two there was no replacement because milking was done on different day. However, the learners answered the first three question three correctly.

Another pedagogical challenge emanating from the nature of the subject matter knowledge was the volatility of probability concepts. Two of the three participants Amon and Messey reported that learners did not retain probability concepts for a long time. When I asked the following question:

MT: *Do you think probability concepts are more difficult to understand than concepts of other mathematics topics?*

The participants affirmed what they wrote in their narratives at the beginning of this study that they regarded probability as one of the most difficult topics in OL mathematics. The participants responded as follows:

Amon: *Probability concepts are parts and parcel of learners' daily lives they are easy to grasp but they are very simple to forget. In fact, probability concepts are very volatile. When one is teaching the concepts, the learners may understand them so easily but if the learners are asked on the following day one can find that they have forgotten. This is so because the probability as done in school is quite different from probability used outside school.*

Messey: *Yes, probability concepts are more difficult than other topics because some of its concepts are rarely dealt with in the learners' daily lives hence, they are easily forgotten. For example, you can find that learners write probability values which are negative.*

Amos: *They may not be more difficult as such but their connection to the learners' real life situation is thin in the sense that the way probability is calculated in the learners' out of school practices is quite different from the way it is calculated at school. The tools that are used at school such as the probability tree are not available in the learners' daily lives.*

From the participants' responses they had challenges of making the learners retain probability concepts for a long time. The learners easily forget what they had been taught. The reason for this forgetfulness was caused by the fact that the participants regarded probability knowledge as not connected to the learners' real-life situations. It was knowledge they thought could be retained by memorising without any real-life application.

6.3.1.2 Lack of knowledge of cultural activities.

Lack of knowledge of cultural activities unveiled itself as one of the challenges which hindered the participants in integrating ethnomathematics in the teaching of probability. This subtheme unveiled itself in the initial interviews and in the lesson observations in all the three participants. I asked the participants if they were familiar with the cultural activities of the learners.

MT: *Do you have enough knowledge about cultural activities so that you can incorporate them in the teaching of probability?*

The three participants acknowledged that they did not have enough knowledge about cultural activities. This lack of knowledge of cultural activities resulted in them either not incorporating cultural activities in the teaching of probability or incorporating cultural activities wrongly or ineffectively. The participants also said that they were usually corrected by the learners when they incorporated cultural activities in inappropriate ways. Messey accused the new generation of kids for changing cultural activities, especially the rules of cultural games.

Amon acknowledged that he was not familiar with the activities.

Amon: *I find it difficult to incorporate cultural activities in the teaching of probability because the cultural activities themselves do not seem to fit in the school probability. Furthermore, each time*

I try to incorporate cultural activities I find that I lack a lot of knowledge about them, and in most cases the learners always correct me when I fail to describe them. It may be a game or any other cultural activity.

Messey mentioned that he was no longer familiar with the cultural activities because they were being changed by the new generation.

Messey: *I grew up in this area and I am familiar with all the cultural activities, however, some cultural games for example have been changed by this new generation of kids who are mixing up cultural activities from various cultures. So, I can say I know the cultural activities but not to an extent of incorporating them in the teaching of probability because they are different from what I used to know. Also, I do not see the match between these activities and probability concepts.*

Amos had this to say:

Amos: *My failure to incorporate cultural activities in the teaching of probability is due to the fact that I do not know cultural activities properly. I have realised that in most cases when I try to incorporate cultural activities the learners tell me that it is not the way it is done. For example, when I was using the game called Zairakaora when teaching about random events the learners pointed out that it was not random there was a lot of bias to fix each other.*

The participants also showed lack of knowledge of cultural activities during lesson delivery in which the following questions were administered to the learners. The questions based on cultural game called Hwai-hwai was meant to test the learners' knowledge of random events

1. There are three boys and four boys playing the game called Hwai-hwai. Find the probability that

a). A girl is chosen to play the role of the mother.

b). A girl is chosen to play the role of a hyena.

c). One of the boys is caught by the hyena first.

d). One of the girls is caught by the hyena first.

Although Amon and Amos were familiar with the game, they had to learn from the learners how the roles were allocated to players in that game. The two participants thought that all the roles could be filled randomly when in fact some roles were reserved for sex. However, they came to know the proper way of role allocation after they had already disapproved of the learners' answers. The following was the answer which some of the learners wrote in their exercise books

Learner A7: *P (A girl being chosen as a mother) =1*

Amon rejected that learner's answer because he thought that anyone could play any role in that game. He interrogated the learners after seeing that a good number of learners had the same answer.

Amon: *How can the probability be one when there are three girls out of the seven players in that group? The question requires you to give the fraction of the girls out of the total.*

One of the learners corrected Amon pointing out that the mother's role could not be selected using simple random process because it was reserved for girls

Learner *A13: The answer is one because the mother is selected amongst the girls. No boy should play the role of the mother when the girls are available. It is only girls who should be chosen to be the mother. It is obvious that the girl is selected.*

The answers which were written by some of the learners in Amon's and Amos's classes which the two participants disapproved when in fact they were correct according to the learners' understanding of that cultural game are as follows:

1. a) P (A girl is chosen to play the role of the mother) =1 b) P (A girl is chosen to play the role of a hyena) = 0. c) P (One of the boys is caught by the hyena first) = $\frac{3}{5}$ d) P (One of the girls is caught by the hyena first) = $\frac{2}{5}$

Amon did not know how the players for different roles were selected as a result he thought that the selection of role players was random across the boys and girls yet some roles were for a particular sex.

The conversation that took place between Amos and the learners in which Amos' showed misunderstanding of the cultural activity was revealed is as follows.

Amos: *How do you get the one in the first question?*

Learners B20: *There are three girls so the mother should come from one of them.*

Amos: *Why are you choosing the mother from the girls only when there are seven people altogether?*

Learner B20: When we play the game only girls should play the role of the mother. Also, the role of the hyena is only occupied by the boys because if a girl is made to be a hyena she cannot catch boys as the prey because they are powerful they always over power her, that is why we put boys only. If the hyena does not catch its prey the game is not interesting.

I recorded the following during Amon's lesson:

MT: *The learners showed understanding of the game and its rules. From the way the learners explained and justified their answers revealed that they had understood the concepts of random events and how it was connected to the game. Also, the learners had mastered certain events and impossible events. Amon did not understand the rules of the game; he marked the learners' answers wrong when in fact they were correct according to the rules of the game. The first questions were not appropriate for random sampling, rather they were for stratified random sampling.*

Amos confessed his lack of understanding of cultural activities when I asked him during the post-lesson reflection interview.
MT: *How familiar were you with the cultural game you used in this lesson?*

In his response Amon acknowledged that he did not understand the game and he was not aware of the rules governing allocation of roles to the players.

Amos: *I overlooked that one, but this new generation of children are transforming the cultural activities to suit their requirements. When we used to play this game there was no roles reserved for different sex as what they are saying here. They are changing the rules because even in that game we used to play called Arauru the rules have been changed you cannot recognize that it is Arauru we used to play.*

The participants' lack of knowledge about cultural activities was also revealed when Messey was observed teaching about random events using a polygamist with five wives. The following questions were given to the learners to answer.

1. A polygamist Mr Chitura has five wives who bring food to him in a single plate every day for supper. The wives are Chihera, Madhuve, Manyuve, Masibanda and Machuma, with Chihera being the first wife and Machuma being the fifth wife in that order respectively. What is the probability that

a). He eats from Machuma's plate first.

b). He eats from Madhuve' plate first

c). He eats from Chihera's plate first

2. A six-sided fair die with sides numbered from 1 to 6 is tossed

a). What are the possible outcomes from the toss?

b). What is the probability of getting a three?

c). What is the probability of getting an even number?

Messey was shocked when he checked what the learners had written in their exercise books. The learners had answered the questions according to their understanding of the cultural practice of polygamy in their area which Messey. Messey did not know the cultural practice of the people who live in that area as a result he disapproved some of the learners' answers which were in fact correct according to their understanding of polygamy. Messey did not realise that there is an order which the polygamist should follow.

In my observation journal I recorded the following:

MT: *The learners had a clear understanding of how polygamist in their area eat from food from each of their wives and their answers were in line with that understanding thereby rendering the activity used unsuitable to teach random events. Messey had overlooked the learners' understanding of adult life such as the way married people conduct themselves. The learners'* *answers were correct. Learners were able to justify their answers hence they could separate random events and non-random events. There was no controversy on Question two the learners answered it in accordance with Messey expected answers.*

The following are the answers from some of the learners which Messey disapproved

1.a) P (He eats from Machuma first) =0
b) P (He eats Madhuve' plate second) =0
c) P (He eats from Chihera plate third)=1

According to the learners understanding their answers were correct because in their cultural practice there is ordered to be followed by the polygamist which Messey did not know. Messey disapproved of the answers that the learners had given as zeros as shown above, he became emotional thinking that the learners were not serious with their work. He thought they had not understood what he had taught them about random events, yet they knew that the event was not random.

The excerpt below shows the dialogue which took place in Messey's class during that lesson reveal how one of the learners understood how the polygamist ate food from his wives.

Messey: *You guys, how come you are just getting zeros?*

Learner C18: *Those are the answers sir.*

Messey: *How can an answer be zero when there are five wives?*

Learner C13: *My mum is the first wife. For example, my daddy always starts with my mothers' meal because she is the first wife.*

Learner C3: *He must follow the order of the number of the wife always if he does not do that the first wife cries foul.*

Messey: Sorry I did not realise that I was assuming that he just eats randomly.

The learners argued for their answers which Messey came to agree with and remarked the learners work correctly. He realised that he had made mistake by assuming that the polygamist eats randomly.

Messey's lack of understanding of cultural activities had resulted in him disapproving the learners' answers which were in fact correct according to the learners understanding of the cultural activity. During the post-lesson reflection interview I asked Messey the following question.

MT: *Why did you back track your decision to mark the answers of the learners correct when you had initially marked them wrong?*

Messey mentioned that he was not familiar with the practices in which the polygamist followed a certain order when he is eating food from his wives. He revealed that he did not know of any order to be followed.

Messey: *I did not realise that these polygamists have an order of eating the meals from their wives I just thought it was just random. However, I have learnt that it is done by the people of the apostolic sect who live around here. In some areas they do not follow orders, which is what I was using. Members of the apostolic church have great respect for their first wives, so I was not taking it as a culture but religion. So those who are not members of that church are also doing it. That is what confused me.*

Based on the above observations the three participants showed that they did not have adequate knowledge of cultural activities as practiced in the learners' out of school mathematics. This resulted in them disapproving the learners' answers which were correct. It was the reason why they did not incorporate cultural activities in the teaching of probability correctly.

6.3.1.3. Trivializing probability concepts found in cultural activities.

One of the sub themes which emerged from the coded data was the participants trivializing probability concepts found in cultural activities. The three participants were of the opinion that cultural activities could only be used in the mathematics classroom as examples. This sub theme emerged from data collected from interviews.

MT*: Is there any similarity between probability concepts found in cultural activities and probability concepts found in school mathematics?*

The participants trivialised the probability concept found in cultural activities. All the participants mentioned that the cultural activities were shallow and that it was a challenge to incorporate cultural activities in some probability concepts. The participants' responses are given below.

Messey*: At times I find it difficult to find ways of fitting cultural activities in the teaching of probability because school probability and probability found in cultural activities are very different although there are some concepts that can be used as examples. At secondary school the learners want real probability; they do not want the teacher to waste their time talking about cultural activities. Cultural activities can only be used as examples of impossible events and certain events in school mathematics class.*

Amon also mentioned that the probability concepts found in cultural activities are shallow.

Amon: *Cultural activities are generally shallow; it is not possible to find cultural activities to use in some school probability concept. There are some topics such as conditional probability, these are difficult areas to find cultural activities to incorporate.*

Amos also mentioned conditional probability as one of the topics in which he has challenges of incorporating cultural activities. His responses also stressed the inferiority of probability concepts found in cultural activities.

Amos: *It is very difficult to find cultural activities to incorporate when teaching probability concepts such as conditional probability because probability concepts found in cultural activities are too simple, they cannot fit into more advanced probability concepts. Furthermore cultural activities do not have procedures for solving probability problems such as probability tree diagrams. This makes it difficult for me to incorporate cultural activities in these advanced probability concepts.*

The findings from the obstacles to probability pedagogical competence which hindered effective integration of cultural activities in the teaching of probability are as follows:

- Amon and Amos had challenges of integrating ethnomathematics in the teaching of probability because they had challenges with probability language which they could not translate into the learner’s language for the learners to understand.

- Messey regarded probability terminology as inconsistent with how the language was used in the school and in the learners’ day-to-day life.

- The three participants did not integrate ethnomathematics because they did not understand probability concepts hence it was a challenge for them to identify probability concepts in cultural activities.

- Amon taught probability in the way he was taught while at school because when he was trained to be a teacher, he was not taught how to use the ethnomathematics approach

- All the participants could not explain probability concepts in the way learners could understand because they could not link the probability concepts to the activities that the learners were familiar with.
- The participants lacked adequate cultural knowledge to enable them to effectively incorporate them in the probability pedagogy.
- Amos and Amon regarded probability as one of the most difficult topics to teach for learners to understand in mathematics and its concepts as very volatile; they could easily be grasped but they were easily forgotten.
- All the three participants lacked probability pedagogical knowledge.
- The cultural activities had changed that the participants were no longer familiar with them, making it difficult for the participants to integrate them in the probability pedagogy
- Amos regarded probability pedagogy as stagnant because he was teaching probability in the way he was taught when he was still at school.
- All the participants used cultural activities only as examples
- All the participants thought that cultural activities were shallow; they could not be incorporated for some more advanced probability concepts.

Amon and Messey regarded incorporation of cultural activities as time wasting

6.3.2. Failure to make connections

The theme of failure to make connections was revealed by coded data. It manifested itself in the three participants on some occasions at the beginning of the PAR, and during PAR. The theme of failure to make connections arose in two dimensions namely what to connect and how to make connections. The first time this theme was unveiled was during the initial interview by all the three participants. According to the coded data there are two sub themes which make up this theme. 1) Underutilization of the incorporated cultural activity. 2) Participants' cultural incompetence.

6.3.2.1. Underutilization of the incorporated cultural activity

When the participants incorporated cultural activities in the teaching of probability it was a form of making a connection between school mathematics and the learners' out of school mathematics practice. Although the participants were able to identify cultural activities to incorporate in the teaching of probability, they could still struggle on how to incorporate them. The coded data in this study revealed that one causes of such failures to make connections was underutilisation of cultural activities. The participants could not use the cultural activities as bridges to connect cultural activities and conventional probability, they underutilised the cultural activities. For instance, in one of the lessons that was observed when Amon was introducing probability he asked the learners the following question:

Amon: *There are some events you come across outside school which are certain like the rising of the sun from the East and some examples which are impossible such as finding meat growing on trees. Write down three examples of such events in your groups*

Amos allocated enough time to the learners to do their work. The question was clear to all the learners. Most of the groups managed to give suitable examples of certain events and impossible events. The responses found in one of the learners' groups are as follows.

Examples of certain events

a) A river flowing downstream

b) A cow with four legs

c) Rain falling from the sky

Examples of impossible events

a) A bird without wings

b) A river that flows upstream

c) A man who can become pregnant

The learners were able to give suitable example of both certain events and impossible events

Amon did not use the learners' answers in any way, he gave the learners work from the learners' textbook not related to the activities that the learners had found. In my observation journal I recorded the following:

MT: *The learners were familiar with the certain events and impossible events although some were localised such as a person born without hands. Amon declared to the learners the probability values of certain events and the probability of impossible events. Amon went on to give the learners written work from the learners' textbook which was based on uncertain events after working as an example. Amos did not follow the lesson plan which guided how to derive the range of probability values. Amon left the cultural activities without making a connection.*

The following dialogue took place in Amon's class during that lesson.

Learner A16: *Sir you gave us the probability of certain events and impossible events as 1 and 0 so why are you getting* $\frac{2}{5}$ *?*

Amon: *We are now talking about uncertain events*

Learner A10: *So how do we use the one and the zero in getting the answers?*

Amon: *We do not use one and zero to calculate the answer, we use the formula I have written on the board*

The dialogue between Amon and his learners reveals that the learners did not see the connection between the cultural activities they had found and the calculation of the probability of uncertain events. There was no smooth transition from the cultural probability concepts to school probability concepts

When Amon was asked during the post-lesson whether he managed to implement the EIM in that lesson.

MT: *Did you manage to follow the EIM properly in this lesson?*

Amon responded that:

Amon: *I failed dismally to move from the cultural activities to the school probability because I dropped the cultural activities before, they served any purpose. I was under pressure that I abandoned the lesson plan, I was supposed to use the impossible events and certain events to derive probability for uncertain events. The learners did not get the intended new knowledge because I did not link the cultural activities introduced to move the lesson forward.*

When Amos was observed teaching about independent events. He introduced the lesson as follows:

Amos: *Today we are going to play the game called Chuti. Who can come forward and demonstrate how the game called Chuti is played.*

The learners demonstrated how the game called Chuti was played, and the learners were given the following questions to answer.

1. A box contains two red balls and three blue balls.

a) What is the probability of taking out:

b) i) A red ball? ii) a blue ball?

c) The ball is replaced, and another ball is taken out, draw a tree diagram to represent these two selections and calculate the probability that:

i) Both are red ii) both balls are blue.

iii) Exactly one ball is red IV) at least one of the balls is red

Amos gave work to the learners; the work was not connected to the game that the learners had demonstrated. There was no effort to show the learners how the game they had demonstrated was connected to the concept of randomness he was teaching. The dialogue dialogue that took place during Amos' class reveals that the learners did not see the purpose served by the game.

Learner B7: *Sir are we going to use the game to answer the question, or we are using the formula?*

Amos: *We are not using the game; we are using the formula. I was only in the game so that you see how the game is connected to the probability.*

Learner B19: *So how do we use the game to answer the questions?*

Amos: We do not use the game. I wanted you to show that we have one person to be out of the game at a time and it does not affect who is going to be out of the game next, the events are independent.

The conversation that took place showed that Amos did not make clear connections between the game and the independent events, and the learners did not see the connection.

MT: *Learners demonstrated how the game Chuti was played, and Amos did not demonstrate to the satisfaction of the learners the connection between the game and the problems that he gave the learners to answer. Amos did not attempt to solve the problems that were developed from the game and start working on the problems from the learners' textbook. Amos helped the learners to come up with the probability tree*

When I asked Amos during the post lesson reflection interview:

MT: *Why did you abandon the problems that we had developed from the game without attempting to answer them?*

Amos responded as follows:

Amos*: I thought the learners had already seen how the randomness of drawing the balls was connected to the game. I prefer to work examples in the textbook so that the learners will resort to them when they are revising their work. However, I failed to make the learners see how the probability diagram can be applied to the game. I should have answered the questions developed from the game before using questions from the textbook.*

The participants' failure to make a smooth transition from cultural activities to conventional probability had been evidenced prior to the PAR and during the early stages of the PAR. The participants were not used to associate problems emanating from cultural activities with the use of formulas. This resulted in them failing to make connections between the cultural activities and the probability concepts they would be teaching. The participants only applied formulas to conventional probability in the learners' textbook thereby missing a key aspect of making smooth connections. The sentiment that cultural activities had no formulas was echoed by the three participants both expressly and impliedly. When Amon was asked to explain the difficulties, he had matching probability concepts found in cultural activities and the concepts he teaches at school.

MT: *You have now realised that probability concepts are found in cultural activities, what difficulty do you face in incorporating them in the teaching of probability?*

Amon did not find the formulas associated with conventional mathematics with portability, he said that:

Amon: *Cultural activities are just based on simple events such as impossible events and certain events, whereas school probability concepts include complex concepts such as probability tree diagrams and various methods of solving probability problems such as multiplication rule and addition rule.*

This was supported by what Messey said:

Messey: *It is very difficult to find ways of fitting cultural activities in the teaching of probability because school probability and school probability and probability found in cultural activities are completely different although there are some cases in which cultural activities can be used as* *examples. I find it difficult to link cultural activities in the teaching of probability except in very simple cases such as impossible events and certain events. The cultural activities do not make use of formula, so one should just use the cultural activities to illustrate the concepts then go to conventional probability and work examples for the learners to do some calculations.*

6.3.2.2 Cultural incompetence

This subtheme unveiled itself at the beginning of the PAR in the initial interview and during the lesson observations of all the three participants. One of the purposes of integrating ethnomathematics in the teaching of mathematics was to promote the coexistence of learners of different cultures in the mathematics classroom. However, data collected in this study shows that at the beginning of this PAR the participants revealed some elements of cultural incompetence in their classes. Cultural incompetence led to the participants to deal with cultural diversity in their classes which might cause the learners not to understand what the participants were teaching about. The way in which this sub theme revealed itself in the interviews and lesson observations which follows:

I asked the participants the following question.

MT: *How do you deal with cultural diversity in your class?*

Amos argued that there was no need of dealing with cultural diversity in the class because probability concepts are culture free.

Amos responded as follows:

Amos*: I do not pay attention to cultural diversity in my class when teaching probability because probability taught at school is designed to suit all cultures. I found that the cultural activities that* *can be incorporated in the teaching of probability are very insignificant to affect the learners' performance in probability. I only use cultural activities to spice up my lesson, but it is not something worth noting.*

Messey also did not see it necessary to manage diversity in his class because he thought there was only one major culture in his class. He said that:

Messey: *There are so many different cultures in my class, and this makes it very difficult to cater for them all. Imagine there are more than ten cultures in the class. It is very impossible to deal with them all. I studied my learners and found that there is one major culture and some minor cultures. For example, in this area most of the learners are of Shona culture origin, so there is no need to think of other cultures. Furthermore, when I am teaching probability, I find very few cases in which these cultural activities can prominently fit in, they just fit as examples to highlight the points covered.*

Amon also said that he only incorporates cultural activities in the teaching of probability when the learners have understood the concepts he wants to teach. He said that his learners regarded the incorporation of cultural activities as time wasting. Amon said that:

Amon: *I do not think there is any need to deal with cultural diversity because I first teach the learners to understand the concepts. When they have mastered the concepts, I can then give them examples of such concepts found in their daily lives which all of them are familiar with.*

The participants' cultural incompetence was also evident during lesson observations. When Messey was teaching about random events he showed his incapability to deal with cultural diversity in his class. The excerpt below was extracted from the conversation that took place in Messey's class in which Messey showed cultural incompetence.

Messey: *Some of the polygamous men in the village have five wives. When the wives bring supper for the husband in what order does the husband eat the food so that some of the wives do not think he favours other wives?*

Learner C11: *He does not eat from all the wives everyday he eats from one wife only per day.*

Learner C7**:** *He starts by taking a piece from the first wife then take pieces from the other wives following the order of their seniority in marriage and put them in one plate and start eating.*

Messey: *Let's assume he eats food from all the wives daily, what is the probability that he eats the food of the fifth wife first?*

According to the conversation given above Messey used an assumption to set aside what some of the minority culture did. Learner C11's family culture was that the man does not eat from all the wives in a single day he ate food from only one wife. Messey ignored and move on to assume that the man ate from all the five wives.

Messey further thwarted the learners' cultural diversity by creating an assumption on the questions. The learners were given the following questions based on the assumption that the man eats from all his wives every day.

1. The polygamist has five wives who give him food in one plate every day. Assuming that the polygamist eat food from all the plates, find the probability that;

a) He eats from the third wife first

b) He eats from the fourth wife second

c) He eats from the first wife on the fourth time

d) He eats from the second wife on the fifth time

The learners ended up with two types of answers, one group with answers with replacement and another one without replacement.

I recorded the following observation:

MT: *Messey showed elements of cultural incompetence when he ignored how polygamists of different cultures' origins eat from their wives. The question did not have further assumption specifying whether the polygamist would repeat eating from the same plate, resulting in some learners giving answers with replacement while others gave without replacement.*

When I asked Messey to explain why he used assumption instead of setting the conditions given by learners. I asked,

MT: *Why did you create an assumption when the purpose of the study is to incorporate the cultural activities of the learners for them to understand better?*

Messey mentioned that he did not consider the cultural alternatives because it would change his original plans

Messey: *You have seen that I had brought the five labelled plates I had prepared to demonstrate the concept. If I used what learner C11 was saying, the teaching aids I had prepared were going to be useless because the randomness was going to be centred on days instead of the plates.*

This shows that Messey was very rigid; he did not want to change despite seeing that what he was doing was not in line with the learners' cultural practices. He did not attend to cultural differences of learners in his class.

Another aspect of cultural incompetency revealed by the participants was failure to recognise the learners' cultural experience initially featured at the beginning of the PAR during the initial interviews with all the three participants and then during the lesson observations. In their understanding of what they understood by teaching from the known to unknown the participants' responses showed that they did not put into consideration the cultural experience that the learner brings into the mathematics classroom.

When I asked the participants the following question:

MT*: What do you understand by teaching from the known to unknown?*

Amon's understanding of the known was centred on the way in which the subject matter is arranged for presentation to the learners. His emphasis of the known knowledge was based on the dependency of mathematics topics on each other. His response is as follows:

Amon: *In my understanding, mathematics is a process subject in which the topics should be arranged in such a way that the learner understand the concept. It is difficult to understand some new concepts without understanding prior concepts that had been taught before. So as far as I can understand it is very good for someone to understand certain information so that new concepts can be developed. For example, I cannot teach probability before I teach addition or multiplication of fractions because probability involves addition and multiplication of fractions.*

Amos depended on the order in which the topics are arranged in the syllabus to determine whether the knowledge is known or not. His response is shown below

Amos: *Teaching from known to unknown means that I begin my teaching from what the learners have been taught before either by me or by other teachers before. In this regard the teachers make use of the syllabus to see the concepts that were taught by the other teachers before. After checking on the syllabus to see the topics that were covered before I can assume that the learners are* *capable of performing fraction multiplication, hence I start teaching the new concepts with this assumption in mind. What I assume the learners were taught by other teachers in their previous grades is what I regard as known knowledge.*

Messey only regarded knowledge as known when he had taught the learners himself thereby disregarding what the learners had been taught by other teachers. Messey said that:

Messey: *Teaching from the known to unknown means that when I want to teach probability I start with what I taught before which is connected to probability such as fractions. I start from what I had taught them before then I go deeper, I do not rely on the assumption of what they know, I should teach them myself to make sure that they have the background required for the new concept. If it is now a long time since I taught them this required background, I can start by asking them questions about those concepts I want to use as known knowledge. When I am satisfied that they still remember those concepts then I can teach them the new knowledge*.

Also, in their attempt to incorporate cultural activities in the teaching of probability the participants were found to impose the cultural activities on the learners to suit what they wanted to teach another element of cultural incompetence. The participants would enter into the classroom with their own understanding of the cultural activity they wanted to incorporate but their understanding might be different from that of the learners. The participants failed to incorporate the cultural activities in a way that the learners knew them, making it difficult for the learners to comprehend the probability concepts that the participants were teaching. The participant failed to accommodate the learners' understanding of the cultural activities.

The theme of the participants' cultural incompetence also emerged when Amos was observed teaching about random events. Amos introduced the lesson as follows:

Amos: *Pumpkin seeds are not sown in large numbers in a field because they disturb the growth of the other crops, however, it is desired that the planted seeds germinate. How do the people who plant the pumpkins know which seed is going to germinate?*

Learner B32: *They know that those seeds planted on the soil which keep moisture for a long time are likely to germinate.*

Amos: *They do not know which one of the seeds is going to germinate; the seeds just germinate at random.* [Amon gave the learners questions from the textbook for them to answer]

I recorded the following observations

MT: *The activity was not appropriate for the concept which was being taught according to the learners according to the learners understanding of the concept. The learners were familiar with the activity and it was not associated with random events. Learners did not take germination of the seeds as a random event. The answer given by Learner B22 showed that the seeds are not sown in the same condition, to warrant random germination patterns. The learner observed that some are sown on the anthill, some on rocky soils and hence learners do not take this activity as random. Amos lacked clarity on the cultural activity under consideration.*

The following was Amos's self-evaluation

Amos: *I rushed the lesson because the learners did not see how the planting of pumpkin seeds was related to the written work, I gave them. If I were to teach the lesson again, I would clarify some* *conditions so that the learners see the activity as random. I would develop questions from the activity for the learners to answer.*

When I asked Amos during the post-lesson reflection interview:

MT: *Do you think the learners understood the concepts of randomness given the way you incorporated the cultural activity?*

Amos realised that he overlooked the learners' understanding of the cultural activity which were pointing to it that the way the cultural activity had been given was not random. Amos said that:

Amos: *I think the learners did not get what I was pushing through because I assumed randomness on the activity when the learners thought it was not a random activity unless some conditions could be created.*

Messey also rushed the cultural activity without giving learners to solve the problem based on it when he was observed teaching about independent events. After the learners had demonstrated how the game was called Zairakaora.

Messey: We are interested in the order in which the players are turned into Zairakaora. We want to find the probability of whether a boy is followed by a boy, or a girl is followed by a girl etc.

Messey worked the example from the textbook based on coloured balls. The question he used was with replacement. He did not show the difference between drawing with replacement and without replacement.

The dialogue which took takes place in Messey' class shown below is testimony to the observation that Messey imposed the cultural attribute on the learners.

Messey: *The person who becomes zairakaora next is independent of who the one who became zairakaora before the two do not affect each other*

Learner C17: *It is not independent but because when one finds that their friend has become zairakaora they may also want to become zairakaora so that they sit in the circle and play together.*

Learner C22*: The person moving around with the object may want to fix some people to make them zairakaora early so that they do not enjoy much of the game while they are seated inside the circle. We know the targets of the person moving around with the object.*

Learner C6: *The person moving around with the object may lie that he had dropped the object behind someone when in fact they were holding it but they might only want to victimise someone.*

Messey: *Let us assume that there is no bias in the game so that we move on.*

From the dialogue that took place in the class, Messey imposed the independence of how people are made to become zairakaora in the game. The learners did not see the outcome as independent. They highlighted the subjectivity of one who is moving with the object's influence on who becomes zairakaora next. Also, the people who are already eliminated affect who is going to be out next.

Messey then gave the learners the following questions to answer.

1. There are four boys and six girls sitting in a circle playing the game called Zairakaora. Find the probability that

a) The first person to become a zairakaora is a boy and the second is a girl.

b) The first two to become zairakaora are girls

c) The first person to become a zairakaora is a girl.

2. A bag contained three back balls and four red balls. Two balls are drawn with replacement. What is the probability that:

a) The first ball is black, and the second ball is red

b) The two balls are red

c) The first ball is red

I recorded the following observations:

MT*: The learners were familiar with the game, and they showed how the game is played. Messey imposed the independence aspect he intended to use on the game ignoring how the learners understood the game. Messey was not aware that the outcome of the events was not independent; it could be predicted who might become the zairakaora next as suggested by the learners. The example that Messey used had replacement, but the game had no replacement, the person who has become zairakaora is removed from the circle. The example used was not in line with the cultural game that was incorporated. The learners' answers were in line with the example worked but diverged from the questions developed from the cultural activities*

Below are items some extracted from some learners' answer sheets in support of the above observation

1. a) P(The first person to become a zairakaora is a boy and the second is a girl is $\frac{4}{10} \times \frac{6}{10} = \frac{24}{100}$

b) b) P(The first two to become zairakaora are girls)= $\frac{6}{10} \times \frac{6}{10} = \frac{36}{100}$

c) c) P (The first person to become a zairakaora is a girl)= $\frac{36}{100} + \frac{24}{100} = \frac{6o}{100}$.

From the above extract the learners did not do well in Question one they did not adjust the denominator as demanded by the question. This was caused by the fact that the players who are made zairakaora are made to sit in the circles formed by those not yet made zairakaora. While Messey thought they were out of the game the learners treat them as if they were the players playing the new roles of being zairakaora.

Messey's self-evaluation

Messey: *The learners were very familiar with how the game is played, however. I quickly abandoned the game without the learners seeing how it was connected to the conditional probability I was teaching.*

When Messey was asked during the post-lesson reflection interviews:

MT*: Do you think the learners benefited from the incorporation of the cultural activity in this lesson?*

Messey admitted that the learners did benefit from the incorporation of cultural activity, and said that:

Messey*: I admit that the learners did not benefit from the incorporation of cultural activity because what I realised what I thought about the game and what the learner understood about it was completely different. I just forced it on them for the sake of continuity. The learners did not answer the first question correctly because the example I used was different from how the cultural game I incorporated is played. Also, according to the learners' understanding the players do not cease to be players by becoming zairakaora but they assume the new role.*

The following findings emerged on the participants' failure to make connections prior to the PAR and during the PAR when the participants failed to effectively implement the EIM.

- All the three participants failed to make a smooth transition from ethno-probability to convention probability.
- All the three participants dumped cultural activities before the learners saw the purpose served by the cultural activity in the lesson, the purpose of incorporating the cultural activities was not clear to them.
- Amon and Amos illustrated how to solve problems using questions from the learners' textbooks and not using problems generated from cultural activities, lacking confidence solving problems without answers.
- Amon and Amos avoided applying the probability formulas to the questions that were developed from cultural activities; they only applied formulas to questions taken from the textbooks.
- The two Amon and Amos answered the questions developed from cultural activities verbally and generally without going down to calculate them numerically.
- It was learnt from the learners that cultural games hardly have random outcomes
- It was also learnt from the learners that cultural games hardly have independent outcomes.
- Amon used the cultural activities to show impossible events and certain events; however, he failed to show how this was connected to the probability values of zero and one.
- The three participants used cultural activities and natural events to illustrate impossible events and certain events and ignored probabilistic events.
- Amos and Messey disregarded the way the learners understood cultural activities and made assumptions to suit his requirement.

- Messey assumed cultural homogeneity in his class he did not cater for cultural diversity, a sign of cultural incompetence.
- Messey Amon and Amos regarded the learners' cultural experience as irrelevant in their classes thus failing to put into consideration the probability knowledge that the learners bring to school.
- Messey generated misconception in the learners by imposing his understanding of cultural activities on the learners when trying to integrate ethnomathematics in the pedagogy

6.3.3. The change

There was an observable change in the participants' ability to integrate ethnomathematics in the teaching of probability as well as in the learners' performance in probability due to their participation in the implementation of the EIM. The learners' performance also changed as the participants became more competent in integrating ethnomathematics in the teaching of probability. Although the magnitude of the change varied from one participant to the other, all the three participants Amon, Amos and Messey demonstrated changes in the way they incorporated cultural activities in the teaching of probability. It became apparently clear that the implementation of the EIM enhanced the three participants' ability to integrate ethnomathematics in the teaching of probability. This also enhanced the learners' performance in solving probability problems during the PAR.

In presenting the changes that took place in the participants I present the change that took place during lesson observations when the participants were teaching the lesson again to make correction on the lessons which they had initially failed to produce desired outcomes and in those lessons in which the participants performed well on the first attempt. The subthemes which emerged from this main theme are hereby given. (a) Mathematizing cultural activities and its impact on the learners' performance, and (b) A shift in pedagogical perspective and understanding of cultural activities.

6.3.3.1. Mathematizing and problematizing of cultural activities.

The implementation of the EIM was meant to assist the participants to integrate ethnomathematics in the teaching of probability. Instead of the participants integrating ethnomathematics anyhow the EIM guided the participants to integrate ethnomathematics in the teaching of probability. The coded data for this study points to it that the participants had improved in their ability to mathematize the cultural activities of the learners and incorporated them into the probability pedagogy. Also, it was revealed that the incorporation of cultural activities in line with the EIM impacted positively on the learners' performance.

One of the key aspects of the EIM is for the teacher to mathematize the cultural activities and problematize them and pose a relevant problem based on that learners' cultural activities. In the following section I present how the participants had improved in mathematizing of cultural activities and incorporated them in the probability pedagogy.

Amon showed skills in mathematizing cultural activity when he was observed teaching about simple probability. The following excerpt shows part of the dialogue that took place in Amon's class in which Amon demonstrated his ability to problematize the cultural activity.

Amon: At times rain can come late and people can realise that when the rains come, they will not be able to plough all the fields in time and plant their crop. How do people know that the rains may be coming soon for them to do dry planting?

Learner A4: They see the type of clouds that are in the sky

Amon*: Good. Any other?*

Learner A8: They see how some rain makes trees bloom.

Amon: *Do these guesses always come true?*

Learner A11: Sometimes they come true but at times they do not.

Amon: The coming of rain is therefore a probability or a chance. Please in your groups write down five events which are probabilistic in nature like the coming of the rains

From the classroom dialogue given above Amon showed improved competence in problem posing skills, an attribute that was missing in him at the beginning of the PAR.

From the learners' answer sheets, the following was observed.

MT: *The learners managed to give the probabilistic events correctly except in one group where they included the setting of the sun every day as a probabilistic event.*

Some of the answers which were given by learners are presented in **below.**

Germination of sown seeds
The sex of the baby still to be born
Death of one's close relative this year
Winning of a game by people playing the game called Dhema.
A person being bitten by a snake when one is walking in tall grasses
Catching an animal when one goes hunting
Catching a fish when one goes fishing
Shooting a bird when one fires at a bird in the tree.
One of the cattle being eaten by the hyena when they are not in the kraal
Setting the sun every day.

Amos has improved in his capacity in addressing the learners' challenges satisfactorily. Amos explained to the learners why setting of the sun should not be included in probabilistic events.

Amon: *Something is probabilistic when it is neither certain nor impossible, hence certain events are not probabilistic. We are focusing on those events whose probability is between zero and one.*

The excerpt that follows illustrates Amon's ability to manage dialogue with the learners as he went further with the lesson.

> Amon: *Let us focus on one of your probabilistic events, the germination of the sown seeds. If you sow ten seeds and one seed germinate what fraction of the total number of seeds has germinated?*
>
> Learner A11*: It is* $\frac{1}{10}$.
>
> Amon: *That is the probability of one seed germinating. Probability* $= \frac{expected\ outcome}{All\ possible\ outcomes}$ [Writing on the board].

Further questions that were given to the learners to write during the lessons were as follows:

1. Your mother sewed twenty pumpkin seeds in her field on the same day. Find the probability that

a) 2 seeds germinated

b) 7 seeds germinated

c) 14 seeds germinated

d) None of the seeds germinated.

2. How do the people in your culture increase the chances of having their pumpkin seeds germinate?

I recorded the following observations:

MT: *The learners did very well in the written work. However, very few managed to reduce the fractions to their lowest terms and very few learners simplified zero divided by 20 to zero. Some answers which were given by the learners to Question Two showed the learners' application of the concepts beyond the classroom.*

The items from Learners A16 given below support the observation given above.

1. a) Probability that two seeds germinate= $\frac{2}{20}$..
b) Probability that 7 seeds germinate= $\frac{7}{20}$
c) Probability that 14 seeds germinated $= \frac{14}{20}$
d) Probability that 0 seed germinated $= \frac{0}{20}$
2) She should sow many seeds in one hole.

Some of the answers given by some learners to Question Two which showed the learners' ability to apply the probability concepts are given in the following excerpt

Learner A7: *The mother should sow them when it is moist.*

Learner A21: *The mother should sow them when he expects that the rain is coming soon.*

Learner A17: *The mother should sow them on loam soil because clay soil is sticky and the seeds cannot germinate.*

Learner A2: *The mother should water them.*

Learner A10: *The mother should sock them in water before sowing.*

I recorded the following observations

MT: *Amon was able to help the learners to understand the difference between probabilistic events and certain events. The connection between the cultural activities and the probability concept which was being taught was clear. Also, the learners performed very well during the lesson and* *their participation was very good. There is noted improvement in Amon's integration of ethnomathematics in the teaching of probability. Amon managed to pose the problem which motivated the learners to participate. Amon also improved in answering the questions asked by the learners to their satisfaction.* When I asked Amon during the post-lesson reflection interviews

MT: *What changed would you make to this lesson if you were to teach this lesson again?*

Amon seemed to have been satisfied by the way he had taught that lesson and he responded as follows:

Amon: *I have mastered the art of integrating ethnomathematics in the teaching of probability, I may just increase the number of questions I developed from the cultural activities, but as far as incorporating cultural activities I did very well there is no need of changing what I have done. I did very well in this lesson the learners understood the simple probability and managed to identify applications of probability concepts in their daily lives. However, I should have helped the learners to see that there was need to reduced fractions to their lowest terms. I found that I was assuming that the learners can realise that any number divided into zero is zero.*

From the above observations, apart from change in the capability to pose the problem properly, Amon also improved in his pedagogical approach, he managed to dialogue with the learners which resulted in him being able to develop the lesson from the learners' responses. Amon could now teach from the known to the unknown, putting into consideration the experiences that the learners bring to school, a shift in his practice which is worth noting. Amon's questioning helped the learners to reflect on their probability knowledge and identify the application probability concepts outside the classroom.

Amos also showed improvement in problematizing cultural activities and management of teacher-learner dialogue when he was observed teaching about probability with replacement. Amos used the game called “Zairakaora” (rotten egg) to introduce concepts of probability with and without replacement. The following excerpt is part of the dialogue that took place when Amos was problematizing cultural activities and efficient classroom dialogue was evident:

Amos: *When you are playing “zairakaora” several players may want to be the first to be the one moving around with the object while others are seated. How is it ensured that the person to play that role is selected without bias?*

Learner B12: *A neutral player one who does not want to play that role is made to conduct mapuza.*

Amos: *How is mapuza conducted?*

Learner B7: *One person secretly put tree leaves in between their fingers with all the leaves cut on their end except one and closed the hand to form a fist such that the cut leaves cannot be identified. The other players are made to choose a leaf. The drawn leaf can be secretly replaced or depending on the agreement of the players. The first person to select an uncut leaf is the winner*. [Demonstrating how mapuza is conducted]

Amos: In that case it is said that the selection is done randomly, all the interested parties have an equal chance of being selected.

The learners were given the following problems to solve in groups.

1. Anesu, Tina, Chedu, Rudo, Chido and Farai are interested to be the one to move around with an object playing "zairakaora". "Mapuza" with seven leaves with replacement are administered on them. Find the probability that

a) Tina wins

b) Chido wins

c) Anesu wins.

2. Suppose the leaves are not replaced after being picked, what is the probability that

a) Tina picks the leaf first and win.

b) Chido picks the leaf second and win.

c) Chedu picks the leaf fourth and wins.

d) Who has the higher chances of drawing a cut leaf, the one who picks first and the one who picks fourth?

I observed and recorded the following

MT: *The learners in some groups initially had a misconception that the number of leaves used affected the probability that each of the six won. They gave the probability of one seventh which represented the probability of the cut leaf.*

The worksheet of one of the groups is shown below

1. a) P(Tina wins)= =$\frac{1}{7}$ *b) P(Chido wins)=* $\frac{1}{7}$ *c) P(Anesu wins)=* $\frac{1}{7}$ The learners in this group misinterpreted the question as they found the probability that the leaf is cut instead of finding the probability that one of the six won. They failed to realise that the probability that one of the players wins is independent of the number of leaves being drawn
2. a*) P(Tina picks the leaf first and win))=* $\frac{1}{7}$ *b) P(Chido picks the leaf second and win) =* $\frac{1}{6}$ *c) P(Chedu picks the leaf fourth and win)* $\frac{1}{4}$ *d) The one who picks first* The learners managed to adjust the number of leaves resulting in getting the correct answers for Question Two.

Amos also showed improvement in guiding the learners to reflect on their probability concepts to overcome their pre-instruction perceptions. The learners said that when the leaves are withdrawn without replacement the person who draws the leaf first has higher chances of taking the cut leaf than the one who picks next.

The following dialogue shows how Amos used improved questioning skills to assist the learners to reflect on their probability concepts.

Amos: *I have seen that all of you suggested that the one who picks the leaf first has higher chances of picking the cut leaf. Initially there are seven leaves with one leaf cut, what fraction of the number of leaves is cut?*

Learner B17: It is $\frac{1}{7}$

Amos: *When the second person picks what fraction of the number of leaves is cut?*

Learner B23: *It is* $\frac{1}{6}$

Amos: *Compare the two fractions and see which one has a higher chance of getting a cut leaf*

The dialogue given above shows that Amos had improved in managing dialogue and help the learners to reflect on their probability knowledge. Also, the learners realised their mistakes on the first question as one of the learners was quoted saying.

Learner B18*: I have seen that we used the probability of getting a cut leaf instead of focusing on the chance that each player had a chance of winning the draw. It was supposed to be* $\frac{1}{6}$ *because there are six players who are expecting to win.*

Amos mentioned that he did his best in implementing the EIM. In his self-evaluation Amos wrote,

Amos: *I think I managed to implement the EIM successfully because the learners understood the probability with and without replacement. I build my lesson based on the EIM starting from posing the problem up to the application of the concepts by the learner which involved decision making on the part of the learners.*

My comment coincided with my comment on this lesson. I wrote, MT*: Amos has improved in pedagogical practice, and he managed to implement the EIM effectively. He succeeded in posing the problem properly and gave the learners time to share ideas which they did freely without his interference. His dialogue management skills were superb. He guided the learners to identify their mistakes and correct themselves thereby reflecting on their understanding of probability knowledge. The learners' performance was very impressive, they participated very well during the lesson, and they could justify their answers.*

When Amos was asked during the post-lesson reflection interview.

MT: *What would you change if you were to teach this lesson again?*

Amos felt that the set objectives had been achieved, his response was:

Amos: *I think nothing should be changed except giving the learners more time to work in groups. I stopped them when some were still arguing on some aspect. Generally, I managed to implement the EIM properly*.

Messey also showed improvement in problematizing cultural activities and managing dialogue during the PAR. He posed relevant problems and conducted meaningful dialogue with his learners, for example, when Messey was observed teaching about mutually exclusive events. Messey employed a very interesting cultural situation. The following excerpt part of the dialogue that took place during Messey's lesson.

Messey: *It is a very busy morning at your home. The cattle had just busted out of the kraal, the baby had just messed herself with mud and there was no firewood. People are waiting for breakfast. How is it determined who is responsible for what in your family?*

Learner C3: *There are well defined roles for boys and girls, so the boys go to turn the cattle while the girls go to fetch firewood and cook breakfast and bathe the baby.*

Messey*: Is it possible for boys to play the roles that are supposed to be done by the girls or vice versa?*

Learner C6: It is possible, but they are not their gender roles.

The way in which the learners took part in the above dialogue showed that they understood their cultural activities and the problem that was posed was relevant to them. Messey also managed to develop the lesson from the learners' responses. Messey gave the learners the following questions to answer in groups.

1. a) List three exclusive gender roles of boys and girls in your culture, naming the set for girls' roles as A and the set for roles of boys as B.

b) Draw a Venn diagram and put the elements in the following sets

i) AUB

ii $A \cap B$

c) Find the probability of the following events

i) $P(AUB)$

ii) $P(A \cap B)$

I observed the following as I was checking what the learners were doing.

MT: *Some learners were arguing on whether cooking was the exclusive role of the girls when in other households' boys also cook. Therefore, they drew a Venn diagram with cooking in the intersection set. The learners did not put into consideration the word exclusive into consideration resulting in ending up with some elements in the intersection set.*

This observation was also made in the other two participants' classes when they gave the learners that same task. Although this was not an expected answer for this work the learners showed that they could analyse their culture properly resulting in them realising how cultural dynamism has distorted gender roles.

One of the learners in Amon's class pointed out that finding exclusive roles can be done for the sake of mathematics. She said that:

Learner A27: *There are no more exclusive roles for boys and girls in the society because some households have boys or girls only which means those girls go to herd cattle, the role that used to be exclusively for boys. Also, in some families with boys only, they can nurse their siblings in the role that was exclusively for girls. So, we can use these exclusive roles for the sake of doing mathematics.*

One of the learners in Amos's classes also had the same sentiments when he said that:

Learner B11*: It is no longer possible to have distinct gender roles for boys and girls because the culture is changing with some mothers with children of the same sex make them to do everything irrespective of their sex and it is becoming a norm.*

However, when Messey challenged the learners to come up with exclusive roles they managed to come up with roles they thought could not be shared by boys and girls. They came up with the exclusive roles and answered the questions they had been given correctly.

The learners' work sheet from Messey's class on this piece of work is shown below

1. ***Boys' exclusive roles***

   C= hunting birds with catapults.

   D= proposing love to girls.

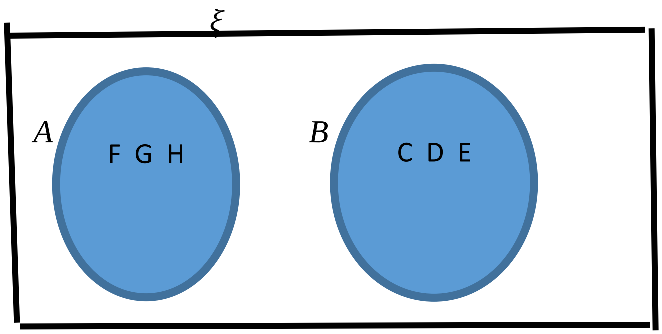
   E=hunting game with bow and arrows.

   Girls' exclusive roles

   F= carrying water in clay pots.

   G= pounding cereal grains into mealie-meal.

   H=decorating houses with coloured mud soil.



b. i) AUB = {F; G; H; C; D; E}

ii) $A \cap B = 0$

c i) $P(AUB) = \frac{3}{6} + \frac{3}{6} = \frac{6}{6} = 1$

ii) $P(A \cap B) = 0$

I recorded the following observation:

MT: *Messey's pedagogical practice has significantly changed. His problem posing skills have notably improved. Messey could converse with the learners meaningfully to understand their understanding of the cultural activities and use them to develop his lesson. Messey has changed* *from using a teacher centred approach to the use of the learners' centred approach. The learners on the other hand had changed for the better. They showed interest and understanding of their cultural activities which they critically analysed and saw how they have been affected by cultural dynamism. Their contribution during the lesson was that of learners who love their culture and were in a position to defend it and justify their probability reasoning. This group of students had a misconception of an empty set and zero, however, their understanding of mutually exclusive events was clear they managed to show that for mutually exclusive*

events

Messey's self-evaluation for this lesson

Messey: *I realised that I should verify ideas with the learners before taking them to the class because this lesson nearly failed when I assumed that the roles such as cooking are for the girls while roles like herding cattle are for boys when the learners knew otherwise. However, I managed to implement the EIM, from the posing of problems to the guidance of the learners to reflect on their work as per EIM.*

According to Messey he has learnt to respect the learners because they have shown to be very analytical of the situation that he had overlooked. When I asked Messey what he would change if he was asked to teach the lesson again his answer was:

Messey: *The way I presented this lesson need not to be changed. I presented it as per the EIM and the learners understood the concept I was teaching properly. Probably there might be a need to increase the number of problems I give for individual work for the learners to do more practice individually.*

Another pedagogical change that the participants made during the PAR was their ability to problematize cultural activity for incorporating in the teaching of conditional probability. For example, part of the dialogue that took place in Messey's lesson in which he successfully posed the problem as he incorporated cultural activities for the teaching of conditional probability is given below.

Messey: *At times when people are herding cattle some cattle can go missing and the people can move around asking if anyone has seen them. What characteristics should the person mention for other people to know if they have seen it?*

Learner C18: He should state its colour or whether it is female or male or whether it has horns or not.

Messey: Today we are visiting Mr Tagwirei's kraal so that we complete the table about his cattle with respect to the sex and colour distribution of Mr Tagwirei's' cattle. [Giving out the blank table to the learners who were to work in groups]

The learners demonstrated knowledge of the activity which was used and came up with the table given in **Table 6.2** below.

Table 6.2: Mr Tagwirei's cattle **characteristics excluding horns**

Colour	Male	Female	Total
Black	6	4	**10**
Brown	2	1	**3**
Other colours	2	1	**3**
Total	**10**	**6**	**16**

The learners were given the following question based on Mr Tagwirei's cattle to answer in groups. Messey also helped the learners to use the formula

P (black/female)= $\frac{N(black\ and\ female)}{N(female)} = \frac{4}{6}$ *to solve the problems*

The learners showed deep understanding of the cultural activity, to an extent of showing that the table does not contain some information that can assist in having the lost cattle be found easier. The learners in their groups found that the table omitted one of the attributes that may allow the lost cattle to be located faster, whether it has horns or it does not have them.

One of the learners said that:

Learner C19: *Why is the formula using only two variables, colour, and sex yet that does not make the description more specific to make the cattle being found faster? I always think that description of a cattle should have colour sex and whether it has horns or not.*

Messey showed that he had improved in the way he respected the learners, he quickly adjusted the table to accommodate the learners' views/

Table 6.3 with two more added attribute 'with horns' and 'without horns' was drawn by the learners.

Table 6.3: Mr Tagwirei's cattle characteristics including horns

Characteristics	Male	Female	Total
Black (horned)	3	1	4
without horned	3	3	6
Brown (horned)	1	1	2
No horns	1	0	1
Other colours (horned)	1	1	2
No horns	1	0	1
Total	10	6	16

Messey went on to use the tables completed by the learners to ask more questions which included the variables that the leaners requested to be included.as follows

Use the table to calculate the probabilities which follow;

2. a) P(horned/male)

a) P (female/ not horned)

b) P (Other colours/not horned)

This showed that Messey had notably improved in dealing with the learners' pre-instruction perceptions.

During Messey's lesson I recorded the following observations:

MT: *The learners at first struggled to complete the table, however, they managed at the end and made sense of the table. The learners showed familiarity with the activity and suggested that three variables be given colour, sex and whether the cattle had horns or not because that could help the* *missing cattle to be identified. The learners misinterpreting the word 'and' for multiplication with other learners taking it for addition. [*See work from the learners' worksheet in this section*]. Majority of the learners quickly realised their mistakes and corrected their answers. The error did not emanate from misunderstanding of conditional probability but a general misconception arising from the multiple use of the word 'and' as it was used in probability by the learners before.*

Items from the learners' answer sheets shown below were testimony to the different ways in which they interpreted the word "and" in the questions

P (male/brown)= $\frac{N(male\ and\ browm)}{N(brown)} = \frac{10+3}{3} = \frac{13}{3}$ The learners misinterpreted the word "and" resulting in them adding the male cattle and brown cattle. The learners later acknowledged that their answers were wrong because it was greater than one which means that they were familiar with properties of probability.
P (brown/female)= $\frac{N(brown\ and\ female)}{N(female)} = \frac{3\times6}{6} = 3.$ The learners interpreted the word 'and' to mean multiplication in probability resulting in multiplying numbers on the numerator. The learners in this category also realised that their answer was not correct by virtue of it being greater than one.

When I asked the participants:

MT: *How did the learners' performance respond to the implementation of the EIM in your lesson?*

Messey confirmed his lack of preparedness on the learners' analysis of the table that was used. He thought he was teaching very difficult topics that the learners could take time to comprehend.

Messey: *This EIM makes wonders, I was not expecting it on this concept of conditional probability. Starting from the completion of the table that we did up to the end of the lesson the learners were highly motivated. I could not imagine it was the same conditional probability that used to cause havoc to learners, they got it without a lot of effort. However, there are some learners who initially had some misconception about the word, 'and' they added the numbers on the numerator but later realised that the answers they were getting were not probabilities since they were numbers greater than one. I just felt there was an omission on my part because I emphasized before that "and" means multiplication, but I failed to tell them that it also means intersection of the given sets. This resulted in some of the learners failing to interpret it properly. After I explained to them the meaning of the word 'and' as used in the formula they did corrections quickly.*

In his self-evaluation Messey stated the following:

Messey: *I did very well in this lesson, however, I should have put into consideration the three variables that the learners were talking about. I realised that learners are the best teachers. I have been made to use the probability tree diagram before I had planned for it. I am pleased that the learners had no challenge with the use of the probability tree.*

When Messey was asked during the post-lesson reflection interview what he would change if he were to teach the lesson again his response was:

Messey: *I was supposed to recap on the use of technical words such as and because it resulted in learners taking more time doing proper substitutions on the formula. I managed to follow the EIM properly and the learners understood the concept of conditional probability that the errors of substitution they were making could affect the learners' understanding of conditional probability. Therefore, there is nothing basic that I should change in this lesson if I were to teach it again.*

According to the data presented in this section, the three participants had improved in a number of ways due to their participation in this PAR in which they integrated ethnomathematics by implementing the EIM. Amongst the changes that took place in the participants included the ability to pose the problem, managing teacher learner dialogue, help the learners to reflect on their probability knowledge and helped the learners to apply their learnt knowledge in real life situations. The participants also showed changes in the way in which they incorporated cultural activities in the teaching of probability. The learners were able to use cultural activities as an introduction to their lessons, build their lesson on the cultural activities. The participants could also develop questions from the cultural activities in addition to use them as examples during the lesson.

6.3.3.2. A shift in pedagogical perspective and understanding of cultural activities.

The use of the EIM resulted in the participants doing things differently. The participants revealed their shifts in their pedagogical perspective and the way they viewed cultural activities during the final interview. During the implementation of the EIM the participants interact with probability content from the rural Shona learners' cultural perspective which gives the participants greater chances of reflecting on their own probability teaching practices. Participating in the implementation of the EIM helped the participants to improve on how to incorporate cultural activities in the teaching of probability and therefore becoming more effective in designing lessons that deal with areas in which the learners experience challenges. Also, taking part in this PAR also helps the participants to value teamwork and shared pedagogical challenges with the view to overcome them. In this section I present the shift in pedagogical perspective that took place in the three participants emanating from the implementation of EIM and how their understanding of cultural activities has also changed.

When the participants were asked how the implementation of the EIM during the PAR changed their perspective about integrating ethnomathematics in the teaching of probability.

MT*: How did the implementation of the EIM during the PAR influence the way you incorporate cultural activities in the teaching of probability?*

Amos mentioned that he has shifted from his view of cultural activities. He has shifted away from his stance of trivializing the probability concepts found in cultural activities. He mentioned that:

Amos: *It is like I have been transformed in many ways through the implementation of the EIM. The first thing I have changed is the way I understand cultural activities. I used to trivialize cultural activities saying that there are no probability concepts found in cultural activity, but I have seen that there is a connection between cultural activities and probability concepts we teach at school.*

Amos continues to state how the EIM was of great benefit to him.

Amos: *The EIM helped me to improve the way I incorporate cultural activities in that it helps me to analyse the cultural activities before I incorporate them in probability pedagogy. This means* *that before I incorporate the cultural activities, I should try to understand them in the way the learners understand them. The EIM helped me to sequence the lesson activities, it lays out clearly how the lesson should be presented. Prior to the use of the EIM in this PAR I could use the cultural activities just as spices to my lesson but now the cultural activities form the core of my probability lessons.*

Amos's view of the learners has also changed; he is now respecting the learners like never before because the EIM is based on the learner-centred approach which is hinged on teacher-learner dialogue as the cornerstone of effective teaching and learning. He mentioned that:

Amos: *I used to treat the learners as the proverbial empty vessels who needed to be filled but I leant through the implementation of EIM that learners have knowledge also. At the beginning of this PAR, I could take some cultural activities assuming that they could be used to teach particular concepts only to learn from the learners that it is totally different from what I thought. For example, I thought some games had random outcomes of which I was wrong. I learnt it from the learners that some had some predetermined outcome. In fact, when implementing EIM it is not possible to neglect the learners' conception because the lesson is hinged on the learners' input into the lesson. I can say I have improved in learners' engagement hence I have become a more effective teacher.*

Amos also learnt how to help the learners to reflect on their probability concepts as he went further to say that.

Amos: *I did not know that questioning the learners can help them to reflect on their work and it can only happen when the teacher uses the learners' prior understanding of concepts to probe the learners to think deeper. I have learnt that further oral questioning of the learners leads them to a higher level of conceptual understanding.*

Messey appreciated the problem posing stage of the EIM. He found it as the most strategic element of the EIM. He thinks the success of the EIM is hinged on problem posing. He mentioned that:

Messey: *Before I took part in this PAR, I used to begin my probability lessons with a question, however, the questions I used to ask were at times could lead the lesson into stagnation. This was due to the fact that the question might be very difficult, and the learners could fail to answer them. This could lead me to answer the question meant for the learners myself for the sake of lesson continuity. The EIM begins the lesson by posing the problem which the learners are very familiar with. As a result, the lesson does not go into stagnation because learners are keen to solve the problem. Therefore, instead of using questions I now use the problem because learners may not be prompted to participate by a question*

Messey went on to mention how the implementation of the EIM has taught him how to analyse cultural activities to incorporate in the probability pedagogy.

Messey: *Due to my participation in the implementation of the EIM I have learnt that I should analyse the cultural activities to incorporate them in the teaching of probability. It is not like the probability concept in cultural activities are bare for everyone to see, but one has to think critically about the activity so that it is made to fit in the selected probability concept. I realised by giving the learners questions based on the dice or playing cards we are asking the learners to apply the* *concepts they had not been taught to understand. I learnt that most of the questions in the textbooks are meant for the learners to apply knowledge. Hence, I should make the learners understand the concepts before I give them application problems.*

Messey went further to explain how he used to look at cultural activities as follows:

Messey: *Prior to the implementation of the EIM when I was observing the cultural activities, I did not look at them from the probability point of view. I was just looking at them like activities that the learners engage in outside school whose place in the mathematics classroom was very limited.*

Amon was also attracted by the problem posing aspect of the EIM which was regarded as the pillar of the EIM. He mentioned that:

Amon: *I realise that as a teacher I should be clear of the difference between a question and a problem because prior to the implementation of the EIM I did not know that there was a difference between the two, I was interchanging using the two words. Trying to find a relevant cultural problem for the lesson helped me as a teacher to reflect on my understanding of probability concepts and this improved my understanding of probability. Starting the lesson with a question instead of a problem resulted in my lesson lacking cohesion and continuity. When I pose a problem, the whole lesson becomes connected up to the end because it hinges on the learners' solution to the problem.*

Amon added that the EIM by virtue of it being hinged on problem posing it helped him to manage teacher-learner dialogue. He went further to say:

Amon: *The implementation of EIM in this PAR helped me to learn how to manage dialogue with my learners. The challenge I had before was that I could not solicit the learners' pre-*instruction *understanding of probability because the participation of the learners was very poor. Instead of giving the learners probability problems which are based on theoretical aspects, the EIM is based on the problems that the learners are interested in solving and the problems are based on the learners' daily activities. Instead of just opening the learners' textbook and giving the learners the questions, the EIM made me think about the questions I was giving to the learners properly because it requires that the teacher comes up with relevant questions based on the cultural activity that has been incorporated.*

When the participants were asked how they have improved in identifying cultural activities and their integration of ethnomathematics in the teaching of probability, all the three participants revealed that the entire process was very important and an eye opener to them.

I asked the lecturers the following question.
MT: *How have you understanding of the relationship between cultural activities and probability improved because of participation in implementation of the EIM during the PAR?*

Messey responded as follows:
The implementation of the EIM in this PA helped me to understand that all probability concepts can be found in cultural activities. What is only needed is one to have skills to identify probability concepts in cultural activities because these probability concepts cannot be identified easily, they are hidden one must mathematize the cultural activities in order to find them.

Messey went further to explain how the incorporation of cultural activities in the teaching of probability was made easy due to meaningful learners' engagement.

Messey: *The implementation of the EIM made incorporation of cultural activity in the teaching of probability easy because it is centered on meaningful learners' engagement. I used to use a teacher centred approach which does not engage the learners meaningfully but during the implementation of the EIM learner centred approach was used. The direction of the lesson was determined by the learners' inputs. Proper involvement of the learners during the implementation of the EIM made me realise learners know all the cultural activities including those probability concepts. The use of the EIM made me know the significance of the learners' input to the lesson, that I should not underestimate the knowledge of the learners if incorporation of cultural activities in the teaching of probability is to be successful. Although at times the learners may pretend not to know cultural activities, when they are meaningfully engaged, they have the capacity to reveal a lot of probability concepts found in culture. Being one of the participants in this PAR to implement the EIM I had an opportunity to focus on how to get the best out of my learners.*

Amon echoed the same sentiment and revealed that the use of the EIM helped him to be able to analyse cultural activities to identify probability concepts. He also revealed how he changed from the way he viewed the relationship between cultural activities and probability concepts taught at school.

Amon: *There is a very good relationship between cultural activities and probability taught at school. But it depends on whether one looks at the cultural activity with the probability eye or not.*

The implementation of the EIM during the PAR helped me to look at cultural activity with any analytical eye that can identify cultural activities to incorporate in the teaching of probability. I gained the skill to analyse cultural activities to incorporate in the teaching of probability including for concepts such as conditional probability which I previously thought there were no cultural activities that could be found.

I further prompted him to be more specific on the skills gained with the following question
MT: *What cultural activities have you found that can be incorporated in the teaching of probability that you didn't know before?*

Amon mentioned the use of the learners' language as one of the ingredients to incorporation of cultural activities in the teaching of probability. He identified a variety of cultural activities which he thought could be incorporated in the teaching of probability.
Amon: The starting point is the incorporation of the language that the learners use outside school to express probability thinking. Cultural has its own way of expressing probability which I had not thought of before. Cultural language differentiates impossible events, certain events and uncertain events. All the activities can be categorized in these three groups hence all activities if analysed properly incorporated in the teaching of probability. Activities such as herding cattle have a variety of sub-activities that can be integrated in the teaching of probability. Mice trapping, fishing, hunting and many other activities can be integrated in the teaching of probability. In fact, I leant that all cultural activities are probabilistic in nature, however, it depends on the teachers' ability to analyse these activities and integrate them in the teaching of probability.

Amos mentioned that prior to the PAR he used to think that only certain events and impossible events were the only probability concept found in cultural activities.

Amos: *The implementation of the EIM in this PAR helped me to incorporate cultural activities in the probability pedagogy more effectively. Initially I did not know what it meant to incorporate cultural activities in the teaching of probability, I thought we should rely on those concepts which are easily comparable such as certain events and impossible events. The use of the EIM was an eye opener because I learnt the level of connectivity between cultural activities and conventional probability. Before I was exposed to the EIM I was expecting to find formulas in cultural activities. I was expecting the probability concepts found in cultural activities to perfectly fit in conventional probability without any adjustment. The implementation of the EIM helped me to realise that I should not expect to find formulas as such in cultural activities, but formulas are the tools that should be applied to both conventional probability and probability found in cultural activities*

I further prompted Amos to elaborate on the activities that he realizes do not have perfect fit, but they can be adjusted by asking him the following question.

MT: *Can you identify the cultural activities that you realised that do not have a perfect fit in school probability concepts, but they can be adjusted for incorporation in the teaching of probability?*

Amos described how cultural games could be incorporated in the teaching of probability and the topics which he thought the activities can be used.

Amos: *Cultural games such as Dhema and Tsoro can be incorporated in the teaching of probability to teach simple events, randomness, probability with replacement, and conditional* *probability since they involve predicting the chances of winning and predicting the order in which the players can win the game. Also, some activities which include farming activities such as cattle rearing- crop production inheritance and natural events can be- incorporated in the teaching of probability*.

Based on the lesson observations and the participants' responses to the final interviews, it was revealed that the three participants Amon, Amos and Messey had shifted in their pedagogical practice and perspective as well as in understanding of cultural activities. The findings on the changes that took place in the participants because of participating in the implementing the EIM are given below:

- All of the three participants had changed in the way they engaged the learners during the lesson.
- All of the three participants changed from using a teacher-centred approach to a learner-centred approach.
- All of the three participants have improved in managing teacher-learner dialogue more effectively.
- All of the three participants Messey, Amon and Amos benefitted on how the learning activities are sequenced when integrating ethnomathematics in the teaching of probability.
- All of the three participants could use questions from the learners' textbooks to test the learners' ability to apply after the learners have understood probability concepts based on cultural activities

- All the participants Amon, Messey and Amos learnt how to create culturally relevant problems and use problem posing as an effective pedagogical strategy to motivate learners to participate during the lesson.
- Amos Amon and Messey had improved in teaching strategies they could help the learners to reflect on their probability concepts through questioning them.
- Messey, Amon, and Amos were able to mathematize cultural activities to find probability concepts embedded in them and incorporated them in the teaching of probability.
- Amos and Messey incorporate cultural activities in the teaching of probability including in conditional probability the topic which they previously thought was not possible.
- Amon, Amos and Messey used cultural activities to develop probability problems that the learners should be able to answer before they are given questions from the textbooks.
- Amos and Messey realised that probability concepts in cultural activities are not laying bare for anyone to see but they are hidden; they can only be seen through mathematizing cultural activities.
- Amon used the learners' mother language as a key component in the integration of ethnomathematics in the teaching of probability.

6.3.4. The participants' reflection.

Reflection on practice was one of the aspects that characterised this PAR. Amon, Amos and Messey reflected on their ability to integrate ethnomathematics in the probability pedagogy on the PAR in various ways. In reflecting on the implementation of the EIM the participants were trying to create a deeper understanding and insight about how best they could improve the integration of ethnomathematics in the teaching of probability. This also helped them in considering alternatives to continue improving working relationships and their practice of integrating ethnomathematics in the teaching of probability. These reflections were captured during the interviews and some journals that the participants kept during the PAR although they did not write much in those journals. Three following subthemes emerged from the coded data as follows. a) Reflecting on the impact of EIM on the learners' performance. b**)** Reflecting on the benefit of participating in the PAR.

6.3.4.1. Reflecting on the impact of EIM on the learners' performance.

Although the success of this PAR would to a large extent be measured by the extent to which the participants changed in the ways they integrated ethnomathematics in the teaching of probability the impact of that change should be reflected in the learners' performance in the eyes of the participants.

When the participants were asked how the implementation of the EIM impacted on the learners' performance during the PAR, all the three participants Amon, Amos and Messey indicated that the learners' performance in probability had improved significantly.

I asked the following question.

MT: In your view how did the implementation of the EIM impacted on the performance of learners in your class?

Messey mentioned that the performance of the learners had improved notably, and they showed interest in representing their groups.

Messey: *The learners' participation in the implementation of the EIM was very good. The learners showed understanding of their culture which helped them to understand probability concepts that were being taught. My learners used to be very passive during the lesson but when I was using the EIM they became very active. They could ask questions when they had challenges which was very unusual for them. I used to have challenges to find learners to represent their groups. At times I could force the learners to represent their groups but during the par everyone was willing to represent their groups.*

Amon also noted improvement in the learners' performance during group work, when doing individual work and in class discussions. He attributed this change to the way the cultural activities were being incorporated in the pedagogy using the EIM.

Amon: *I saw that the performance of the learners during the implementation of the EIM has improved. The way the learners participated in groups one could see that everyone was taking part in the discussion. Their written work has improved too, and the learners could justify their answers. This was different from the time before the PAR when some learners were asked how they arrived at their answers they could not respond. The implementation of the EIM during the PAR gave confidence to the learners due to the way the cultural activities were incorporated.*

Amos mentioned that the learners' performance improved especially during the class discussion because they were allowed to use their mother language to explain their points when they had challenges in explaining their points in English.

Amos: *The learners' work was very good during the implementation of the EIM. Their contributions during the class discussion were very immense. I think this was due to the fact that at times I allowed them to use vernacular language since some of the cultural activities we used would be difficult to explain in English. They would ask questions where they had challenges and they would explain their answers.*

Amos went further to explain how the learners' analytical skills had improved.

Amos: *I saw that the learners had developed analytical skills, when I was using the game called Zairakaora to teach about random events the learners in their discussion outlined that players in most cases manipulate the outcome of the game hence the outcomes cease to be random events.*

6.3.4.2. Reflecting on the benefit of participating in the PAR.

Participants at their school usually prepare for their lessons individually. In rare cases if ever existed when teachers at a school could work together to solve problems pertaining to improvement of teaching instructions. When it could be acknowledged that the problem really existed the teachers are usually called for workshops where the teachers become passive participants listening to someone the knower who would be prescribing solutions to their problems. The three participants who took part in this study revealed that this PAR helped them to build a culture of working together.

The participants were asked how they felt about participating in this PAR to implement the EIM.

MT*: How did you feel about your participation in the PAR to implement the EIM?*

Amos pointed out his pleasure for participating in this PAR as follows:

Amos: *This PAR was liberating because I felt the power in us as a team to solve problems that affected us. At the beginning of this PAR, I could not believe it was me who was discussing openly without fear about my weaknesses that affected my practice of teaching probability. I was not used to opening to my colleagues. I was afraid to be judged, however, I found it as an opportunity to work together.*

Amos went further to say that the PAR was synonymous to intensive training.

Amos: *To me this PAR was a training on its own because I learnt a lot of things in an open environment in which I was free to ask questions on things I did not understand.*

Messey shared the same sentiment and said that:

Messey: *For me the PAR encouraged openness with each other in dealing with the problem that affected us. My fear for openness went away during the time when we were observing cultural activities. I discovered that at times we knew the cultural activities differently so to convince the other participants that the cultural activity was suitable for a particular concept I had to open to them. I learnt a lot of new ideas in an open environment in which we treated each other as equal partners. It made me open my mind for new ideas from the other participants and the learners as* *well. It created a mathematics class with no hierarchy where the participants were prepared to learn from their learners.*

Amon felt that the free environment did not affect him alone, but he could see it amongst the learners as well and said that:

Amon: *The PAR encouraged us to work together to address the problem that affected all of us. We openly shared ideas in every stage of the PAR and discussed openly where we had differences in opinion. The discussion we held when we were preparing lesson plans were eye openers, they were very informative. I found that even the learners were free to share ideas with the teacher as well as with each other without any fear as used to be the case. To me the PAR transformed the classroom into an atmosphere which is for everyone to cooperate and play their part.*

From the participants' responses on their reflection on the impact of implementation of the EIM on the learners' performance and their participation in the PAR it was found that:

- All the three participants noted improvement on the learners' performance emanating from the use of the EIM and they reported that the learners asked questions when they find challenges.
- Messey reported that his learners became willing to represent their groups.
- Amon's learners were reported to have interest in participating in both group and class discussions.
- Amon and Messey reported that the learners were showing analytical skills of cultural activities which were being incorporated and they had gained confidence in what they were doing including justifying their answers

- Although the PAR was not meant to have some social benefits accruing to the participants, there are some social benefits inherent in the PAR. The social benefit arising from the PAR reported by the participants was that it created a conducive environment for the participants to conduct their lessons without fear. The following are the finding on the participants reflecting on the social benefits of the PAR:
- All the three participants found the PAR to be liberating in that there was no hierarchy. All the participants and I as a researcher were equal.
- All the three participants found that the PAR created an open environment in which the participants were free to open up to each other. Messey said that he managed to overcome his fear for his colleagues and worked with them to solve the probability pedagogical problems which they were all experiencing.

6.4. Conclusion

In this chapter I presented the findings of this qualitative study which is based on semi-structured interviews with three participants at the beginning and at the end of the PAR. Data generated from lesson observations with the participants completed the topics in different numbers of cycles and data from post-lesson reflection interviews were reported to corroborate the interview. I analysed the data collected and organised the findings into four themes and eight subthemes. In chapter seven I analyse and discuss the finding under the themes and subthemes.

CHAPTER SEVEN

DISCUSSION OF FINDINGS

7.1 Introduction

In this study I explored how the rural secondary school mathematics teachers integrate ethnomathematics in the teaching of probability. To accomplish this a participatory action was conducted with three OL rural mathematics teachers who tried to implement an EIM to help learners to understand probability concepts through integrating ethnomathematics in the teaching of probability. This study was guided by the following research questions.

- What are the difficulties faced by mathematics teachers in integrating ethno-mathematics when teaching probability?
- Which mathematical concepts found in the rural Shona learners' out of school mathematical practices can be integrated in the teaching of probability?
- How can the mathematical concepts in the rural Shona learners' daily activities be integrated in the secondary school mathematics for the teaching of probability?
- How can the integration of ethnomathematics in secondary school mathematics improve on the cultural relevance of the pedagogy in the mathematics classroom?
- What should a policy framework for facilitating the integration of ethno-mathematics in secondary school mathematics in the teaching of probability look like?

In this chapter I start with the analysis of data to highlight the findings of this study. In this narrative I synthesise the findings highlighting how the findings relate to the research questions. The analysis is followed by the implications of the findings, recognizing the limitations of this study, and finally give recommendations to advance this dimension of mathematics education research.

7.2. Analysis and discussion of findings

Data from this study was collected at the beginning of the PAR, during the PAR and at the end of the PAR. At the beginning of the PAR the participants wrote narrative about themselves regarding their teaching experience, understanding of the nature of mathematical knowledge, teaching approaches, their perception of the learners and the topics they regarded most difficult to teach. The participants were also interviewed at the beginning of the PAR and lesson observations were conducted during the PAR. After each lesson observations a post-lesson reflection interviews were also conducted. Finally, the last interview was conducted at the end of the PAR. The interviews and lesson observations were transcribed and coded for emerging themes. The following themes were evident to explore how the three participants integrated ethnomathematics in the teaching of probability. (a) Hindrance to effective incorporation of cultural activity in the probability pedagogy, (b) Failure to make connection, (c) The Changes, and (d) Participant's reflection. These themes and their sub themes are discussed in detail with reference to the theoretical framework and literature review below**.**

7.3. Hindrances to incorporation of cultural activities in probability pedagogy.

During the initial interview and the lesson observation it was revealed that there are some hindrances which prevented the participants from integrating ethnomathematics in the teaching of probability. The way in which the hindrance affected the participants in integrating ethnomathematics is given in the following subsections.

7.3. Lack of probability pedagogical knowledge

There was evidence of inadequate in-depth probability pedagogical knowledge emanating from lack of probability subject matter knowledge as well as lack of knowledge of cultural activities. The inadequacy of probability of pedagogical knowledge manifested itself at the beginning of this

PAR in the initial interviews and in preliminary lessons which were taught by the participants. Although this lack of pedagogical knowledge occurred in different magnitudes amongst the three participants, all the three participants demonstrated at least one of the components of lack of in-depth pedagogical knowledge.

7.3.1. Amon's lack of probability pedagogical knowledge.

Amon displayed a lack of pedagogical knowledge when he acknowledged that he cannot explain probability terminology such as the use of the word "or" and "and" to the learners. Those words are used technically in probability, and this demands that the mathematics teacher must know how to explain them to the learners, and Amon failed to do that. These two words "or" and "and" underpin the overlapping and the non-overlapping events hence Amon's failure to explain them clearly to the learners implies that the learners might not understand probability concepts which depend on those words such as addition and the multiplication rule of probability.

Amos also failed to explain the context in which the term "with replacement" is used in probability. Amos failed to explain to the learners satisfactorily whether giving birth to a baby boy by a woman who had given birth to three boys before represents probability with replacement or not. Amon's pedagogical inadequacy was revealed when he didn't explain the difference between probability "with replacement" and probability "without replacement" which was raised in that question. One of the learner's questions exposed Amos's pedagogical incompetence: The question was, "*How can the probability of giving birth to a baby boy be half when the mother has already given birth to three boys before*?" The learner's question exposes how probability concepts are used differently at school and in the learners' out-of-school mathematics practice. Amon's perspective contradicted the learners' understanding of chances which involve replacement. Amon was concerned about the calculation of probability before the learners understood exactly how the replacement had occurred. What happened concurs with Rosa and Orey (2011) who say that mathematics teachers should know that mathematics skills that learners learn in school are not logically constructed based on abstract cognitive structures but rather they are forged out of a combination of previously acquired knowledge and skills and new cultural inputs. Amon failed to reconcile the learners' understanding of replacement with the school's understanding of the same concept and this resulted in learners failing to understand the concept of probability with replacement.

The question was tricky resulting in Amon concentrating on "with replacement" without seeing the effect the sex of the babies the woman had given birth to before which triggered the experimental probability effect on the question. Amon was not prepared for this and was caught unaware as evident from his response: "*Do not worry about her previous births.*" This response shows that Amon lacked probability pedagogical knowledge. Amon failed to explain to the learners how the previous births do not affect the probability of giving birth to a boy or a girl in general. This also shows that Amon was not prepared for the lesson. He could not also explain to the learners why the previous births were included in the question if they should not be put into consideration.

Amon also admitted his failure to motivate the learners to concentrate on their work: "*How can you expect hungry learners to concentrate. Some of the learners did not have breakfast and walked these long distances to school*"

Amon's observations that some of the learners were hungry might be true; however, the role of the teacher is to find ways of motivating the learners to concentrate on their work in their different and difficult situations. Admission of failure on the grounds that the learners may be hungry is not an acceptable reason for failing to deliver. Amon instead of concentrating on how to motivate the “hungry” learners, he tried to justify his lack of pedagogical skills. However, Amon’s understanding of why the learners did not concentrate on their work concurs with ((News Day, September 2014) which says that rural secondary school learners are the most disadvantaged group of learners in Zimbabwe, they walk very long distances to the nearest school. Amon’s failure to motivate the learners might be caused by lack of motivation on his part as a rural teacher as Mandina (2012) says that some mathematics teachers due to their poor remuneration are forced to find additional income which usually impacts negatively on their performance. Therefore, generation of additional income may consume a lot of the teacher's time, hence they find little time to prepare for their lessons resulting in poor pedagogical approach.

7.3.2. Amos’s lack of probability pedagogical knowledge

Amos displayed lack of pedagogical knowledge when he was observed teaching about probability with replacement. When the learners failed to understand what Amos meant by probability with replacement, Amos did not have any other alternative word to explain what he meant which nearly led the lesson into stagnation. The context in which “with replacement” is when used in probability it means with constant probability. However, the examples which Amos used were to do with physical replacement. Amos showed lack of pedagogical knowledge by creating in learners an impression that the replacement should be witnessed by a naked eye.

The misconception about the concept of replacement as a physical exercise was revealed by one of Amos’s learners: “*In the example that you did you showed us that you were returning the fruit back into the bag and drawing again*.” In this statement the learner was arguing that the child who is born is not returned into his mother’s womb hence there was no replacement. Amos’s example did not exhaust all the aspects of replacement as it is dealt with in probability exposing his lack of pedagogical knowledge. Amos also failed to deal with the learners' pre-instruction conception that their understanding of replacement was with immediate effect.

"*If the cows are milked every day and go back to the pastures and when they are milked the following day, we cannot say there is replacement because it is now another day*." This type of thinking that a new day comes with its new things is constant with the Shona children at play. For example, if a game is not completed in one day it is not carried over the following day. They start again and the roles of players can change. As a result of his pedagogical weakness, Amos did not consider the context in which the term "with replacement" is used in the learners' out-of-school mathematical practices.

Amos also revealed his lack of pedagogical knowledge when he bemoaned lack of textbooks as one of the causes of his failure to teach probability effectively. Amos could not improvise with the resources which were found in the learner's environment to teach probability. His argument that probability needs practice by both the learners and the teachers was plausible, but to suggest that his teaching was poor because there were not enough textbooks at school was not justified. What Amos said was consistent with Mandina (2012) who affirm that the social realities of rural secondary schools put the learners at a disadvantage as they do not usually have the textbooks that they needed. However, Amos missed the point when he said lack of textbooks affected his pedagogical practice since it contrasts Mukeredzi (2013) who points that lack of textbooks and material should lead the rural secondary school mathematics teachers to improvise and make the pedagogy interesting. In that regard, failure to improvise especially for rural secondary school teachers is a sign of pedagogical knowledge deficiency since the rural areas are rich in activities that the teachers can utilize in the teaching of probability. This is also affirmed by Mutambara

(2012) who says that rural communities have well knitted and mortal cultural activities with diverse mathematical concepts that the teacher can use for the benefit of the pedagogy.

7.3.3. Messey's lack of probability pedagogical knowledge

Messey acknowledged lack of pedagogical knowledge when he was responding to questions in the initial interview. Messey mentioned that he could not explain some of the probability concepts to the learners due to the complexity of probability language. Failure to explain concepts may be because the concepts are not clear to the teacher. However, Messey argued that he understood the concepts but the learners experience difficulties in understanding them because the probability language is used in a way different from the way it is used in the learners' daily lives. He argued that the context in which the probability concepts are used at school contrasts with the way it is used in the daily lives of the learners. This concurs with Garfield and Ahlgren (1988) who say that learners appear to have challenges developing correct intuition about fundamental ideas of probability because probability concepts taught at school often appear to conflict with the learners' everyday experiences.

Messey could not explain the word "or" to the learners because the learners use the word in their daily context to mean one of but used in probability to mean addition. Messey also revealed lack of probability subject matter knowledge when he failed to explain satisfactorily to the learner the term "with replacement" as used technically in probability. Messey employed an example of the rising sun the following day as an example of an event with replacement but failed to clarify where the replacement lies. The use of the rising sun was not an appropriate example because it is a certain event.

Messey exhibited pedagogical failure in that lesson when he failed to convince the learners that the replacement is not with immediate effect but is based on the next observation whenever it might be, even on the following day, month or year whenever the next observation will be the concept of replacement in probability is still valid.

Messey also confessed his inability to make learners retain probability concepts for a long time. This might be caused by the way Messey taught the learners which did not connect probability concepts to the learners' real-life experiences. According to Begg (2001) learners can understand mathematics better if the teacher strives to link mathematics with everyday familiar contexts within school and outside school. Some methods which are teacher centred do not make the learners understand the concepts. Such methods include drilling learners on procedures without making them understand the reason why they are doing that. Hence such type of knowledge can be forgotten so easily.

Messey revealed his lack of probability subject matter knowledge when Messey mentioned that probability concepts were the most difficult concepts to understand compared to other topics in the mathematics OL mathematics syllabus. Messey's reason was that the probability concepts taught at school were different from how probability is practiced in the learners' life outside school. According to Bansilal, James and Mji (2010) many students fail mathematics due to the failure of the teacher to make the ordinary people see the everyday application of mathematics in school. Messey's admission that probability concepts are difficult to teach is an admission of pedagogical failure on its own.

Messey also admitted his pedagogical failure when he said that probability concepts needed a lot of concentration on the part of the learners, but the learners at his school could not concentrate on their work because they walk very long distances to school hence, they are always tired they cannot give maximum concentration. What Messey said on the learners' lack of concentration is consistent with Admassie (2003) who says that rural learners mix school and domestic chores hence they come to school very tired. However, failure to concentrate might be caused by lack of motivation due to the methods that Messey employ in the mathematics classroom.

7.4. Lack of knowledge of cultural activities

The three participants Amon, Amos and Messey showed some elements of lack of knowledge of cultural activities during the implementation of EIM although it occurred in different magnitudes in each participant. In this section I present how the theme of lack of knowledge of cultural activities manifested itself in the three participants.

7.4.1. Amon's lack of knowledge of cultural activities

During the implementation of the EIM Amon showed some elements of lack of knowledge of cultural activities at various levels of implementing the EIM. Amon acknowledged that he did not know cultural activities as a result he found it challenging to incorporate cultural activities in the teaching of probability. Amon was familiar with the cultural activities in general, but he lacked the details that might be of use in the probability lesson. It was found in this study that when integrating ethnomathematics in the teaching of probability using the EIM one does not only need to know the cultural activities in general but should have the necessary details about the cultural activities required when integrating those activities in the teaching of probability. During some lessons Amon was corrected by the learner when he failed to incorporate the probability concepts from the cultural activities correctly. Amon took cultural activities for granted since he had been staying in the area for a long time hence, he assumed that he knew the cultural activities. Amon did not implement the EIM properly because the first stage of the EIM is for the teacher to understand the cultural activity which is being incorporated in the way learners understand it.

Hence, the lessons simply failed due to lack of knowledge of cultural activities on the part of Amon.

Amon lacked enough knowledge about the cultural activities as he could not find the probability concepts in the cultural activities. He said, *"...I do not see the match between the cultural activities and probability concepts as used at school*." This statement is evident to show Amon's lack of knowledge of cultural activities. This is confirmed by Madusise (2014) who points out that mathematics teachers do not see the connection between mathematics and culture. This lack of knowledge might be since the teachers were not taught about ethnomathematics at teachers training colleges, hence they cannot identify probability concepts in cultural activities. It was found in the initial interview that Amon did not have adequate knowledge about cultural activities and was able to match probability concepts found in cultural activities and the probability concepts taught in the mathematics classroom. Amon lacked knowledge expected probability concepts found in cultural activities to use the same formulas as those used in the mathematics classroom. According to Rosa and Orey (2013), there is no way mathematics found in cultural activities can employ the same tools as those employed in the mathematics classroom because mathematics concepts found in cultural activities are not meant to do mathematics but to solve problems the people encounter in their daily lives.

In one of the lessons in which Amon was observed teaching random events using the game called Hwai-hwai, Amon showed that he lacked knowledge of the game by allocating all roles to the players randomly when some of the roles are reserved for sex. Amon did not know the details of the game hence he could not incorporate it effectively in the teaching of probability. Lack of the fine details of the cultural activity that one wants to incorporate in the pedagogy may lead to distortion of the concept resulting in learners getting confused. Amon would at times disapprove the learners' answers which were in fact correct according to the learners understanding of the cultural activity because some events in the cultural activities which appeared to be random events were not random. This concurs with Borba (1990) who affirms that mathematical concepts in cultural activities are hidden. Amon did not verify his understanding of the game with the learners before the lessons, he assumed that he knew about the cultural activities. This is a sign of lack of preparedness on Amon's part which emanated from lack of knowledge of cultural activities. According to D'Ambrosio (1985) mathematics learning can only be meaningful if the teachers incorporate cultural activities into the pedagogy. Therefore, knowledge of cultural activity is one of the milestones which every mathematics teacher should reach to be able to integrate cultural activities in the teaching of probability. Amon's lack of knowledge of cultural activities resulted in Amon being corrected by his learners during the lesson and hence exposing his lack of preparedness for the lesson. It is through knowledge of cultural activities and being prepared for the lesson that make Amon be able to integrate ethnomathematics in the teaching of probability which Amon lacked.

7.4.2. Amos's lack of knowledge of cultural activities

Amos acknowledged during the initial interview that he did not know the cultural activities properly. His admission might have arisen after he realized that each time, he tried to incorporate cultural activities in the teaching of probability there would be a challenge. " *When I was using the game called Zairakaora to teach about random events the learners pointed out that it was not a random event*." Amos like Amon knew the cultural activities in general but lacked adequate knowledge to effectively incorporate them in the teaching of probability. Amos's lack of knowledge of that cultural game might be caused by his failure to follow trends in cultural changes and he was left behind by changes which took place in that cultural game. In the post-lesson reflection interview Amon mentioned that he used to play the game Zairakaora when he was still young, and it seemed the rules of the game have changed. Amos's lack of knowledge of the new rules of that game was due to cultural dynamism, there were some changes that took place in cultural activities that Amos was not aware of. Amos was left behind by cultural dynamism as he accused the modern kids of changing the rules of cultural games to suit them. Those changes which are made to the game affected how the cultural games were to be incorporated in the teaching of probability hence Amos was not abreast with the changes that took place in cultural activities that he intended to incorporate in the probability pedagogy hence the learners could not understand the concept of randomness he was teaching about. Changes in cultural activities confirm with Tsindoli (2019) who points out that indigenous knowledge is always evolving hence the mathematics teacher should be abreast with them. The fact that Amos was not abreast with the cultural activity he incorporated meant that the posed problem was not properly solved hence the EIM was not properly implemented in those lessons.

Also, the way in which Amos incorporated the cultural game called Zairakaora was not challenging to the learners. Amos just mentioned the game without even asking the learners to illustrate how to play the game. This disregards how the learners benefit from doing any activities therefore contrasting Vygotsky (1978) Socio-Cultural Theory which advocates for learners' taking part in activities to enhance their understanding of mathematical concepts. When Amos incorporated cultural games in the pedagogy in a manner that was not challenging to the learners, the learners regarded incorporation of cultural activities as time wasting. Amos did not require the learners to play games nor to illustrate how the game is played because he thought he knew the rules of the cultural game when in fact he did know.

Amos like Amon was not aware of the role allocation according to sex in the game called Hwai-hwai. According to the learners the role of the hyena was reserved for the male players while the role of the mother to the female players. The dialogue part of the EIM requires that the teacher understand the cultural activity in the way the learners know it, failure of which may result in the posed problem not being solved. Amos was rigid in that he wanted to allocate the roles randomly to the entire group as had been planned before disregarding the learners' understanding of the cultural game. The learners are a cultural group that practice mathematics in their own way. By demanding that the learners practice the cultural activities the way it used to be done in his time as a young boy Amos contrasts D'Amboise (2001) who regards people of the same age group such as learners as having ethnomathematics of their own that the mathematics teacher should not ignore. When integrating ethnomathematics in the teaching of probability the mathematics teacher should incorporate the cultural activities in the way they are understood by the learners. What is important in the integration of ethnomathematics using the EIM is not just the cultural aspects but to understand how the learners practice the cultural activity outside school. Amos did not know how the learners understood the cultural game thus rendering him ineffective in integrating ethnomathematics in the teaching of probability using the EIM due to lack of cultural knowledge. His failure to cope with the cultural dynamism of the learner's culture is reflected in his statement, "*...the new generation of children are transforming the cultural games to suit their requirements."* Amos's failure to recognize the changes that took place in the cultural activity of the learner is tantamount to lack of knowledge of cultural activity. According to Vygotsky's (1968) Social Constructivism that underpin this study, culture plays important roles in both human intellectual developments. Hence, Amos's failure to understand the learners' cultural activities had a detrimental effect on the learners' understanding of the probability concepts he was teaching.

According to the EIM the cultural activities should be integrated in the probability pedagogy in the way in which they are practiced by the learners which Amos failed to do. It was noted that the moment Amos incorporated the cultural activities in a way that is different from how the learners understood it the learners started to make noise and Amos could resort back to his traditional role.

7.4.3. Messey's lack of knowledge of cultural activities

During the PAR Messey like the other two participants also showed lack of knowledge of cultural activities. When Messey was observed teaching about random events he incorporated the way the polygamist ate food from his five wives into his pedagogy. Messey did not know exactly how the cultural activity was practiced in the learner's homes. He assumed that he had enough knowledge about how the polygamists ate food from their wives. Messey was supposed to know exactly how the cultural activity is practiced by the learner outside school before incorporating them in probability pedagogy, but Messey did not know, he assumed that he knew.

During the lessons Messey's would give the learners questions to answer in groups or individually. The questions were appropriate for the level of the learners, but the cultural activity was not suitable for the probability concept that Messey intended to teach. When Messey incorporated the polygamist to teach random events the learners told him about the ways in which the polygamist concepts could be used to teach about random events which was different from how Messey incorporated it. One of the learners told Messey that the polygamist eats food from one wife per day, but Messey did not base his questions on different days rather he based them on one meal which was against the learners' understanding of polygamy. Messey ignored the learners' inputs that the questions were supposed to be based on different days and Messey maintained that the polygamist ate from all the five wives in one day. This was not consistent with what the learners observed outside school, showing that Messey lacked knowledge of the cultural activities. This confirms with Tsindoli (2019) who opined that teachers' inability to integrate indigenous knowledge in their practice might be resulting from limited knowledge of what aspect to integrate. Messey did not know that there was order which the polygamist should follow when he decided to eat food from all the wives during the same meal. If that occurred, the polygamist had to eat food from the first wife's plate first rendering the probability of eating from the first wife the second time to be zero. Learners showed that they had mastered the probability of impossible events as they argued that the probability that the polygamist ate from the second wife first was zero since they knew that the polygamist eats from the first wife first so there were no chances of him eating food from the second wife first. Messey therefore failed to integrate ethnomathematics in the teaching of random events because of lack of knowledge of cultural activities. The cultural activity that Messey selected could be used to teach about random events but the way of incorporating it should be carefully thought of.

Because Messey lacked knowledge of cultural activities he marked the answers of the learners wrong when the answers were in fact correct according to the learners understanding of the cultural activity. The learners defended their answers and practices resulting in Messey reversing his decision and marked the answers correct. When dealing with mathematics concepts emanating from cultural activities Jojo (2015) observed that learners were able to use mathematics conventions, rules and techniques to build arguments that no one could refute. This illustrates that the learners develop greater understanding when mathematics ideas are built around their cultural activities.

Lack of knowledge of cultural activities may result in the teacher marking correct answers wrong as what Messey did. However, this might happen Messey maintained the traditional role of the teacher whereby he was an authority in the classroom. A teacher facilitator does not make such a mistake because he/she puts the learners' voices in the mathematics instructions. According to Puruama (2015) a teacher facilitator gives comprehensive attention to learners' work submitted for marking. Although Messey later changed his mind and remarked on correcting the learners' work he had previously marked wrong this might have reduced the learners' confidence in him as a mathematics teacher. Messey did not find out more about the cultural practice before incorporating the activity in his pedagogy, a sign of lack of preparation for the lesson. This contracts Boutte, Kelly, and Johnson (2010) who say that mathematics teachers must engage in some form of micro-ethnographies of some sort to get information about the learners' out of school lives. Messey's apology to the learners that he did not know the practice affirmed the point that Messey lacked knowledge of the cultural activities, hence could not integrate ethnomathematics in the teaching of probability effectively. However, by publicly apologizing to the learners Messey proved to the learners that even the teacher can learn from others and that he respected the learners, and it motivated the learners to participate in the lesson.

Messey mentioned that the practice of the polygamist following a particular order when eating food from his wives was the practice of the members of the apostolic sect who lived in that area. It showed that Messey was aware that there was a section of the community which had that practice, but Messey did not regard it as a culture worth noting when integrating ethnomathematics in the teaching of probability. In this regard Messey separated religious practice from the cultural practice yet people practicing a particular religion share a common cultural practice. Hence, they have their own ethnomathematics that Messey was not supposed to ignore. Messey's failure to regard a religion group as a cultural group which practice and use ethnomathematics of its own contradicts Sunzuma, Zezekwa, Zinyeka and Chinyoke (2013) who studied religious mathematics of the Apostolic Sect of Zimbabwe and recommended their incorporation in the teaching of geometry in the school mathematics.

Lack of knowledge of the learners' cultural activities made Messey to incorporate the way the polygamist eats food from his wives in a way that did not suit the random events which he wanted to teach about. Instead of the activity being used in teaching about random events the activity revealed characteristics of certain and impossible events which Messey did not intend to teach. When integrating ethnomathematics in the teaching of mathematics, the mathematics teacher needs to understand the cultural activity from the learners' perspective. According to Nicola and Jovanovich (2011) learning of mathematics can only be approached through a culturally relevant lens if and only if the mathematics teachers can see themselves learning and seek to develop their understanding first. Messey understood the polygamist's feeding routine in a way which did not match the way the learners understood it, hence he failed to incorporate it effectively in the teaching of random events.

7.5. Trivializing probability concepts found in the cultural activities

The participants trivializing probability concepts found in cultural activities is discussed in the next section.

7.5.1. Messey's trivializing of probability concepts found in cultural activities.

In the initial interviews Messey mentioned that he found it difficult to incorporate cultural activities in the teaching of probability because school probability and probability concepts found in cultural activities do not match. Messey mentions in the initial interview that the probability concepts found in cultural activities can be incorporated in the probability pedagogy only as examples. Messey's views concurred with Mtetwa and Jaji (2006) who studied the Zimbabwean youngsters and mathematics teachers' views on ethnomathematics and concluded that secondary school teachers regarded mathematics concepts found in cultural activities as shallow. However, by mentioning that he could use cultural activities as examples meant that Messey saw some similarities between probability concepts found in cultural activities and probability concepts found in school probability. This implies that Messey's trivializing of ethnomathematics is because he did not know how to incorporate the cultural activities in teaching probability in a more effective way. Ladson-Billing's (1985) Culturally Relevant Pedagogy Theory, one of the theoretical frameworks that underpin this study does not say that the cultural concepts match the school mathematical concept, but they should be used as the starting point. Messey trivialized the probability concepts found in the cultural activities to an extent of seeing only certain and impossible events which he used as examples. Messey's failure to see probability concepts in cultural activities concurs with Rosa and Orey (2011) who say mathematical concepts in cultural activities are hidden. The teacher must mathematize the cultural activities in order to see them. Messey trivialized the probability concepts found in cultural activities and regarded incorporation of cultural activities in the teaching of probability as time wasting. Messey regarded integration of ethnomathematics in the teaching of mathematics as time wasting because he was examination oriented and was only concerned with covering the syllabus. This contradicts Ladson-Billing (1985) and Gay (2000) who say the use of culturally relevant pedagogy may enhance understanding and efficient learning resulting in higher performance of learners in mathematics. According to Tsindoli (2019) the syllabus gives the topics to be covered but how to cover is determined by the teacher to choose the approach that makes the learners understand the topic to be covered. Messey did not think that there are some probability concepts in cultural activities hence he did not use integration of ethnomathematics in the teaching of probability as a strategy to make learners understand the probability concepts better.

Messey trivialized probability concepts found in cultural activities by regarding them as non-real probability. His statement, "*…at secondary school level learners need real probability"* gives a false impression that probability concepts found in cultural activities are not real and hence failing to take probability concepts found in cultural activities seriously. Messey's failure to integrate ethnomathematics in the teaching of probability might also lead his learners to regard incorporation of cultural activities as time wasting because he failed to make connections between cultural activities and the probability concept he was teaching. Messey's views on probability concepts concurred with Alverez and Oliveraz (2014) who hint that there is an obstacle between mathematics and ethnomathematics because mathematics teachers doubted the value of ethnomathematics. Messey's view of ethnomathematics may be caused by a lack of understanding of ethnomathematics.

7.5.2. Amon's trivializing of probability concept found in cultural activities

Amon, like Messey, mentioned during the initial interview that probability concepts found in cultural activities were shallow. Amon's perception about probability concepts found in cultural activities contradicts Mpofu and Mpofu (2019) in their study to explore the mathematics embedded in the indigenous game of the Karanga people of Zimbabwe. They found some complex mathematics and probability concepts that can be incorporated in secondary school mathematics. Although the games are played by learners of primary school age mostly the mathematics inherent in the games can be incorporated in the teaching of mathematics at high school level. Therefore, Amon trivialized probability concepts found in rural Shona learners' cultural activities because he was not able to identify more complex probability concepts in cultural activities embedded in the cultural activities. The fact that Amon did not see the probability concepts in the rural Shona learner's cultural activities does not mean that there are no probability concepts but simply that Amon was not able to locate them. According to Seepe (2000) there is a challenge of locating and identifying the scientific skills, knowledge and process embedded in the cultural practice of the African majority.

During the initial interview Amon mentioned that there were some topics such as conditional probability for which it was impossible to incorporate cultural activities. Amon's view of probability concepts found in cultural activities might be caused by his failure to mathematize cultural activities. This contradicts Powel and Frankenstein (1997) who point out that ethnomathematics like academic mathematics is stratified, there is both simple and complex mathematics. Also, Amon was expecting to find refined probability concepts in cultural activities which automatically fit in the school probability concepts. This understanding of ethnomathematics contradicts Borba (1990) who points out that mathematical concepts found in cultural mathematics are hidden. There are no way probability concepts found in cultural activities can exactly fit in the school mathematics because the two-school mathematics and ethnomathematics were developed by different cultures and hence they are practiced differently. Expecting probability concepts which fit exactly in conventional probability concepts also contradicts Cimen (2014) who pointed out that different cultures use different symbolism to express their mathematical ideas.

7.5.3. Amos trivializing probability concepts found in cultural activities

Amos like the other two participants Messey and Amon trivialized cultural activities when he mentioned that probability concepts found in cultural activities are too simple, they cannot fit into advanced probability concepts such as conditional probability. Amos's view of cultural activities also concurs with Tsindoli (2019) in his study to explore the integration of indigenous knowledge in teaching of mathematical concepts in primary schools in Kenya found that mathematics teachers undervalue the effectiveness of indigenous knowledge in teaching. However, Amos's view contrasts Nyaumwe (2006) who studied the geometric concepts on the construction of the Great Zimbabwe monument and found that there are some geometric concepts which most of the secondary school learners may find to be very difficult. Cultural activities therefore consist of both simple and complex mathematical concepts; however these concepts are not bare for everyone to see. Although the EIM can help mathematics teachers to integrate ethnomathematics in the teaching of probability the mathematics teacher should have the skills to extract probability concepts from cultural activities, a skill which was found lacking in Amos.

Amos was expecting to find formulas in cultural activities like those found in school probability concepts when he said, "… *cultural activities do not have procedures for solving probability problems such as probability tree diagrams.*" In this statement Amos failed to realize that the probability concepts found in cultural activities are not meant to do probability but to solve real life problems that people encounter daily. By expecting to find probability formulas like those found in school probability Amos contradicts Borba (1990) who says that school mathematics is different from ethnomathematics in that school mathematics is done for its own sake whereas ethnomathematics is problem solving oriented, and it is linked to the problems that was encountered by the cultural group in the past. Probability found in cultural activities like those found in school mathematics originated from different cultures, hence they use different tools, but the probability concepts are the same. Formulas and probability trees diagram that Amos mentioned are tools used in conventional mathematics, probability concepts found in ethnomathematics of different cultures have their own way of solving problems which are different although formulas and the probability trees can be applied to ethnomathematics. Amon contradicts Rosa and Orey (2008) who state that different cultures use different techniques in solving their problems. Amos's failure to identify techniques and procedures used to solve probability problems in cultural activities may be due to lack of probability subject matter knowledge as has been revealed before. According to Madusise and Mwakapenda (2015) successful integration of ethnomathematics requires sufficient and appropriate mathematical content knowledge, inadequate content knowledge is a hindrance to reading and comprehending cultural activities. The EIM assumes that the mathematics teacher can identify probability concepts in cultural activities for them to be able to identify relevant cultural problems to pose. Therefore, by trivialising probability concepts in cultural activities Amos could not come up with relevant cultural problems.

7.6 Failure to make connections

When the participants were implementing the EIM participants were able to identify suitable cultural activities to incorporate for the concepts they intended to teach about. However, at times participants could fail to make connections. Some of the reasons why the participants failed to make connections are discussed in this section.

7.6.1 Underutilization of the incorporated cultural activity

Based on the data presented in chapter six the participants were found to be underutilizing the cultural activities which were found to be suitable for teaching the concepts. In those cases, the participants failed to make the desired connections between the selected cultural activity and the conventional probability. This resulted in the learners failing to see the reason why the cultural activities were incorporated resulting in the learners becoming confused. The participants were able to pose relevant problems as required by the EIM and the learners were motivated to solve the problem to the satisfaction of the participants. However, the participants would abruptly drop the cultural activities for the worked examples and questions found in the learners' textbooks. In other words, they broke the cycle of the EIM resulting in learners failing to benefit from the integration of ethnomathematics in the teaching of probability. In the following section I present how Amon and Amos underutilized the cultural activities that had been identified to be suitable for teaching the probability concepts. Messey did not show elements of underutilization of cultural activities.

7.6.2 Amon's underutilization of cultural activities.

During the PAR when Amon was observed introducing probability, he asked the learners to identify examples of impossible events and certain events. The learners gave very good examples of the activities to that effect. Amon without saying anything about the cultural activities that the learners had identified went on to tell the learners about the probability values of impossible events and certain events that they are zero and one respectively. Amon did not explain to the learners how the numerical values were arrived at using the cultural activities that had been identified by the learners. In this regard Amon failed to implement the EIM; he managed to identify the suitable cultural events and posed the relevant but failed to manage the dialogue that could enable him to incorporate the learners' conception to develop the lesson based on learners' inputs. According to the EIM the lesson development should be based on the inputs of the learners which Amon failed to do. In that process Amon would be showing the learners how the cultural activity is connected to school mathematics. Failure to show how the cultural activities were connected to the probability values was a typical example of underutilization of the cultural activities. The example which Amon later used which was based on drawing balls of different colours from the bag was neither an impossible event nor a certain event which Amos had asked from the learners before, but it is a probabilistic event whose probability lies between zero and one. Hence Amon abandoned the cultural activities the learners had identified completely without utilizing them showing that he failed to make the desired connections.

The confusion that was caused to the learners by Amon's failure to utilise the feedback from the learners was evident in one of the learner's questions asked in a mixture of vernacular language and English, "*Saka tinoshandisa sei one nazero yamataura kuti tiburise answer yacho one fifth?*" [How do we use one and zero you have mentioned to get one-fifth?] This was with reference to the probability of drawing a green ball which was one-fifth. In the analysis of this learners' question, Amon confused the learners by prematurely dropping the cultural activities that the learners had identified. The learners were looking forward to the utilization of the cultural activities they have identified to help them to generate the answers to the question, but Amon had changed to probabilistic events a new concept to the learners altogether. The learners could not understand the probability of certain events and impossible events when Amon mixed them with probabilistic events and certain events. It was noted that failure to utilize the cultural activities led to a disjoint lesson in which the learners could not follow what the teacher was teaching about. What Amon did concur with Jameel and Ali (2016) who assert that the methods teachers use do not help learners to develop conceptual understanding of mathematics. Amon failed to implement the EIM required because he did not go beyond the problem posing stage of the model. By failing to consider the learners' input during the lesson Amon used the teacher centred approach. Teacher centred approach when used in mathematics results in learners memorizing the procedures of how to get the correct answer without fully understanding the concept. What Amon did concur with D'Ambrosio (1985) who points out that mathematics taught in the traditional classroom is taught as though mathematics is about the rules and procedures to be followed without making any connection to the learners' experiences. The cause of Amon's failure to utilize cultural activities may be because Amon lacked training in incorporation of cultural activities in the teaching of mathematics. The time Amon trained as a teacher, teachers' colleges in Zimbabwe were not training mathematics teachers in integration of ethnomathematics in the teaching of mathematics. Although the OL Mathematics syllabus states that mathematics should be taught in context, this aspect seems neglected by teachers' training colleges since graduates of teachers' colleges struggle to incorporate cultural activities in the teaching of mathematics. This concurs with Tsindoli (2019) who found that teacher preparation in teachers' college does not incorporate indigenous knowledge in the mathematics curriculum. Also, Sunzuma (2018) says that the mathematics teachers who participated in her study on the teachers' preparedness to incorporate ethnomathematics approach to geometry teaching reported that their previous college courses did not include teaching integration of ethnomathematics. Therefore, Amon's underutilization of the cultural activities was likely caused by the fact that he was not equipped with skills to incorporate cultural activities in the pedagogy. Under such situations Amon might not have a clear understanding of the purpose the cultural activity was supposed to serve during the lesson.

7.6.3 Amos's underutilization of cultural activities

Amos also failed to effectively utilize the cultural activity he had incorporated when he was observed teaching about independent events. In that lesson Amos asked the learners to demonstrate how the game called Chuti was played. The learners demonstrated how the game is played and they showed a lot of interest in the lesson, Amos did not fully utilize the cultural game to the learners' expectations. Amos rushed to tell the learners that the player to be eliminated next was independent of the player who had been eliminated before. Amos like Amon assumed his traditional role of the teacher. Instead of guiding the learners to find out whether it was important to know the person who has been eliminated before in order to know who is going to be eliminated from the game next, In this case, Amos did not implement the EIM properly leading to the failure of the lesson because he relinquished his role as a facilitator and became an authority in the classroom going against the Socio-Cultural Theory and the Social Constructivism Theory that underpinned the development of the EIM Amos like Amon did not go beyond the problem posing stage of the EIM and indication of failure to implement the EIM. Amos told the learners about the nature of independent events and went on to use the worked example in the learners' textbook to illustrate how to calculate the probability of independent events. This concurs with Cheung, Lan, Siu, and Wong (1986) who point out that in the teaching of probability mathematics teachers put more emphasis on computational techniques at the expense of conceptual understanding. Instead of developing the concept of independent probability in the learners, Amos got interested in calculations showing the learners how to calculate the probability of independent events. The EIM give precedence to conceptual understanding through sharing of ideas amongst the learners working in groups or in pairs. This is consistent with Akpan, Igwe, Mpamah, and Okoro (2020) say the social constructivist see knowledge as what learners do in collaboration with other learners, teacher or peers.

Amos diverted from the lesson plan, and this resulted in the learners failing to understand why the game was introduced and how it was connected to independent events. According to the lesson plan Amos was supposed to ask one learner to leave the class while the others were playing the game. While he/she was out there he/she would be told that one of the learners say Chido has been eliminated from the game and he/she was supposed to predict the next player to be eliminated.

This could continue with different learners going out until the learners could realise that knowing the player who had been eliminated does not help them to predict the next player to be eliminated.

The cultural game was suitable to teach about independent events. Incorporating games to teach probability concepts is plausible, children enjoy playing games. This concurred with Fauze and Amit (2017) who studied the games played by the Negev Bedouin people of Israel and explained how the game helped the learners to understand mathematics concepts better. However, Amos did not make the learners see how the game was connected to the school mathematics, it may be one of the reasons why learners sometimes regard integration of cultural activities in the teaching of mathematics as time wasting. Amos's learners might regard integration of cultural activities as time wasting because Amos spent a lot of time on the cultural activity but failed to make connections between the cultural activity and school mathematics. Amos was supposed to ensure that the incorporation of the game helped the learners to see the connection between the cultural activity and school probability. According to the EIM such connection is made when the learners are solving the posed problem or during class discussion. Some learners who may not see the connection out right can be assisted by other learners or the teacher which concurs with Hein (1991) who points out that according to the social constructivist the level of potential academic achievement is the level of development that the learner can reach in collaboration with peers. When using the EIM the learners can visualise and develop insight on the connection between cultural activity that has been incorporated and the conventional probability during the problem-solving stage when the learners work in groups or when being guided by the teacher during dialogue stage.

In that lesson Amos failed to utilize the cultural game leading to the learners failing to see the connection between the game and the questions based on drawing cards from pack of playing cards that Amos later assigned the learners. The questions from one of the learners during the lesson in vernacular language "*Saka mazita evanhu vanotamba vacho tinomashandisa sei kuti tiburise anza yacho?*" which translates to "*How do we use the name of the players to get the answer*?" The environment in the class was sombre because the learners did not see any connection between playing cards and the game called Chuti. In Shona culture playing cards are associated with gambling hence many learners were not familiar with the names of cards in the pack of playing cards. The learners had challenges with the questions which were based on the playing cards. This concurs with Cheung et al (1996) who point out that in the teaching of probability too many examples given are related to gambling giving the learners a lopsided impression of the subject. Although there are some worked examples in the learners' textbooks based on coins, dice and playing cards the teachers should use them cautiously because they may be associated with bad things in some cultures, hence this may put the learners off. This was evident to show that Amos had underutilized the cultural game and the learners were not clear on how the cultural game was linked to the work assigned to them which involved playing cards. The probability problems which Amos assigned to the learners which were based on drawing cards from a pack of playing cards did not make sense to the learners. Generally, the question did not make sense to the learners because there was no reason why the cards were to be drawn from the pack of cards. This was contrary to the way mathematics is practiced outside school. This concurs with Chikodzi and Nyota (2010) who say the rural learners' situation is worsened by the textbooks that teachers use which do not have tasks that deal with the learners' out-of-school mathematical experiences. According to the EIM, the learners can be given questions from the textbook when they have understood and master the probability concepts to apply their knowledge, the final stage of the EIM.

By dropping the cultural game before fully utilizing it and resorting to the use of formula demotivated the learners, because the problems were far detached from learners' real-life situation where mathematical problems are linked to solving authentic problems. Amos had problems that had been developed from the cultural game but did not assign them to the learners he told the learners to go and look at them as homework. Amos did not use the formula to solve the problem emanating from the cultural game. The reason why Amos did not solve the problems developed from the culture using the formula might be that he depended more on worked examples in the textbook and the answers from the teachers' guide. It shows that Amos lacked confidence in solving probability questions without answers. By failing to apply the formula to the problems emanating from the cultural game Amos failed to make the learners see how the mathematics formulas are connected to the cultural activity, of the most important aspect of the EIM.

7.7 Cultural incompetence

One of the purposes of integrating ethnomathematics in the teaching of probability in this study was to ensure that learners of diverse cultures coexisted in the mathematics classroom. However, the data presented in this this study revealed that at some point the participants were culturally incompetent; they did not promote that coexistence of learners with diverse cultures in their classes.

7.7.1 Amon's cultural incompetence

Amon revealed cultural incompetence during the initial interview. Amon mentioned that he did not manage cultural diversity in his mathematics class because of the way he incorporated cultural activities in his lessons which he said did not necessitate catering for cultural diversity. Amon believed when cultural activities are incorporated as examples there was no need to manage cultural diversity in the mathematics classroom. His statement, "*I first teach the concepts for* *learners to understand the concepts then I can give examples of how those concepts are used in the learners' daily lives.*" Amon tried to justify his cultural incompetence by arguing that when the cultural activities are used as examples in a probability lesson there is no need for managing cultural diversity. How Amon first teaches the learners to understand without connecting to the learners' out-of-school mathematics experience is not surprising that he concentrates on mathematical procedures to get correct answers. This approach of teaching mathematics agrees with Kline (1990) who points out that despite the advantages emanating from integrating ethnomathematics the situation in the mathematics classroom puts more emphasis on procedures and number operation without giving reasons why those operations are necessary.

Also, Amon's understanding of teaching from the known to unknown revealed his high level of cultural incompetence. Amon's understanding of what is known by the learners is hinged on the way he presented the mathematics for presentation to the learners. According to Amon, what the learners know begin with the knowledge that the learners are taught at school. Amon's understanding of teaching from the known to unknown as revealed in the initial interview shaded more light on the source of his cultural incompetence. Amon understood teaching from the known to be based on the order in which the topics should be presented to the learners. In Amon's statement, "*I cannot teach probability before I teach about addition and multiplication of fractions,"* The arrangement of topics in chronological order is very noble. There are topics that are supposed to be taught before the others to promote the learners' understanding of the concepts. However, Amon disregarded the probability knowledge that the learners learn outside school, failing to make connections between the probability knowledge that the learners learn outside school with school probability concepts. Amon regarded only what the learners have been taught at school as what is known by the learners. Amon disregarded the experiences that the learners brought to school is contrary to Garfield and Ahgren (1988) who found that before learners go to school, they already have developed some probability concepts although these ideas may be spontaneous. Therefore, Amon's failure to take cognisance of the learners' probability spontaneous ideas into consideration in deciding the learners' known knowledge for lesson planning purpose is tantamount to negligence on his part.

Amon also showed that he was culturally incompetent when he was observed teaching about random events. The problem that Amos had developed involved the learners finding how the polygamist could eat food from his wives so that none of his wives could complain of favouritism. Disregarding that the learners told Amon that the event was not random because there was order to be followed, and that the polygamist does not eat food from all his wives he ate from one per day Amon insisted that the event was random and went ahead to give the learners the question which he assumed that the polygamist ate from all his wives every time. By telling Amos that in their families their fathers who are polygamist did it differently the learners showed that they had different family cultures which Amon was not supposed to ignore. Amon ignored all the cultural aspects given by learners showing that he was culturally incompetent, and he had challenges in integrating ethnomathematics in the teaching of probability. What Amon did was consistent with Shirley (1988) who lamented school mathematics lessons for giving an impression that there is only one way to perform a given task.

7.7.2 Amos's cultural incompetence

The data presented in this study revealed some instances in which Amos showed some elements of cultural incompetence. One of measure of cultural incompetence which Amos showed during the initial interview and in lesson observation was failure to manage cultural diversity in his class. Amos's *statement "I do not pay attention to cultural diversity in my class when teaching* *probability because probability taught at school is designed to suit all cultures."* Amos was of the opinion that probability concepts taught at school were meant to suit learners of all cultures, hence there was no need to manage cultural diversity. Amos's understanding of probability is contrasts Borba (1990) who points out that different cultures mathematize differently.

Amos also mentioned that the way he integrated cultural activities in the teaching of probability did not demand that he paid attention to cultural differences in his class. He did not use cultural activities to develop probability concepts but just used cultural activities just for learners to see that some of the probability concepts are also found in cultural activities. Amos's statement that, *"I only use cultural activities to spice up my lesson hence there is no need to manage cultural diversity…"* is evident enough to show that Amos lacked understanding of the impact of managing cultural difference amongst the learners in the mathematics class. Whatever way the cultural activities are integrated the Amos should show cultural competence by managing cultural diversity because the learners already know those concepts but in a unique way. There is no justification for failing to consider the cultural difference of the learners in the mathematics class because already the learners come from different families and hence use cultural activities in different ways. No matter how Amos incorporated cultural activities in his probability pedagogy the purpose is to connect the learners' out of school probability practice and school probability, and this demands that he shows cultural competence by putting into consideration the learners' cultural differences.

Amos also showed cultural incompetence in his understanding of teaching from the known to unknown. Amos's understanding of what is known by the learners is only limited to the knowledge that the learner had been taught at school. Therefore, Amos does not put into consideration the informal knowledge that the learner brings to school. In his statement, "*By checking on the syllabus* *to see the topics that have been covered I can assume what the learners know*…" This understanding of what is known by the learners does not put into consideration the probability knowledge that the learners bring into the mathematics classroom. Amos's understanding of teaching from the known to unknown contracts Bishop (1994) who asserts that ignoring the learners' out-of-school mathematics practice leads to learners experiencing dissonance arising from the cultural difference between cultural tradition represented outside the school and the culture represented inside the school. Failure to recognize the learners' out-of-school probability concepts may confuses the learners in that they may not know whether the knowledge they gain outside the school is required in the mathematics classroom. By ignoring the learners' out-of-school probability concepts Amos failed to make connections between school and the learners' cultural experience, hence the failing to integrate ethnomathematics in the teaching of mathematics. Amos also showed some elements of cultural incompetence when he was observed teaching about random events using sowing of pumpkin seeds. According to the learners' understanding of germination of pumpkin seeds they do not germinate randomly; it depends on who had sown the seeds. The learners believe that their germination depends on the luck of the person who sowed them. However, Amos ignored the learners' beliefs and went on to use the germination of pumpkin seeds as a random event ignoring the learners understanding of the concepts. The inclusion of statement such a 'lucky sower" or "unlucky sower" should be included in questions to determine the degree of randomness of germination. In Amos's statement, *"They do not know which seed germinates the seeds germinate randomly*" Amos was openly contradicting the learners' belief about the germination of seed, showing that Amos was culturally incompetent by setting aside the learners understanding of the cultural activity and went on to impose randomness on the activity. What Amos did contracts Gay (2010) who advocates for a pedagogy that uses the learners' cultural knowledge and their prior experience as the frame of reference of teaching the learners. Again, Amos was side-lining the learners' reality in contradiction to Bartolome (1994) who advocated for humanizing the pedagogy so that it uses the reality and the perspective of the learners. Failing to incorporate the cultural activity in the way it is understood by the learners outside school is therefore an element of cultural incompetence.

7.7.3 Messey's cultural incompetence

During the initial interview Messey indicated that he did not understand the reason for integrating ethnomathematics in the teaching of probability and hence did not see any reason for managing cultural diversity in his mathematics classroom. Messey believed cultural activities can only be integrated in mathematics class where there is cultural homogeneity hence in a class with cultural diversity there is impossible to integrate ethnomathematics and hence no need for management of cultural diversity. Messey is of the opinion that it is not possible to cater for cultural diversity where there are several different cultures in the mathematics classroom. Messey's view concurs with Byrd (2016) who posts that culturally relevant pedagogy is only possible in a monoculture mathematics classroom. However, Messey' understanding of why ethnomathematics should not be integrated in the teaching of probability is contrary to D'Ambrosio (1990) who affirms that the role of integrating ethnomathematics is to cater for cultural diversity in the mathematics classroom. The integration of ethnomathematics therefore demands that the teacher manage cultural diversity in the mathematics classroom. The EIM is designed in such a way that it can be implemented in a mathematics classroom with learners with diverse cultural backgrounds

Although Messey like the other two participants could manage to identify the suitable cultural activities such as agricultural activities and cultural games to incorporate in the teaching of probability one of Messey's major shortfalls was failure to consider the learners' differentiated cultural viewpoints on those cultural activities. Instead of using the learners' understanding of the cultural activities, Messey entered the class with his own perspectives of the cultural activities which he imposed on the learners. As a result, he could not effectively implement the EIM because the model is based on the learners' inputs that arise from the teachers facilitating the learning not in a classroom where the teachers dictate what the learners should know.

In the lesson when Messey was observed teaching about independent events Messey incorporated the game called Zairakaora. Messey intended to illustrate that the way in which the participants in that game could be eliminated from the game was an independent event in which the one who is eliminated now did not affect who was going to be eliminated next. Messey's understanding of the game was different from the learners' understanding. According to the learners' understanding of the game the way in which the players are made 'zairakaora' is not independent because the one moving around with the object targets some certain individuals whom he wants to eliminate from the game earlier than others. In fact, the order in which the players were eliminated is predictable with some certain degrees of accuracy. Also, there is sometimes an element of cheating in that the person moving around with the object may lie that he had dropped the object behind the person when he had not but only wanted to victimize that player. Messey did not put into consideration vindictiveness on the part of the person moving around with the object in that game and all these factors that affected independence as articulated by the learners and went on to declare that the events were independent. The fact that Messey failed to consider the learners inputs it implies that he did not make connections between the cultural activities and the probability concepts he intended to teach. Messey's statement during dialogue with the learners is evidence enough to show that Messey was culturally incompetent, "…*assuming that there is no bias...*" In this statement Messey was indirectly acknowledging that some of the characteristics of the game did not suit the intended purpose for this lesson but he still wanted to use it.

By creating an assumption on culture Messey did not only violate the implementation of the EIM but he defeats the whole purpose of incorporation of cultural activities in the teaching of mathematics. Applying assumptions to incorporate on posing problem based on cultural activities removed the problem from the context of the learners and makes the problem a pseudo problem that the learners may not be interested to solve. Messey's assumption disconnected the probability concepts from the way the learners experienced them outside school. This concurs with (D'Ambrosio, 1985; Bishop, 1988; Madusise, 2014) who castigated mathematics teachers concentrating on rules and procedures without making connection to the learners' real-life situation. The disconnection of the cultural activity from the learners' context which Messey did demotivated the learners as observed in that lesson, the learners started to make random movements in the class, and some even excused themselves to go to the toilet.

Creation of an assumption on cultural activities as happened in Messey's class was an indicator that the teacher did not put the learners' pre-instruction cultural perceptions in developing the lesson hence the concepts became abstract. The learners struggle to understand the concepts because the concepts were unlike what they witness in their daily lives. This also meant that the teacher-learner dialogue had collapsed, and the teacher had switched back to their traditional roles of being the knower which contradicted the EIM. The tasks that were given to the learners after creation of assumption no longer reflected the learners' cultural characteristics, hence there was no more connection between cultural activities of the learners and the probability concepts that

Messey was teaching. The making of assumptions on the cultural activities is in contrast to Matthew (2008) who said for the teacher to make connections between mathematics and the learners' culture the mathematics teacher should design tasks from which the learners can read cultural information. If the learners could not read the cultural information, then the Messey is failing to implement the EIM to integrate ethnomathematics in the pedagogy.

7.8 The change

The data presented in this study showed that there was change in the ability of the three participants to integrate ethnomathematics in the teaching of probability. This change was evident in the lesson observation when the participants were making corrections to the lesson which they found that they had not properly implemented the EIM and those lessons they did the right thing the first time. The change in the participants was also revealed in the final interview and the final reflection. The aspects in which the participants' indicated changes are discussed in the following sections

7.8. Mathematizing and problematizing cultural activities

The three participants had improved in their ability to mathematize the cultural activities and incorporated them in probability pedagogy. This led to the improvement in implementing the EIM which in turn impacted positively on the learners' performance. In the following section I discuss the changes that took place in the three participants because of taking part in the implementation of the EIM.

7.8.1. Amon's change in mathematizing and problematizing of cultural activities

Amon showed improvement in his ability to mathematize the cultural activities when he was observed teaching about probabilistic events. He mathematized the way the Shona people predicted the coming of the rains and problematized the unpredictability of the coming of adequate rainfall during the rainy season. Through mathematizing waiting for the rains in the Shona culture, Amon managed to make the learners understand what probability events were. In this regard Amon managed to identify the suitable cultural activity and came up with relevant problem that he posed for the learners to solve in line with the EIM. When mathematizing the cultural activities Amon in most cases put the learners in groups in which they mathematize the cultural activities on their own and give examples of probability events found in their culture and the learners did that precisely. Putting learners in groups complies with the constructivism that views learners' interaction, collaboration and group work as meaningful learning. This also concurs with Zubaidi (2015) who points out that collaborative learning creates a sense of a community in which the learners can be moved from Vygotsky's (1978) guided learning to independent learning. Thus, the learners could help each other to come up with probability events and finally they could do it on their own without assistance. Amon's ability to lead the learners to jointly mathematize the cultural activity meant that he had also improved in managing teacher-learner dialogue one of the milestones elements of EIM.

The learners were motivated during the lessons, and they participated very well in solving the problem since they were familiar with the activity that were being mathematized and incorporated into the pedagogy. In their mathematizing the learners came up with a number of cultural aspects used by the Shona people to predict the coming of the rains such as the blooming of muswati tree flowers, the appearance of large numbers of ground hornbills and swallows in the beginning of summer season, and the abundance of mazhanje fruits in that particular year is a regarded as a sign of poor rainfall season that year The learners could reflect on their understanding of probability understanding when they were asked whether these predictions are always correct. According to the EIM learners can be made to reflect on their understanding of probability concepts by being asked questions as Amon did. The learners also reflected on their understanding of probability concepts through talking to each other as they solved the problem which resulted in them being able to differentiate probabilistic events from other form of events.

Amon allowed the learners to use vernacular language during their group discussion because he did not want them to be disadvantaged when expressing their ideas in English which they were not fluent in. The use of vernacular language during mathematics lesson concurs with Chikodzi and Nyota (2010) who observe that rural secondary school learners are further disadvantaged using English as a medium of instruction. Amon had developed the skill to question the learners very skilfully to elicit responses from the learners. After the learners had presented their probabilistic events Amon singled out germination of seeds and asked that:

Amon: *How does your mother improve the chance of germination for her pumpkin seeds at home?*

This type of question required each of the learners to explain the methods that they use at their homes. It is not a general question; it is loaded to unveil each individual learners' family culture. This concurred with Matthew, Jones, and Parker (2013) who say that at times it is necessary for the pedagogy to be culturally specific. According to Matthew, Jones, and Parker (2013) a pedagogy becomes culturally specific when the teacher deals with cultural variables as they apply to a specific group of learners. In response to Amon's question the learners gave different approaches that they used in their families which were unique. The learners were motivated to show the superiority of their methods of increasing the probability of the seeds to germinate. Every learner was able to show that their home had a unique approach of improving the probability of seeds germination hence their unique family ethnomathematics. Apart from improving the learners' performance in probability Amon's question required the learners to apply probability knowledge to improve their practices of seeds sowing outside school as required by the EIM.

Through Mathematization Amos managed to make connections between cultural probability concepts and conventional probability concepts. In doing that Amon did not take mathematizing cultural activities as his sole responsibility but he involved the learners so that together they could come up with probability knowledge. This concurs with the social constructivism where the role of the teacher is to elicit to understand the learners' pre-instruction knowledge and help them to create new knowledge and make connections to their existing knowledge. Through improved mathematizing brought about by the implementation of the EIM, Amon had improved in his command of the subject. This was revealed by the confidence he was showing in responding to learners' questions; hence his preparedness for the lessons, and the effective implementation of the EIM. Generally, a teacher usually shows seriousness for his work by preparing for work thoroughly. Amon developed the lesson based on the learners' input and his understanding of probability concepts found in cultural activities now seemed to be at par with that of the learners. Amon also changed in the manner he was treating his learners. He started to treat his learners as adults who were capable of thinking on their own. Amos gave them chances to articulate their own cultural probability ideas. This was in line with the social constructivism that advocates for the teacher to facilitate learning in the mathematics classroom. When the EIM is implemented properly the teacher develop respect for the learners because the lesson is developed based on dialogue. Amos showed his skills of mathematizing cultural activities by the following:

- Generating relevant cultural probability problem
- Problematizing cultural activities by developing content questions from cultural activities.
- Guiding learners to reflect on their probability understanding through questioning them
- Guiding the learners to apply probability knowledge to improve their ethnomathematics.

When Amos was asked during the post-lesson interview why he no longer use the learners' textbooks for examples and questions, his response was:

"Questions from the textbooks ask about things that the learners are not familiar with. I use them when I want the learners to apply knowledge. I found that by giving the learners questions from the textbook I will be requiring learners to apply the knowledge they have not yet acquired. The learners should first understand the concepts in their context from cultural experience. Textbook questions are not in the learners' context."

Amon's response shows that he has changed; he realised that learning of probability can only be effective when it is in context. However, such confidence in ethnomathematics can only manifest itself when a teacher can mathematize cultural activities effectively. The use of the EIM helped Amon to mathematize cultural activities helped him on how to integrate the ethnomathematics in the teaching of probability. When the learners gave the answers of the probability that it rained as half-half Amos accepted the answers as correct because he realised that from the learners' cultural activities it meant the probability was between impossibility and certainty. This understanding of probabilistic is consistent with the conventional understanding of the same concept. Amon developed very good questions based on the germination of pumpkin seeds which he gave to the learners as written work showing his capacity to mathematize and problematize cultural activities had changed. Amon was satisfied by the way the EIM has guided him to integrate ethnomathematics in the teaching of probability and how the learners were motivated when this framework was used.

7.8.2. Amos's change in mathematizing and problematizing of cultural activities

Amos like Amon revealed changes in ability to mathematize and problematize the cultural activities during the lesson observation. Of note was Amos's ability to select suitable cultural activities to incorporate in his probability pedagogy. In one of the lessons in which Amos showed changes in mathematization skills was when he was observed teaching about probability without replacement using a cultural game called Hwai-hwai. The use of cultural games in teaching mathematics concurred with Powel and Temple (2001) who said that the use of cultural games in teaching mathematics makes the learners develop skills in mathematics investigation such as arrangement, probability, and chance. Therefore, the game was a suitable cultural activity for the EIM since the first stage of the framework is to identify a suitable cultural activity for the concept that the teacher wants to teach.

In that lesson Amos mathematized the game called Hwai-hwai and came up with a relevant problem as introduction to the lesson. Unlike at the beginning of implementing the EIM when Amos could use the cultural activities just as examples during the lesson, Amos used the cultural game as the source of the problem and as an introduction to his lesson. In trying to solve the relevant problem that had been posed by Amos the learners brought in another cultural activity called Mapuza which the learners used to select players to fill roles to be played by each player randomly. Through proper guidance the learners also showed their ability to mathematize the cultural activities as they illustrated how to solve the problem of role allocation in that game Hwai-hwai which had been posed by Amos. During integration of ethnomathematics in the teaching of mathematics, using the EIM framework, mathematizing cultural activities are not the sole responsibility of the teacher but it is shared with the learners so that the teacher and the learners co-create probability knowledge together. The sharing of mathematization of cultural activities with the learners in solving probability problems concurs with McLeod (2004) who says that under social constructionism knowledge is socially constructed through participation as members of a given social group. In this regard Amos and the learners constructed probability knowledge together. The mathematizing stage of the EIM stimulated the exchange of ideas which resulted in active learners' participation during that lesson.

Amos and his learners revealed high levels of mathematizing cultural activities capability when they dealt concurrently with two cultural activities, the game called Hwai-hwai and a cultural activity called Mapuza which the learners roped in to explain how the role players of Hwai-hwai are selected randomly. Amos had not planned for Mapuza but he quickly adjusted and mathematized and problematized the cultural activity called Mapuza and developed the questions that he assigned to the learners to solve. Amos showed changed mathematization skills when he identified the learner's misconception on mathematizing mapuza which Amos resolved by explaining to the learners through mathematizing the cultural activity with the learners.

The misconceptions which Amos resolved through his improved skills of mathematizing are:

- If there are six players and the winner of mapuza is one who picks the cut leaf then if there are seven leaves to pick from, the probability that one of them wins were determined by the turn of picking leaf, whether the person picks the leaf first or second etc.

- The person who picks first has a higher chance of losing than the one who picks next

Amos managed to illustrate to the learners how they were wrongly mathematizing the cultural activity. Amos even roped in another game played by the Shona children which is called “manangetange” (one who comes first wins the game in which.) to explain how they were wrong and the learners' lapped hands for him. Amos helped the learners to reflect on their probability concepts because Amos could use different strategies to explain the same concepts for learners to understand. This showed that Amos was fully prepared for the lessons. Amos also successfully mathematized Mapuza to show the learners that if there is no replacement the person who picks the leaf next has higher chances of winning than the one who picks before them by virtue of denominator of the fraction being reduced by one each time one withdraws a leaf. Because the learners had understood the concept about randomness, they performed well in the applications questions which were taken from the learners’ textbooks

7.8.3 Messey’s change in mathematizing and problematizing cultural activities

Messey, like the other two participants, showed improvements in mathematizing and problematizing of cultural activities at the end of implementing the EIM. Messey’s understanding of cultural activities had also improved notably. Messey posed very relevant problems which motivated the learners to participate in the lesson. In mathematizing cultural activities Messey could create culturally specific problems which were meant specifically for every learner in his class. Messey mathematized the cultural activities by asking questions which prompted every learner to think about the cultural activities and come up with their probability truth. He could ask culturally specific questions. For example, when he was teaching probability of mutually exclusive events posed the following problem, Messey*: How do you determine who is responsible for what in your family?*

According to the EIM follow up questions to the posed problem the teacher should touches all the learners in the class. This type of a question required that each learner responded on his/her own because each learner's family determines the family members' roles differently in unique ways. This type of questioning concurs with Akpan et al (2020) who point out that social constructivism advocates for teaching strategies that consider the learners opinion or contribution as important whether right or wrong. This question recognizes that the learners do not start at the same point in building probability concepts. Messey made sure each learner responded and used the learners' responses to guide the learners to go to the higher level of mathematizing probability concepts. This concurs with Gergen and Gergen (2003) who say that Social Constructivists do not have problem with locally claimed realities as they are anticipated and honoured. To ensure that the learners were fully engaged in the mathematizing of the cultural activities Messey put the learners in groups which would give feedback to the class the result of their mathematizing as required by the EIM. This also concurs with Amineh and Asl (2015) who affirms that social constructivists are of the opinion that meaningful learning occurs when individuals are engaged in social activities and collaborating with each other. In these groups the learners could share ideas in vernacular language since Messey knew that the learners could not put across their arguments clearly in English although Messey could help the learners to use conventional mathematics language in their exercise books. According to the requirement of the EIM the learners should mathematize freely without being obstructed by the language which concurs with Vygotsky's (1968) social constructivist who sees language and culture as important for intellectual development.

Messey shared mathematization of the learners' domestic chore such as herding cattle, fetching firewood, and babysitting the siblings. Through collaborative mathematizing to activities the learners managed to come up with mutually exclusive events which Messey used to develop the probability questions which the learners answered during the lesson. Under Messey's guidance the learners came up with the Venn Diagrams showing mutually exclusive events. The learners in further mathematizing of the cultural activities under Messey's guidance became critical of their cultural activities. This concurs with Rosa and Orey (2011) who affirm that teaching mathematics through cultural relevance and personal experience help the learners to know more about reality, culture, and the society. It was through improved mathematizing of cultural activities that in several times the learners reflected on their probability knowledge and became critical of mutually exclusiveness of cultural gender roles due to cultural dynamics. For example, lack of clear-cut gender roles leading to the questioning of the mutually exclusiveness of the roles. Such critical analysis of events was evident when one of the learners pointed out, "*We can say that for the sake of doing mathematics.*" This statement shows that this learner had reflected on their knowledge of mutually exclusive gender roles and seen how they were affected by cultural dynamism. According to the EIM, reflection is one of the pillars of the framework which the mathematics teacher should make sure it takes place in the process of mathematics. Messey afforded learners chances to present their ideas on the chalkboard to share their ideas and challenge each other to arrive at a consensus. This enabled the learners to develop reflective thinking as they talked and thought about what they were doing. Messey's improved skills in mathematizing and problematizing the cultural activities was evident by his shift from using cultural activities only as an example to using the cultural activities to develop probability problems and the questions that the learners were required to solve during the lesson. When Messey gave the learners problems from the textbook their performance was very good. Showing the learners were able to apply their probability knowledge.

Messey also showed improved mathematizing of the cultural activities, when he used mice trapping to derive range of probability values, a shift from his previous position when these values were just dictated to learners as rules for the learners to memorize. Messey through mathematizing mice trapping activities helped learners to conceptualize the probability of zero, one and explained the values in between. Messey’s improved ability to mathematize the cultural activities led him to break the barrier that was preventing him from integrating ethnomathematics in the teaching of probability effectively. The existence of barriers could make Messey think that there were some school probability concepts in which cultural activities could not be found.

Guided by the EIM Messey could mathematize cultural activities and see how the cultural activities could be incorporated in the probability concept in the mathematics classroom. For example, Messey together with the learners mathematized the cattle herding activity and developed conditional probability questions which the learners answered. The use of EIM made both Messey and the learners see how the cattle rearing activity was connected to conditional probability; the learners were able to solve the probability problems that were developed from these cultural activities. This concurs with Ensign (2003) who showed that learners’ interest in mathematics is raised when learners are solving their own problems rather than those found in the textbooks. The learners were keen to solve the problems because they had been developed from the activity, they were familiar with.

Messey could get the learners' understanding of the cultural activities before he could guide them to mathematize the cultural activities unlike at the beginning of the PAR when he could employ assumptions to make the activities suit the probability concepts that he wanted to teach about. Messey mathematized and problematized an activity of cattle herding, leading to the development of conditional probability, an aspect which he previously described as impossible to come up with cultural activities to match with. The use of the EIM helped Messey to mathematize the cultural activities to show the learners how mathematical formulas could be connected to the probability concepts found in cultural activities. Messey also used the probability tree diagrams in solving them, making the learners see how the probability tree diagrams could be connected to their out-of-school probability concepts.

7.9. Shift in pedagogical perspective and understanding of cultural activities

The implementation of EIM resulted in the participants' shift in pedagogical perspective and understanding of cultural activities. In this section I present each participant's shift in pedagogical perspectives and understanding of the learners' cultural activities due to participation in this study to implement the EIM.

7.9.1. Amon's shift in pedagogical perspective and understanding of cultural activities.

Participation in the implementation of the EIM resulted in a shift in Amos's pedagogical perspective in several ways. Amon changed from being a traditional teacher who did not have respect for the learners' views to become a facilitator who facilitated learning. At the beginning of the implementation of EIM Amon regarded the learners as empty vessels waiting to be filled but he had since shifted from this perspective and began to treat learners with respect whose views should be put into consideration when developing a lesson. This shift in pedagogical perspective is in line with the Social Constructivist Theory which advocates for the teacher to be a facilitator and not the knower. The EIM in line with the social constructivism puts emphasis on collaborative nature of learning under the guidance of a teacher playing the role of a facilitator. Instead of dictating to learners what to do and creating assumptions on the cultural activities, Amon gave himself time to understand the learners' pre-instruction perceptions and used them to develop the lessons as required by the EIM. Amon helped the learners to understand probability concepts by asking them questions which led them to develop reflective thinking on their understanding of probability concepts. One of the requirements of the EIM is collaborative learning hence after implementing the EIM Amon could engage the learners in groups so that they shared ideas amongst themselves. One of the learners could present group work on the chalkboard so that other learners could ask questions if they did not understand what the other group had done. According to Vygotsky's (1968) Social Constructionist Theory which underpin this study, collaborative peer groups help the scaffolding of ideas and encourage learners or their peers to reflect on their own ideas.

One of the key elements of the EIM is defining the role of the teacher as a facilitator which saw Amon being transformed. Instead of him being a teacher as before, Amon had become a facilitator, who developed the lesson from the learners' contribution as he helped them to develop the probability concepts. Amon's roles shift from being a knower to the facilitator is consistent with the Social Constructionist Theory which is since knowledge is not only socially constructed but it is also co- constructed. In this regard the learners co-constructed probability knowledge together with Amon as the facilitator. His role had changed from that of a knower who dictates everything that the learners should do in the mathematics class. Amon could move from one group to the other listening to what learners were saying and assisting them where need arose.

Due to the change in his role Amon created a conducive environment for learning in which the learners were free to participate and contributed to the development of the lesson in an atmosphere that was non-intimidating, and, in that regard, Amon developed skills to elicit answers from the learners. Amon shifted from the teacher-centred approach to a learner-centred approach which regards the learners' input as crucial for lesson development. At some point during the implementation of the EIM Amon helped the learners to reflect on their probability concepts understanding. For example, Amon used the learner centred approach to help the learners understand the difference between probabilistic events and certain events. Amon did not tell the learners what probabilistic events were but the learners themselves ended up giving examples of probabilistic events and ended up defining what probabilistic events were for themselves. Amon’s shift concurs with Barry and William (2004) who say that Social-Constructivists advocate for learner-centred learning in which the teacher is only a facilitator of learning. According to Social-Constructivism facilitating helps learners to go to higher levels of understanding because after attaining the highest level of understanding on their own learners can get into the zone of proximal developments by getting assistance from the teacher or the peers.

The use of EIM helped Amon’s to understand cultural activities and how to integrate them in the teaching of probability. Due to his understanding of cultural activities Amon no longer employed assumptions when incorporating cultural activities in the teaching of probability. Amon realised that using assumptions when integrating ethnomathematics was as good as not integrating ethnomathematics because the incorporated cultural activities are unlike what the learners see in their out of school mathematical practice. The EIM helped Amon to understand the purpose of integrating ethnomathematics in the teaching of probability. His understanding of cultural activities resulted from his change in teaching approach. Amon no longer dished out probability rules to the learners, but he guided the learners to derive the rules for themselves whenever possible as emphasized by the EIM. For instance, the range of probability values were no longer something to drill the learners about, but the learners were guided to derive the values. Amon used to teach probability the way he was taught when he was a learner, but he is now using different approaches which help the learners to understand probability concepts through integration of ethnomathematics in the teaching of probability as guided by the EIM.

7.9.2 Amos's shift in pedagogical perspective and understanding of cultural activities.

Participating in the implementation of EIM resulted in the shift in Amos's pedagogical perspective and understanding of cultural activities in several ways. Amos used not to understand the probability concepts found in cultural activities but the use of the EIM helped him to know the link between cultural activities and conventional probability. During the initial interview Amos mentioned that cultural activities did not have any probability concepts worth incorporating in the teaching of probability at secondary school except certain events and impossible events. He therefore taught probability concepts as abstract and unrelated to the learners' cultural activities. Amos therefore contradicts Cheung, Lau, Siu and Wong (1985) who found that probability has by far the closest direct link with daily life as compared to other strands of mathematics. However, his stance changed with his participation in the implementation of the EIM. Amos came to see the connection between cultural activities and school probability concepts. Prior to his participation in implementing the EIM Amos used the cultural probability concepts found in cultural activities only to spice up his lesson.

"*I use cultural activities just as spices during my lessons but now the cultural activities form the core of my probability lessons*"

In this statement Amos acknowledged understanding of probability concepts found in cultural activities. Amos no longer used cultural activities as spices but use them as lesson introduction and lesson development as well as sources of probability problems that the learners were required to solve. According to Social Constructivist Theory learners new construct knowledge on their existing knowledge which has been acquired before. Hence Amos's ability to use the learners' cultural experience in his probability pedagogy helped the learners to construct new probability knowledge.

Amos, like Amon, also shifted in pedagogical perspective from his previous position in which he treated the learners like empty vessels which needed to be filled. Amos learnt that the learners should be respected and that he could learn from them. According to Akpan, Igwe, Mpamah and Okora (2020) in a constructivist classroom the teacher's role is to consider the learners' contribution as important whether they are right or wrong. Amos started to respect the learners when the learners showed him that the way he was incorporating the cultural activities was not proper for the probability concept he was teaching. This showed the learners had clear ideas of probability events and where they occurred in the cultural activity. The learner's understanding of probability in their out of school activities concurs with D'Ambrosio (1985) who asserts that before they go to school all children in the world become matherate. Amos used some games to teach random events when in fact those games could not be appropriately used like that. In that process Amos realized that when integrating ethnomathematics in the teaching of probability the learners' input was of paramount importance hence resulting in his shift from his original stance of knowing it all and started to regard the learner's pre-instruction conception as important. Amos developed questioning skills which could help the learners to reflect on their probability concepts.

7.9.3 Messey's shift in pedagogical perspective and understanding of the cultural activities

Messey like the other two participants shifted in his pedagogical perspective and the understanding of probability concepts found in cultural activities. At the beginning of implementing the EIM Messey was observed beginning his lessons with a question which might be even difficult for the learners to answer and the difficult question that at times could lead the lesson to fail. When the learners failed to answer the question Messey could end up answering the question himself. The posing of the question was not consistent with the EIM which required that the lesson be introduced by a culturally relevant problem. Messey did not know the difference between question posing and a problem posing. Messey could ask the learners to define concepts which normally proved to be difficult for the learners and could lead the lesson into stagnation.

Messey changed from the practice of introducing the lessons by asking questions, to introduction by posing problems that motivate the learners to participate in line with the requirement of the EIM. Apart from that Messey used probability problems that were common to the learners, and they were interested in solving them. Thus, Messey was now able to motivate his learners to participate during the lesson. Messey used to be rigid during the lessons, he did not want to change what he had planned although there might be enough evidence to show that the way he had incorporated the cultural activities in his pedagogy did not work. At one point after being told by the learners that a polygamist did not eat randomly from his wives Messey insisted that he wanted to use it as a random event something that was contrary to integration of ethnomathematics in the teaching of mathematics. The implementation of the EIM made Messey realize that for the lesson to be successful he had to incorporate the cultural activities in the way that the learners understand them. According to Zeichner (1996) the teacher can only implement the principle of cultural congruence if they have knowledge and respect for the learners' culture in the mathematics classroom. To use the cultural activities in a way that the learner understands them Messey put the learners' pre-instruction perception into consideration. Messey developed the ability to answer the learners' questions satisfactorily. Messey like the other two participants shifted from the teacher centred approach to learner centred approach. In this change Messey assumed the role of the facilitator where he allowed the learners to learn in a free environment.

Initially Messey was not able to identify and incorporate cultural activities in his probability pedagogy. Failure by mathematics teachers to incorporate cultural activities in the teaching of mathematics is not something new as Naresh (2015) observed that the teachers were not trained to integrate ethnomathematics in teachers' training colleges. However, during the implementation of the EIM Messey was able to analyse the cultural activities to identify the probability concepts in the cultural activities and integrate them in the probability pedagogy. Messey's understanding of probability in cultural activities shifted for the better as indicated by his statement: "*Before I took part in this PAR, I was not looking at the cultural activities from the probability point of view but just like activities that the learners engaged in outside school. The implementation of EIM helped me to mathematize cultural activities and integrate them in the teaching of probability"*

Messey's statement is evidence that due to the lack of understanding of cultural activities Messey did not see the connection between probability concepts found in cultural activities and school probability. The use of EIM helped Messey to shift from his practice of applying probability formulas only to probability questions from the learners' textbooks; he also started to apply formulas to probability questions which were developed from the cultural activities during the implementation of the EIM. His pedagogical shift helped learners to see that mathematics formulas can also be applied to probability problems outside school. Messey was observed applying formulas and probability trees to conditional probability questions which were developed from cattle herding activity while the learners used conditional probability formulas to solve questions which had been developed from cultural activities.

7.10 The participants' reflection of the impact of EIM on the performance of the learners.

At the end of the PAR to implement the EIM the participants reflected on the impact of the EIM on the performance of the learners. In this section I present the participants' reflection on the impact of EIM on the performance of the learners.

7.10.1 The impact of EIM on the performance of Messey's learners

Messey viewed the learners' participation during the EIM as very good. During the implementation of the EIM Messey posed the problems which were very relevant to the learners. Most of the problems were like the problems that the learners encountered and solved outside school although the methods they used outside school did not involve formulas. The use of problems familiar to the learners during mathematics lessons concurs with Rosa and Orey (2010) who pointed out that mathematics teachers should find problems taken from the learners' reality that translate their deepened understanding of real-life situations through application of culturally relevant activities. Hence the learner participation during the implementation of the EIM was triggered by their familiarity with the cultural activities that Messey incorporated in the teaching of probability. Learners usually participate in class when they are motivated. During the PAR to implement the EIM the first stage of the lesson was the posing of problems which the learners solved in groups first before they were allowed to work individually on their own. Working in groups encouraged Messey's learners to participate because learners in general like talking to each other. Vygotsky' (1978) social constructivist theory advocates for collaborative learning which it argues enhances learners' participation and takes the learners to the higher level of conceptual understanding.

"*I cannot imagine that these are the same learners I have been teaching for the last three years because when I put them in groups it was a struggle to find anyone who would be willing to represent the group but during the implementation of the EIM everyone was willing to represent their groups, they were highly motivated*…" The learners were willing to represent their groups because they understood what they were discussing,

Messey in the final reflection meeting said: "*I have never seen these learners participating like this before, even those learners who were always passive had become active and I could see that they were interested in what they were doing."* The implementation of the EIM created the environment that was conducive for learners to participate which might have been caused by the fact that during the implementation of EIM Messey had relinquished his traditional role of the teacher and became a facilitator. When the teacher is facilitating the learners feel respected because the teacher develops the lesson from the learners' views some of which might be different from those of the teacher. This concurs with D' Ambrosio (2001) who affirm that during integration of ethnomathematics learners are allowed to construct their personal understanding of mathematics. Under such a situation the learners become interested in the topic that is being taught. The learners might have been motivated to participate during implementation of the EIM because they realized that the methods, they use outside school are also permissible in the mathematics classroom.

During the group discussion Messey allowed the learners to use vernacular language since the cultural activities that were incorporated such as cultural games could explicitly be explained in Shona their mother language. The use of vernacular language might have caused the learners to be more active during the group discussions. When vernacular language is used during mathematics lessons the learners are likely to understand the mathematics concept since the learners would be able to relate the mathematical concepts to their out-of-school mathematical concepts. The use of vernacular language during the mathematics lesson concurred with Panthi and Belbase (2017) who emphasized the significance of using vernacular language in learning mathematics concepts. In a traditional mathematics classroom only, English is used as a medium of instructions. The use of vernacular language when using ethnomathematics approach concurs with Brandit and Chernoff (2014) who point out that ethnomathematics has the potential to help engage, inspire and empower learners in a meaningful way that a traditional school mathematics has failed to do.

Messey's learners improved in asking questions when they faced challenges during the lesson, and this was unusual before the implementation of the EIM. Before the implementation of the EIM Messey could try in vain to make the learners ask questions during the lessons, but during the implementation of the EIM the learners could ask questions more frequently. This concurs with

Ezeife (2002) who affirm that including the learners' out of school mathematical activities of the learners in the school mathematics makes learners to develop self-confidence which makes them to improve their participation as well as performance.

Messey had this to say during the final reflection,

"*Some of the learners shocked me because since I started teaching them three years ago they never asked a single question during my lessons but in this implementation of the EIM, they were asking questions which are very reasonable*." Learners usually ask questions in mathematics lessons when they understand what the teacher is teaching. The implementation of the EIM therefore made the learners understand probability concepts and hence the learners could ask questions to further their understanding of probability concepts. The implementation of the EIM increased Messey's learners' confidence in the mathematics classroom that they could argue their way through unlike previously when there was no debate at all during the lesson. Messey remembered one of the lessons in which the learners stood their ground arguing that the way the polygamist ate food from his five wives could not be regarded as a random event. It showed that when the probability concepts were connected to the learners' out-of-school activities learners understand the concepts and they become confident to argue for their views. According to Lipka and Adam (2004) indigenous students' performance improve when cultural and linguistic practices are employed in the classroom, During the initial interview Messey mentioned that his learners did not want him to integrate ethnomathematics in the teaching of mathematics because they regarded it as time wasting. The learners could start making noise or even go to an extent of leaving the classroom going to the bathroom once Messey started integrating ethnomathematics in the teaching of probability. The behaviour which Messey's learners showed was also observed by Horsethemike and Schafar (2014) who hinted that learners might regard some ethnomathematical aspects as old fashioned which they may not want to be associated with. Messey hinted during the initial interview that he only used cultural activities as examples, and this might have become a routine that the learners regarded as boring, and this might also be the reason why the learners were not interested in him incorporating cultural activities during their lessons. However, during the implementation of EIM the learners changed, and they became interested in ethnomathematics. The implementation of the EIM helped Messey to incorporate the cultural activities in a way that the learners found challenging hence the learners were motivated to participate during the lesson.

The use of the EIM did not lead to learners' performance to improve in participation in group and class discussion only but there was also notable improvement in written work, the learners fared far much better in written work than ever before. Messey's statements: *The EIM had led the performance of learners to improve notably because they were familiar with the concepts which I incorporated in the lessons.* This concurs with Johnson (2017) who found that learners perform better in ethno mathematically created words problems than in routine words problems. The learners performed better in probability problems that were developed from the cultural activities which the learners were familiar with. The probability problems that were assigned to the learners were developed from the cultural activities and they were connected to the problems that the learners experienced outside school. The EIM helps the teacher to present the learners' out-of-school probability practice in a way that makes the learners solve their out-of-school probability challenges in a situation in which the best practice was needed. The learners were motivated seeing their out-of-school probability practices compared fairly with the school mathematics.

7.10.2. The impact of the EIM on the performance of Amos's learners

The implementation of the EIM during the PAR impacted positively on the performance of Amos's learners. During the final reflection Amos said, "*This was the best performance I ever witnessed with my learners since I started teaching them*..." The learners' written work had improved notably. As if what Amos said was not enough in the reflection on the improvement of his learners he said, "For *the first time I witnessed the learners doing their corrections properly without my follow up*…" Learners may make corrections when they realize that they did it wrongly the first time. That realization can only come into existence when the learner understands the concepts that they wrote about. The EIM made the learners understand probability concepts to an extent they were not capable of correcting their errors. Matthew, Jones and Parker (2013) point out that if mathematics tasks are made meaningful it impacts on the learners' understanding of mathematical concepts and therefore improves their performance. Amos's learners could do correction with Amos's minimum supervision because they understood the probability concepts that had been taught and they were highly motivated.

The implementation of the EIM during the PAR resulted in Amos's learners participating well during the lesson and the participation was more vibrant when the learners were in groups. This concurs with Sunzuma (2018) who says learning occurs when the learners interact with more knowledgeable peer or teacher in the classroom. Amos like Messey allowed the learners to use vernacular language during their group discussions because the learners would be able to put across their argument more clearly in Shona their mother language than in English. At the same time the probability concepts in cultural activities which were incorporated in the probability pedagogy were better understood when articulated in the language that the learners use outside school. When the learners use their mother language during mathematics lessons they are able to argue their way defending their answers. The use of vernacular language during ethnomathematics approach concurs with Brandt and Chernoff (2014) who opined that when using ethnomathematics approach in the mathematics classroom teachers are empowering those whose voices and ideas are marginalized in a traditional mathematics classroom. In a traditional mathematics classroom learners are not allowed to use vernacular languages thereby silencing those who cannot communicate in English properly. When reflecting on the learners' performance during the implementation of the EIM Amos said. *"I did not know that these learners can think so critically…"* Amos noted that the learners had all the probability concepts, but they only lacked the school probability terminology and symbols. The learners could analyse the cultural activities such as games critically and reach sound conclusions on the probability concepts embedded in them. The learners in Amos's class brought it to the attention of their teacher that some games he was incorporating did not have the probability concepts that he intended to teach about. Amos wanted to use the games to teach randomness, but it was brought to his attention that the outcomes of some games were not random; they were subject to manipulation by the players. The use of EIM to integrate ethnomathematics in the teaching of probability gave the learners an opportunity to give their views in a free environment resulting in improved learner participation and performance. This concurs with Bracey (2013) who affirm that culturally relevant pedagogical approaches positively affect engagement, motivation, and mathematical performance for the poor underperforming learners.

Amos's learners also improved in asking questions during the lessons. The learners were free to ask questions when they did not understand. Amos created an enabling environment for learning where the learners were free to ask questions when they do not understand. In his reflection on the way the learners asked questions during the PAR. "*The atmosphere that was created during the* *implementation of the EIM was very free that the learners could ask questions and defend their answers freely without any fear and this enhanced the learners' performance…*" The implementation of the EIM redefined Amos's role as a teacher resulting in the creation of an environment conducive for learning. The conduct of Amos's learners concurs with D'Ambrosio (2001) who states that learners taught using ethnomathematical approach construct their own personal mathematics understanding and develop alternative ways to explain their mathematical understanding which may be at variance with that of the teacher. Hence the learners were able to give their own perspectives of understanding probability concepts.

7.10.3 The impact of EIM on the performance of Amon's learners.

The implementation of the EIM during the PAR impacted positively on the performance of Amos's learners. Amon was surprised by the participation of his learners during the implementation of the EIM. The learners were very motivated to participate in both the group discussion and the class discussions and their performance in written work improved significantly. According to Chihane (2013) linking school mathematics to the learners' out-of-school mathematical experience promotes learners' participation and better understanding of mathematical concepts by the learners.

During the final reflection Amon said: *When the EIM is being used it is like the learners had been taken out of the classroom to a playground where they were free to do as they pleased yet it was in a classroom where the probability lessons were in progress*. Amon was emphasizing the freedom with which the learners were participating during the lessons. The implementation of the EIM created an environment in which the learners were free to participate without fear. Learners normally participate freely in a classroom in which the teacher plays the role of a facilitator. The use of the EIM makes the teacher relinquish his/her traditional role and becomes a facilitator, thereby creating an environment in which the learners can participate freely.

Amon also had this to say during the self-reflection, “*The use of the EIM charmed the learners because the confidence which the learners had developed in answering questions was extraordinary.”* The learners normally develop confidence in answering questions when they are familiar with what is being taught. According to Horsthemke and Schafer (2014) learners taught using ethnomathematical approach can contribute and participate meaningfully in the society in which they live with confidence. In the implementation of the EIM the learners were familiar with the cultural activities that were being incorporated hence they could confidently participate during the lessons, and they were also able to defend their answers when they were asked to do so. The implementation of the EIM did not only help the learners to understand probability concepts but it also helped the learner to share ideas with each other. Although in most cases it is the teacher who is required to facilitate dialogue in a traditional classroom during the implementation of the EIM the learners could facilitate their own dialogue which were very meaningful and leading to reasonable conclusions. The EIM puts emphasis on concepts development in learners rather than on getting the correct answer.

The learner developed probability concepts and could reason critically because the probability concepts that they were exposed to emanated from the cultural activities they use outside school. According to Mama and Alam (2021) integration of ethnomathematics in the teaching of mathematics is not only interesting to the learners but reduces difficulties that learners experience in learning mathematics. This also concurs with Bonoto (2001) who says local strategies developed in practice are more effective than the algorithm approach used in a traditional mathematics classroom. The learners in their learner-learner dialogue could convince each other on the probability concepts which were involved in some activities. Those dialogues were allowed to take place in the language that the learners used outside school. This was done to promote conceptual understanding since the concepts they were learning were coded in the language that the learners use outside school. This concurs with Nyoni (2014) who found that when integrating ethnomathematics in the teaching of differentiation, differentiation concepts can be understood better when they are presented in the language that the learners use outside school. Also Chidziva (2021) in his study of using ubuntu values to enhance distruptive pedagogies for effective teaching of Euclidean Geometry found that learners participate better when they are using their mother language for group discussions. Using vernacular language during the group discussions the learners were able to see the connections between ethno probability and conventional probability, a situation that has never been witnessed in Amon's class before the implementation of the EIM.

7.11 The participants' reflection on the PAR

The three participants reflected on the benefit of participating in the implementation of the EIM. In the following section I discuss the three participants' reflection on the benefit of participating in the PAR to implement the EIM.

7.11.1 Amos's reflection on the benefit of participating in this PAR

Amos felt the power of self-liberation in working as a team during the implementation of the EIM. The liberation emanated from the fact that the participants worked together as a team to solve pedagogical issues that affect them. According to Herr and Anderson (2005) a PAR is carried out in collaboration with the others who share the same problem. In this regard the implementation of the EIM was carried out in collaboration with the three participants who were facing challenges of integrating ethnomathematics on the teaching of probability. Using the PAR as the research design of this study Amos was afforded the freedom to communicate to the other participants the weaknesses of his probability pedagogical practice. and his fears and hence being able to implement the EIM in the mathematics classroom successfully. It was a benefit to Amos to find someone to confide in his probability pedagogical weaknesses without being judged. The PAR created an enabling environment in which the participants worked together to implement the EIM in the mathematics classroom and Amon was able to share ideas in a conducive environment. The use of the EIM helped Amon to create a culturally relevant pedagogy

During the implementation of the EIM, the participants worked together as a team to identify the rural Shona learners' cultural activities and incorporated them in the probability pedagogy using the EIM in a free environment that was created through following the PAR design. Amos matched the implementation of the EIM to a training program for the participants since he learnt a lot on integration of ethnomathematics in the teaching of probability and this resulted in him changing his probability pedagogics practice. Amos in his final reflection said, "*The EIM is a very effective tool for integrating ethnomathematics because I now understand what it means to integrate ethnomathematics in the teaching of probability"* Amos benefited the skills to integrate ethnomathematics in the teaching of probability through implementation of the EIM

7.11.2 Messey's reflection on the benefit on the PAR

The benefits of the PAR as the chosen research design for implementing the EIM to Messey was that it created an open atmosphere in which he could open to other participants on the challenges he experienced in the integration of ethnomathematics in the teaching of probability. His statement: *We were like toddlers who can open to each other and speak their minds without harbouring any motive.* From this statement Messey resembled the way in which the EIM was implemented to the toddlers who gather to play because the PAR as a research design enables participants to be free. In such a setup there is no hierarchy and they shared whatever they have in a manner that does not harbour any motive and Messey overcame his fears for openness. Messey like any mathematics teacher used to have fears of disclosure, which dominates in many teachers' practices who may feel that by being open their colleagues could regard them as weak. The implementation of EIM to integrate ethnomathematics could be made difficult if it was carried out using the conventional approach to research because the people affected by the problems being studied would be treated as objects. This concurs Baum (2004) confirms that in a PAR the researchers cease to be the object and become partners in a research process. During the implementation of the EIM, Messey's fears disappeared as soon as he found that the other two participants and the researcher were not judgemental. Messey also regarded the implementation of EIM as a form of training in which he gained more knowledge on the mathematizing of cultural activities and incorporated them in the teaching of probability. His statement during the final reflection, "*I benefitted more by taking part in implementing the EIM in this PAR than I gained during my three years of training at a teachers' college…"* Messey regarded what he learnt in the implementation of the EIM to be more than what he gained at a teachers' training college. Apart from guiding on integrating ethnomathematics the EIM taught Messey how to create a conducive environment for learning in his class. "*Through the implementation of the EIM I now know what it means to be a teacher…"* was Messey's reflection at the end of the study. Messey also mentioned during the final reflection that the EIM taught him to respect the learners, and this resulted in him being able to create an environment in which he could learn about cultural activities from the learners and the learners could participate freely and learn from each other. Hence according to Messey the PAR was the best design to facilitate the implementation of the EIM in the mathematics classroom.

7.11.3 Amon's reflection on the benefits of the PAR

Amon benefitted from the teamwork that was created during the implementation of the EIM to solve the challenges that affected their probability pedagogy. Lack of hierarchy that was created during the PAR was of benefit to Amon who could air his different opinions at all the levels of the implementation of the EIM. The PAR as the research design enabled the three participants to employ the EIM and assess its effectiveness in a way that they find suitable to improve their probability pedagogy. Because the implementation of EIM took place under a PAR, a research design which is aimed at improving the practices of the participants, Amon improved his practice of teaching probability. According to Manion and Marrison (2018) PAR promotes in participants understanding and change

Amon in his final reflection how he found the PAR to be the best research design for the implementation of the EIM*: "If another research design would have been used, we were just going to be asked a few questions and it ends without us even talking to each other, yet our problem is common. Other types of research do not allow participants to share ideas and help each other."* Amon indicated that he benefited from the implementation of the EIM because the research design that was employed was supportive of free communication amongst the participants. The implementation of EIM helped Amos also improved his understanding of probability concepts found as he was learning together with the learners as he said, "*The EIM proved to be a superior tool to me because it guided me step by step."* Through the PAR Amon was helped to understand his problem of teaching probability and developed skills of solving such problems. The implementation of the EIM in a PAR environment helped Amon to create a learning environment in which there was no hierarchy between the learners and the teacher, nor amongst the learners themselves. Amon had never before participated in a research in which he was actively involved in collecting data and sharing its analysis, this helped him to know how to carry out AR in future.

7.12. Conclusion

The chapter presented a discussion on data presented in chapter six of this study which was based on the integration of ethnomathematic in the teaching of probability in Zimbabwe. The study developed an ethnomathematics framework that can facilitate the integration of ethnomathematics in the teaching of probability at OL. The findings of the study reveal that the use of the EIM in the teaching of probability impacts positively on the teachers' probability pedagogy. It was also found that the use of the EIM enhances the learners' participation during the lesson and promotes learners' understanding of probability concepts. Another aspect that was revealed by this study was that learners' performance can be enhanced when they are allowed to use the vernacular language when the EIM is being used. In the next chapter I present conclusions, limitations, recommendations, and suggestions for further research.

CHAPTER EIGHT

OVERVIEW, SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

8.1 Introduction

In this chapter I presented an overview of this study, summary of the findings, implications, conclusion, and recommendation of this study. The recommendations are meant for the Ministry of Primary and Secondary Education while the conclusions are meant to guide further research in integrating ethnomathematics in the teaching and learning of probability in secondary school mathematics.

8.2. Summary of the chapters

In this section I present an overview of this study. In this chapter I provide the summaries of chapters in this research study. In chapter I presented the introduction, background, motivation, research problem, aim, and objectives of the study.

The main purpose of this study was to explore the integration of ethnomathematics in the teaching of probability as a strand of secondary school mathematics in Zimbabwe.

The study focused on the following objectives: it sought to identify the mathematics teachers' difficulties in integrating ethno-mathematics in the secondary school mathematics when teaching probability, explore the rural Shona learners' out of school mathematical practices that can be integrated in the teaching of probability, explore the integration of ethno-mathematics in the form of the rural Shona learners' out of school activities in the teaching of probability, and to determine the impact of integration of ethno-mathematics in the secondary school mathematics in the teaching of probability in the secondary school.

In order to answer the research questions, the aim and objectives of the study were developed, and the literature review attempted to address the research questions. Chapter two addressed the context in which this study was carried out and reviewed literature on integration of ethnomathematics mathematics in Zimbabwe Secondary school mathematics.

Chapter three was focused on the theoretical framework outlining the key elements of Socio-cultural Theory, Social Constructionist Theory, and the Culturally Relevant Pedagogy Theory. The chapter culminated into the development of an ethnomathematics instructional model which was used by the three participants to integrate ethnomathematics in the teaching of probability.

Chapter 4 has explained the methodology, the research design, data collection and analysis, ethical considerations and validity and reliability of the study. Chapter 5 presents the research team. Chapter six presents data analysis and presentation. Chapter 7 focused on discussion of findings guided by literature review and theoretical framework

The study used PAR as a research design. Three mathematics teachers teaching at a rural secondary school in Bikita District of Masvingo Province of Zimbabwe together with their Form three learners were purposely selected to participate in this study. Data from this study was collected at three levels of the study. At the beginning of the PAR the participants wrote narratives about themselves regarding their teaching experiences as some aspects regarding teaching and learning of mathematics. Also, data was collected using semi-structured interviews and lesson observation. The three participants were involved in observation of cultural activities to identify probability concepts embedded in them with the view of incorporating them in the teaching and learning of probability in secondary school mathematics. I observed the lessons which were taught by the three participants using the jointly developed lesson plans. After every lesson a post lesson reflection interview was conducted with the participants. Finally, the semi-structured last interviews were conducted at the end of the PAR. The interviews and lesson observations were transcribed and coded for emerging themes.

8.3 Summary of findings

This section presents the summary of findings on every objective in relationship to the themes that emerged in this study.

8.3.1. Difficulties experienced by mathematics in integrating ethnomathematics in the teaching of probability

8.3.1.1 Lack of probability pedagogical knowledge: It was observed that the three participants who took part in this study lacked in-depth probability pedagogical knowledge. The three participants despite being fully qualified had lacked pedagogical skills. One of the sources of the three participants' problem was that they lacked probability content knowledge, as a result they could not explain some of the probability concepts to the learners properly. It was found that the dual meaning of words used in probability was one reason why the participants were facing challenges. Of note was also the fact that the mathematics content taught at the teachers' college does not pay attention to the teaching of probability, the teaching of probability is formula-based and that does not adequately prepare teachers to teach probability in context resulting in the participants teaching probability in the same way they were taught when they were still at school. Also, it was revealed that the three participants were not taught on how to integrate ethnomathematics in the teaching of probability hence they could not take it as an optional teaching strategy.

8.3.1.2 Lack of knowledge of cultural activity: The data from the interviews and lesson observation revealed that the three participants lacked knowledge of cultural activities. The rural setting of the purposely selected school in Bikita District has rich cultural activities that the mathematics teacher can utilize but the three participants showed that they do not have detailed knowledge of the cultural activities for the purpose of integrating them in the teaching of probability.

8.3.1.3 Underutilization of cultural activities: It was found that the participants could be able to identify the cultural activity to incorporate in the teaching of probability but could fail to make connection between the cultural activity and the probability they intended to teach. Such challenges were brought about by the fact that the participants were not trained to integrate ethnomathematics hence they were not clear of the purpose that the cultural activity was supposed to serve.

8.3.1.4 Cultural incompetency. The data collected from this study revealed that the participants despite managing to identify the cultural activities they showed some elements of cultural incompetency. The participants did not manage cultural differences in the mathematics classroom, hence the cultural activities which were incorporated did not appeal to some the learners in the class. Also, their teaching did not put into consideration the learners out of school experiences resulting in failure to connect home and school activities.

8.4 The cultural activities found in the culture of the rural Shona people that can be incorporated in probability pedagogy.

In this study the participants incorporated a variety of cultural activities in their pedagogy. It has been revealed in this study that the probability concepts found in cultural activities are hidden. The participants had to mathematize the cultural activities to find the probability concepts embedded in them. In this study it was revealed that cultural games have some probability concepts that the participants incorporated in the teaching of probability. The games were frequently incorporated to teach about random events. However, it was revealed by the learners that those games which seem to show characteristics of randomness are in fact not random, they have some elements of bias embedded in that which cannot be seen at first sight. This resulted in the participants wrongly incorporating them in the teaching of probability concepts.

Another group of cultural activities which was used in this study was agricultural activities ranging from traditional crop production and animal husbandry. When incorporating cultural activities in probability teaching, it was found that mathematics teachers needed to put into consideration the belief that the learners have about those activities. Ignoring the learner's belief was found to affect the expected outcome. The participants also mathematized cattle herding and some associated cultural activities that the learners engaged in while herding cattle such as Mapuza, Chifemberwa, and some games played while the children are herding cattle.

The participants also incorporated social aspects such as polygamy, family gender and cultural mirth, and beliefs to teach random events, independent events, and mutually exclusive events. The participants could incorporate these cultural activities to cultural activities to teach both simple and complex probability concepts taught in OL mathematics.

Apart from cultural activities the participants in this study could also incorporate natural events specially to express the probability of impossible and certain events. This study could not prescribe which cultural activity can be used for which probability concepts, but all those cultural activities could be mathematized and problematized to be incorporated in the probability pedagogy.

8.5. Ways in which cultural activities can be incorporated in the teaching of probability.

Ways in which cultural activities can be incorporated in the teaching of probability are presented under the categories which emerged in the theme obstacles to effective integration of cultural activities in the pedagogy as follows:

8.5.1 Change in mathematizing and problematizing of cultural activities: During the initial interview the three participants mentioned that they incorporated cultural activities in the form of examples. It was also observed that when the participants incorporated cultural activities as examples some learners were not motivated to participate instead, they could regard integration of ethnomathematics as time wasting. Also, one of the participants indicated that he used cultural activities as spices to his lessons. It was also revealed that when cultural activities are used as spices the aim is not to make the learners see the connection between the cultural activities and the probability concept but simply to make the learners see that there are similar concepts in the cultural activities. Hence incorporating cultural activities as spices was found not to be an effective way of incorporating cultural activities in the pedagogy as it does not lead to connection of cultural activities with mathematics understanding in the pedagogy.

During the implementation of the EIM the three participants improved in the way they mathematized and problematized the cultural activities and incorporated them in the teaching of probability. Cultural activities can only be incorporated in probability pedagogy after being mathematized. The concept of mathematizing involves thinking mathematically about the cultural activity and identifying the probability concepts embedded in them. After mathematizing the cultural activities the participants were able to problematize the cultural activities, thus coming up with the relevant problem which they posed for the learners to solve. The cultural activities could therefore be incorporated in the pedagogy in the form of a relevant problem that the learners were interested in solving. The learners were in most cases required to solve the posed problem in groups or in pairs so that they could be able to share ideas. When incorporating the cultural activities in the teaching of probability the learners were allowed to use home language for them to be able to articulate their ideas clearly although they were to write their work in the workbooks in English.

8.5.2 Change in pedagogical perspective and understanding of cultural activities

The data presented in this study reveals that the EIM led the three participants to improve in their pedagogical practices. The use of the EIM resulted in the participants improving in their ability to integrate ethnomathematics in the teaching of probability. The implementation of the EIM resulted in the participants shifting from their traditional to become facilitators. It was found that ethnomathematics can be integrated more effectively when the participants facilitate learning. When implemented properly the EIM created an environment in which participants could facilitate rather than become knowers who dictate to the learners what they must know. Facilitation creates a conducive environment for integration of ethnomathematics and this enables the participants to understand the learners' pre-instruction conceptions. The EIM put emphasis on facilitation in line with Vygotsky's (1968) Social Constructivism theory; hence the three participants found themselves using the learner-centred approach. It was also found that when integrating ethnomathematics in the teaching of probability the learners should work collaboratively. Also, when in collaboration the learners were allowed to use vernacular languages to enable them to articulate their understanding of the cultural activities clearly.

The first stage of the EIM ensured that the learners were familiar with the cultural activities that were incorporated, and the participants could incorporate the cultural activities in the way the learners understood them. By virtue of making the participants facilitators, the EIM shows that ethnomathematics can be successfully integrated into the pedagogy when the participants respected the learners. Successful integration was witnessed when the participants could manage dialogue with the learners, one of the prerequisites of the EIM. In this study the participants successfully integrated ethnomathematics when the cultural activities were used as the source of problem during the introduction of the lesson as well as the source of questions instead of questions from the learners' textbooks. While the learners were first given questions developed from the cultural activities this research found that the questions from the learners' textbook could be used in order for the learners to apply the probability concepts after the learners have shown understanding of concepts from the cultural activities. During the implementation of the EIM there was an impact in the learners' understanding of probability concepts when the participants applied formulas to problems developed from cultural activities. When the EIM was used the learners' answers which fell short of the required standard were not rejected, they were accepted and perfected and in this process the learners reflected on their probability concepts and reached a higher level of understanding.

8.6 Ways in which incorporation of cultural activities can improve on the cultural relevance of the probability pedagogy

In the data presented in this study the three participants were impressed by how the use of the EIM led to improved performance of their learners. The implementation of the EIM improved the cultural relevance of the pedagogy through using the cultural activities that the learners were familiar with. The learners' participation was triggered by their familiarity with the variety of cultural activities that were incorporated in the probability pedagogy. One of the key features of the EIM framework that accounted for the active participation of the learners was the posing of the problems that the learners encountered outside school. Also, the use of culturally specific problems that required that each of the participants gave an account of how the problems were solved uniquely in their homes was found to be another trigger for the high level of participation and therefore improved the cultural relevance of the pedagogy. It was interesting during the implementation of the EIM to see some learners who had never been active in those classes becoming active. For example, in Messey's class there were some learners whose voices were first heard in that class when he integrated ethnomathematics in the teaching of probability using the EIM.

The relevance of the pedagogy emanating from the use of the EIM did not only lead to improvement in learners' participation in groups, but their written work also improved notably. Learners in Amos's class were able to do their corrections correctly without his help highlighting how the EIM impacted on the relevancy of probability pedagogy. The use of the EIM improves the relevancy of the probability pedagogy and hence motivated learners. The EIM required that learners be put in groups and were allowed to share ideas to solve the problems. The learners were allowed to use their mother language during group discussions, and this was found to be one of the reasons why the learners were participating very well. By requiring learners to work collaboratively the EIM allowed the learners to share ideas and it was found that through group work the learners came to know how different cultures solve the problems, leading them to appreciate other learners' cultures. It can be concluded that the use of EIM makes the learners participate during the lesson by creating an enabling environment therefore it improves the cultural relevance of probability pedagogy.

Apart from being active the learners became analytical of their cultures so that they could criticise some of the ways in which the participants incorporated the cultural practices in the pedagogy. This led the participants to reflect about their beliefs about the learners' cultural activities. The use of the EIM provided a free environment that the learners were free to ask questions when they did not understand and defended their answer when required to do so, and hence it fostered confidence in the learners. This means that the EIM has impact on the cultural relevance of the probability pedagogy which resulted in the learners being critical of their cultural activities and become able to reflect on their understanding of probability concepts.

8.7. Emerging theories on the use of cultural games in teaching randomness and independent events

There are two possible theories that emerged from the collected data, which may go a long way to assist mathematics teachers in the incorporation of cultural games when integration of ethnomathematics in the teaching of probability. The two emerging theories are briefly outlined below.

8.7.1 Cultural games randomness determination theory.

The randomness determination theory of cultural games emerged from the lesson observations of the two participants Amos and Amon. The theory established why the mathematics teachers should cautiously incorporate cultural games for teaching randomness because according to the learners the outcomes of cultural games are never random unless there are only two players playing the game. The theory highlights what takes place in the mind of the rural Shona learner's mind when he/she starts to play a game. The random determination theory emanates from the point that the Shona people are social beings who are either vindictive or associative when playing a game where several players are participants at the same time. The vindictiveness comes in the spirit to victimize those who are not of one's social group or to please those belonging to one's social circle. This emerged when the two participants incorporated cultural games to teach random events. Feedback from the learners indicated that games outcomes are not random because there is tendency by players to be vindictive to those who are not part of one's social groups or associative to those belonging to one's social group.

It was found that the elimination of the players from the game called Zairakaora for example is not random, there is an element of association and vindictiveness on the part of the person moving around with the object, there is tendency to victimise by eliminating or to associate by avoiding eliminating those associated with them. All the learners in the classes of the two participants agreed that the outcomes of the game Zairakaora cannot be random although they are assumed to be even by the players themselves. All the players are either associated or vindicated to each other in one way or the other which affects the randomness of cultural games.

This position was also reached in 'mapuza', one of the methods the rural Shona children use to allocate responsibilities "randomly" learners indicated that one bringing mapuza can gesture in one way or the other to his associates so that they do not pick the undesirable cut leaves. Although the learners were in different classes, they reached the same conclusions and their teachers also realised that and agreed with them that outcomes of cultural games although meant to be random they are not random. The learners also pointed out that in the game called Hwai-hwai the one playing the role of a hyena can become vindictive by starting by catching boys so that they do not enjoy the game for long**.** **Figure 8.1** illustrates how randomness of the game is determined.

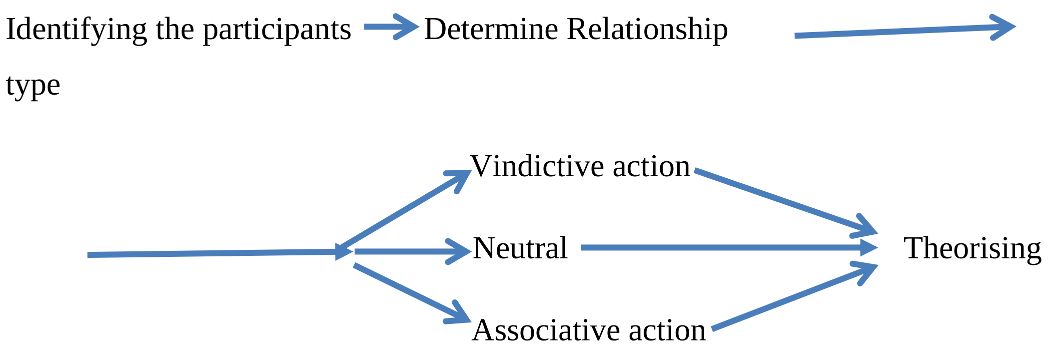


Figure 4.1: Flow chart for Determination of Randomness Theory

During the implementation of the EIM there was some disagreement between Amos and Amon with their students. The learners challenged the Amon and Amos that the outcome of cultural games was not random and was not random as they are based on vindictiveness or association. They argued that in games where one person determines the fate of the other players, he/she is likely to favour people who are associated to them to the disadvantage those who are not their associates and become vindictive to those whom they bear “grudges” with. The learners argued that there is no one who is neutral in the rural Shona children’s society due to things such as totems and the history of their parents living together in the community. The two participants argued for randomness, but they were convinced by the learners that randomness does not have a place in the rural Shona cultural games because almost everyone is connected to everyone else in one way or the other which affects the randomness of the outcome. Their argument was that the outcomes of the cultural games are predicted to some extent due the connections of children in the rural Shona children's society.

8.7.2. Determination Independence Outcome Theory

The Determination of independence outcome theory emanated from the cultural activities' randomness determination theory. It is since, since the game outcomes are not random events then it follows that the outcomes of two consecutive events are not independent. The participants used games to teach independent events. However, the learners pointed out that knowing the person who had been eliminated from the game can help them to predict the person who is going to be eliminated next with some high degree of accuracy. Depending on the game being played, friends are likely to be negligent when one of them has been eliminated so that they are also eliminated. On the other hand, the players who are not associates can be targeted intensively so that anyone with the knowledge of the relationship circle of the players can be able to predict the outcome of the events of the game. **Figure 8.2** below is the flow chart showing how theorizing can be done.

Identifying the relationship between the eliminated and the eliminating players

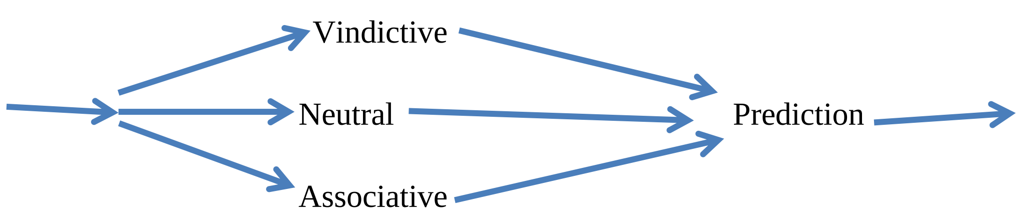


Figure 8.2: Flow Chart for Determination of independence outcome theory

The theory asserts that if one knows the relationship between the person who had been eliminated from the game and the one eliminating one can predict the next player to be eliminated. It was noted that when playing Zairakaora that when one's friend has been eliminated their friend became loose so that they could also be eliminated. On the other hand, it was found that there were few cases in which the relationship between the eliminated player and the one doing elimination was neutral. Therefore, the mathematics teachers should understand these games in the way the learners understand them so that they do not use the game to teach the concepts which the learners understand differently.

8.8 Contribution of this study to the body of knowledge

The findings of this study show that the use of the EIM impacted positively on the participants' ability to integrate ethnomathematics in the teaching of probability. The participants managed to overcome their challenges of integrating ethnomathematics in the teaching of probability in secondary school mathematics. The participants were able to integrate ethnomathematics in the teaching of probability even in those probability concepts they initially thought it was impossible to find matching concepts in the cultural activities of the learners. This was evident enough to show that the EIM improved the participants' ability to mathematize cultural activities. It was also observed that the EIM transformed the participants from their traditional roles to become facilitators who could be able to help learners to reflect on their probability concepts. The positive impact of the EIM was also observed amongst the learners of the three participants. The learners were motivated to participate actively during the lesson, and it was observed that even those learners who used to be dormant during the lessons became active when the EIM was being used. There was evidence that the learners improved significantly in their analytical skills when solving probability problems showing that the use of the EIM made learners understand the probability concepts. It can be concluded that the use of the EIM enables the participants to integrate ethnomathematics in the teaching of probability more effectively than before. This study also contributed two theories which can assist mathematics teachers when integrating cultural games in the probability concepts. The proposed Ethnomathematics Instructional Model under consideration is shown in **Figure 3.2.**

8.9 Educational implication of the study

The implications from the findings of this study are as follows:

- The use of the EIM in the integration of ethnomathematics in the teaching of mathematics for the teaching of probability at OL improves the mathematics teachers' probability pedagogy. The effectiveness of the EIM was observed when the mathematics teachers who were guided by this framework to integrate ethnomathematics to teach probability concepts were able to integrate ethnomathematics in the teaching of probability successfully. It was noted that the mathematics teachers successfully incorporated cultural activities in their probability pedagogy.
- The implementation of the EIM improved the learners' understanding of probability concepts as the learners were found to be able to identify probability concepts found in the cultural activities and showed improved capability to apply their knowledge to solve problems found in their textbooks. It was found that the learners after being taught using the EIM they were able to do their corrections to their work without the teacher's help.
- The use of the EIM motivated learners to participate meaningfully during the lessons.
- The use of the EIM helps the teacher to sequence lesson activities when integrating ethnomathematics in the teaching of probability in a way that makes the probability concepts understandable to the learners.
- The use of EIM makes the learners to be critical and confident. It was noted during this study that the way the cultural activities are incorporated in the pedagogy promote critical thinking

as the learners were able to critically analyse the probability concepts in the cultural activities and argue for their answers a situation that had not been witnessed before in these classes

- The learners' prior knowledge of probability concepts should be taken seriously by the mathematics teachers. It was noted in this study which was conducted in Bikita District of Masvingo Province that mathematics teachers were corrected by the learners on the probability concepts found in cultural activities when they wrongly incorporated the cultural activities in the pedagogy. It was also noted in this study that the learners have knowledge of almost all probability concepts taught in OL mathematics but what they lack is the school symbolisms and language.
- Incorporating vernacular languages during integration of ethnomathematics in the teaching of mathematics as highlighted by the EIM motivates learners to participate actively during the lessons. It was noted in this study that learners can articulate probability concepts in cultural activities better if they are to present them in a language the learners deal with outside school.

8.10. Limitations of this study

There were a lot of challenges at the time the data collection of this study was conducted. The major challenge was the prevalence of the COVID-19 pandemic. Data collection of this study took place during LEVEL 2 of COVID-19 lockdown in Zimbabwe and schools were operating under several restrictions such as social distances, wearing of face masks, the use of sanitizers, and restrictions of visitors in schools during that period. COVID-19 restrictions affected the implementation of the collaboration aspect of the EIM because the learners were required to maintain social distance of two metres apart making it difficult for learners to discuss in group. The learners had to raise their voices for them to hear each other. The prevalence of COVID-19 delayed the data collection by more than one year. Data collection was supposed to be done in 2020 but due to COVID-19 lockdown it was impossible for me to travel to

Zimbabwe from Eswatini where I am based and at the same time the schools were closed most of the time.

The COVID-19 lockdown resulted in government workers in Zimbabwe to work from home. Working from home by workers in the Ministry of Primary and Secondary Education resulted in delay in processing applications for the people who were seeking such permission to collect data. The most affected group were those like me who were seeking permission to collect data for their master's and Doctorate Degrees, the permission of which can only be granted by the Permanent Secretary of the Ministry of that ministry. Hence it took me one year and three months to get a clearance letter from the Permanent Secretary and it was emailed to me in March 2021.

Data was collected under uncertain circumstances without knowing whether the learners could come to school the following day or not as the spike of COVID-19 could lead to the closure of schools any time. After observing cultural activities, we had to break for four months from June 2021 to September 2021before doing lesson observations due to COVID-19 lockdown. Apart from the challenges of COVID-19, teachers in Zimbabwe were not working due to industrial action citing incapacitation. Due to this incapacitation the number of learners in the class could be less than twenty because learners were not coming to school since most of the teachers were not attending their classes. However, the learners became interested in the data collection lessons which were being taught and there was no more a challenge of fewer learners in the class. The incapacitation of the teachers was a blessing in disguise for me because the participants were the only teachers who were conducting lessons with their classes for the data collection. However, they were afraid to be labelled as sell outs of struggle hence the data was collected hurriedly for fear of being victimised by the other members. The COVID-19 lockdown in Eswatini also made us work from home the entire year. I did not have a challenge in doing the lesson observations because I was not required to report for work, so I decided to work from home while I was in Zimbabwe. However, I was not very settled because I was thinking that I might be called to go back to work before I completed data collection.

8.11 Conclusions

The findings from the implementation of the EIM the participants developed skills to integrate ethnomathematics in the teaching of probability. Through the guidelines provided by the EIM, the participants were able to mathematize the cultural activities and incorporated them in probability pedagogy. The EIM also helped the participants to problematize the cultural activities. Above all the EIM provides clear guidance on how to sequence classroom activities during integration of ethnomathematics.

The teachers' ability to integrate ethnomathematics in the teaching of probability is important in that it helps the learners to understand probability concepts better, but most teachers are unlikely to be able to effectively integrate ethnomathematics in the teaching of probability, they were not trained to use the ethnomathematics approach. The finding of this study reveals how the use of the EIM effectively guided the participants in integrating ethnomathematics in the teaching of probability.

The superior features of the EIM that contributed significantly towards the participants' ability to integrate ethnomathematics in the teaching of probability were: (a) mathematizing and problematizing of cultural activities (b) free dialogue that culminates into learners' reflection. These features are briefly discussed below.

- The participants through being guided by the EIM were able to mathematize the cultural activities and identify the probability concept in cultural activity. Their ability to mathematize the cultural activities enabled them to problematize the cultural activities. They were able to create or find suitable relevant problems based on the cultural activities. The EIM helped the participants to overcome their challenges of mathematizing cultural activities because EIM does not make it the sole responsibility of the teacher to mathematize cultural activities, but it was shared with the learners. It was through this stage of the EIM that made the participants realize that the probability concepts in cultural activities were hidden and unique. Through their curiosity the participants and the learners' brainstormed to understand how the cultural activities are understood from the learners' perspective. The participants came to realise that probability concepts in cultural activities have their own tools which are different from those used in conventional probability. The use of the EIM helped clear the participants' misconceptions about probability concepts in the cultural activities.

- Another feature of the EIM which helped the participants to effectively integrate ethnomathematics in the teaching of probability is the facilitating role of the teachers. This enabled the learners to participate freely in the process of mathematizing the cultural activities. Due to the free environment through which the EIM should be used the learners could use vernacular languages so that they could articulate their mathematization clearly without being hampered by using English language in which they could not mathematize the cultural activities clearly. Using vernacular language, the learners were found to be participating actively and they could mathematize the cultural activities to an extent of correcting their teachers when they incorrectly incorporated cultural activities in the pedagogy. It was through the free environment learners working in collaboration and the use of vernacular language that the learners could effectively reflect on their understanding of probability concepts.

8.12. Recommendations

The recommendations for this study are meant for the Ministry of Primary and Secondary Education and for further research.

8.12.1. Recommendations for the Ministry of Primary and Secondary Education

I. Teachers should be encouraged to implement the EIM in the teaching of probability.

II. Teachers should be encouraged to integrate ethnomathematics in the teaching of probability.

III. Teachers' colleges should train mathematics teachers on the integration of ethnomathematics in the teaching of mathematics.

IV. New mathematics textbooks with Zimbabwean context should be introduced in the secondary schools at OL.

V. When teaching probability teachers should be encouraged to incorporate ideas of the social constructivism which advocates for the teacher to play the role of facilitator and the co-creation of knowledge by the teacher and the learners in the mathematics classroom.

VI. Teachers should be encouraged to familiarise with the learners' cultural activities if they are to be able to incorporate them in the teaching of probability effectively.

VII. The mathematics teachers should be encouraged to allow learners to use vernacular languages during class discussion during integration of ethnomathematics to enhance conceptual understanding.

VIII. Mathematics teachers should be equipped with skills to conduct PAR for them to be able to address their teaching practice challenges involving integration of ethnomathematics in a holistic manner.

IX. Teachers should be encouraged to use the EIM to integrate ethnomathematics in the teaching of other mathematics topics to improve the learners' performance in those topics.

8.12.2 Recommendation for further studies

I. A similar study should be conducted at a larger scale to assess the effectiveness of the EIM.

II. Further studies should be conducted to find out ways in which the EIM can be effective in other topics in mathematics.

III. Further studies should be conducted outside Zimbabwe to determine the framework is compatible with cultural activities in other countries.

8.13. Conclusion

This chapter presents the synopsis of this study. The purpose of this study was to develop an ethnomathematics framework that can facilitate the integration of ethnomathematics in the teaching of probability at OL in Zimbabwe. The literature review highlights two gaps which this study sought to address. Firstly the literature highlights the insignificant link between mathematics instructions and the learners' culture. Secondly it highlights the need for an ethnomathematics framework that can facilitate the integration of ethnomathematics in the teaching of probability. The EIM was developed to incorporate the rural Shona learners' cultural activities in the probability pedagogy as a way of connecting probability instructions and the learners' culture. The development of an EIM focused on the improvement of mathematics teachers' probability instructions. The findings of this study reveal that the use of the EIM impacted positively on the mathematics teachers' probability instructional practice. This is best achieved when learners work collaboratively with each other, and they are allowed to use vernacular language. Furthermore this study provide evidence to show that teachers' ability to integrate ethnomathematics using the EIM in the teaching of probability is greatly impacted if they listen to the learners on how cultural activities are carried out in their daily lives. The study also resulted in the emergency of two theories, The Determination of Randomness Theory and The Detemination of Independent Outcome Theory. The two theories guide mathematics teachers when cultural games are being used in the teaching of probability. I came up with a conclusion which was based on the findings of this study as well as the recommendations directed at the Ministry of Primary and Secondary Education and recommendations for further research.

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LIST OF ANNEXTURES

ANNEXURE A: Permission letter to the Provincial Education Director [PED]

UNISA university of south africa

The Provincial Education Director
Ministry of Education
Private Box 89
Masvingo

20 November 2020

Dear Provincial Education Director

Re: Request for permission to conduct research in one secondary schools in Bikita District: Myseltf

I, **Munamato Turugari** am doing research with Prof Jojo, M.M, Zingiswa a professor in the Department of Mathematics Education. I am studying towards a PhD in Mathematics Education at the University of South Africa. We are requesting permission to carry out our research entitled **Integrating Ethnomathematics in Secondary School Mathematics in Zimbabwe.** The aim of the study is to explore the integration of ethnomathematics into the secondary school mathematics in Zimbabwe.

Your schools **Tabudirira Secondary School** has been purposively selected because of invaluable traditional activities in the community in which the school is located that the study intends to utilize to develop an ethnomathematical model for teaching probability concepts in secondary school mathematics.

The study will entail mathematics teachers to participate in a participatory action research in which they will integrate ethnomathematics in the form of the rural Shona people's out of school mathematical practices. The participating mathematics teachers will teach probability concepts to Form Three learners using the lesson plans in which the Shona people's probability concepts have been imbedded.

The benefits of this study are that the mathematics teachers will develop skills in creating culturally relevant pedagogy for the teaching of probability in secondary school mathematics which will help the learners to understand probability concepts better. There are no potential risks in the study.

Feedback procedure will entail meetings with the participants on results analysis and drawing of conclusions. Also a copy of the thesis will be given to the school library and the District library for the benefits of the mathematics teachers who are not going to be part of the research team.

Yours sincerely

Munamato Turugari

Researcher

Cell: 0773906026 Email address: mturugari@gmail.com

Supervisor: Professor ZMM Jojo (University of South Africa: Mathematics Education Department)

Telephone: +27124296627 email: jojozmm@unisa.ac.za

ANNEXURE B: Permission letter from the permanent secretary of the Ministry of Primary and Secondary Education

All communications should be addressed to
"The Secretary for Primary and Secondary Education
Telephone: 794895/796211
Telegraphic address: "EDUCATION"
Fax: 794505

ZIMBABWE

Reference: C/426/3
Ministry of Primary and Secondary Education
P.O Box CY 121
Causeway
HARARE

29 March 2021

Munamato Turugari
University of South Africa
Department of Mathematics
P. O. Box 392
UNISA 003
South Africa

Re: PERMISSION TO CARRY OUT RESEARCH IN MASVINGO PROVINCE: BIKITA DISTRICT: TABUDIRIRA SECONDARY SCHOOL

Reference is made to your application to carry a research at the above mentioned school on the research title:

"INTEGRATING ETHNOMATHEMATICS IN SECONDARY SCHOOL MATHEMATICS IN ZIMBABWE"

Permission is hereby granted. However, you are required to liaise with the Provincial Education Director Masvingo Province, who is responsible for the schools which you want to involve in your research. You should ensure that your research work does not disrupt the normal operations of the school. Where students are involved, parental consent is required.

You are also required to provide a copy of your final report to the Secretary for Primary and Secondary Education.

30 MAR 2021
HARARE, ZIMBABWE

T. Thabela (Mrs)
SECRETARY FOR PRIMARY AND SECONDARY EDUCATION

ANNEXURE C: Permission letter from Masvingo Provincial Education Director

ALL communications should be addressed to "The Provincial Education Director for Primary and Secondary Education"
Telephone: 263585/264331
Fax: 039-263261

ZIMBABWE

Ref: trugari m

Ministry of Primary and Secondary Education
P.O Box 89
Masvingo

26 March 2021

The Secretary
Ministry of Primary and Secondary Education

Attention: Director Policy Planning Research and Statistics

RE: SEEKING PERMISSION TO CARRY OUT AN EDUCATIONAL RESEARCH AT TABUDIRIRA HIGH :BIKITA DISTRICT: MASVINGO PROVINCE

The above matter refers.

Mr Munamato Turugari, a student at University of South Africa(UNISA), South Africa, is seeking permission to carry out research at the above mentioned school in Masvingo District on,

"Integrating Ethno mathematics in Secondary School Mathematics in Zimbabwe"

Attached please find the applicant's letter, research instruments and a copy of the student's I.D. The application is supported since it meets the minimum requirements. Your authority to grant permission is therefore sought.

PP Mhike S
A/Provincial Education Director
MASVINGO PROVINCE

26 MAR 2021

ANNEXURE D: Permission letter to the headmaster

The headmaster
Tabudirira Secondary School
Private Box 1170
Nyika

3 April 2021

Dear Headmaster

Re: Request for permission to conduct research in one secondary schools in Bikita District: Myself

I, **Munamato Turugari** am doing research with Prof Jojo, Zingiswa, a professor in the Department of Mathematics Education. I am studying towards a PhD in Mathematics Education at the University of South Africa. We are requesting permission to carry out our research entitled **Integrating Ethnomathematics in Secondary School Mathematics in Zimbabwe.** The aim of the study is to explore the integration of ethnomathematics into the secondary school mathematics in Zimbabwe.

Your schools **Tabudirira Secondary School** has been purposively selected because of invaluable traditional activities in the community in which the school is located that the study intends to utilize to develop an ethnomathematical model for teaching probability concepts in secondary school mathematics.

The study will entail mathematics teachers to participate in a participatory action research in which they will integrate ethnomathematics in the form of the rural Shona people's out of school mathematical practices. The participating mathematics teachers will teach probability concepts to

Form Three learners using the lesson plans in which the Shona people's probability concepts have been imbedded.

The benefits of this study are that the mathematics teachers will develop skills in creating culturally relevant pedagogy for the teaching of probability in secondary school mathematics which will help the learners to understand probability concepts better. There are no potential risks in the study.

Feedback procedure will entail meetings with the participants on results analysis and drawing of conclusions. Also, a copy of the thesis will be given to the school library and the District library for the benefits of the mathematics teachers who are not going to be part of the research team.

Yours sincerely

Munamato Turugari

Researcher

Cell: 0773906026 Email address: mturugari@gmail.com

Supervisor: Professor ZMM Jojo (University of South Africa: Mathematics Education Department)

Telephone: +27124296627 email: jojozmm@unisa.ac.za

ANNEXURE E: Invitation to teachers to participate in the study.

30 September 2021

Dear Prospective Participant

Title: **Integrating ethnomathematics in secondary school mathematics in Zimbabwe**

My name is **Turugari Munamato,** and I am doing research with **Jojo, Z.M.M,** a professor in the Department of Education towards a PhD, at the University of South Africa. We are inviting you to participate in a study entitled Integrating ethnomathematics in secondary Schools mathematics in Zimbabwe

WHAT IS THE PURPOSE OF THE STUDY?

I am conducting this research to find out the effects of integrating the indigenous mathematical practices in the teaching and learning of probability in Ordinary Level mathematics in Zimbabwe. …

WHY AM I BEING INVITED TO PARTICIPATE?

You are being invited because you are one of the teachers who are teaching mathematics at the selected school in the district. In fact, the researcher invites all the mathematics teachers teaching Ordinary level at the school. The researcher obtained the contact details of all the mathematics teachers from the school headmaster. The researcher needs 3 teachers from the school. If the number is not reached at one school, he is going to request for more teachers from the neighboring school. Only 3 mathematics teachers will be required for the group to be manageable.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

The study involves being interviewed by the researcher. The interviews are centered on the rural Shona people's mathematical practices can be integrated in teaching and learning secondary school mathematics. The research will also entail the participants to collect data by observing the mathematical concepts found in the daily life of the Shona pupil. The participants will also be observed when teaching using the mathematical models that will be developed during this action research. The participants will also be interviewed after the lesson to assess the effectiveness of the mathematics models which will be used. The participants will also be required to attend feedback meetings after their observations and results analysis meetings. Since this is an action research data collection will only stop when we find results that inform our research. To that end data collection may take 6 months.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

The benefit benefits of this study participants are that by participating in this action research the teachers are going to be equipped with skills of how to develop mathematical models from the learners' home based mathematical practices for them to be able to create culturally relevant pedagogy. The development of an indigenized teaching and learning topic will go a long way in improving the teaching and learning of probability and hence the improvement of the mathematics pass rate will improve.

If this research goes through the findings of this study will be used as a benchmark for further studies on integration of ethnomathematics in the secondary school curriculum in Zimbabwe.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

There are no negative consequences for you to participate in this research project.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

Confidentiality

Your answers will be given a code number, or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. The researcher will be responsible for coding and transcribing meaning that anyone else will be access the data after coding. Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Review Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

Anonymity

Your name will not be recorded anywhere, and no one will be able to connect you to the answers you will give. The anonymous data from this study may be used for other purposes such as conferences proceedings, journal articles and a report of the study may be submitted for publication but no individual participants will be identified in such a report.

A focus group discussion is a focused discussion designed to obtain perceptions, attitude, feelings and experience in a defined area of interest in a permissive non-threatening atmosphere of disclosure from a predetermined and limited number of people. *While every effort will be made by the researcher to ensure that you will not be connected to the information that you share during the focus group, I cannot guarantee that other participants in the focus group will treat information confidentially. I shall, however, encourage all participants to do so. For this reason I advise you not to disclose personally sensitive information in the focus group.*

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet *at House number 372, Duma, Nyika Township Zimbabwe,* for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

The participants will be given daily financial allowances in line with the Public Service prevailing rates for teachers for the days they will be engaged in feedback meeting/focus group discussions for food.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has received written approval from the Research Ethics Review Committee of the *CEDU*, Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Turugari Munamato on +263773906026 or mturugari@yahoo.com. The findings are accessible for 5 years. Please do not use home telephone numbers. Departmental and/or mobile phone numbers are acceptable.

Should you have concerns about the way in which the research has been conducted, you may contact Prof ZMM Jojo, Telephone number 0027114296627, jojozmm@unisa.ac.za. .

Thank you for taking time to read this information sheet and for participating in this study.

Thank you.

Munamato Turugari

ANNEXTURE F: Teachers' consent to participate (Return slip)

I, ___________________ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the interview

I have received a signed copy of the informed consent agreement.
Participant Name & Surname (please print)____

____

Participant Signature Date

Researcher's Name & Surname (please print) **Munamato Turugari**

30 September 2021

Researcher's signature Date

ANNEXURE G: Letter requesting assent from learners in secondary school to participate in a research project

23 September2019

Dear Learner

Title of study: **Integrating ethnomathematics in secondary schools mathematics in Zimbabwe**

I am doing a study on integration of ethnomathematics in the secondary school mathematics as part of my studies at the University of South Africa. Your principal has given me permission to do this study in your school. I would like to invite you to be a very special part of my study. I am doing this study so that I can find ways that your teachers can use to teach probability concepts in a better way. This will help you and many other learners of your age in different schools.

This letter is to explain to you that I would like you to do. There may be some words you do not know in this letter. You may ask me or any other adult to explain any of these words that you do not know or understand. You may take a copy of this letter home to think about my invitation and talk to your parents about this before you decide if you want to be in this study.

I would like to observe your teacher's teaching probability to your class using the indigenised the lesson plans that your teachers and I will produce.

I will write a report on the study, but I will not use your name in the report or say anything that will let other people know who you are. You do not have to be part of this study if you don't want to take part. If you choose to be in the study, you may stop taking part at any time. You may tell me if you do not wish to answer any of my questions. No one will blame or criticise you. When I am finished with my study, I shall return to your school to give a short talk about some of the helpful and interesting things I found out in my study. I shall invite you to come and listen to my talk.

The benefit of this study is that it assists mathematics teachers in terms of how to create culturally relevant pedagogy in the teaching of probability and as a result the learners will understand the concepts better. There is no potential risk in participating in this study. You will not be reimbursed or receive any incentives for your participation.

If you decide to be part of my study, you will be asked to sign the form on the next page. If you have any other questions about this study, you can talk to me or you can have your parent or another adult call me a 00263773906026. Do not sign the form until you have all your questions answered and understand what I would like you to do.

Researcher: **Turugari Munamato** Phone number: 00263773906026.

Do not sign written assent form if you have any questions. Ask your questions first and ensure that someone answers those questions.

WRITTEN ASSENT

I have read this letter which asks me to be part of a study at my school. I have understood the information about the study, and I know what I will be asked to do. I am willing to be in the study.

Learner's name(print): Learner's signature: Date:

_

Witness's name (print) Witness's signature Date:

(The witness is over 18 years old and present when signed.)

Parent/guardian's name (print) Parent/guardian's signature: Date:

Munamato Turugari **30 September 2021**

Researcher's name (print) Researcher's signature: Date:

ANNEXURE H: Letter requesting parental consent/assent for minors to participate in the study.

23 September 2019

Dear Parent

I am inviting your child is to participate in a study entitled **Integrating ethnomathematics in secondary school mathematics in Zimbabwe.** I am undertaking this study as part of my PhD research at the University of South Africa. The purpose of the study is to assist mathematics teachers in terms of how to integrate ethnomathematics in the secondary school mathematics for the teaching of probability in Ordinary Level Mathematics and the possible benefits of the study are to improve the teaching methods of probability and the improvement of Ordinary Level mathematics results in rural areas. I am asking permission to include your child in this study because the research intends to involve all the Form 3 students at the school, I expect to have 90 other children participating in the study.

If you allow your child to participate, I shall request him/her to be part of the class that I will observe when the teachers will be teaching probability using the lesson plans that the researcher is going to develop jointly with members of the research team. The lessons will be audio recorded I am also requesting permission to audio record your child as he/she participates in these lessons

Any information that is obtained in connection with this study and can be identified with your child will remain confidential and will only be disclosed with your permission. His or her responses will not be linked to his or her name or your name or the school's name in any written or verbal report based on this study. Such a report will be used for research purposes only.

There are no foreseeable risks to your child by participating in the study. Your child will receive no direct benefit from participating in the study; however, the possible benefits to education are that the research will produce an indigenized topic on probability which will make the learners understand probability better and hence improve the performance of the students in the Ordinary

Level mathematics examination in Zimbabwe. Neither your child nor you will receive any type of payment for participating in this study.

Your child's participation in this study is voluntary. Your child may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly, you can agree to allow your child to be in the study now and change your mind later without any penalty.

The study will take place during regular classroom activities with the prior approval of the school and your child's teacher. However, if you do not want your child to participate, an alternative activity will be available; the mathematics teacher will prepare work for him/her to do.

In addition to your permission, your child must agree to participate in the study and you and your child will also be asked to sign the assent form which accompanies this letter. If your child does not wish to participate in the study, he or she will not be included and there will be no penalty. The information gathered from the study and your child's participation in the study will be stored securely on a password locked computer in my locked office for five years after the study. Thereafter, records will be erased.

The benefit of this study is that it assists mathematics teachers in terms of how to create culturally relevant pedagogy in the teaching of probability and as a result the learners will understand the concepts better.

If you have questions about this study, please ask me or my study supervisor, Prof Jojo, ZMM Department of Mathematics College of Education, University of South Africa. My contact number is 00263773906026 and my e-mail is mturugari@gmail.com The e-mail of my supervisor is jojozmm@unisa.ac.za. Permission for the study has already been given by Provincial Director of Masvingo Province and the Ethics Committee of the College of Education, UNISA.

You are deciding about allowing your child to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow him or her to participate in the study. You may keep a copy of this letter.

Sincerely

Parent/guardian's name (print) Parent/guardian's signature: Date:

Munamato Turugari **30 September 2021**

Researcher's name (print) Researcher's signature Date:

ANNEXURE I: Participants consent to participate in post-lesson interviews and meetings

I____ grant consent/assent that the information I share during the post lesson delivery meeting be used by **Turugari Munamato** for research purposes. I am aware that the meetings will be digitally recorded and grant consent/assent for these recordings, provided that my privacy will be protected. I undertake not to divulge any information that is shared in the meeting to any person outside the group to maintain confidentiality.

Participant 's Name (Please print): __________________________________

Participant Signature: ____

ANNEXURE J. CEDU ETHICS CLEARANCE LETTER

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2019/10/16

Ref: **2019/10/16/55781063/16/MC**
Name: Mr M Turugari
Student No.: 55781063

Dear Mr Turugari

Decision: Ethics Approval from 2019/10/16 to 2024/10/16

Researcher(s): Name: Mr M Turugari
E-mail address: mturugari@yahoo.com
Telephone: +26 87 817 4163

Supervisor(s): Name: Prof ZMM Jojo
E-mail address: jojozmm@unisa.ac.za
Telephone: +27 12 429 6627

Title of research:

Integrating ethnomathematics in the secondary school mathematics in Zimbabwe.

Qualification: PhD in Mathematics Education

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2019/10/16 to 2024/10/16.

*The **low risk** application was reviewed by the Ethics Review Committee on 2019/10/16 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.

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www.unisa.ac.za

3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
7. No field work activities may continue after the expiry date **2024/10/16**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number **2019/10/16/55781063/16/MC** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Kind regards,

Prof AT Motlhabane
CHAIRPERSON: CEDU RERC
motlhat@unisa.ac.za

Prof PM Sebate
ACTING EXECUTIVE DEAN
Sebatpm@unisa.ac.za

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ANNEXURE K: Initial semi-structured interview with the teachers.

1. What challenges do you have in teaching probability?

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2. What do you understand by teaching from the known to unknown?

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3. How do you incorporate cultural activities in the teaching of probability?

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4. Is it always possible to find cultural probability concept to match probability concepts found in school probability concepts? Explain your answer.

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5. How do you deal with cultural diversity in your mathematics class?

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6. Which cultural activities do you incorporate in the teaching of probability?………………………………………………………………………………………

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7. How do you incorporate cultural activities in the teaching of probability?

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ANNEXTURE L: Final semi-structured interviews with the teachers.

1. How did the implementation of the EIM impacted on your ability to integrate ethnomathematics in the teaching of probability?

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2. How did the use of EIM impacted on the learners' performance during the implementation of the EIM?

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3. What can you say is the most important component of the EIM?

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4. Learners can get a deeper understand probability concepts through reflection, how did the use of the EIM helped you to assist the learners to reflect on their understanding of probability concepts?

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5. Are there some probability concepts which you found difficult to find matching concepts in the cultural activities?

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ANNEXURE M: Lesson plan

1.Date 2.Class: 3.Topic: Probability 4.Lesson Topic	5.Time 6. Assumed Knowledge 7. Cultural Activity identified:	
8. Phase	Teaching Activities	Learning Activities
9. Introduction		
Phase 1	Teacher identifies a cultural activity and ask the learners to describe it	Learners describe how the activity is performed
Phase 2	Teacher poses a problem associated with the activity identified and ask the learners to solve the problem in the way they solve it outside school	Learners solve the problem in pairs/in groups
Phase 3 ……………………. Phase n	Following the stages in the ethnomathematics model	
Conclusion		
Evaluation	Participants commented on the success of the lesson.	

ANNEXTURE N: Classroom observation schedule

ITEM	OBSERVATIONS
1. What cultural activities were used during the lesson?	
2. How familiar were the learners with the cultural activities that were employed during the lesson? How the learners did show that they were familiar with the cultural activities.	
3. How relevant was the problem posed by the participants? How the problem did appeal to the learners' real life situations.	
4. Were the learners able to solve the problem posed? Was the participant's understanding of cultural activity the same as that of the learners? How the participants did address the disparities that emerged if any.	
5. How did the participant deal with cultural diversity and teacher-learner dialogue?	
6. Did the participant manage to make connections between the cultural activity and conventional mathematics? How did the learners perform in the written work assigned? Was the participant's marking of work helping the learners/	
7. How the participant did help the learners to reflect on their understanding of probability concepts.	
8. Did the participants helped the learners to apply the probability concepts taught? Did	

the learners identified the application of the concepts taught in their daily lives	
9. How effective was the cultural activity in teaching about the probability concepts?	

ANNEXURE O: Data Collection Timeline

Phase	**Activity**	**Duration**
First Phase	Ground-breaking and familiarisation	1st April to 24th April 2021
Second Phase	First interviews	30th April 2021
	Observations of cultural activities	1st May 2021 to 30rd May 2021
	Feedback meeting on cultural activities	30th October 2021
	Lessons observations	11th November 2021 to 5thDecember 2021
	Second interviews	6th December 2021
	Data analysis meeting	11th to 15th December 2021
Third Phase	Final reflection meeting	17th December 2021

ANNEXURE P: Editorial Certificate

EDITORIAL
CERTIFICATE

Author: Mr Munamato Turugari

Document title: INTEGRATION OF ETHNOMATHEMATICS IN SECONDARY SCHOOL MATHEMATICS IN ZIMBABWE

Date issued: 20/04/2022

This document certifies that the above manuscript was proofread and edited by Prof Gift Mheta (PhD, Linguistics).

The document was edited for proper English language, grammar, punctuation, spelling and overall style. The editor endeavoured to ensure that the author's intended meaning was not altered during the review. All amendments were tracked with the Microsoft Word "Track Changes" feature. Therefore, the authors had the option to reject or accept each change individually.

Kind regards

Prof Gift Mheta (Cell: 073 954 8913)