EDITORS
Prof C. Kasanda & Mr. J. S. Uugwanga,

EDITORIAL COMMITTEE
¹Prof Chosi Kasanda, ¹University of Namibia
²Mr. Jafet S. Uugwanga and ³Ms. Lydia P. Aipinge, ²,³National Institute for Educational Development

EDITORIAL OFFICE
NIED
Reform Forum
Private Bag 2034
Okahandja
NAMIBIA
E-mail: juugwanga@nied.edu.na

Copyright © 2019 NIED, Ministry of Education, Namibia

Any part of this publication may be reproduced or transmitted for non-commercial and educational purposes, in order to further the ideas involved. Please acknowledge the source and send a copy to the Editorial Office, Reform Forum.

The Reform Forum is a periodical distributed gratis to University of Namibia Campuses of Education (former colleges of education), Regional Education Offices, Teachers’ Resource Centres, Schools and other educational institutions in Namibia. It is published three times a year to stimulate discussion about educational reform and to further the development of education in Namibia.

Authors are fully responsible for the contents of their articles and are encouraged to express their opinions freely on professional matters. The Editorial Committee reserves the right to edit articles unless otherwise stated by the authors. Opinions expressed in the Reform Forum do not necessarily reflect the opinions of the National Institute for Educational Development (NIED), the Ministry of Education, the Editors or the Editorial Committee.
EDITORIAL

Inventive mathematics teaching practices using learner-centred to teach mathematical operations of fractions in the Zambezi Region
C. Sibuku and Muzwa Mukwambo

Examining the psychometric validity of the beliefs about nature of science questionnaire
Simson N. Shaakumeni and Benő Csapó

Western science knowledge evolve from indigenous knowledge
Muzwa Mukwambo, Kenneth M. Ngcoza and Charles Chikunda

Grade 12 learners’ performance on direct algebraic equations vis-à-vis word problem equations: A case study of one school in Oshana Region, Namibia
H. L. Kamukonda and S. T. Naukushu

The integration of hands-on games in the learning of probability: A case of Grade 12 learners in the Oshana Cluster of Oshana Region
S. T. Abisai, S. T. Naukushu and C. D. Kasanda

Towards a paradigm shift in conceptualizing multilingual models of language education throughout Africa: A review of literature
Haingura Paulinus

How Grade-R teachers’ inability to promote a ‘love for books’ influences the acquisition of early literacy skills in Grade-R learners in Zambezi Region, Namibia
Kenneth Nzwala

Contributors’ List
Editorial

Welcome to the National Institute for Educational Development’s (NIED) 2019 Volume 27, Issue 1 of the journal Reform Forum. This volume includes seven most recent articles contributed by our readers which include titles like: Inventive mathematics teaching practices using learner-centred to teach mathematical operations of fractions in the Zambezi Region; Examining the psychometric validity of the beliefs about nature of science questionnaire; Western science knowledge evolves from indigenous knowledge; and The integration of hands-on games in the learning of probability: A case of Grade 12 learners in the Oshana Cluster of Oshana Region. This latest publication fulfils NIED’s mission of dissemination of educational information, experiences and the results of studies which is an essential part of the Institute’s mandate, closely linked with its (teacher) training, research activities and curriculum development. We invite you to it down while you read this edition with great interest and think about contributing an article towards the next publication. The reader should visit our website: www.nied.edu.na where you will find the latest titles in the Reform Forum (all downloadable), as well as additional information on the Institute and its programme of activities.

Our journal, The Reform Forum, as a periodical, is distributed freely to all UNAM Campuses of education, Regional Education Offices, Teachers’ Resource Centres, National Libraries and other educational institutions in Namibia. It is published to stimulate discussion about educational development and to further the “reform” in Namibia. Authors are fully responsible for the contents of their articles and are encouraged to express their opinions freely on professional matters. The Editorial Committee reserves the right to edit articles before publication as they see fit. Opinions expressed in the Reform Forum do not necessarily reflect the opinions of the National Institute for Educational Development, the Ministry of Education, Arts and Culture, or the Editors. Kindly contact us if you are interested in contributing an article or subscription (juugwanga@nied.edu.na or use our mailing address: P/Bag 2034, Okahandja, Namibia, tel: +264-62-509000).

The Editorial Committee
Inventive mathematics teaching practices using learner-centred to teach mathematical operations of fractions in the Zambezi Region

C. Sibuku and Muzwa Mukwambo
1&2 University of Namibia, Katima Mulilo Campus
1 csibuku@unam.na and 2 mmukwambo@unam.na

Abstract
Various factors are associated with high failure rate witnessed in mathematics in Namibian schools. Some of these factors which researchers, policy makers, teachers and learners suggest are: (a) Teaching strategies; (b) Content knowledge and understanding; (c) Motivation and interest; (d) Laboratory usage; and (e) Syllabus non-completion and many more which might be resource or system related. To address some of these factors, innovative mathematics practices are encouraged in the teaching of mathematics in Namibian schools. These innovations are manifested in the use of learner-centred approach in mathematics teachers’ practices. To gain insight on strategies teachers use to teach mathematical operations; addition, subtraction, multiplication and division of fractions, and the content knowledge teachers pose to teach operations of fractions, innovative mathematics teaching practices using learner-centred methods were investigated.

To answer the research question posed, in order to gain insight into inventive mathematics teaching practices using learner-centred to teach mathematical operations of fraction in the Zambezi Region, this qualitative study used document analysis, interviews and observations. To support the data yielded, which can be recommended to others, the study looked into fractions and how they are taught and possible ways to transform the current practice. The constructs learner-centred, traditional and modern methods of teaching fractions, cognitive and social constructivist as theoretical frameworks were discussed. Some of the findings were; teachers lacked fraction content knowledge and they did not engage habits of mind to ensure that their approaches adopted learner-centred teaching.

Keywords: learner-centred, innovative, habits of mind, basic operations

Introduction and background
The learning of mathematics was optional in Namibia before the reviewed curriculum was implemented (Angula, 2015). A learner after grade ten was allowed to drop mathematics and opt for subjects he/she felt comfortable with. This paved a way for the majority of learners to abandon the learning of mathematics that is a useful tool in all subjects and any other human cultural activities (Attard, 2014). The viewing of mathematics as a useful tool in Namibia surfaced soon after independence when mathematics was made a compulsory subject by the current SWAPO government. Mathematics was made compulsory up to grade twelve but before it was compulsory up to grade ten. Even though this decision was reached a large number of learners had already built a view that mathematics was a challenging subject. This has led to mathematics learnt by fewer learners. Some in their careers might have managed to train as mathematics teachers even though some might not have done mathematics up to grade twelve. The majority who did not do mathematics up to grade twelve sometimes went through some various courses with private institutions and then finally got a post as lower primary school teacher where mathematics as a tool is needed to build number sense concepts which Faulkner (2009) considers pivotal for mathematics understanding in other situations in daily life. To upgrade their mathematics skills these teachers enrolled with University of Namibia to gain more understanding in the teaching of lower primary phase.

As a mathematics educator involved in supporting these teachers it aroused my interest to find out the content knowledge these teachers pose that enables or constrains the
teaching of mathematical operations; addition, subtraction, multiplication and division of fractions and what are the teaching strategies involved when they teach these operations. The Namibian mathematics teachers’ lack of subject content knowledge in fractions at the primary school level and their operations is not manifested by them only. Faulkner (2009) reports the same phenomenon observed in the United States of America. He revealed that qualitative studies done show that elementary mathematics teachers tend to lack a “profound understanding” of the fundamentals of the mathematics they teach. The importance of gaining insight into the stated research questions might help in improving teachers’ strategies in dealing with operations involving fractions, their content knowledge of fractions and thereafter improve the mathematics pass rate. The experience was gained when visiting trainee teachers on school based studies (SBS). Several times after observing the trainee teachers I checked learners’ books to see how they assess and comment in the workbooks but I never saw where an invented mathematics teaching strategies (IMTLS) was used. Cuoco, Goldenberg and Mark (1996) encourage developing habits of mind in learners and invent is one. This justify why we came with the idea of IMLTS. This led to have the problem which this study aims to address to be expressed as in the paragraph which follows.

Statement of the problem

While on SBS, observing trainee teachers teaching mathematics to primary school learners, some challenges were observed. After learners were given a test where some of the concepts were based on fractions, the majority of the learners in lower primary phase did not make it. This aroused our interest to find how the concept of fractions and operations were answered in answer sheets of fifty eight learners. Questions on fractions in the test paper were analysed to support this study. The aim was to find out how these teachers solved the questions related to fractions. The results emerging from the analysis was not impressive as Figure 1 reveals. This paved the way to find out how concepts of fractions are taught in lower primary classes while engaging learner-centred approach.

Figure 1: Performance of teachers on questions related to the concept of fractions and their operation

In Figure 1, question 6, 20 and 23 reveal that the grade three mathematics learners who wrote the paper had very low scores. Most of them did not manage to get those questions correct. Even though the trend in question 19 changed it still does not give a good picture. Those who managed to score correct marks were almost equal to those who failed to get the question correct.

In the curriculum documents, the concept of fractions shows conceptual cohesion and progression (Kriek & Basson, 2008). That is, concepts are introduced in Pre-primary and then are revisited in the next grade but each concept is at a higher level of the
rung. Each time the concepts are revisited, the ideas gained in lower grades serve as prior knowledge for the same concepts being introduced by the teacher. Failure of teachers to teach the concept of fraction and their mathematical operations; addition, subtraction, multiplication and division using what the curriculum recommends, learner-centred approach, is one of the factors contributing to high failure rate in mathematics. This is manifested when learners write national examinations. According to Mateya, Utete, and Illukena (2016) suggest that some of the factors; researchers, policy makers, teachers and learners mention include; (a) Teaching strategies; (b) Content knowledge and understanding; (c) Motivation and interest; (d) Laboratory usage; and (e) Syllabus non-completion and many others which might be resource or system related.

This study focused on teaching strategies these teachers used to teach fractions and also investigated the fraction content knowledge and understanding the teachers possessed. To understand how operations of fraction were taught in the Zambezi Region.

Conceptual frameworks
A conceptual framework is a synthesis of the existing views in the literature concerning a given situation (Imenda, 2014). Liehr and Smith (1999) suggest that a conceptual framework is a model or integrated way of looking at a problem. In this study, the conceptual frameworks were the traditional mathematics teaching and learning strategies (TMTLS) which are generally teacher-directed and where students are taught passively (Tularm, 2018). However, opponents to TMTLS claim that the invented mathematics teaching strategies (IMTLS) are encouraging developing of habits of mind (Cuocco, Goldenberg & Mark, 1996) bring about learner-centred (LC).

Traditional mathematics teaching and learning approach (TMTL)
Teachers whose worldview is behaviourist according to Karten (2009) entertain the idea that learners respond to stimuli in their environment and teachers’ responsibility is to provide necessary and useful stimuli. Also, behaviourists believe that there are some learners with a talent to learn mathematics. This is in sharp contrast to Chambliss (1989) who views a talent as a social construct. Chambliss (1989) asserts that there is no one born with a talent but through practice one constructs and gains mathematics knowledge to excel. Behaviourist teachers use an approach in which initiation-response-evaluation (IRE) are dominant (Mehan, 1979).

According to Mehan (1979) also supported by Wang (2014) a mathematics teacher initiates the conversation. In most cases the teachers present known facts about the concept under study. For example when dealing with fraction operations involving division, which is sharing, the teacher presents on the board how the parts in the problem are dealt with using mathematical symbols representing the mathematical language of terms under consideration. Thereafter, the teacher expects that the learners have been drilled enough to work another example which will have the same pattern. He pauses for the learners to give a response. The learners are expected to follow the same steps like what he had done. When he sees that sufficient time for pausing has been given to the learners he starts his evaluation. In his evaluation the teacher ensures that learners have followed all the steps like what he did in the examples he had presented. Sometimes those learners who would have given a response using their inverted methods are reprimanded. This allows the teacher to adhere to his TMTL approach. For example in the case of a problem on mean and also involving fractions, the question might be:

Four learners, Mary, Peter, John and Jane had their bags searched. Mary’s bag had 4 pencils, Peter’s bag had 3 pencils, John’s bag had 5 pencils and Jane’s bag had 6 pencils. Find the mean.

One of the learners might have not used the long division to arrive at getting the value of the mean. Instead he might have worked the question as follows:

To calculate the mean one learner proceeded as follows:
Mary  Peter  John  Jane
Sometimes such a learner who resorted to using an inverted method is reprimanded. The teacher believes it is good to drill the learner. The particular learner sees finding the mean as sharing objects equally. To share the remainder the learner first divided each remaining pencil into four parts, gave each out and repeated the process. He found that the two \( \frac{1}{4} \) each member receives will add up to \( \frac{1}{2} \). The total for each yield is \( 4 \frac{1}{2} \).

In cases where the teacher uses questions to initiate, pause for response and then evaluate, this does not allow a learner to participate cognitively as he constructs maths knowledge. The classroom talk is teacher-centred and resonates well with the behaviourist worldview. This restricts the learners from developing their mathematical language and conceptual development is hampered. If one’s language of mathematics is not developed then the habits of mind are weak.

Habits of mind are dispositions or skills learners need to have in order to understand mathematics concepts. There “is no one correct or complete list of mathematical habits of mind” (Seeley, 2014, p. 248). Some of the habits of mind Cuoco, Goldeberg, and Mark (1996) propose enable learners to; sniff out patterns, create, invent, conjecture, experiment, describe, tinker, visualize and guess.

Weakened habits of mind mean that mathematics is still viewed using the same lens used in its ontogenesis. However, it is important that the use of other lenses foster better understanding. A better understanding entails that better models to represent mathematical concepts come from learners. That is mathematics learners do not just copy what already exists but as learners who might be pushed to work nearer to the level of the real mathematician, they will be like any mathematician who brings new mathematics ideas in a community of practice (Lave & Wenger, 1991).

Even though TMTL anchored on behaviourism is limited since power and control is invested in teachers, it leads to non-cognitive participation of learners. Also, TMTL limits learners to use strategies which the teacher employed during classroom discussion. On the other hand, the RMTLS to be discussed below encourages learners to participate physically or cognitively in Mathematics. The RMTL anchored on constructivism is compatible with other theories of teaching and learning as will also be seen in the section which follows.

**The reformed mathematics teaching and learning approach (RMTL)**

The RMTL is responsive to the current theories of teaching and learning namely constructivism and all its strands. The teachers engage learners and this facilitates the emerging of arguments. As the learners argue they develop their mathematical language during classroom talk (Lemke, 1990; Krajčík & Sutherland, 2010). A cognitive conversational or inquiry based approach allows learners’ mathematical creativity to develop. Furthermore, more strategies can be created which favour learner-centred approach and some of these strategies which are inquiry based favour learner-centred. The learner-centred (LC) approach is used in Namibia and other Sub-Saharan African countries. The LC approach favours the RMTL and is suitable for coming up with strategies to teach operations as discussed below.

**Use of learner-centred strategy to support RMTL**

According to Weimer (2002) learner-centred approach is anchored on ensuring that classroom power is shifted to learners to foster active learning. LC encourages critical thinking among learners. The teacher ceases to be an authority. Also, in the LC approach learners take part in directing their knowledge and employing effective assessment that inform future practices.

Sibuku (1997) points out that Namibian government after gaining political power overhauled the apartheid education system which entertained TMTLS only. The aim was to align teaching approaches that embrace LC with social theories of teaching and learning in line with the Harambee prosperity plan. Nakale (2016) suggests creative conducive
conditions. According to Nakale (2016), Harambee construct reflects the Unhu/Ubuntu worldview to flourish which encourage teaching and learning in Namibia not to privilege cognitive theories which do not allow learners to contribute while using their cultural resources but embrace social theories. The IMTLS in which LC features replaced behaviourists’ theories. However, to ensure that the tenets of LC Weimer (2002) mentions are engaged, the teachers view is that this requires teaching resources. Sibuku (1997) in support states that trainee teachers sometimes fail to engage learner-centred approach on account of lack of facilities and basic materials. 

This is true that resources need to be in place. Faced with the large number of schools which the Namibian government supplies educational materials to, sometimes makes it difficult to ensure that every school has the required materials. Sometimes in under-resourced schools the teaching and learning material are not there. Schweisfurth (2011) also is in support of Sibuku (1997) by pointing out that LC implementation is riddled with stories of failure attributed to lack of materials. Gaining of political power does not imply a nation has the economic kit or credentials to finance the buying of teaching resources for all schools. In view of the identified challenges how can maths teachers ensure that practices in operation of fractions are LC compliant?

One of the benefits of adopting the RMTL approach is its compatibility with learner-centred. LC entails that teachers teach students how to think, solve problems, use the four “Es” namely; engage, explore, elaborate and evaluate evidence. This resonates with the characteristics of constructivist theory of teaching and learning. Learner-centred teachers work to develop mediating practices that promote shared commitments to learning. Mediating tools such as models, case studies, iconic, practical activities, patterns and vocabulary which Conole (2008) suggests allow teachers to present operations of fractions using concrete procedures. This study investigated how the use of area model can be used to ensure that operations of fractions are taught using LC approach. Relating the concepts of fractions and their operations to area model sometimes does not only prevent the mathematics concepts to be inert (Hale, 2013), but also allows the teacher to culturally contextualize teaching and learning as the examples they might use might possibly come from the community of the learners even if learners are from heterogeneous cultural groups. That is RMTL comes with culturally responsive pedagogical styles.

Learner-centred used in IMTL encourages learners to develop the mathematics vocabulary through conversations or arguments as we have suggested above. Sometimes teachers and learners on account of using English as a language of teaching and learning which is not properly understood (It is their second language) can start from analysing patterns of geometrical shapes to be used in area model to represent fractions which are in a learners’ community. As they come to know what a pattern and geometrical shape are they can then relate them to analyse patterns of area in mathematical expressions representing operations. This will then help them solve operations of fraction since they would have understood the meaning of the term pattern.

The use of IMTL through embracing LC does not only address pedagogical styles as we have explained above or curricular inadequacy but it also addresses the goals of education in Namibia namely; equity, democracy, quality and access. The need to adhere to the tenets of LC compels mathematics teachers in under-resourced schools to search and relate mathematical practical activities which engage learners’ cognitive system.

Another benefit of employing area model to engage LC is the habits of mind mentioned in previous section are developed. This then consolidate the idea that mathematics is dynamic as new ideas will not only come from the teacher who is viewed as the central figure in TMTL. The four “Es” we have mentioned allows the learners to be sniffers of patterns, creators, inventors, conjecturers, experimenters, describers, tinkerers, visualizers and guessers as they come with equivalent fractions needed in addition to fractions with different denominators using invented methods. To investigate how operations of fraction are taught in the Zambezi Region the following research questions were asked.

**Research questions**

1. Which teaching strategies do teachers use to teach operations of fractions?
2. Are the mathematics teachers in possession of fraction content knowledge needed to teach fractions?

Methodology
To answer the stated questions this qualitative and interpretive study was supported by cognitive constructivism. The study was conducted in two schools in the Zambezi Region of Namibia. In each of the schools which were selected purposefully twenty learners were observed. Purposeful sampling was done in order to select four mathematics teachers whose characteristics matched those described in the background of this study. This was aimed at gaining insight into the strategies teachers use to teach fractions and their mathematical operations. Ten learners from each of the two different grades, three and six participated. One was a lower primary class and the other was an upper primary class. This was the same with the other school. This allowed seeing the strategies used to introduce fraction concepts in lower primary classes and to see the strategies used in upper primary classes.

The twenty learners who were the participants were initially observed while they were being taught fractions and mathematical operations in fractions. This was aimed at addressing research question 1 that was aimed at understanding the teaching strategies teachers used to teach operations of fractions. Thereafter, twenty learners were involved in the use of area model in understanding fractions and their operations. The use of area model acted as the intervention which saw the learners actively participating in using algorithms that used the area model to solve problems related to fractions and operations of fractions. The intervention, which took two weeks, was necessary to empower teachers to use IMTL methods.

To validate data yielded from observations, document analysis of learners’ worksheets was carried out. This was aimed at finding the emphases the curriculum material had on the teaching of fractions. This allowed to emerging the subject content knowledge that the teachers are supposed to have in order to be able to teach the concept of fractions to the learners. One observations done in each of the four classes also aimed to assist in finding an intervention suitable which enabled teachers to move from the TMTL to RMTL. When an intervention was in place, learners were supported by researchers and the participating teachers to answer questions involving operation of fractions using area model. Worksheets where learners did their task which they were given by the teacher using TMTL were collected and analysed. Also worksheets they used to solve fraction problems using area model were collected for further analysis. Thereafter, learners were asked to answer interview questions conducted by the researchers. The lower primary learners were questioned using their first language. The responses were transcribed then translated into English. The use of the instruments allowed triangulation and validation to be done. The data which emerged from worksheet analysis is presented below.

Data presentation and analysis
Data that emerged through the use of document analysis, observation and interviews are presented below. The data yielded were found to answer the research questions, which was selected and presented. This was done in order to respond to the research questions.

Data from document analysis and its analysis
The syllabus for lower primary analysed indicated that mathematics teachers should introduce fraction concepts using area model (Namibia Ministry of Education, 2015). This is evident since in the syllabus, the discussion of fraction concepts is accompanied with area model diagrams to explain what is 1/2; 1/4; 1/3 and a whole. Besides using area model, the diagrams which the syllabus use or illustrate for teaching the concept of fractions are those which the learners know very well. For example, a glass used for drinking liquids is presented with 1/2 a mount of water and then it is also presented full of water. A glass of water is cultural artefact seen in the community of the learner which can make the concepts of fraction not appear abstract if used.

The upper primary learners were given a task to do after the teacher completed the teaching of fractions and their operations. The questions in which concepts of fractions and their operations were asked were analysed in the answer scripts from the learners. Figure 2 represents how these learners performed.
Figure 2: Performance of learners in questions related to concept of fractions and their operations

In question 2.1 of the question paper, all 20 learners failed to get the correct respond. In question 2.2 also about fractions, 16 learners got the question wrong and only 4 got it correct. In question 2.3, all 20 learners failed to get the correct response. The analysis paved the way to find ways to assist the learners. A selection of ten learners from upper primary and ten from lower primary was done by the researchers. The twenty selected learners by researchers were taught how to use the area model to deal with problems related to fractions and their mathematical operations. This was done for a week.

The worksheets which the learners used to work operations of fractions on were analysed. These worksheets were based on operations of fractions using area model. The product of their work was reorganized and the data which they yielded is presented below.

Figure 3: Synthesized work from learners who used area model to solve problems in operations of fractions

An analysis of the work done on the worksheets showed that learners were better placed in working out mathematical operations of fractions after an encounter with their
teachers. They were cognitively involved and this means learner-centred approach was used even though physical resources were not available. In contrast, before the workshop, the majority of the learners were grappling but what is shown in Figure 3 is what all learners did to arrive at the required answer. This comes as evidence that use of IMTLS equips learners with the right skills to perform mathematical operation of addition of fractions. So, one of the problems was lack of resources which hampers the use of learner-centred. Schweisfurth (2011) found that learners become active in the activities in which they used the idea of area model to perform mathematical operation of addition of fractions. Learner-centred approach is not only achievable through use of physical resources but also through cognitively engaging learners in cognitive activities as they used inventive strategy and this promoted self-regulation as it related area and addition and use of models to represent a fraction (Weinstein & Mayer, 1986). Learner-centred strategy was involved only at lower primary when observed teachers brought for example an orange. A half was then presented as representing an orange which has been cut into two equal parts. The upper primary teachers could have involved learner-centred approach successfully if they had used area model after their introduction of fraction concepts and use the area model to teach mathematical operations of addition.

It was found that teachers’ non-use of area model, an invented method prevented learners from understanding the concept of fractions and their operations. This explains why in the worksheets which were analysed most of the learners could not understand fractions and algorithms associated with operations of fractions. This is evidenced from the worksheets analysed after the learners were done with a classroom task on fractions. The majority failed to arrive at the required answer. However, the opposite is true when they were supported in using the area model. All the learners who were supported were able to follow an algorithm which gave them the right response after using the RMTL strategies which teachers could not use before. Absence of indication of work in which learners never involved inventive strategies in their workbooks observed during SBS was a clear indication that of failure of teachers to engage IMTL. This comes as a clear indication that their subject content knowledge on operations of fractions using models (Namibia Ministry of Education, 2015) in the curriculum is questionable. This is also evidenced in the data found and presented in the section of the statement of the problem in Figure 1.

Data from observation and analysis
Figure 3 came after observation of worksheets of students. These observations revealed that lower primary mathematics teachers used area model to present the concept of fractions to the learners as the worksheets revealed. From the document in Figure 3, it is observed that teachers even went to the extent of asking learners to draw shapes showing fractions like 1/2; 1/4; 1/3. Diagrams showing an apple split into 1/2; 1/4 and 1/3 were observed in the worksheets obtained from learners in contrast to what was observed during SBS when there was no sign of engaging learners in inventive strategies that the Namibia Ministry of Education (2015) syllabus encourages teacher to use. With the analysis of the results obtained from Figure 3, it shows that the lower primary mathematics teachers achieved teaching fractions through the use of area model, representing fractions being added using models and in doing so they engaging in a habit of mind of inventing. Cuoco, Goldeberg and Mark (1996) suggest that it is useful to make learners active. Before workshop done with teachers, teachers restricted learners understand fractions using a traditional strategy which does not allow them to participate actively in classroom practices. The teachers’ failure to engage inventive strategy short changes learners since the introduction of concepts of fractions provides the cohesion and progression needed when teaching mathematics concepts at upper primary level and other levels support (Kriek & Basson, 2008).

The scenario in which teachers do not engage a habit of mind of inventing observed in lower primary is not similar to that observed when upper primary mathematics teachers teach operations of fractions. Upper primary mathematics teachers involved area model to teach operations of fractions only at the introduction level. The teachers indicated that parts of an apple obtained after dividing an apple into two equal parts represent two halves and most observed teachers brought a model and used the model to demonstrate in ideas
about fractions. This did not go further when he started to show operations of fractions. Most teachers at upper primary restricted themselves to teaching practices where fractions were represented symbolically. Symbolically representing fractions makes learners not understand the roles fractions play namely; part-whole, measure, quotient (division), operator or ratio (Kieren, 1980). This short changes learners as cohesion and progression were lacking in teachers’ teaching practices (Kriek & Basson, 2008). This does not support what learner-centred advocates (Sibuku, 1997; Weimer, 2002). Teaching without engaging inventive strategies is not supportive of cognitive constructivism and was not taking place among the learners before the workshop that teachers had. Learners’ cognitive systems were passive as they continued copying what the teacher was presenting.

In lower primary, after the workshop, the teachers developed the habits of mind of the learners. Cuoco, Goldeberg, and Mark (1996) and Seeley (2014) advocate as evidenced from the fact that learners finally managed to add fractions when they fully involved with area model since learner-centred was embraced. Before the workshop with teachers, use of learner-centred learning was constrained as the learners’ performances were not up to standard as evidenced in Figure 2. The fact that only two teachers in lower primary used area model while those two teaching upper primary distanced themselves from using area model is an indicator that the teachers had the fraction pedagogical content knowledge for teaching operations at upper primary. However, the two upper primary teachers have content knowledge but lack the pedagogical content knowledge to teach fraction promoting learner-centred.

Observation done during SBS and after the workshop shows that lower primary teachers understood the need to teach fraction using area model while the upper primary teachers did not find the use of area model as useful. This allows answering research question as lower primary school teachers finally embraced the use of inventive strategies after the workshop while upper primary mathematics teachers used TMTLS to understand fractions and this answers research question 1.

Data from interviews and its analysis

Interviews were carried out with ten lower primary and ten upper primary school learners. The lower primary school learners were first interviewed and the last to be interviewed were those from upper primary. In response to interview questions which aimed to gain insight on strategies teachers use, the revelations from lower primary learners were that learners were in a position to define or explain what a fraction is. The theme which was a major in their definition was a fraction represents part of a whole. The other themes of what a fraction represents; measures, quotient (division), operator or ratio were not mentioned.

When asked whether they encountered challenges with learning fractions, learner 1 responded that, “it is not difficult since I can draw, divide, shade the required portion, count how much is shaded, which represent the numerator, the total obtained represent the denominator”. This reflects that classroom talk (Lemke, 1990; Krajcik & Sutherland, 2010) propose to be useful in learner-centred succeeded as learners managed to talk the mathematics language. Other procedures used to ensure teaching and learning of fractions and their operations engaging learner-centred teaching was revealed when learner 2 said, “the teacher draws shapes on the chalk board, divide the shape into portions and explain. Sometimes, materials from the Namibian ministry of education are used by the teacher but they are not sufficient for us to interact with them”. This statement from learner 2 supports the tenets of learner-centred approach (Weimer, 2002). When asked what the teacher does when learners do not understand fractions, some of the learners had this to say, “the teacher repeats”. There was no further probing to find out how the teacher repeats.

Interview results from upper primary learners who responded to research question 1 and 2 can be known through an excerpt which came from some learners.
From the excerpt from the upper primary learners’ responses, it is clear that they were struggling to understand fractions. Also, they revealed that the teachers’ content knowledge and pedagogical content knowledge about fractions and their operations is questionable. These learners believed that the teacher must use other strategies that made their life easy as they will not keep on struggling to understand fraction concepts which are abstract.

**Results**

Mathematics teachers when teaching fractions used a combination of symbols and area model. However, this is done mostly by lower primary school mathematics teachers. The upper primary mathematics teachers distance themselves from the use of area model since in their classroom practices related to fractions they were never observed relating to any of those roles fractions play namely; measure, quotient (division), operator or ratio. These teachers concentrate more on use of symbols representing fractions. Teaching strategies used in teaching operations of fraction is a combination of symbols representing fractions and area model at lower primary level. At upper primary level, the mathematics teachers avoid the use of area model (Lamon, 2012). Some of the mathematics teachers had the content knowledge but some did not have and this is evidenced from Table 1. However, some upper primary teachers have the content knowledge but the majority lacked the pedagogical content knowledge. This is evident from what was observed that area model was used at the introduction and was never used throughout the lesson by upper primary level school teachers.

To respond to question one the data from the three instruments revealed that mathematics teachers at lower primary school level used a combination of RMTL and TMTL strategies. However, this is not the same with mathematics teachers teaching upper primary school level. They restricted their strategies to TMTL strategies. This is evidenced from data from the excerpt and also data obtained when the worksheets of the learners were analysed (see Figure 2). The learners were found to be capable of understanding concepts of fractions and their operations if strategies which comply with LC were involved. This is evident in Figure 3. All the questions on operations given to learners were done successfully by those learners who were involved in the intervention but could not be done before the intervention.

The intervention used was found to mitigate issues related to lack of materials to teach fractions and their operations. The strategy used enabled learners to actively participate cognitively. This paved a way to see how LC could be applied in the teaching of operations of fractions when teaching and learning materials were in short supply.

**Conclusion**

Some teachers have the content knowledge but they lack the pedagogical content knowledge. This then makes it difficult for learners to understand operations of fractions. At upper primary school level where they are expected to keep on using the area model the teachers did not use it. From what the lower primary school learners indicated during the interviews, use of area model mitigates some problems associated with operations of fractions.

**References**


Attard, C. (2014). "I don't like it, I don't love it, but I do it and I don't mind": Introducing


Examining the psychometric validity of the beliefs about nature of science questionnaire

1Simson N. Shaakumeni and 2Benő Csapó
1Doctoral School of Education, University of Szeged, Hungary.
1sshaakumeni@gmail.com | shaakumeni@edu.u-szeged.hu and 2csapo@edpsy.u-szeged.hu

Abstract
The purpose of this study was to validate a new questionnaire for assessing students’ beliefs about nature of science. Existing instruments have limitations in terms of psychometric validity. A new questionnaire termed “beliefs about nature of science” (BANOS) was developed to address some of such limitations. The BANOS is based on dimensions of nature of science as a theoretical framework. The BANOS was administered to 860 Grade 12 students in Namibia, using the paper-and-pencil method. Data analysis employed reliability analysis, exploratory factor analysis (EFA), confirmatory factor analysis (CFA) and parallel analysis. The reliability of the BANOS was good at \( \alpha = .87 \). EFA revealed a final interpretable five-factor structure and the factor solution accounted for 67.73% of the total variance. However, parallel analysis revealed that only four factors had eigenvalues that were statistically significant and the resultant scree plot also supported the retention of four factors. CFA results showed that the measurement model had poor statistical fit for the data. These findings indicate that the eight-dimension framework could not be confirmed at EFA level. However, the BANOS had adequate construct validity and reliability. Results are discussed in terms of intricate similarities among the dimensions of nature of science.

Keywords: nature of science; scientific epistemic beliefs; Namibia; BANOS; validity

Introduction
The National Curriculum for Basic Education (NCBE) in Namibia which is the broad curriculum, demands that students develop into scientific literate citizens (Ministry of Education, 2010). According to the NCBE, one of the components of scientific literacy is the understanding of the nature of scientific knowledge. The nature of science entails what makes science different from other disciplines. In other words, it characterises scientific knowledge that is derived from how the knowledge is developed (Lederman et al., 2014). However, the assessment of science knowledge in Namibian schools does not include this aspect of scientific literacy. All assessments mainly focus on subject content knowledge and hardly focus on assessing students’ understanding of the characteristics of scientific knowledge and knowing, which is essentially the development of their scientific epistemic beliefs. Since this aspect of scientific literacy is not assessed in schools, there is hardly any means through which to ascertain the extent to which the ideals of the national curriculum are being met. One way to ascertain students’ understanding of the nature of scientific knowledge and knowing is to assess their scientific epistemic beliefs. Advancing students’ beliefs about the nature of scientific knowledge and knowing has featured prominently in recent research in science education (Chen, 2012; Chen, Metcalf, & Tutwiler, 2014; Conley, Pintrich, Vekiri, & Harrison, 2004; Tsai, Jessie Ho, Liang, & Lin, 2011). However, none of such studies appear to have been conducted in Namibia.

The main aim of this research was to develop and validate a new questionnaire (BANOS) for assessing Grade 12 students’ scientific epistemic beliefs based on the eight-dimension theorisation of nature of science. This age group was chosen following previous studies that assumed that it was somewhat difficult to measure epistemological thinking
among younger students (Conley et al., 2004). However, this paper reports on the validation aspect of the study only.

The research endeavoured to answer the following questions:

1. How is the reliability and construct validity of the new beliefs about nature of science (BANOS) questionnaire?
2. What is the factorial validity of the theorised eight-dimension nature of science questionnaire?

Namibia as a developing nation needs to keep abreast with the rest of the world in terms of educational reforms particularly in science education. Studies related to scientific epistemic beliefs do not appear to be done in Namibia. This research is hence pioneering in this context. Scientific epistemic beliefs are individual domain-specific beliefs about scientific knowledge and the acquisition of such knowledge. These beliefs have an important role in several aspects of academic learning and achievement (Leal-Soto & Ferrer-Urbina, 2017; Paechter et al., 2013). It attempts to instigate future research on students’ science learning in Namibia’s basic education sector particularly using cross-sectional design.

Theoretical background

Scientific literacy consists of different components, namely, content knowledge, nature of science and scientific inquiry. This research focuses on the nature of science component. Although it has been shown to be difficult to define (Hillman, Zeeman, Tilburg, & List, 2016), Lederman and colleagues described it as “the epistemology and sociology of science, science as a way of knowing or the values and beliefs inherent to the development of scientific knowledge” (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002, p. 498). With regards to this view of science epistemology, students should develop certain habits of mind such as believing that scientific knowledge: 1) can change over time (tentative), 2) empirically-based (based on observations of the natural world), 3) there is no one way of doing science called “the Scientific Method”, 4) subjective, 5) is influenced by imagination and creativity, 6) socially and culturally embedded, 7) observation and inference are different, and 8) theories and laws are distinct kinds of scientific knowledge (Abd-El-Khalick et al., 2017; Abd-El-Khalick & Lederman, 2000; Chen, 2012; McComas, 2008; Niaz, 2008; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003).

This eight-dimension hypothesised theory though validated through an interpretivist approach, its validity has not been demonstrated psychometrically, thus inhibiting the confidence in its use. Moreover, research following this theorisation found that students and teachers do not possess appropriate conception of the nature of science (Bell, Blair, Crawford, & Lederman, 2003; Khishfe & Abd-El-Khalick, 2002; Moss, Abrams, & Robb, 2001).

Conley et al. (2004) proposed that students’ scientific epistemic beliefs have four dimensions: 1) source (science comes from authority or experts), 2) certainty (science knowledge has one right answer), 3) development (science knowledge is changing), and 4) justification (science knowledge depends only on evidence from experiments). Epistemological beliefs span from naïve to sophisticated (Kampa, Neumann, Heitmann, & Kremer, 2016). Literature revealed that it is generally difficult to measure epistemic beliefs using self-reporting instruments (DeBacker, Crowson, Beesley, Thoma, & Hestevold, 2008; Schraw, Bendixen, & Dunkle, 2002; Tsai et al., 2011) however, domain-specific epistemic beliefs studies have produced favourable results (Kampa et al., 2016; Kaya, 2017; Liang & Tsai, 2010; Lindfors, Winberg, & Bodin, 2017).

Scientific literacy such as inquiry skills and the understanding of the nature of scientific knowledge ought to develop in students implicitly. Implicit approach assumes that “students’ participation in authentic scientific investigations in itself would help students develop more accurate understandings of the nature of scientific inquiry and knowledge” (Bell, Matkins, & Gansneder, 2011, p. 415). However, the literature shows that this approach has not been effective in facilitating students’ and teachers’ understanding of nature of science (Gess-Newsome, 2002; Norman G Lederman, Lederman, & Antink, 2013; McDonald, 2010). Despite that students and teachers views about the nature of science have been studied
extensively in the last two decades, it has not been possible to locate such studies done in Namibia. Moreover, there is no shortage of instruments for exploring students’ views about the nature of science (Lederman, Wade, & Bell, 1998). However, many existing instruments have some limitations in terms of psychometric validity as they were based solely on qualitative validations. Qualitatively validated questionnaires such as the Views of Nature of Science (VNOS) developed by Lederman et al. (2002) became a popular choice for researchers in recent times. This open-ended questionnaire has several versions A, B and C. The versions are meant for use at different grade levels. Each version focuses on a particular dimension of nature of science and were validated through response coding through interviews. Although the validation method used is pretty solid, one version is not suitable for capturing multiple dimensions of a student’s beliefs about nature of science. The use of VNOS is also time-intensive in terms of essay responses coding and follow-up interviews (Hillman et al., 2016) which may not be favourable for every researcher. The belief about nature of science (BANOS) questionnaire was developed to address some of these limitations but also considering the cultural context of Namibia. The development of a psychometrically validated questionnaire for assessing students’ views about nature of science in Namibia was the main goal of the present study.

Methods

**Instrument and sample**

A new 28-item Likert scale questionnaire termed “Beliefs about Nature of Science” (BANOS) was developed. This questionnaire is new in the sense that although ideas for possible items were obtained from existing scales in the literature, no similar questionnaire exists. The theoretical framework for the development of the instrument for assessing beliefs about the nature of science was based on the eight general dimensions of nature of scientific knowledge as proposed by Lederman and others (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Lederman & Abd-El-Khalick, 1998; McComas, Almazroa, & Clough, 1998, Lederman et al., 2014). The items are declarative statements describing particular dimensions of nature of scientific knowledge. Respondents give their personal level of belief or agreement with the five-point Likert scale (Cohen, Manion, & Morrison, 2007) namely 1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree and 5 = strongly agree. The statements are also in a form of nuanced views of respondents about nature of science obtained from the literature (Chen, 2006; Dogan & Abd-El-Khalick, 2008; Khishfe & Abd-El-Khalick, 2002; Summers & Abd-El-Khalick, 2017; Vhurumuku, 2010). The statements were all positively worded so that a high score indicates more sophisticated beliefs about the nature of science and knowing.

The questionnaire was administered to a sample of 860 (male 52% and female 48%) secondary school students in Namibia, using the paper-and-pencil method. The mean age of students $M_{\text{mean}} = 18.3$ and standard deviation $SD = 1.32$. Sampling was inherently purposive because the aim of the study was not to generalize findings but rather to obtain sufficient sample suitable for advanced statistical analysis to examine psychometric properties of the questionnaire. All participating students were in senior secondary level (Grade 12), from Omusati, Oshana and Ohangwena regions. On average, students spent approximately 13 minutes to complete the questionnaire. English is the official language in Namibia and all items in the questionnaire were presented in English.

**Procedure**

After obtaining ethical approval from the university’s institutional review board as well as permission from the gate keepers of the Ministry of Education in Namibia, consent forms were signed by participating students in conjunction with their parents or guardians. Data were collected at the beginning of the first school trimester in January. This was deemed the best time to visit schools as they had barely started with their academic programme. Moreover, this was also in conformity with stringent conditions attached to the research permission; not to disturb academic activities. Scientific epistemic beliefs (beliefs about nature of science and knowing) were measured with self-report questionnaires using pencil-and-paper method.

The sample was randomly split into two, 503 students’ scores were used for exploratory factor analysis (EFA) by means of principal components and 357 students’ scores were
used for confirmatory factor analysis (CFA). This was done because it is advisable to use different samples for EFA and CFA (Cabrera-Nguyen, 2010; Henson & Roberts, 2006; Worthington & Whittaker, 2006).

**Data analysis**

Ordinal scales were analysed as if they were interval (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011). In this case items are assumed to be generally parallel indicators of the underlying latent variable (DeVellis, 2003).

Data was analysed using Cronbach’s alpha coefficient (Summers & Abd-Khalick, 2017), using the Statistical Package for Social Sciences (SPSS) version 25 to determine reliability of responses. Exploratory factor analysis using principal components extraction and varimax rotation (Henson & Roberts, 2006) was used to assess the questionnaire factor structure. Confirmatory factor analysis in AMOS version 25 was used to assess the questionnaire factor structure. Confirmatory factor analysis in AMOS version 25 was used to assess the measurement model fit using the $\chi^2/df$, RMSEA, SRMR, TLI and CFI as fit indices (Glynn et al., 2011; Teo, 2013). Construct validity was assessed considering two criteria: convergent and discriminant validity (Cristobal, Flavián, & Guinalíu, 2007).

**Results and discussions**

**Reliability**

Reliability is a measure of how well the items in a scale measure the same construct (Streiner, 2003). This measure is commonly estimated using Cronbach’s alpha reliability coefficient. Streiner (2003) suggested that the alpha coefficients of .70 and higher are ideal for research tools. Based on the results from exploratory factor analysis, items that were loading on multiple factors were systematically culled resulting in the final 16 items and five factors. The reliability of scores on the resultant 16-item questionnaire determined using Cronbach’s alpha coefficient was .87. Reliability of individual factors ranged from .72 to .83 (Table 1). These results suggest that the questionnaire had good overall reliability for the sample used.

**Construct validity**

**Convergent validity**

Convergent validity measures the level of correlation of multiple variables of the same construct that are in agreement (Ab Hamid, Sami, & Sidek, 2017). To establish convergent validity, factor loadings of indicator variables, composite reliability (CR) and the average variance extracted (AVE) should be used (Ab Hamid et al., 2017). The recommended thresholds for these measures are that the AVE should be above .50 and the CR should be .70 and above (Huang, Wang, Wu, & Wang, 2013). Convergent validity was evaluated using AVE and CR values computed using Microsoft Excel (Gaskin, 2016) and factor loadings from confirmatory factor analysis computed in AMOS. The AVE values for the five factors model ranged from .46 to .64. The CR values ranged from .75 to .81 (Table 2).

**Table 1: Reliabilities of factors and whole questionnaire**

<table>
<thead>
<tr>
<th>Factor</th>
<th>M</th>
<th>SD</th>
<th>No. of items</th>
<th>Cronbach's alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjectivity</td>
<td>9.9</td>
<td>3.0</td>
<td>5</td>
<td>.72</td>
</tr>
<tr>
<td>Empirical</td>
<td>16.5</td>
<td>5.1</td>
<td>3</td>
<td>.83</td>
</tr>
<tr>
<td>Socio-cultural</td>
<td>8.84</td>
<td>3.0</td>
<td>3</td>
<td>.76</td>
</tr>
<tr>
<td>Scientific Methods</td>
<td>10.6</td>
<td>2.8</td>
<td>3</td>
<td>.72</td>
</tr>
<tr>
<td>Tentativeness</td>
<td>6.5</td>
<td>2.8</td>
<td>2</td>
<td>.75</td>
</tr>
<tr>
<td>BANOS</td>
<td>52.2</td>
<td>11.6</td>
<td>16</td>
<td>.87</td>
</tr>
</tbody>
</table>

**Table 2: Five-factor model CR, AVE, MSV and correlations**

<table>
<thead>
<tr>
<th>Latent factors</th>
<th>CR</th>
<th>AVE</th>
<th>MSV</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjectivity</td>
<td>.77</td>
<td>.52</td>
<td>.55</td>
<td>.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Empirical</td>
<td>.81</td>
<td>.46</td>
<td>.37</td>
<td>.58</td>
<td>.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Socio-Cultural</td>
<td>.81</td>
<td>.59</td>
<td>.33</td>
<td>.56</td>
<td>.50</td>
<td>.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientific Methods</td>
<td>.75</td>
<td>.50</td>
<td>.55</td>
<td>.74</td>
<td>.61</td>
<td>.56</td>
<td>.71</td>
<td></td>
</tr>
<tr>
<td>Tentativeness</td>
<td>.78</td>
<td>.64</td>
<td>.29</td>
<td>.54</td>
<td>.32</td>
<td>.38</td>
<td>.48</td>
<td>.80</td>
</tr>
</tbody>
</table>

_Note:_ The diagonal numbers in italics are the square root of the AVE values.
Although the AVE values for one factor was below the acceptable minimum cut-off point of .50 (empirical = .46) convergent validity may still be adequate because all latent factors had CR values above .70 (Fornell & Larcker, 1981). Malhotra and Dash (2011) also argued that the AVE is often too strict and validity can be established through CR alone.

**Discriminant validity**

The extent to which latent factors differ from each other empirically defines discriminant validity (Hair, Hult, Ringle, & Sarstedt, 2016). This means that a latent factor should explain the variance of its own indicators better than the variance of other latent factors (Ab Hamid et al., 2017). Discriminant validity was assessed by comparing the square root of the AVE with the correlation of latent factors (Hair et al., 2016). The square root of the AVE should be greater than .50 (Fornell & Larcker, 1981) and greater than inter-latent factor correlations within the model (Hair, Black, Babin, & Anderson, 2010). The maximum shared variance (MSV) was also compared to the AVE values. The AVE values should be greater than the MSV values for each latent factor (Rebelo-Pinto, Pinto, Rebelo-Pinto, & Paiva, 2014). As evident in Table 2, not all latent factors met the requirements and their discriminant validity may not be adequate. For the five-factor model, although the square root of the AVE for all latent factors were greater than .50, it was not greater than inter-latent factor correlations for all factors. The square root of AVE for subjectivity was less than its correlation to scientific methods (Table 2). The MSV values for the two factors (subjectivity and scientific methods) were greater that the AVE values which is contrary to recommendations. However, for the four-factor model (Table 3), all latent factors support the requirements and discriminant validity of all latent factors was adequate, thus construct validity was confirmed.

**Table 3: Four-factor model CR, AVE, MSV and correlations**

<table>
<thead>
<tr>
<th>Latent factors</th>
<th>CR</th>
<th>AVE</th>
<th>MSV</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjectivity</td>
<td>.82</td>
<td>.43</td>
<td>.42</td>
<td>.66</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Empirical</td>
<td>.82</td>
<td>.48</td>
<td>.32</td>
<td>.56</td>
<td>.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Socio-Cultural</td>
<td>.81</td>
<td>.59</td>
<td>.42</td>
<td>.65</td>
<td>.49</td>
<td>.77</td>
<td></td>
</tr>
<tr>
<td>Tentativeness</td>
<td>.78</td>
<td>.64</td>
<td>.33</td>
<td>.57</td>
<td>.34</td>
<td>.38</td>
<td>.80</td>
</tr>
</tbody>
</table>

Note: The diagonal numbers in italics are the square roots of the AVE values

**Exploratory factor analysis**

Exploratory factor analysis is meant for cases where the relationships between the observed and latent variables are uncertain (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011). It was necessary to apply exploratory factor analysis to assess the factorability of the eight-dimension theorisation of nature of science. The assessment of the correlation matrix for the 16 items was found to be appropriate for factor analysis by means of a Bartlett’s test of sphericity, $\chi^2 = 3055.17$, $df = 120$, $p < .01$, and the Kaizer-Meyer-Olkin measure of sampling adequacy, KMO = .84. These tests of normality and sampling adequacy indicated that the correlation matrix was of acceptable quality (Glynn et al. 2011). Exploratory factor analysis ($N = 503$) using principal components extraction with varimax rotation produced a final interpretable five-factor structure consisting of 16 items after the culling of cross-loading items and the factor solution accounted for $67.73\%$ of the total variance. The five factors retained based on eigenvalues greater than one and the percentage of variance were: empirical (5.49, 34.30%), sociocultural (1.78, 11.13%), subjectivity (1.36, 8.50%), scientific methods (1.19, 7.44%), and tentativeness (1.02, 6.37%). Table 4 shows the rotated factor loadings.

**Table 4: Rotated factor matrix of the questionnaire**

<table>
<thead>
<tr>
<th>Factor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Empirical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientists can use human senses to make scientific claims (observations).</td>
<td>.830</td>
<td>-.054</td>
<td>.164</td>
<td>-.073</td>
<td>.117</td>
</tr>
</tbody>
</table>
Experiments support rather than prove scientific claims.
Scientific theories are conclusions about observable phenomena.
Experiments are not the only source of scientific evidence.
Models like atoms and species are products of human imagination.

2. Socio-cultural
Science is influenced by cultures.
The values of the culture determine how science is practiced.
Science is influenced by economic factors such as research funding.

3. Subjective
Scientists can look at the same evidence or set of data and come up with different conclusions.
Scientists’ backgrounds and beliefs influence their work.
Scientists use their creativity to analyse data.

4. Scientific methods
There is no single step-by-step method that all scientists in the world follow.
Scientists use different procedures to study the natural world.
Scientific laws are descriptions of the relationship among observable phenomena.

5. Tentative
Some scientific ideas today were different in the past.
Scientific ideas can change due to advances in technology.

Note: Factor loadings of items in italics all exceeded the 0.40 criterion on their targeted factor (N=503)

However, using the eigenvalue greater than one criteria only may not be sufficient to decide on the number of factors to retain (Cabrera-Nguyen, 2010). Hence, parallel analysis was also employed. This procedure entails randomly ordering the respondents’ item scores and conducting a factor analysis on both the original data set and the randomly ordered scores. The number of factors to retain is determined by comparing the eigenvalues determined in the original data set and in the randomly ordered data set. The factors are retained if the original eigenvalue is larger than the eigenvalue from the random data (Worthington & Whittaker, 2006).

Table 5: Raw data eigenvalues, means and percentile random data eigenvalues

<table>
<thead>
<tr>
<th>Number of items</th>
<th>Raw Data</th>
<th>Means</th>
<th>Random data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.488*</td>
<td>1.317</td>
<td>1.381*</td>
</tr>
<tr>
<td>2</td>
<td>1.780*</td>
<td>1.250</td>
<td>1.295*</td>
</tr>
<tr>
<td>3</td>
<td>1.359*</td>
<td>1.200</td>
<td>1.240*</td>
</tr>
<tr>
<td>4</td>
<td>1.191*</td>
<td>1.155</td>
<td>1.190*</td>
</tr>
<tr>
<td>5</td>
<td>1.018</td>
<td>1.114</td>
<td>1.144</td>
</tr>
<tr>
<td>6</td>
<td>0.830</td>
<td>1.077</td>
<td>1.105</td>
</tr>
<tr>
<td>7</td>
<td>0.684</td>
<td>1.042</td>
<td>1.072</td>
</tr>
<tr>
<td>8</td>
<td>0.558</td>
<td>1.008</td>
<td>1.037</td>
</tr>
</tbody>
</table>
The analysis revealed that only four factors (Table 5) had eigenvalues that were statistically significant for retention at $p = .05$ (O’connor, 2000). The resultant scree plot also shows that only four factors can be seen at or above the intersections of the graphs thus supporting the retention of four factors (Figure 1).

**Table 5:**

<table>
<thead>
<tr>
<th></th>
<th>Item</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>0.520</td>
<td>0.975</td>
</tr>
<tr>
<td>10</td>
<td>0.461</td>
<td>0.942</td>
</tr>
<tr>
<td>11</td>
<td>0.428</td>
<td>0.909</td>
</tr>
<tr>
<td>12</td>
<td>0.421</td>
<td>0.876</td>
</tr>
<tr>
<td>13</td>
<td>0.349</td>
<td>0.842</td>
</tr>
<tr>
<td>14</td>
<td>0.343</td>
<td>0.807</td>
</tr>
<tr>
<td>15</td>
<td>0.322</td>
<td>0.767</td>
</tr>
<tr>
<td>16</td>
<td>0.249</td>
<td>0.720</td>
</tr>
</tbody>
</table>

* $p = .05$

**Figure 1:** Scree plot

**Confirmatory factor analysis**

Using a separate sample of 357 students, confirmatory factor analysis was performed on the 16 items to validate the measurement model in which convergent and discriminant validity were assessed. The assessment of the model fit was done using the standardisation method where all covariances were set to 1.0 (Teo, 2013). The goodness of fit of the measurement models (hypothesized five and four-factor models) were assessed by three absolute ($\chi^2$, RMSEA, & SRMR) and two incremental (TLI & CFI) fit indices. The chi-square ($\chi^2$) statistic assesses the extent to which the proposed model varies from the data (Glynn et al., 2011). Its $p$-values are acceptable when they are nonsignificant, indicating adequate model fit. However, this index is sample dependent, hence it is recommended that it should be divided by the degrees of
freedom ($\chi^2/df$) (Garson, 2015) and the resultant values be in a recommended range of 1.0-3.0 (Glynn et al., 2011).

The root-mean-square error of approximation (RMSEA) and the standardized root mean square residual (SRMR) are independent of the sample size but are sensitive to model misspecification and adequate fit values should be 0.06 and 0.08 or less respectively (Teo, 2013). The Tucker-Lewis index (TLI) and the comparative fit index (CFI) are incremental indices with a recommended cut-off value of 0.95, indicating goodness of fit, however, values above 0.90 are acceptable (Hooper, Coughlan, & Mullen, 2008). Maximum likelihood (ML) estimation was used to estimate the model’s parameters and fit indices.

Confirmatory factor analysis (N = 357) results showed that the five-factor model had poor statistical fit for the data, with the following fit indices: $\chi^2/df = 0.5024$, TLI = 0.80, CFI = 0.85, RMSEA = 0.11, SRMR = 0.07. However, the four-factor model had better statistical fit for the data, though still below recommended thresholds, with the following fit indices: $\chi^2/df = 4.163$, TLI = 0.85, CFI = 0.88, RMSEA = 0.09, SRMR = 0.06.

It is not surprising that a better measurement model had less factors than hypothesized. Conley et al. (2004) also found that students’ scientific epistemic beliefs had four dimensions. Moreover, some of the dimensions were highly correlated. High correlations among epistemic belief scales point to redundancy in the measurement. In this sample, the highest correlation in the five-factor model was between subjectivity and scientific methods ($r = .74$) and between sociocultural and subjectivity ($r = .65$) in the four-factor model. However, proponents of the eight-dimension theorisation had acknowledged that the dimensions of nature of science were intricately intertwined (Abd-El-Khalick et al., 2017).

**Conclusion**

This study set out to assess the factorial validity of the hypothesised eight dimensions underlying nature of science. The findings indicate that the eight dimensions model that had been qualitatively suggested could not be supported at EFA level. This could be attributed to the inherent similarity among the dimensions of nature of science. However, the questionnaire had adequate construct validity and reliability though it had poor fit statistics values lower than the recommended thresholds, except for the $\chi^2/df$ and SRMR (Hair et al., 2016). It can be concluded that the questionnaire showed potential to be psychometrically valid. However, it needs to be examined for possible flaws that affected measurement model fit. Furthermore, some methodological limitations may have influenced the findings of this study. First, students were not interviewed to ascertain accuracy of interpretation of the questionnaire items. It was assumed that students interpreted the items as expected. Secondly, the indices of model fit obtained from CFA might be biased due to departure from multivariate normality (Cabrera-Nguyen, 2010). The BANOS questionnaire is still being validated however; it is available on request from the first author via email.

**References**


Kampa, N., Neumann, I., Heitmann, P., & Kremer, K. (2016). Epistemological beliefs in science-a person-centered approach to investigate high school
students’ profiles. *Contemporary Educational Psychology*, 46, 81–93.


Schraw, G., Bendixen, L. D., & Dunkle, M. E.


Western science knowledge evolve from indigenous knowledge

1Muzwa Mukwambo, 2Kenneth M. Ngcoza and 3Charles Chikunda
1UNAM (Katima Mulilo Campus) and 2&3Rhodes University, Grahamstown, South Africa
1mmukwambo@unam.na; 2k.ngcoza@ru.ac.za and 3Charles@award.org.za

Abstract
The incorporation of indigenous knowledge is a contemporary issue in science teaching practices, most useful, in particular in areas where teaching and learning resources are scarce. Indigenous knowledge in this study is proposed as knowledge in the essence of the identities and world views of Indigenous people manifest in their cultural practices. As a contemporary issue, sometimes science practitioners grapple with incorporating science principles in indigenous knowledge as prior knowledge in their practices that might culturally contextualise, authenticate or localise science teaching practices. The need to explore usefulness of prior knowledge found in cultural context paved way for this study in order to answer the research question: What are the enhancers and constraints of using indigenous knowledge to engage situated cognition to ensure that understanding of science concepts is achieved?

To gain insight into the posed research question, this study sought to find out whether the situated cognition approach could be involved through incorporation of indigenous knowledge in under-resourced rural schools in the Zambezi Region, Namibia. Analogies, cultural practices and artefacts in indigenous communities reflecting science were analysed in order to gain insight into how such knowledge can be transformed in order to close the gap encountered when senior secondary science teachers grapple to incorporate the knowledge reflected. Sociocultural theory of learning was used as a theoretical framework and as a lens to look at the data that contextualise science teaching and learning. Additionally, qualitative data indigenous communities have were gathered through observations and brainstorming. Thereafter, analysis of cultural practices in the presence of an indigenous community member was done. Furthermore, four science teachers from the same community in Zambezi Region were interviewed at their schools and their reflections complemented the interview data. Document analysis of Namibian senior secondary science curriculum position on indigenous knowledge and western science knowledge lens were done. Thereafter, such triangulated data were analysed as informed by themes that emerged from common patterns. Some findings from the analysed data were; use of analogies found in indigenous communities can produce a measurable effect in concept learning. The second key finding was that learners’ prior knowledge with connotation of indigenous knowledge played a key role in facilitating learning when cultural artefacts and practices were embraced.

Key words: contextualised curriculum, analogy, cultural artefacts and practices, indigenous knowledge, western science knowledge

Background
Some theorists such as Thompson (2013), propose that some approaches such as learner-centred in teaching and learning process is only suitable to the countries from where it originated. This also applies to other approaches and theories of learning. The use of Eurocentric approaches or theories in developing countries such as those in the Southern African Development Community (SADC) has need of a cultural translation (Bhabha, 1994). Bhabha (1994) understands cultural translation as adapting an approach or theory of learning to the cultural context of the area under which it is to be involved. Cultural translation acts as an activity to involve SADC region to adapt curriculum material to suit the Afrocentric view. To Asante (2003), Afrocentrism is premised on perceiving the world through the eyes of an African culture and strives for a more multicultural and balanced approach in order to allow
approaches and theories to work in the SADC region.

Schweisfurth (2011) in support reveals in her reports on the success and pitfalls on the implementation of approaches such as learner-centred approach. She points out that learner-centred implementation in SADC region is riddled with constraints. According to her, these range from material constraints, limited resources, poor teacher training programs which do not embrace Afrocentric views of science teaching. Material constraints and limited resources are a result of the curriculum materials anchored on theories of learning which are only suitable to other areas if they are not adapted. Rahmani, Mohajelaghdam, Fathiazar, and Roshangar’s (2008) view is that theories or approaches to learning are desirable and useful in a particular place. The fact that they did not mention the need of theories to be adapted as Bhabha (1994) suggests using the idea of cultural translation allows this study to focus on how indigenous knowledge, a view with cultural connotation can be used to enable theories to be applicable to schools in SADC in order to engage situated cognition.

Such theories may be helpful to a minority group of learners and might hinder learning to the broader group of learners who do not find it easy to adapt in such context. On the other hand equipping trainee teachers with non-aligned Afrocentric programs (Schweisfurth, 2011) benefits non-embracing of Afrocentric views which are not useful for cultural adaptation. There are some worldviews on teachers’ disposal that can be used to adapt theories and their approaches to particular areas they are used. If not done, this might cause failure to culturally translate western modern science (WMS) knowledge into useful transformed knowledge for learners whose cultural background is not based on western knowledge systems. As a result, epistemological transfer becomes difficult. Breidlid (2013) sees the absence of materials and improper training given to trainee teachers as privileging western epistemology to flourish whilst that may suppress the individuals’ culture of different knowledge view. Breidlid (2013) shares the same opinion with Thompson (2013) as he suggests that western modern science exerts a powerful and controlling effect in such a way that embracing of other views about knowledge construction cannot be entertained in order to culturally translate what needs to be known in WMS. Science teachers’ practices adopt a monocultural stance. Mthethwa-Somers (2014) opposes that notion of viewing science teaching and learning from the WMS perspective as it does not favour a multicultural approach or social justice in facing social realities of SADC region schools.

According to Mthethwa-Somers (2014) social transmission theories of knowledge are functionalism and structural functionalism. Both DeMarris and LeCompte (1995) and Mthethwa-Somers (2014) identify functionalism as aligned to the belief that schools should serve to perpetuate the prevailing social and political order. Our view is that without the inclusion of Afrocentric views as Asante (2003) proposes, this might align teaching and learning of science concepts to functionalism. Adherents of social transmission theory, for instance Paz (1987) believes in encouraging assimilation of students/learners into a homogenous culture. Are our cultures in the SADC region homogenous? Considering Mthethwa-Somers’s (2014) opinion that culture is homogenous constrains the use of other knowledge sources to be embraced that can allow the engagement of learner-centred approach and situated cognition approach. This might come with materials, unlimited resources and better teacher training programmes embracing indigenous knowledge worldviews.

On the other hand, (Putnam, 1999; Kaplan, 2004) oppose the existence of a unique perspective in knowledge construction and suggest the idea of non-existence of God’s eye view on knowledge to explain phenomena in nature. Activities that indigenous communities engage in reflect empirical knowledge and reality and are revisable at any point, yet science teachers viewed only cultural activities related to WMS as the only ones which reflect reality (Stanley & Brickhouse, 2001). And, in doing so, learner-centred approach and situated cognition cannot be involved in some schools. This is due to materials, limited resources and teacher training programmes non-embracing of other knowledge sources are constraints.

The power and control western science perpetually exerts in SADC education systems makes science teachers mostly embracing of western epistemological worldview and
question the influence that most of teachers’ and learners’ indigenous knowledge systems bring into education. This favours only those whose cultural background is anchored in that view and makes learner-centred approach acknowledged but highly inapplicable. Situated cognition also, on account of it sharing some similarities with learner-centred approach in that it also supports constructivist theories of learning can also not be involved. Both approaches, support the idea that learners should actively participate in the learning process. But this meets resistance as teachers are challenged by what Schweisfurth (2011) declares as the chief constraint in the implementation of approaches or theories exported to other areas which are not their origin.

In view of these constraints, this study sought to analyse why situated cognition approach can be involved through incorporation of indigenous knowledge in under-resourced rural schools in the Zambezi Region by answering the following research sub-questions:

1. What are the enablers and limitations teachers in the Zambezi Region face when they use indigenous knowledge to engage situated cognition to achieve understanding of science concepts?
2. What role can indigenous knowledge play to act as prior knowledge that teachers can use to incorporate western modern science during situated cognition?

Essentially, this study explored the role indigenous knowledge can play to facilitate engagement of situated cognition in under-resourced rural schools in the Zambezi Region. It aimed to lessen challenges faced in allowing western science knowledge to be successfully constructed through creating conditions for situated cognition approach to be involved successfully in under-resourced schools in the SADC region. Embracing Afrocentric cultural analogies that Gentner (2002) mentions as applied in WMS is acceptable as a science teaching practice since in WMS analogies are used but bear a Eurocentric context.

**Theoretical framework**

Sociocultural theory was used as a lens to view answers from the research questions of which the main aim was to analyze why situated cognition approach can be involved through incorporation of indigenous knowledge in under-resourced schools. This qualitative study anchored on sociocultural theory used indigenous knowledge (IK) perspectives during intervention to generate science situations of which Aikenhead (2001) suggests can culturally contextualises science teaching practices to emerge pedagogy adaptable to a given cultural context. IK during intervention acted as a medium where WMS evolve from as in Sfard’s (1998) opinion.

Sociocultural theory is premised on the understanding that the social and cultural activities which are in each community reflect science concepts. The knowledge can be used as prior knowledge in learning of new knowledge (Vygotsky, 1962). Surprisingly, the individuals’ indigenous cultural practices reflecting science are sometimes not infused in science practices in order to ensure that situated cognition is involved in schools which cannot do so. Curriculum materials needed to engage with situated cognition, a theory which according to Brown, Collins and Duguid (1989) proposes that knowledge is rooted in the activity, context, and culture in which it was learned, but those in use in SADC, most are based on WMS only. However, infrastructure reflecting the Eurocentric perspective of viewing scientific phenomenon or concepts is absent in under-resourced schools and hence constraining situated cognition (SC) engagement. Acknowledging how an Afrocentric perspective views science concepts in communities with under-resourced schools sanctions the infusing of IK artefacts and cultural artefacts and cultural analogies. Cultural analogies can be stories with base domain knowledge which can be used to emerge target domain knowledge (Gentner, 2002). Cultural analogies, artefacts and language used to transmit them can be used to facilitate engagement of SC approach. Examples of analogies from the community of a learner can be the cloud, air and ground that can be used to teach the concept of a capacitor in the section on electricity.

Furthermore, sociocultural theory is anchored on the premise that learning is a product of social interaction. Adults who can be teachers and peers play the role of scaffolding novices for them to be in the zone of proximal development (ZPD) as Vygotsky (1978) suggests. Vygotsky further brings the
idea that everything is learned at two levels, namely, interpsychological and intrapsychological (Vygotsky, 1978). The interpsychological also known as the lower mental function is characterized by interacting socially with the knowledgeable individual as Pritchard and Woollard (2010) suggest. Communication is of importance in the interpsychological function where learners as community members serve apprenticeship programs unknowingly in different activities where science concepts are applied as Rogoff (1995) posits.

Learners in their communities assist in cultural activities that employ science knowledge to process food; such as distilling a mixture to make a spirit to be discussed later, fabricating tools for the family or sustaining the environment. In these activities they are unknowingly apprenticed, activities with base knowledge that are analogies reflecting science learnt as WMS are interacted with. Another example is when fermenting milk using indigenous cultural practices for the milk to be preserved longer than any other milk which is processed under normal conditions of not adding additives. Cleaned roots of an omunkuzi plant are added. The roots are responsible for increasing the acidity thereby preventing invading bacteria. Lactic acid in milk preserves milk but when roots of the plant are added acidity is increased. This knowledge is transmitted to a novice, the learner by an experienced knowledgeable adult. The knowledgeable adult considers normally fermented milk as the base domain analogy and the milk preserved with roots as the target domain analogy. The fact that the given example contains base domain is an indicator that it is an analogy as Gentner and Jeziorski (1993) and Gentner (2002) suggest that an analogy has base domain which can be mapped into target domain.

Importance of prior knowledge
Sfard (1998) proposes that all learning theorists emphasize the need to take into account the prior knowledge as a base of construction of new knowledge. Changes of theories of learning from the behaviourist worldview to the constructivist all emphasize the importance of prior knowledge of learners. Sfard (1998) supports this idea and states that “new knowledge germinates in old knowledge and that has been promoted by all of the theoreticians of intellectual development” (p. 4). Her analysis arrived at encouraging taking cognizant of theories which encourage acquisition of knowledge and those encouraging participation. Situated cognition encourages participation in cultural activities from the learner. Failure to have it involved in under-resourced schools has been attributed to failure to use the right and relevant old knowledge in learners, for instance, prior knowledge which is indigenous knowledge. This study used indigenous knowledge in learners’ environment as an intervention tool
to facilitate the engagement of situated cognition (SC) with the aim to answer the research questions stated earlier.

**Indigenous knowledge compatible with situated cognition approach**

Situated cognition (SC) according to Brown, Collins and Duguid (1989) is premised on the understanding that knowledge is constructed within and linked to doing an activity, context, and culture in which it was learned. In the activity, learners serve apprenticeship programs unknowingly in their communities; context provides the circumstances that make the learner engage in the activities embedded with knowledge. On account of the activities being part of a learner’s culture, a learner constructs it to gain social identity (Miike, 2007). A cultural activity or practice teachers adapt during intervention as the premises of SC is explained in the following section.

In the context of this study, is in the four neighbouring schools in the Zambezi Region where the teacher component of the research participants found that there were no fractional distillation apparatus, the factory with fractional distillation infrastructure was far and their learners cannot reach it. Even if an excursion is arranged learners are economically disadvantaged. Instead, the science teachers took the science learners to an indigenous community member (ICM). The ICM uses local cultural artefacts to produce an alcoholic beverage. At the site, the teachers allowed the ICM to give a site talk and learners were allowed to ask questions and even to perform the activities done by the ICM. Thereafter, the science learners pointed out the science phenomenon involved in the whole system they visited.

Back at the individual school, the teachers related the process observed with fractional distillation diagrams in the curriculum material. Learners were tasked to answer some questions related to what they had observed in the curriculum material reflecting WMS and those reflecting IK. The activity done by the teachers during intervention constituted part of what Asante (2013) proposes on how Afrocentric views can be included in science practices. In doing so, this might answer the research question statements seeking to explore: the enablers and limitations of using indigenous knowledge to engage situated cognition to make certain that understanding of science concepts is achieved and also the role that indigenous knowledge plays to act as prior knowledge that teachers can use to incorporate western modern science during situated cognition.

**Methodology**

This study used analysis of cultural practices reflecting science to intervene and thereafter reveal why situated cognition approach can be involved through incorporation of IK in under-resourced rural schools in the Zambezi Region. Analysis of cultural practices in research involves positioning personal knowledge and understanding into a magnified image of knowledge in a community (Blakey, Milne, & Kilburn, 2012). Analysis of cultural practices was done and was based on observation and brainstorming of practices within a community. To understand the data obtained from brainstorming, cultural practices were analysed, interviews were conducted and reflections obtained from four science teachers teaching senior secondary learners in the Zambezi Region of Namibia.

The use of observation, reflection and activities facilitated triangulation. This also addressed validity. Analysis of emerging data was done by identifying comparable explanations of phenomena which were common in the two knowledge systems, namely, IKS and WMS.

The four participating teachers were tasked to find activities depicting science and their applications. The analysis of cultural practice, its cultural artefacts and jargon in their communities were found and suggestions where they could be used as science-related situations to initiate a science classroom talk (Krajcik & Sutherland, 2010). For the sake of concentrating on one issue and gaining more knowledge on what science knowledge one cultural practice had, the participants after brainstorming selected one cultural practice where a fermented mixture was fractionally distilled to yield a pure alcoholic beverage, by the name *kachipembe*, consumed in the community. The knowledge gained allowed the teachers to take their learners to the site. Thereafter, the researchers were interested to know how indigenous knowledge could be used to engage situated cognition to ensure that understanding of science concepts was achieved and also might respond to what role indigenous knowledge might play to act as
prior knowledge teachers can use to incorporate with WMS. The findings from the data that emerged are presented below.

**Findings and discussion**
The data generated from observation, brainstorming, document analysis, interviews and reflections are displayed below.

**Table 1: Data generated from observation, interviews and brainstorming**
<table>
<thead>
<tr>
<th>Indigenous knowledge concepts / artefacts from which western modern science concepts can germinate in</th>
<th>Relation of concepts / artefacts observed with science concepts in western modern science</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heat supply to an earthenware pot with fermented mixture.</strong></td>
<td>In a conventional distillation apparatus at school level a flask is in the place of the earthenware pot whereas at an industrial site which learners cannot access large tanks with the mixture are in place.</td>
</tr>
<tr>
<td>Wood or coke supplied as a source of heat in a mapukuta (a device for smelting metals and moulding tools).</td>
<td>At a site with modern technological infrastructure coke or electricity is used as a source of heat.</td>
</tr>
<tr>
<td>Steam from the earthenware pot is observed escaping as some enters through the delivery tube which is made of a metal connected to a wooden condenser.</td>
<td>In a school laboratory, the flask is connected to a condenser and all the materials are made from glass but sometimes rubber tubes resistant to heat are used and they are opaque.</td>
</tr>
<tr>
<td>The condenser is made up of wood. Water is poured into it and removed when they feel that it is warm. However, in areas where abundant streams are the wooden condenser is connected to water coming from the stream and is also allowed to flow out.</td>
<td>The condenser is made of glass and the tubing inside are seen clearly revealing the gas being changed to liquid.</td>
</tr>
<tr>
<td>Distillate is collected in a dish</td>
<td>Distillate collection at school level is in a beaker.</td>
</tr>
<tr>
<td>Mixture to be distilled comes from many earthenware pots and when the one on the fire has its content used up another is replaced.</td>
<td>This is also true at school level. When they see that no more steam is coming from the burning contents the one being supplied heat is replaced with a fresh one.</td>
</tr>
</tbody>
</table>

To gain more insight into how cultural practice can be used as science-related situations to engage SC, audio-visual techniques were embraced. Cultural practices acted as starting points that can be used in science classroom talk which Krajcik and Sutherland (2010) suggest as useful. This allowed gaining more insight into why SC can be embraced as this allowed the participants to analyse the artefact during their own time. Figure 1 below captured some cultural artefacts used for distillation.
To understand the views of the four teachers on insight into the enablers and limitations of using IK and WMS to make certain that understanding of science concepts in disadvantaged communities can be achieved, their brainstorming discussions were analysed. The analysis is shown below.

Data from brainstorming

The questions asked in brainstorming were why do you think the practice you selected has science concepts and they are applied by ICM and what can the intervention do for science teachers to incorporate the findings in science teaching? In response they had this to say:

Teacher 1 “Indigenous community members are employing science concepts related to distillation when they process a mixture of fermented fruits into an alcoholic beverage. The indigenous community member representative disclosed to us that heating is done to change the liquid to gas. The choice of the pipe they use to connect the earthenware pot being heated to the cooling system takes into account that it need to be a material which does not get burnt as it is near heat. They could have used a straw to pass the gas through the cooling trough; instead, they still opted for a metal pipe. Also, they are selective on the material that the pipe is made of. Copper pipe was used that has good properties to conduct the heat from the gas and in doing so they turn the gas into a liquid”.

Teacher 2 “Furthermore, the indigenous community member seems to be aware of separating a liquid mixture by taking advantage of the difference in boiling points. Even though they did not employ a fractionating column, they went to replace the collecting container with three other different containers and the contents were never mixed. This might have meant that at different times during the process different substance are produced at different temperatures. The indigenous community member observation as he regularly uses the artefacts, the temperature rises as the system stay longer on the fire”.

Teacher 3 “Now if we are to intervene, we need to take the learners to the site where this cultural activity is done. The learners must participate and also ask questions on why particular materials are used. In doing so, this might allow learners to familiarise with terms used and when we relate them during science teaching this might bring a change in understanding science concepts related to distillation. Finally, we suggest that since the artefacts are used seasonally, the indigenous community members depend on certain time of the year to have a mixture to distillate. Teachers must have these artefacts in their storerooms. This improves accessibility so that they can refer to them during time they are not being used in the community. This can be done when teaching fractional distillation or distillation as they might allow learners to see how the concepts in fractional distillation are applied in their communities.

The synthesized teacher 1, 2 and 3 voices reflect the science concepts indigenous communities use, they viewed to be of importance. Also from the excerpts some themes emerged. These themes were WMS is compatible with explaining activities involved, in indigenous communities, engaging SC using activities from IC and social and cultural artefacts are mediating tools. The three teacher’s explanation uses WMS to reveal how WMS is used by indigenous communities. Our view is the same explanation is done when a
teacher and his learners are at a site with WMS infrastructure that does distillation. The compatibility which WMS has to explain distillation process at a site with IK infrastructure is an indication that IK enables the teaching of WMS.

Further the analysis of the explanations from the three teachers shows that these teachers went to see that sites where IK practices are performed can be used for SC engagement. They see IK practice sites as grounds where learners can participate in situated cognition while interacting with IC members. Active participation is what Brown, Collins, and Duguid (1989) viewed as constituting SC. Finally, the excerpts from the three teachers revealed that the materials used for distillation in IC were cultural and social that can play the role of mediating artefacts. This is where sociocultural theory used as a lens enables us to see that cultural activities reflect science and this is supported by Brown et al. (1989) who view knowledge as rooted in social and cultural activities.

From our view, teachers’ selection of the cultural artefacts did not come with limitations. Instead, this might meet the requirements of engaging a situated cognition approach at a school and enabled to have teaching and learning materials to refer to when teaching science concepts and make them easily accessible to science learners on account of their financial position. In doing so, we view it as preventing transmission of inert knowledge as Hale (2013) suggests.

To validate what was obtained in relation to the research questions the teachers were tasked to do reflections. The excerpts obtained from data generated from these reflections and interviews are displayed in Table 2.

<table>
<thead>
<tr>
<th>Excerpt</th>
<th>Claim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher 1. Situated cognition engagement in our region is based on taking learners to other regions with western modern science technological infrastructure yet those examples learners view to contextualize are not those learners interact with in their culture. If we then include the cultural practices reflecting science in their communities we might improve engagement of situated cognition</td>
<td>Cultural translation</td>
</tr>
<tr>
<td>Teacher 2. Usefulness of using local indigenous examples reflecting science lies not only in providing some tools to use when conducting situation cognition activities but also comes with the benefit of allowing a learner to interact with what occurs in his social and cultural plane.</td>
<td>Sociocultural</td>
</tr>
<tr>
<td>Teacher 3. Teachers’ science language is not blended with social science jargon a learner has got already such as situations reflecting science in his community. The terms teachers use improve the way they will explain science concepts.</td>
<td>Pedagogical content knowledge</td>
</tr>
<tr>
<td>Teacher 4. The challenges teachers face when intending to engage situated cognition is lack of materials supporting use of one knowledge source to explain science concepts. Other views of how science knowledge is understood by learners, learners’ community or even from the teachers are not used. This perpetuates the sole use of one knowledge source.</td>
<td>Social realism</td>
</tr>
</tbody>
</table>

The data generated and displayed above paved way to come with the findings supporting the discussion. Analysis of data from observation, experiences of teachers and interviews.

Table 2: Data generated from reflections and interviews

To triangulate data obtained from brainstorming which was presented in the form of excerpts from teacher 1 to 3, we also presented data generated using reflections and interviews. This is presented below. Unlike in excerpts generated from brainstorming, interviews and reflections allowed the four teachers to give their opinion.
suggested that the use of cultural artefacts used locally for making an alcoholic beverage and some explanations of how it operates culturally translate science pedagogy Bhabha (1994) proposes. This allows SC to be involved. Learners on account of them knowing what happens in a cultural device such as a mapiukuta, a traditional furnace using coke to generate heat energy is similar to what is happening in a convectional fractional distillation apparatus or at any industrial site which manufactures alcoholic beverages through use of distillation. Such a scenario is a science-related situation which Aikenhead (2001) suggests is suitable for making learners take a participatory role in science learning since situated cognition will be in place. The relations shown in Table 1 reveal that prior knowledge is necessary in science teaching as earlier proposed by Lakoff (1993), Gentner (1983) and Gentner and Jeziorski (2012). Sfard (1998) understands such type of background knowledge as a medium from which WMS can germinate. Also, this is in support of Rogoff (1995) who reveals that learners already have this knowledge as they are unknowingly apprenticed in such cultural activities that reflect science.

If reference is made that distillation entails separating a mixture through conversion of a liquid into gas and then back into a pure liquid without paying a visit to the site, does not bring aspects of situated cognition to the learning situation. The ideas in WMS to be learnt remain abstract. In most cases, during the teaching and learning process, learners remain with cognitive conflicts as they try to relate concepts the teacher transmits to what they already know. In doing so, time is wasted. Instead of embracing in other concepts the teacher will be still teaching as Piaget (1990) suggests when he explains learning using accommodation and assimilation. This is also supported by Ogunniyi and Hewson (2008) using cognitive and argumentation theory and this case might not be entertained. This loses the focus of teaching and learning using learner centred approach of which learners’ context enhances understanding of science concepts built from their culture. The study focused on cultural artefacts observed being used for distillation and suitable to be adapted as an indigenous technological artefact. If embraced, it might address the material shortage under-resourced rural schools in the Zambezi Region. Schweisfurth (2011) suggests that material shortage is the cause of disparities in ways in which approaches and theories imported to SADC region lessen their applicability.

From the interviews teacher 4 said that the learners can even be taken to the site in order to have more understanding of the meaning of change of state. The liquid mixture placed in the earthenware pot changes to gas in view of the observers whereas if taught in abstract the participants would have ended up getting inert knowledge as Hale (2013) suggests. Learning of other concepts through use of cultural artefacts and practices to initiate a science classroom talk (Krajcik & Sutherland, 2010) suggest are necessary and can be made possible as situated cognition is involved in areas where it could not have been involved on account of lack of resources. This is still revealed in Table 1 and Figure 1. Observation revealed that for condensation of the gas to occur, water in the wooden device needed to be maintained cool. Interviews yielded that in cases when a stream is nearby, the cooling system is connected to the stream to ensure that a constant supply of cold water is available. The explained activities which are analogous to what happens in a conventional dry distillation artefact acts as science practices that are science related and Aikenhead (2001) refers to them as important in science development. These are suitable to be labelled as science pedagogies which can elevate levels of engagement of situated cognition in disadvantaged communities. This revelation is also supported from excerpts synthesized from the reflections of teacher 1 to 4 as this can be seen from the excerpt suggesting that science concepts taught do not embrace situations learners are aware of. That might constrain understanding of such science concepts, for instance, the process of fractional distillation and its related concepts together with local and scientific applications.

In Table 2, a suggestion from the teachers in row one was, failure to engage situated cognition was attributed to failure to adapt the curriculum to the context of the learners. Admitting that there is lack of cultural translation (see Bhabha, 1994) conforms to the need to bring some changes in science pedagogies which encourage engagement of situated cognition for those learners whose cultural, social and historical
encounters are not mentioned in the curriculum. The challenge could be as (Kumar, 2010; Lindh & Haider, 2010; Sithole, 2007) suggest that IK is not documented as observed, that data based on it was gathered more through observations, brainstorming and interviews which were the oral and indigenous methods of accessing data in the IK world. That was confirmed by consulting the indigenous community member in this study in order to orally access data which was still in the IK realm of learning. The document analysis, which is a modern method of data gathering technique within science procedures, is widely accepted because knowledge is recorded and it is easy to refer to it. This raised the concern of the teachers since found that their practices were divorced from allowing a learner to interact with what occurs in his/her social and cultural plane (see Vygotsky, 1978).

The knowledge which learners have on cultural practices, artefacts and jargon can be used as pedagogical indigenous content knowledge (PICK). PICK which is a blend of pedagogical content knowledge and indigenous knowledge is vital since it allows learners to actively partake in science classroom talk (Krajcik & Sutherland, 2010) and in doing so they might acquire scientific literacy.

Finally, the teachers went on to suggest that the cultural practices, artefacts and jargon which they had as part of their experiences were also other ways of using science concepts. That is, they saw that science concepts cannot be explained using only one view, but also using other views from other sources as suggested in excerpt 4 in Table 2 and this supports Putnam’s (1999) suggestions. The idea of the non-existence of a God’s view on knowledge were removed and this suggested some relationship with social realism in which other views to knowledge on certain issues can be accepted in the science community of practice as evidenced from the fact that science explanations in IK are congruent to explanations in WMS.

The concept of fractional distillation is a topic in most science curricula. However, teacher interviews and reflections indicated that teachers did not discuss such experiences. So, the use of IK allows teachers to weave real–world authentic and context based science situations with WS. Intertwining the two knowledge systems possibly leads to learners’ understanding of the world and being in a position to solve problems faced by the real world using science procedures to maintain harmony with nature.

The data obtained from the instruments used did not reveal limitations of using indigenous knowledge to engage situated cognition. Brown et al. Duguid (1989) suggest allowing learners to learn by doing in order to make certain that understanding of science concepts is achieved. The data revealed that cultural practices and artefacts found in indigenous communities are suitable for use in under-resourced schools to provide science related situations, Aikenhead (2001) proposes. This is evidenced from the data in Figure 1. Also, in support that IK can be used in situated cognition is the data obtained during brainstorming where teachers went to draw some similarities which are found in the two knowledge systems, namely: WMS and IK.

The role indigenous knowledge plays is also revealed in Figure 1. Besides using IK as prior knowledge (Sfard, 1998; Campbell & Campbell, 2009) teachers can use IK views to incorporate western modern science during situated cognition, IK can also be used in hands-on practical activities and in doing so promotes use of tenets of situated cognition (Brown, Collins, & Duguid, 1989). The same materials that ICM use as suggested by the teachers can be used in the classroom to relate and conduct hands-on practical activities. The usefulness of IK for incorporation is also evidence from the data from the interviews that teachers revealed in Table 1.

Conclusion

Engaging situated cognition in disadvantaged communities can be achieved through understanding that the curriculum needs to be used as a guideline to come up with a hybrid curriculum. Hybrid curriculum takes cognizance of cultural, social and historical encounters in a community which reflects science in WMS. The cultural, social and historical encounters are part of the knowledge which a learner uses while they engage with any of the five categories in the contiguity argumentation theory. Integrating the observed and discussing activities then allows one to embrace situated cognition in order for learners to participate fully in a classroom talk. Without taking cognizance of cultural practices, artefacts and jargon, situated
cognition might limit SC engagement in schools that are under-resourced. From the instruments used; analysis of cultural practices, observation and reflections reveal that cultural practices, cultural artefacts and language indigenous knowledge employed can play the role of prior knowledge on which WMS is anchored on. Failure to embrace IK as prior knowledge in under-resourced rural schools seems to imply that SC is only suitable for schools with resources.

References


Grade 12 learners’ performance on direct algebraic equations vis-à-vis word problem equations: A case study of one school in Oshana Region, Namibia

H. L. Kamukonda and S. T. Naukushu

Department of Mathematics, Science and sport Education, University of Namibia, Namibia

linekelaomuwa@gmail.com and snaukushu@unam.na

Abstract

The purpose of this study was to compare the Grade 12 learners’ performance in Direct Algebraic equations and Word Problem equations. Data were collected from school X in Oshana region. The study sought answers to the following two questions: “How does the performance of learners in Word Problem Equations (WPE) compare with Direct Algebraic Equations (DAE)?” and “What is the correlation between the performance of learners in WPE and DAE?”. The mixed method was used to collect the data from the sample from 19 learners who were randomly selected to take part in this study. The study employed written tests as instruments for data collection in this study. It was found that both qualitative and quantitative data indicated a lower performance in WPE as compared to DAE. On the relationship between the performance of learners in DAE and WPE the study found a weak positive correlation (r=0.446). The study also found that the weaker comprehension of WPE was fueled by learners’ limited fluency in translating the wordy mathematical problems into direct equations that they could then manipulate algebraically.

Keywords: direct algebraic equations; word problem equations, performance, Namibia

Background of the problem

Mathematics was to become a compulsory subject in Namibian schools in 2012 (Ministry of Education, 2010). Reed (2009) notes that mathematics possesses the ability to equip learners to develop a passion for problem solving. It also encourages learners to opt to study science and mathematics courses at tertiary level. However despite this claim, the learners at secondary school phase still continue to underperform in mathematics especially in the topic on algebraic manipulation (Robert, Samuel, & Samuel, 2018). This poor performance is of great concern to teachers and public at large and needs an intervention to enhance learner performance in mathematics.

In contemporary Mathematics Education many methods of teaching and learning are problem solving centred. This allows problems to be contextualized (Robert, Samuel, & Samuel, 2018). Algebra is one of the topics in the school curriculum and has been found to negatively impact learners’ performance.

According to Reed (2009) and Ellis (2014), algebraic problems can be classified into two: word problem equations and direct algebraic equations. Therefore, it can be argued that any algebraic problem can be stated into two ways; that is, as a word problem equation where the learner has to translate the problem into a mathematical context. On the other hand there are direct algebraic equations where the learner has to use direct algebraic manipulations without necessarily having to contextualize and synthesize the problem (Paige & Simon, 2009). Literature in other parts of the world (Carraher & Schliemann, 2011; Nathan, 2012) has it that the learners tend to perform better in direct algebraic equation problems as compared to word problem equations. However, the local literature in Namibia such as (Robert, Samuel, & Samuel, 2018), seem to suggest that the performance of learners in Algebra seems to be very low. This situation calls for interventions in order to seek means by which low student performance on algebra questions could be mitigated.
Statement of the problem
Panasuk & Beyranevand (2010) indicate that the demands for Algebra increases as learners move to the next grades. Allegations from literature (Ministry of Education, 2010; Panasuk & Beyranevand, 2010) have it that there is poor performance in Algebra particularly in solving different kinds of equations among Grade 12 extended learners. Also, Ministry of Education (2010) holds the opinion that Grade 12 learners perform poorly in Algebra as compared to any other topic in Mathematics. Therefore, it can be argued that if unattended, this the learners’ poor performance in solving different kinds of equations will ultimately affect their overall performance in Mathematics.

It appears that there is a need to compare this group of learners’ performance in direct algebraic equations against their performance in algebraic equations expressed as word problems. Therefore, this study was carried out to establish how the performance of learners in the Direct Algebraic Equations (DAE) compared with performance on Word Problem Equations (WPE). The study also attempted to establish the correlation between the learners’ scores in direct algebraic problems vis-à-vis their scores in algebraic word problems.

Research questions
The following research questions were addressed in this study:

1. How does the performance of learners in WPE compare with their performance in the DAE?
2. What is the correlation between the performance of learners in WPE and DAE?

Limitations of the study
The successful data collection of this study depended on the willingness of the participants (both learners and teachers) to participate in the study. It was anticipated that some participants in this study might not take part due to some other activities of the time. Since the data was drawn from a particular school only, the results of this study might not be generalized to other populations of different settings.

Literature review
Learners’ Performance in Algebra
Passing in Mathematics calls for teachers and learners to share feedback about the current state of knowledge in the area for improvement. This appears to imply that, knowing the learners’ performance is a constructive part of learning through which one finds out weather the learner understands the content (Ziegler & Kapur, 2018). This follows the argument that it helps to identify the extent to which the learners understand and figure out how they can master the part they did not understand. However, in the context of learning algebraic manipulation skills, we define failure as errors students make in the application of these Algebraic skills such as solving problems in Algebra.

Performance in Algebra varies depending on individual differences in intelligence, high-intelligence students usually make fewer errors when handling and manipulating algebraic problems compared to low-intelligent students, as creativity and intelligence share a common cognitive base (Ziegler & Stern, 2012). Therefore, supporting the foregoing argument presented in the aforementioned literature, it is possible to argue that the learner’s intelligence influences his/her ability to manipulate algebraic expressions. It is therefore imperative that the learners are prepared both knowledge wise and psychologically to cope with this perceived difficult topic.

Teacher-related factors on the learners’ performance in Algebra
According to Nhlanhla (2014) the teacher’s experience and level of understanding of the concept were some of the factors affecting the performance of learners in Algebra. The argument by Nhlanhla leads to the conclusion that some of the teachers who do not possess enough knowledge of the content, end up making excuses such as “the school was not provided with enough study material to aid the instruction in algebra”.

On the other hand Silas (2014) argues that teachers often do not provide the learners with enough practice for them to master Algebra content. It is thus advisable that teachers ensure that learners are provided with enough learning materials that present algebraic practice from different perspectives to ensure that the learners are acquainted with
different kinds of situations and contexts that boost their algebraic manipulation skills.

**Learner-related factors to their performance in Algebra**

A few factors have been identified in the literature as impacting the learners’ performance in Algebra. For instance, Nhlanhla (2014) holds the idea that learners lack strategic competencies in solving algebraic problems and equations, they lack conceptual understanding, learners are supposed to master procedures and processes of problem solving rather than becoming obsessed with their finding the correct answer.

In addition, the literature e.g., Zachariah, Komen, George, & George (2012) found that learners also tend to ignore the rules of Algebra that they ought to master and to apply when solving several algebraic problems and equations, ending in confusion and misapplications of rules leading to low performance in Algebra.

**The social factors effect on the learners’ performance in Algebra**

Some learners are not motivated to do mathematics, while some learners believe that mathematics is a very difficult subject especially Algebra. These learners are discouraged by the feedback they get on the mathematics test.

Additionally, there are learners who believe that mathematics can only be done by certain people and that boys only perform better in mathematics. In some cases, learners also look up to their role model and if they use not to do better in mathematics, thus if their role model has a phobia of mathematics they will be discouraged do mathematics and vice versa (Mayer, 2011). It is therefore, imperative that the learners are role modeled by their teachers to stimulate their interest in learning Algebra and Mathematics.

**Learners’ performance on Direct Algebraic Equations (DAE)**

A limited number of research studies focusing on direct algebraic equations have documented the techniques learners use while solving direct algebraic equations, learners’ understanding of and difficulties with solving direct algebraic equations (Lima, 2008; Zákarı & Maat, 2010), the teaching and learning of direct algebraic equations in classrooms (Olteanu & Holmqvist, 2012), relating how direct algebraic equations are handled in mathematics textbooks in different countries (Sağlam & Alacaci, 2012), and the application of the history of quadratic equations in teacher preparation programs to highlight prospective teachers’ knowledge (Clark, 2012).

For most learners, direct algebraic equations create challenges in various ways such as difficulties in algebraic procedures, and inability to apply meaning to the equations. Kotsopoulos (2009) suggests that recalling main algebraic facts directly influences a learners’ ability while engaged in solving equations. Lima (2008) and Tall (2014) concur that learners’ lack of understanding on the procedures of direct algebraic equations, and their understanding based on “procedural embodiments,” affect learners’ work on direct algebraic equations. Learners tend to assign meaning to equations and solving methods, however, the given meaning is related to the movement of the symbols rather than the mathematical concept. Furthermore, Lima (2008) also documents that learners perceive direct algebraic equations as mere calculations, without paying attention to the unknown as a fundamental applicability of an equation to real-life situations. Therefore, it can be deduced that learners mostly focus on the symbolic world to perform operations with symbols.

Vaiyavutjamai (2009) proposed that learners’ difficulties with direct algebraic equations stem from their lack of instrumental understanding and relational understanding of the specific mathematics associated with solving direct algebraic equations. They suggest that while teacher-centred instruction with strong emphasis placed on the manipulation of symbols, rather than on the meaning of symbols, increases learner performance on solving direct algebraic equations, their (relational) understanding would still be quite low, and they could develop misconceptions.

**Learners’ performance in Word Problem Equations (WPE)**

Olteanu & Holmqvist (2012) content that application problems habitually appear in the form of words, Judi & Robert (2017) reckon that equations are considered helpful in tracking learners’ understanding of procedures and detecting differences among learners’
solutions of word problem equations. These studies have to some extent exposed the fact that solving algebraic word problems equations can be challenging for the majority of learners because the prescribed algebraic system generates a serious barrier to generating equations that represent the relationships within the problems.

Seling (2016) on the other hand, notes that learners’ challenges depend, not only on a formal algebraic outline in the solution phase, but also on the linguistics form of the word problems in the comprehension phase. Literature (e.g., Cai, Mayer, Wand, & Nie, 2011; Koedinger & Nathan, 2010) hold the idea that the process of solving algebraic word problem equations consists of a “comprehension phase and solution phase”. This means, in the comprehension phase, a problem-solver attempts to understand and then forms the text base of the problem, using words as an internal representation. Additionally, in the solution phase, she or he expresses this internal representation externally and applies the rules of Algebra to reach a conclusion.

A number of research studies (Koedinger & Nathan, 2010; Seling, 2016; Olteanu & Holmqvist, 2012; Judi & Robert, 2017) have offered evidence that WPE could be a challenge to many learners. Additionally, Acosta-Tello (2010) indicates that learners’ difficulties in solving algebraic word problem equations stem from the difficulties they have in symbolizing meaningful relationships within algebraic equations whereas Judi and Robert (2017) attributed the word problem-solving difficulties to the learners’ psychological processes of words in the problem, the presence of cue words and the magnitude of the numbers which affect the learners’ abilities to comprehend and provide a solution to the algebraic problem.

In addition to the foregoing, the text comprehension factor could be the main issue for learners in solving word problems (Xin, 2008). However, Nhlanhla (2014) stresses that inadequate mapping of phrases retards learners’ abilities of solving word problems. Additionally, Koedinger & Nathan (2010) point out that students make errors because they fail to see how the situational aspect of the problem is related to the formal expressions in their attempt to produce the proposed internal representations. There is hence a need for teachers to offer professional support and guidance in these areas. Despite the fact that language forms the problem’s text and bears the significant factors that affect the comprehension process as stated in the foregoing, Stacey and MacGregor (2009) claim that learners’ difficulties with word problems also arise from failing to understand the algebraic logic of a problem.

It is therefore clear on the basis of studies cited in this section that researchers argue that due to prior experiences with arithmetic word problems, learners perceive the problem-solving process as a series of calculations and shift their thought process from algebraic thinking to arithmetic thinking when solving algebraic word problem equations. It can also be deduced that it is possible that learners read, understand and accept challenging questions but become confused when translating the story problem to mathematical statements thereby using the substitution method to solve mathematical statements leading to unsatisfactory performance in Algebra.

In summary, the literature review indicates that learners’ performance in Algebra is not satisfactory due to the fact that some teachers do not provide enough learning materials to learners for them to practice more to minimize errors made by learners when solving algebraic problems. Also, it was noted that learners themselves also tend to ignore the rules of algebra when solving algebraic problem, since their desire is just to find the correct answers as opposed to knowing the right procedures that are applicable when solving the problems. The literature also indicates that learners find it difficult to translate the word problems into arithmetic problems.

However, based on the available literature, it appears that researchers did not compare the performance of learners in the two categories of Algebra (Direct algebraic equations and Word problem equations). According to the DNEA (2017), in the Grade 11-12 syllabus, algebra makes up 35 percent of the assessment. This implies that learners need to be comfortable with Algebra as a topic to avoid compromising their overall performance.

The foregoing situation causes learners’ poor performance. If intervention is not done, it will compromise the learners’ performance to a greater extent. This is due to
the fact that learners will continue to experience problems with formulating equations and applying algebraic rules in algebraic problems which will affect them negatively in the overall performance.

It is therefore against the foregoing that this study sought to assess the learners’ performance in WPE as well as in the DAE to find out whether a relationship exists between the two. This was done to find ways to mitigate the problem of poor performance in Algebra as a topic in the syllabus. The literature review shows that it is of great significant to study the learners’ performance in DAE and WPE.

**Methodology**

The study used a mixed method approach; i.e. both the qualitative and quantitative methods were utilized to collect data from the participants. The population of this study was all Grade 12 learners taking the mathematics extended syllabus at one selected secondary school in Oshana Region. Random sampling was used to choose the participants, to ensure that every learner had equal chance to participate in the study. The sample consisted of 19 learners. The study utilized two written tests one test was on the DAE while the other was on WPE. These tasks were similar to those that are used in assessing mathematics at Grade 11 in the Namibia Senior Secondary Certificate O-level (NSSCO) curriculum. However these were expressed as real life situation problems. All learners took both tests at an interval of four weeks between the two tests. Their marks in the two tests were correlated. The learners’ responses were also presented analysed qualitatively by attempting to understand the reason why the learners responded the way they did in order to draw closer to the reasons why they responded the way they did.

**Findings**

**Biographical information of participants**

This section presents the biographical information of the participants. The study drew data from 19 participants of which 8 were males and 11 females. This appears to suggest that there were more females than males in the study, which could be true for the population considering that a random sample was used and each participant had an equal chance of being selected from the population.

**Comparison of learners’ performance on the WPE and DAE**

This section presents the data comparing the learners’ performance on WPE and DAE. This section is divided into two further sections, one section consists of analysis quantitative data regarding the comparison of learners’ performance in WPE and DAE and another one consists of analysis of qualitative data derived from the responses of the learner to the test regarding the comparison of learners’ performance in WPE and DAE. The aim of this section is to give the response to the first research question posed in this study (i.e., How does the performance of learners in WPE compare with that on the DAE?).

**Comparison of learners’ performance on the WPE and DAE tests**

This section commence by presenting the comparison of the mean marks of the learners in the WPE and DAE tests. The mean score of WPE was 9.95 whereas the mean score for DAE was 10.74; this seems to suggest that learners performed slightly well in DAE than in WPE. This finding seems to support Stacey and MacGregor (2009) who said that most learners perform better on the DAE compared to the WPE. Further, Seling (2016) argued that most learners struggle in converting word problems into arithmetic problems resulting into wrong answers, a situation that affected their performance negatively.

However, there were some learners that could have performed well in DAE, but they failed to follow the instructions. As a result they ended up answering part of the questions which resulted in the loss of marks. From the results it is clear that the learners do understand and can solve the DAE but they are still struggling to solve WPE.
From Figure 1, 17(89.5%) of the learners performed better in DAE compared to WPE. However, 2(10.5%) of the learners performed better on the WPE test than on the DEA. The results seem to suggest better learner performance on the DEA than on the WPE.

Figure 2 shows a comparison of the five-point summaries for the DAE and WPE tests.

As indicated in Figure 2, the learners’ scores on the DAE were concentrated more on the right while the five-point summary of the WPE were concentrated more on the left. The lowest percentage scores were 13% and 25% on the WPE was and the DAE respectively, suggesting better learner performance on the DAE. The same trend is seen when one scrutinises the lower quartile the median and the upper quartile values. They were all higher for the DEA as compared to those of the WPE suggesting better performance on the DAE compared to that on the WPE. Further, in the highest score, on the WPE was 67% as compared to 80% on the DAE, again revealing a better performance in DAE compared to WPE. The results in this study support Lima’s (2008) suggest that learners perform better on DAE compared to WPE. According to Lima this is because most learners lack the strategies to convert mathematical word problems into mathematical equations.

Figure 2 also shows that the DAE scores are distributed on the right reflecting a tendency towards negative skewness whereas the scores on the WPE are more concentrated on the left suggesting a positive skewness. This appears to show that in general learners scored high marks in the DAE compared to the WPE.

The Quantitative data regarding the performance the comparison of learner’s performance in WPE vs DAE

This section presents the quantitative data from the written tests regarding the comparison of
learners’ performance on WPE and DAE. Mean score of the WPE. Figure 3 presents the comparison of the answers produced by a learner on the question assessing the same concepts on both the WPE and DAE tests.

Figure 3: Learner 1’s working on question … on the WPE and DAE tests

As seen from Figure 3 Learner 1’s answers to Question 2 of both WPE and DAE were different, despite the fact that these were essentially the same, except one was in word form while the other was a direct problem. Learner 1 solved the direct problem successfully getting all the marks, but failed to translate the WPE to DAE. It seems Learner 1 failed to recognise the mathematical concepts reflected in the word problem to enable Learner 1 to construct the required equation that would have led ultimately to the desired solution. This therefore suggests that the learner was not competent in WPE despite the fluency illustrated in DAE.

Figure 4 compares the answers for Learner 2, on the same task of DAE and WPE. The idea is to understand the reasoning that guided the learner in giving the answers to both the questions.

Figure 4 Answers by Learner 2 in both the WPE and DAE tests

Again as in the case of Learner 1 Learner 2 also answered well the DAE but failed to answer the WPE despite the fact that these were assessing the same task. Thus, according to the answers provided, Learner 2 could also not translate the mathematical problem stated in word to provide the correct direct equation that should be solved to produce the anticipated correct answer. This suggests a weak WPE grasp as compared to DAE. Based on the foregoing, it appears that the learners are performing relatively weaker in WPE compared to DAE.

Also, notwithstanding the foregoing, Figure 5 illustrates a comparison of Learner 3’s response to both the DAE and WPE asking the same task.
Figure 5 shows that Learner 3 failed to construct the equation from the given statement, but the same learner solved the same statement problem when it was given in the DAE. This seems to suggest a poor grasp of WPE compared to DAE. It also appears that the greatest challenge the learners were experiencing was to construct equations that needed to be solved in order to solve the given problem.

The findings presented in figures 3, 4 and 5, seem to support Acosta-Tello’s (2010) findings with regard to learners’ difficulties in solving algebraic word problem equations. Acosta-Tello is of the view that these difficulties stem from the difficulties they have in symbolizing meaningful relationships within algebraic equations. Moreover, Judi and Robert (2017) attributed the word problem-solving difficulties to the learners’ psychological processes of words in the problem, the presence of cue words and the magnitude of the numbers affect the learners’ ability to both comprehend and provide a solution to the algebraic problem leading to poor performance in WPE compared to DAE.

On the basis of both the quantitative and qualitative information gathered, the data revealed that learners performed relatively better on DAE compared to WPE. Moreover, the qualitative data indicated that the greatest challenge among the learners that prevented them to perform better in DAE is the fact that they were unable to understand the problem to convert it into a mathematical language and/or using mathematical symbols, which is prerequisite to solving WPE.

The quantitative and qualitative data presented revealed that the learners’ performance in DAE was better as compared to WPE. Therefore, to answer Research Question one of this study (How does the performance of learners in WPE compare with that in the DAE?), both the quantitative and qualitative data revealed that the performance of learners in DAE was better than in WPE.

**The relationship between the learners’ performance in DAE and WPE**

This section presents and discusses the data regarding the relationship between the learners’ performance on DAE and WPE. This was done in an endeavour to respond to the Research Question 2 (What is the correlation between the performance of learners in WPE and DAE?). The Scatter Plot, Pearson’s Correlation Coefficient and the Coefficient of Determination were used to answer question 2 of the study. Figure 6 shows a Scatter Plot showing the learners’ performance on the DAE and WPE.
Fig 6 shows that there is a weak positive correlation between learners’ performance on the DAE and the WPE. This implies that for the learners who had higher scores in DAE had a very slight chance of scoring higher in WPE.

In order to find out the strength of the relationship between the learners’ performance on the two tests Pearson’s Correlation Coefficient and the Coefficient of Determination were calculated and these are presented in Table 3.

Table 3: Pearson’s Correlation Coefficient and the Coefficient of Determination

<table>
<thead>
<tr>
<th>Statistical value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>0.446</td>
</tr>
<tr>
<td>CoD (r^2)</td>
<td>19.9%</td>
</tr>
</tbody>
</table>

Table 3 shows the correlation coefficient (r) of 0.446. This implies a weak positive correlation between learners’ performance in DAE and WPE. That is, there is a slight chance that learners whose scores were high in DAE were not likely to score high scores in WPE. Also, for the learners whose scores were low in DAE were also not likely to score low on the WPE.

It is obvious that the performance of learners in WPE depends on other variables. The coefficient of determination of 19.9% (see Table 3) implies that if all the variables that have an impact on the performance of learners in WPE were to be kept constant, the performance of learners in WPE can be explained by their performance in DAE up to only 19.9%. About 80.1% is due to other parameters other than DAE.

On the basis of the foregoing data (see Figure 6 and Table 3), and to answer Question 2 of this study (What is the correlation between the learners performance in WPE and DAE?) the study found a weak positive correlation of 0.446 between the learners’ performance in WPE and DAE.

Both the quantitative and qualitative data show that the learners’ performance in DAE was better as compared to their performance on the WPE. Teachers should therefore teach problem-based algebra in order to strengthen learners’ understanding of word problems in the Algebra part of the syllabus. The fact that the WPE solving abilities were weaker, implies the need for mathematics teachers to place more emphasis on the teaching of wordy problems to direct algebraic equations. There is also need to explain in detail the concepts of WPE and how to approach these in teaching in order to mitigate the poor problem-solving abilities found in this study.

Further, there is a need for strengthening the teaching of DAE to facilitate learners’
understanding of WPE. Moreover, there is a need for teachers to stimulate the learners’ interest in word algebraic problems and direct algebraic problems thereby harmonizing the two sections of Algebra and the learners’ performance in DAE and WPE. That is the Namibia Senior Secondary Certificate (NSSC) Mathematics teachers need to align their teaching methods to the competencies of the DAE because this algebraic part seems to have a little significant impact on the learners’ performance in another part of Algebra which is WPE.

Conclusion
This study found a weak positive correlation (r) of 0.446 between grade 12 learners’ performance on WPE and the DEA. The learners’ limited fluency in translating the mathematical problems stated in words into direct equations seems to have contributed to their low performance on the WPE. In this study only 19.9% of the total variance could be accounted for by the interaction of the performance in the WPE and the DAE.

Recommendations
Based on this study, the use of activities that enhance learners’ understanding in DAE must be boosted in order to be able to aid their performance in WPE. When assessing learners’ Algebra, both the DAE and WPE questions must be balanced to avoid disadvantaging learners’ performance in Algebra this means there is a need to strike a balance between the two kinds of activities. Further research should be carried out on identifying other factors influencing learners’ performance on WPE.

References


The integration of hands-on games in the learning of probability: A case of Grade 12 learners in the Oshana Cluster of Oshana Region

S. T. Abisai, S. T. Naukushu and C. D. Kasanda
1Ministry of Education, Reverend Juso Shikongo Secondary School, Oshikoto Region
2,3Department of Mathematics, Science and Sport Education, University of Namibia, Namibia.
1abisaist@gmail.com, 2snaukushu@unam.na and 3kasanda@unam.na

Abstract
This study sought to investigate the effects of integrating hands-on games in the learning and their effects on the performance of Grade 12 Mathematics extended learners in probability in Oshakati cluster schools, in Oshana region. The study tested the following hypothesis at the significant level α = 0.05: 

$H_0$: There is no significant difference in the Grade 12 Mathematics learners’ mean scores on probability between those who were taught using hands-on games and those taught using the traditional method only ($\mu_1 = \mu_2$).

$H_1$: There is a significant difference in Grade 12 Mathematics learners’ mean scores on probability between those who were taught using hands-on games and those who were taught using the traditional method only ($\mu_1 \neq \mu_2$).

A quantitative paradigm, quasi-experimental design was used to gather data from participants. A pre-test-post-test control design was used to assess the effects of hands-on games on the learning and performance of Grade 12 Mathematics extended learners in probability. A sample of 57 Mathematics extended learners was drawn and randomly assigned to the experimental or control group. Each group was pre-tested using the same test after which 8 days of intervention of teaching probability using games was administered to the groups. The control group was taught probability content through the integration of hands-on games while the control was taught the same content using the traditional approach. The same test with changed numbering on the test items was administered to both groups. The findings revealed that, the experimental group performed better in the post-test compared to the pre-test. The t-test performed at the 0.05 significant level indicated a significant difference in the performance of the experimental group. Results provided the evidence that, the integration of hands-on games in teaching and learning of probability facilitated learning and enhanced learners’ performance. The study therefore recommends that hands-on games should be used in teaching mathematics as a means of facilitating learning and enhancing learners’ performance in probability.

Keywords: probability, hands-on games, extended level mathematics, grade 12 learners, Oshana region

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

Therefore, this study was carried out on the assumption that giving learners opportunities to use hands-on games allows them to advance and explore their knowledge on probability and might improve their
performance on probability. Various researchers (Dollard, 2011; Xiayan, 2015; Nicolson, 2005) argue that teaching probability to students is difficult due to its abstractness as well as teachers’ insufficient theoretical knowledge and inexperience with probability. They emphasise that learners need proper instructions such as hands-on games that actively engage them if the learners are to learn the content; Use of hands-on games might enable them to build on their existing knowledge and foster understanding of probability.

**Research hypotheses**

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

- $H_0$: There is no significant difference in the Grade 12 mathematics learners’ mean scores on probability between those taught using hands-on games and those taught using the traditional method ($\mu_1 = \mu_2$).

- $H_1$: There is a significant difference in the Grade 12 mathematics learners’ mean scores on probability between those taught using hands-on games and those taught using the traditional method ($\mu_1 \neq \mu_2$).

**Theoretical framework and literature review**

**Theoretical framework of the study**

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

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

![Diagrammatic presentation of the theoretical framework of the study](image)

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

Furthermore, Ojose (2008) points out that, learners find it difficult to automatically link probability to its activities. It is therefore, important for teachers to provide various mathematical presentations that will help learners make connections and facilitate learning of probability, taking into consideration the uniqueness of learners. Knowledge of Piaget’s stages can help teachers understand the cognitive development of learners as they plan cognitive stage-appropriate activities to keep learners active and fully engaged in learning.

**Teaching and learning of probability**

Grinstead and Snell (2012) indicate that, probability theory began in the seventeenth century with French mathematicians based on games of chance. Probability continued to influence early research until it was a well-established branch of mathematics that has applications in every area of scholarly activity in daily experience. Dollard (2011) explains that high school probability where teachers are likely to use random chance devices like dice and spinners is described in terms of equally likely outcomes and defines probability as the ratio of desired outcome to total possibility outcome.
Nicolson (2005) and Taylor (2011) indicate that, the development of learners’ mathematical reasoning through the study of probability is essential in daily life because probability offers the fundamental theory for the development of statistics and problem solving in science and mathematics related fields. Probability presents real-life mathematics and connects main areas of mathematics such as counting, statistics and geometry. Probability is also used in medicine such as in predicting the risk of new infections or new medical treatments (Grinstead, & Snell, 2012).

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

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

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

Use of hands-on games and activities in probability
Taylor (2011) indicates that many high school learners find it difficult to understand probability. He also points out that inadequate pre-requisite mathematical skills and abstract reasoning as well as lack of instruction that enables learners to be actively engaged in learning contribute to difficulties in learning probability. He further notes that instruction that encourages learners to discover and construct their own understanding of probability concepts may result in understanding of probability.

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

Ojose (2008), Nicolson (2005) and Budimir (2016) emphasise that implementing random phenomenon, such as games of chance like tossing coins, rolling dice and drawing candy from a bag and spinning spinners, are good ways of acquiring understanding of mathematical principles in probability learning. This approach is important for learners to gain basic knowledge, develop logical thinking, and acquire skills of recognising, describing and solving real life problems by probability methods.

Several studies (Nicolson, 2005; Dunn, 2005) explain that dice are used to determine and understand the probability of simple events, assuming equally likely outcomes. Learners are allowed to roll dice several times, record the number of times each number (1 to 6) comes up and discuss the results. Tossing coins involves throwing a coin in the air; the
coin will turn a number of times in the air and land randomly “heads or tails”. This is done to seek and find explanation and interpretation of equally likely outcomes. Drawing candy from the candy bag is used to demonstrate the chances of pulling out candy depending on number of their particular type in the bag compared to other candy types. These activities help learners to understand the probability of independent and dependent events.

Nicolson (2005) and Dunn (2005) further describe spinning spinners as a common tool for exploring and understanding classic probability. For each spinner, learners use a circle divided into six equal parts and a paper clip twirled around the point of a pencil. They repeatedly spin and shade the area where it stops. These enable learners to predict the next possible outcome. These hands-on games can be used to create random, equally likely outcomes for experiments in probability, thus help learners to understand probability and form the connection between mathematics and real life situations. These hands-on games are used to create random and equally likely outcomes for experiments in probability.

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

The benefits of using manipulatives including hands-on games

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

Nareh’s study used games such as the Game of Plinko (a game of chance) and the Game of Pachisi (originated in India and involves two dice and four players) that showed a statistically significant difference in the performance of the learners as compared to the ones that were taught with the traditional method. Hence, emphasising the importance of tools or game activities set in everyday context or cultural context as they help learners to establish connections between probability content, context, and culture. This creates an in depth exploration of probability concepts, allowing learners to discover the importance of studying mathematics and its application which enhances learners’ interest, learning and improve learners’ performance.

Boggan, Harper, & Whitmire (2010) indicate that even though the National Council of Teachers of Mathematics (NCTM) has encouraged schools to use manipulatives in mathematical instruction, teachers are reluctant to plan, construct and use them in their lessons. This is despite the fact that most valuable learning occurs when learners actively construct their own mathematical understanding which is often accomplished through the use of manipulatives. It is therefore important for learners to engage with a variety of material to manipulate and have opportunity to sort, classify, weigh, stack and explore if they are to construct mathematical knowledge.

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

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

**Methodology**

This study used a quasi-experimental design to collect the data from the learners. A sample of 57 extended mathematics learners was drawn and randomly assigned to the experimental and the control groups. The experimental group consisted of 27 learners and the control group had 30 learners. Figure 2 presents a diagrammatical presentation of the sample and sampling procedure used.

A pre-test was administered to the two groups before the intervention. During the four weekends (8 days) of intervention on probability the experimental group were taught probability using the traditional method integrated with the hands-on games. The traditional method only was used to teach the control group probability. After the intervention, the two groups were post-tested using the same test with altered numbering of the test items. The t-test was used to find out whether significant differences existed between experimental and control groups, at α = 0.05 (5%) level.

**Findings**

The results reported herein were an attempt to find out whether the experimental group’s performance was better than that of the control group that was taught probability using the tradition approach only. Accordingly, a number of hypotheses were tested as indicated in this section.

**T-test for the pre-test for the experimental and control group**

To find whether the two groups were the same before the intervention, a pre-test was administered to both groups. The following hypothesis was tested:

- $H_0$: There is no significant difference in the pre-test mean scores of the control and the experimental groups.
- $H_1$: There is a significant difference in the pre-test mean scores of the control and the experimental groups.

The results of the t-test for the above hypothesis are given in Table 1.
The t-test on the probability pre-test scores for independent groups with degrees of freedom (df) = 55, using the two tailed test, the critical t-test value ($t_{\text{critical}}$) at $\alpha = 0.05$ level of significance was 2.021. The $t_{\text{calculated}}$ absolute value $| -0.6532 |$ is less than the $t_{\text{critical}} = 2.021$.

The pre-test mean score of the experimental group of 7.85 was close to 8.20 of the control group (see Table 1). Accordingly, the null hypothesis is accepted showing that the two groups were similar at the beginning of the intervention.

**T-test for the pre-test and post-test for the control group**

These tests attempted to test the hypothesis:

- $H_0$: There is no significant difference in the pre-test and post-test mean scores of the control group.
- $H_1$: There is a significant difference in the pre-test and post-test mean scores of the control group.

Table 2 shows that at $\alpha = 0.05$ and degree of freedom (df) = 29, the $t_{\text{calculated}} = 6.209$ and using the level of significance for two tailed test, the t-test value $t_{\text{critical}}$ is 2.045. The $t_{\text{calculated}}$ is greater than the $t_{\text{critical}}$ which shows that there is a significant difference between the control group’s pre-test and post-test scores. The results seem to suggest that the control did improve from the instruction that they received during the period of the study.

**T-test for the pre-test and post-test for the experimental group**

The following hypothesis was tested in order to find out whether the experimental group’s scores on the pre- and post-tests were different:

- $H_0$: There is no significant difference in the pre-test and post-test mean scores of the experimental group.
- $H_1$: There is a significant difference in the pre-test and post-test mean scores of the experimental group.
With the degree of freedom (df) = 26 and α = 0.05 the critical value of the \( t_{\text{critical}} \) is 2.056. Table 3 shows the t-test result of 10.036. The \( t_{\text{calculated}} \) is greater than \( t_{\text{critical}} \), therefore, the \( H_0 \) is rejected and conclude that there is a significant difference in the experimental group’s pre-test and post-test mean scores.

### Table 3: Comparison of the post-test results of the experimental and control groups

<table>
<thead>
<tr>
<th>Statistical value</th>
<th>Experimental group (N = 27)</th>
<th>Control group (N = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>17.1</td>
<td>13.1</td>
</tr>
<tr>
<td>Standard Deviation (SD)</td>
<td>4.62</td>
<td>3.64</td>
</tr>
<tr>
<td>Variance</td>
<td>21.53</td>
<td>13.2</td>
</tr>
</tbody>
</table>

Table 4 shows that the calculated t-test value was 3.745 which is greater than \( t_{\text{critical}} = 2.021 \) at \( \alpha = 0.05 \) with df = 55. Therefore, the \( H_0 \) is rejected and the researcher concluded that there is a significant difference in the post-test mean scores of the experimental and the control groups on the probability topic. It can be seen from the results that the experimental group benefited from the hands-on games and performed relatively better than the control group.

### Conclusion

Based on these findings of the study we conclude that the integration of hands-on games in teaching probability in mathematics improved the performance of the extended level mathematics learners’ performance in the Oshakati Cluster schools, Oshana Educational region. These findings provide strong evidence of the effectiveness of the use of hands-on games (or manipulatives) in improving learners’ learning and performance. The use of hands-on games in probability has the potential to provide teachers with an effective method of facilitating teaching and learning of mathematical concepts.

### Recommendations

Based on the findings, the following recommendations are made:

1. Mathematics teachers should integrate hands-on games in their lessons on probability in order to improve their learners’ understanding of mathematics concepts and performance. The traditional approaches alone are not enough to enhance learners’ grasp of the mathematics content especially probability.

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

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

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

### References


Towards a paradigm shift in conceptualizing multilingual models of language education throughout Africa: A review of literature

Haingura Paulinus
National Institute for Educational Development (NIED), Okahandja, Namibia
phaingura@nied.edu.na

Abstract
This paper aims to critique the monolingual characterization that has informed language planning and policy throughout Africa. This entails an exploration of the utility of certain language planning and policy pronouncements, as well as models arising out of these. The paper contends that one of the major drawbacks of current policy is that it is still based on Western and colonial notions of multilingualism, which basically involves multiple monolingualisms. Further, the paper offers a critical review of the theory of multilingual education in Africa. It draws on the notion of multilingualism as social practice to critique post-colonial language planning and policies in Africa. In turn, the paper faults monolingual biases in the notions and models used to describe and promote multilingualism in Africa, which mirror descriptions of the language situation in Western socio-cultural contexts.

Furthermore, the paper explores the models of language education implemented in Africa. The paper unpacks the concepts and characteristics of bilingual education, ranging from subtractive and additive arrangements to the newly proposed recursive and dynamic models including the heteroglossic interpretation of bilingual and multilingual communicative practices. Moreover, the paper underscores the different Western models of bilingual education that have not worked in Namibia before, followed by a discussion of the kind of models that Namibia should adopt. It emphasizes the prospects for linguistic repertoire-based multilingual education models in Africa. The paper critiques the monolingual habitus, and advocates for a repertoire-based multilingual models for Africa. If multilingualism is to be recognized as a key model which may be followed in multilingual contexts and, as such, a crucial element in education, then we need to find ways of developing and introducing an explicit and critical pedagogy in our schools, to foster the development of multilingual and critical multilingual literacy.

The paper begins with the reconciliation of the main theoretical models with particular programme types and explores aspects of bilingualism from many sociolinguistic and psycholinguistic perspectives. It highlights the distortions in the conceptualization of multilingualism and multilingual education, and what it entails in Africa’s socio-cultural contexts which may be attributed to the monolingual biases in the notions and models used to describe and promote multilingualism in Africa. It suggests a move towards greater flexibility, i.e. towards heteroglossic multilingualism. Finally, the paper recommends a paradigm shift in conceptualizing multilingual education models in late modern globalized societies in Africa.

Keywords: multilingual education, language education models, language planning and policy

Introduction
This paper discusses the models which are most commonly used in African settings using terminology which is currently in use in the (international) literature. It is worth mentioning that this terminology is frequently misunderstood or used in different ways by a number of people. As Heugh (2005) notes, there are three dominant education models, viz. the subtractive education models, transitional education models with earlier or later exit strategies and additive education models which are often implemented in Africa. As she further notes, the aim of the subtractive model is to move learners out of the mother tongue (MT)/home language (HL)/first language (L1) and into the second language (L2), called here the official/foreign language, as a medium of instruction (MoI) as early as
possible. Sometimes this involves a straight-forward L2 medium from the first grade of school. The bottom line is the use of the L2 mainly or only for teaching and learning. As Heugh (2005) points out, the transitional models have the same end goal as subtractive bilingual models. She further points out that it is a single target language at the end of school; and the target is the L2 as MoI. She maintains that learners may start school in the L1 and then gradually move towards the L2 as the MoI. If the transition (switch) to L2 takes place within 1-3 years, it is called the early-exit (from the L1) transitional model, and if the transition (switch) is delayed to Grades 5-6, it is called late-exit (from L1) transitional model.

The Namibian bilingual education model may fall within the ambit of early-exit transitional (or early transit) model. It may as well fall within the ambit of ‘subtractive bilingualism’ (Plüddemann, 2010). ‘Subtractive bilingualism’ refers to schooling that neglects or prematurely abandons learners’ MT/HL as language of learning and teaching (LoLT) after only using it for three or four years. However, the notion of subtractive bilingualism appears to be conceptually flawed. The key question is: How can bilingualism be subtracted? The basic premise of this concept is that learners come to school with only one single mother tongue. This is tantamount to monolingualism, that is, if the mother tongue is replaced, for argument’s sake with English; it means that one monolingualism based on the mother tongue is replaced with another one based on English. The question remains: What happens when these learners go back to their respective homes? To overcome the problem of ‘subtractive bilingualism’, therefore, Weber and Horner (2012) suggest that the best system of education might be a flexible system of additive bilingual education, giving the children access to both English and indigenous African languages (IALs).

According to Plüddemann (2010), additive bilingualism stands for the maintenance of the mother tongue as LoLT for a minimum of 6 years, either alone or alongside a second LoLT. In the South African context, as Banda (2017) notes, additive bilingualism is premised on 6-7 years of primary education in the mother tongue before switching to English or Afrikaans as the sole language of education. As Banda (2017) puts it, the African mother tongue is discarded altogether or becomes an (optional) additional (language) subject. In terms of classroom practice, this effectively means monolingual/monoglot mother tongue practices being replaced by monolingual/monoglot English practices (Banda, 2010). Consequently, as Mohamed and Banda (2008) state, after 6 years or more of mother tongue medium of instruction, it is a waste of time and resources that the language is replaced with English in a monolingual educational system, without giving learners the alternative to a bilingual education model in which both languages are used as languages of content matter instruction.

I therefore argue that the additive bilingual model is not different from other transitional approaches, as it envisages a switch to English medium of instruction (EMoI), mainly for those that start education in an African language. The difference is that the transition from instruction in the learner’s mother tongue to the L2 may take a bit longer. In my view, this makes the additive model a transitional model, just like the early- and late-exit models. The difference only lies in that the additive bilingual education model envisages the switch to take place after 6-7 years of mother tongue instruction. The assumption of the additive bilingual education model is that 6-7 years of mother tongue education (MTE) will enable learners to have acquired the cognitive competence required to handle learning in their second language, viz. English, French or Portuguese. This is tantamount to replacing mother tongue-based monolingual education with English-based monolingual education, both of which are incompatible with multilingual discourse practices that characterize the late modern multilingual spaces of Africa (Banda, 2010). Models and language development strategies, deemed suitable for Western countries with a monolingual speaker at their centre, are mistakenly applied to African contexts with a multilingual speaker at their centre. For example, the concept of ‘additive bilingualism/multilingualism’ makes sense when a language is ‘added’ to a monolingual speaker’s repertoire, but not when it is added to the linguistic repertoire of a person who is already bi-/multilingual (Banda, 2009b).

The fundamental question, in my view, is: In what way does one ‘add’ a language
when that language is already part of the speaker’s repertoire? The notion of ‘adding’ a language only makes sense in monolingual contexts, and not in the African context with its multilingual heritage (Brock-Utne, 2009). Banda (2010) questions static models, and the appropriateness of using Western models of multilingual education in African contexts. In the light of the failures that these models have engendered, we are beginning to question the belief that there are universal truths and recipes that apply without taking specific historical situations into consideration. As Africans, we should henceforth stop the ‘one-size-fits-all’ approach to the notion of multilingual education. We should look for solutions to our problems stemming from the profound socio-economic and political changes inherent in Africa, rather than relying on Western models which do not necessarily fit the African context (Haingura, 2017).

Multilingualism and the colonial legacy in Africa

It is notable that multilingualism is a reality in Africa. As Mchazime (2003, p. 3) points out, “Many [African] children come to school when they have already been exposed to one or two other local languages”. Nevertheless, it is also worth mentioning that multilingualism does not lend itself to an easy definition, possibly, as multilingualism means many things to many people. As Aronin and Hufeisen (2009) put it, most psycholinguistic scholars define multilingualism as the use of three or more languages. I therefore argue that, if we regard multilingualism as the use of three or more languages then researchers need to be able to count an individual’s languages in order to know whether the potential participant is a member of the category of multilingual individuals (Haingura, 2017). As Aronin and Hufeisen (2009) observe, counting languages is difficult and even problematic.

According to Mchazime (2003), the term ‘multilingualism’ refers to the situation in which a person or a group of people has some knowledge and ability to use more than two languages. As Ouane (2009) aptly points out, a number of definitions suggest that when we talk about bilingualism, we also talk about multilingualism, and that multilingualism means everything that is ‘more than one language’. By way of explanation, Ouane (2009) shows what multilingualism is by going through a list of what it is not. As Ouane (2009) argues, multilingualism is not multidialectism or many varieties of the same language. Ouane (2009) emphasizes that it is not a problem of two or three languages existing side by side, but it is that so many languages exist, and are used in one way or another within the same country.

In view of the above, and being perfectly aware of term confusion, particularly emanating from the literature, this paper, following Weber and Horner (2012, p. 3-4)

... presents an alternative view of multilingualism not in terms of ‘languages’ but in terms of linguistic resources and repertoires, and advocates this as a more successful way of capturing what is often an elusive and intractable linguistic reality. It takes a broad definition of multilingualism as verbal repertoires consisting of more than one variety (whether language or dialect).

This paper therefore takes a more holistic view of speakers’ communicative repertoires. As Weber and Horner (2012, p. 3-4) so aptly point out, “Most speakers in the world have a repertoire of varieties at their disposal, and hence are multilingual, whether these varieties are traditionally included within the same ‘language’ or under separate ‘languages’ …”. Furthermore, Blommaert (2010, p. 102) suggests that “Multilingualism … should not be seen as a collection of ‘languages’ that a speaker controls, but rather as a complex of specific semiotic resources, some of which belong to a conventionally defined language”. As Weber and Horner (2012, p. 3) succinctly summarize:

We all have a large number of linguistic resources at our disposal, and it does not really make a difference whether they belong to only one conventionally defined ‘language’ or several of them. Hence, multilingualism is a matter of degree, a continuum, and since we all use different linguistic varieties, registers, styles, genres, and accents, we are all to a greater or lesser degree multilingual.
Given the multilingual trends in Africa, therefore, multilingualism should be seen as social practice with which people conduct their interactions and by which they assume new social identities and index their social experiences. Multilingualism as social practice in Africa also allows greater permeability of identities as it enables people to adopt and discard identities when there is a need to (Prah, 2010). Thus, Heller (2007, p. 1) suggests a different approach to researching multilingualism which shifts away from “a highly ideological view of coexisting linguistic systems, to a more critical approach that situates language practices in social and political contexts and privileges language as social practice, speakers as social actors and boundaries as products of social action”. Blackledge and Creese (2010) support this approach to multilingualism; because it explains how new multilingualisms emerge, as people, more particularly the young, create meanings with their diverse linguistic repertoires.

The most fundamental question is: Is multilingualism new to Africa? As Banda (2009b) points out, patterns of trans-tribal commerce and trade, and the close proximity and density of related and not-so-related dialects in several parts of Africa suggest that forms of multilingualism have been the norm in Africa for centuries, even before colonialism. According to Banda (2010, p. 231), “Colonialism merely added another dimension to the complex multilingual contexts”. As a consequence, as Banda (2017) puts it, the European (and Arab) influences only added different (colonial and religious) dimensions to the linguistic situation in Africa (Banda, 2010, 2016). As Banda (2017, p. 3) argues:

… even before Europeans came to Africa, the nature of African society in which people moved from one area to another in pursuit of new land for farming, grazing for cattle, trade and also due to wars of conquest means that language contact and multilingualism are not entirely new to the continent.

As far as the Namibian situation is concerned, Haingura (2017, p. 118) reminds us about “… The click sound [found] in the first syllable of the toponym Gciriku [cf. the second syllables in the ethnonym muGciriku/vaGciriku, which refers to people, and in the glossonym ruGciriku, which refers to the language]”, coupled with the many click sounds found in some of the IALs in Namibia, as indicative of the language contact between the indigenous people of Namibia and the Khoisan people. Consequently, as Banda (2017, p. 3) puts it, “The European and Arab sojourns and subsequent urbanisation in Africa only helped to accelerate multilingualism and linguistic diversity whose roots were already in place”.

**Conceptualization of the appropriate models of multilingual education**

There are a number of challenges and contestations surrounding the conceptualization of multilingual models of language education throughout Africa. For instance, several concepts with regard to language policies and multilingual education are not always understood in the same way by all in a diverse continent such as Africa. A closer look at the conceptualization of possible models of bilingual education in institutional documents in Africa reveals ideological meanings that narrow the perspective of bilingualism (Banda, 2016).

As Mtenje (2009) argues, one of the fascinating things about multilingualism and the question of language-in-education are the differences in conceptualization of the appropriate model of multilingual education a country may implement. He further argues that this follows the fact that there are different conceptualizations with regard to possible models in multilingual education with different
consequences. As Mtenje (2009, p. 67) succinctly puts it:

… it has been generally acknowledged that the multilingual nature of most African societies has been conceived by many African governments and language planners as a source of complexity. The situation has also been worsened by the linguistic typological classification and grouping by scholars.

As a case in point, one can take Ferguson’s (1966) national, sociolinguistic profile formulas which group languages into three types, according to characteristics such as language functions, status and demographic size, namely major language, minor language, and language of special status. As Mtenje (2009, p. 68) points out, “It is very difficult to use Ferguson’s language classification without distorting the sociolinguistic realities of most African nations because of the inherent problems regarding the typology”. As Mtenje (2009, p. 68) further points out, in the planning of languages for use in education, the classification of languages into groups such as those proposed by Ferguson has had a direct influence on the decisions on which languages should be used. Further, Mtenje (2009, p. 70) notes that:

In some cases where there have been no obvious ‘dominant’ languages to qualify as major languages, exoglossic (former colonial languages) have been adopted as candidates for use in schools; the argument being that there would be no justification for choosing the appropriate language(s) from among the minor languages. The foreign language in this case has been perceived as a ‘neutral’ choice.

In my view, this is exactly what had happened in the Kavango Region. The classification of minor versus major languages had been the biggest problem hampering the promotion of Rugciriku (now Rumanyo). For example, the South African colonial apartheid regime, of course, with the tacit support from their local henchmen, did not see the need to develop a minor language, in this case Rugciriku, using government resources if these very same resources could be channeled to promote a major language of the region, viz. Rukwangali. I argued elsewhere (Haingura, 2017) that, in Namibia, even today, the notion of major versus minor languages still continues to be applied in the language development arena. As an example, for every donor-funded project that comes into Namibia to assist with the development of indigenous languages only the major languages are selected for piloting.¹

Mtenje (2009) observes that attempts to empower indigenous African languages within the domain of education, through their intellectualization, are affected by other classification terminologies. For instance, according to him, Emenanjjo (1990) suggests a three-tier language developmental typology of Nigerian languages based on their participation in technological development: developed, developing and underdeveloped languages. The developed languages are those with well-established orthographies, standard written varieties, long traditions of writing, large and varied corpora of written literature, as well as sophisticated and dynamic meta languages. As Adegbija (2001, p. 3) points out, using Emenanjjo’s definition, “none of the more than 400 languages spoken in Nigeria would qualify as a developed language, because there is no indigenous African language which is used as a medium of teaching all the subjects at higher levels of education in the country”.

Consequently, as Mtenje (2009) states, there are inherent problems with classifying languages along the parameters followed by Emenanjjo. Mtenje (2009, p. 71) further states that:

Firstly, language development … is relative to the function(s) it is intended to serve in specified contexts. This being the case, a better alternative would be to consider it as a process rather than an absolute or complete state of a

¹ The training of African language teachers to acquire the Diploma in Education African languages (DEAL) at UNAM, which was sponsored by SIDA, is a case in point. In the Kavango Region, only Rukwangali was chosen, at the expense of Rumanyo and Thimbukushu. As a result, all the teachers from the Kavango Region who studied the course had to use Rukwangali. Other minority languages such as Setswana, Ju’hoansi, etc. were also excluded.
language. Thus languages may be considered to be ‘developed’ in relation to the specific functions that they are intended to serve in the societies where they are used. Secondly, there is a danger that by classifying languages in this manner, one may provide excuses to language planners for excluding the so-called underdeveloped languages from the language planning activities on the basis that they cannot be used in domains like science and technology, or higher education.

He maintains that:

This may result in circular arguments like some languages cannot be used in domains such as education, science and technology because they are not yet developed and that there is no need for developing them because they cannot be used in high status domains like education, science and technology anyway (Mtenje, 2009, p. 71).

As Mtenje (2009) notes, a further dimension with regard to the conceptual differences in multilingual education resides in the multiplicity of language policy alternatives, and the models of education which may be followed in multilingual contexts. Macdonald and Burroughs (1991), for instance, present an extensive classification of models of bilingual education which Luckett (1995) uses in a detailed comparative survey of sub-Saharan Africa, and group them into different categories. The first category contains models which are adopted under exoglossic language policies in countries where the principal medium of communication is a foreign language. The second category is transitional bilingualism and the third refers to models adopted under endoglossic language policies which seek to promote local or national languages which are spoken by the majority of the population.

However, this paper’s conceptualization is informed by recent post-structuralist thinking (Banda, 2016) about multilingual education. Therefore, the definition and description of multilingual education, in this paper, conforms to UNESCO’s (2003) definition and description. In a 2003 position paper titled “Education in a multilingual world”, UNESCO discusses the following aspects of ‘multilingual education’ thus:

Bilingual and multilingual education refer to the use of two or more languages as mediums of instruction. In much of the specialized literature, the two types are subsumed under the term bilingual education. However, UNESCO adopted the term ‘multilingual education’ in 1999 in the General Conference Resolution 12 to refer to the use of at least three languages, the mother tongue, a regional or national language and an international language … (UNESCO, 2003 in Legère, 2003, p. 43).

As Legère (2003, p. 47) succinctly captures it, “To summarise again the UNESCO position about multilingual education … accounts for a well-structured approach to (i) the mother tongue (MT-LI), (ii) a regional or national language (L2); and, (iii) an international language (L3)”. Nevertheless, judging from the above statements, Legère (2003, p. 47) argues, “… the African response to the multilingual education issue as outlined by UNESCO is rather vague. Relevant documents on education and language policy in sub-Saharan Africa do not use this term expressis verbis”. Legère (2003, p. 51) further points out that:

… multilingual education as … defined and described by UNESCO (2003) does not exist in sub-Saharan Africa in the form of nationwide education programs. Whether African languages play a role as MoI in education (…) or not, their position is still weak in comparison to foreign languages like English, French or Portuguese. Even if African languages are used in school as MoI in lower primary grades, most of these languages (with the exception of Swahili) are withheld the chance of being officially accepted as MoI after Grade 3 or 4.
Sooner or later in the primary cycle subtractive bilingualism is the rule, i.e. a foreign language (L3) that is hardly mastered by the learners after a short exposure to this language as a subject abruptly becomes the medium of instruction.

**The main models of multilingual education implemented throughout Africa**

The three main models under the category of exoglossic language policies are the submersion, immersion and delayed immersion models. As Mtenje (2009, p. 73) points out, “The submersion model usually applies to situations where a minority of children (for example immigrants) from a subordinate language are exclusively subjected to education in a dominant language, and no teaching occurs in their mother tongue”. Similarly, Kosonen and Young (2009) argue that:

Submersion education is the opposite of using learners’ mother tongue in education, and refers to the deployment of a language of instruction that the learner does not understand. Submersion education commonly takes place when minority children with limited proficiency in the majority language (…) are put into the majority language classrooms without any provision for accommodating or alleviating the learners’ disadvantages caused by not knowing the language (Skutnabb-Kangas, 2000 in Kosonen & Young, 2009, p. 13-14).

In Africa, the submersion education model is often the opposite of what has been defined and described above. That is, submersion education ordinarily takes place when a majority of African children, with limited proficiency in the minority language are subjected to education in a minority language, and no teaching occurs in their mother tongue. As Mtenje (2009, p. 72) notes, “In the immersion model, the aim is to teach the children in a class through the medium of a second or foreign language from the first year of school. The children’s first language may be used orally and it may also be taught as a subject”. However, in the delayed immersion model, as Mtenje (2009) further notes:

… the child is taught basic reading and writing skills in his/her mother tongue from grade one to grade four and English, the second language, is taught as a subject from grade one up to the end of secondary education. English takes over as a medium of teaching at the primary level from grade five to the end of the education system. The local languages which were used as media of instruction may continue to be taught up to secondary school level … (Mtenje, 2009, p. 74-75).

He maintains that:

The delayed immersion model applies to situations similar to the immersion cases, except that there is a period of adjustment before the child begins to learn in a second language. That is, in the early years of their education, children are taught reading and writing skills in their first language. As this is happening, the second language, which eventually takes over from the mother tongue, is taught as a subject. When it takes over as a medium of instruction, the second language is used across the curriculum and the children’s first language usually continues to be taught as a subject in later years of primary and secondary education (Mtenje, 2009, p. 72).

Furthermore, as Mtenje (2009, p. 73-74) states, in the category of endoglossic models of bilingual education, “… there are various models of language policies in education whose common goal is to develop indigenous languages in a given country”. For Mtenje (2009, p. 74), “One alternative is to use the learner’s first language as a language of teaching throughout their education, with the second language being taught as a subject”. He observes that an alternative approach under endoglossic models of bilingual education is to use the learners’ linguistic resources which
they bring to the class as a basis for the MoI. In this case, as Mtenje (2009) puts it, two or more of the languages spoken by the children are used in the same class as languages of instruction, in a structured or an unstructured manner.

Moreover, the Namibian educational system uses different ‘national languages’ and English as the mediums of instruction, in line with the country’s language-in-education policy (LiEP) which emphasizes ‘bilingualism’ in these languages. However, what is meant by the concept ‘bilingualism’, in the Namibian context, remains controversial. In most cases, “… even the weakest two-language models, requiring minimal use of the learners’ first language as a language of instruction, have been called bilingual education” (Kosonen, 2009, p. 40). Nevertheless, this seems to be the case throughout Africa. As Banda (2009a) notes, “… what constitutes a bilingual education programme is often a matter for debate. For some, what makes a bilingual programme is a mere fact that two languages are used in the education system, that is, one as LoLT and the other as subject …” (Banda, 2009a, p. 109).

The question remains: To what extent are the education models in vogue (throughout Africa) bilingual? As Skutnanb-Kangas (2000) notes, although these models use the term bilingual education, they do not fall within the understanding of the classic definition of such. Most of them just use the term ‘bilingual’ in “sheer rhetoric” (Holmarsdottir, 2001, p. 39), and do not justify the label bilingual education let alone multilingual education (Haingura, 2017).

Finally, I argue that, currently, the basic philosophy and ideology regarding language education policy throughout Africa is informed by monolingualism and is not so different from the policy promoted by colonialists (Banda, 2009b). I therefore suggest that there is a need to explore models in which two or more languages are used as media of instruction. As Miti (2009: 163) points out, “… Monolingual Education refers to a system in which one language, usually another tongue, is used in the learning areas including the language in question”.

Towards alternative concepts of multilingual education

Having briefly discussed the various bilingual models, I now explore what consequences this has on decisions with regard to language-in-education policies in Africa. For Mtenje (2009), the main issue that arises out of these models of bilingual education is that language planning, in some cases, may possibly not follow a single model. Instead, there may be a blend of aspects from exoglossic, transitional and endoglossic models in one policy which may result in inconsistencies in the application of language policy guidelines. This may be one of the reasons why Bamgbose (1991) states that language policies all over Africa are characterized by one or more of the following complications: avoidance, vagueness, arbitrariness, fluctuation and declaration without implementation. As Mchazime (2003) succinctly puts it:

> It is generally difficult to implement multilingual education in Africa ... This is mainly so because policy-makers are faced with challenges which put them in dilemmas of various kinds. Some of the dilemmas are caused by lack of credible information on which to base decisions. Language experts and practitioners should, therefore, play a special role not only in doing research but also in providing such information in a more digestible form (Mchazime, 2003, p. 23).

As a consequence, Miti (2009) suggests a few models that should be used as a form of bilingual education in southern Africa. He offers a brief explanation of some of these models, namely monolingual education, bilingual education and multilingual education, and reconceptualises what they might mean for language issues in post-colonial Africa. According to Miti (2009), bilingual education may take two forms:

---

2 As Miti (2009: 163) points out, “… Monolingual Education refers to a system in which one language, usually another tongue, is used in the learning areas including the language in question”.

3 Miti (2009: 163) observes that “… Bilingual Education occurs when learning and teaching are carried out in two languages. In this approach, classes are taught in both the mother tongue and a second language”.

4 According to Miti (2009: 164), “… Multilingual Education refers to the use of more than two languages in the learning and teaching of most if not all learning areas”.

---
In One-way Bilingual Education, the same class, which is made up of speakers of one and the same mother tongue, is taught through the medium of both their mother tongue and a second/foreign language, whereas in Two-way Bilingual Education, speakers of two different mother tongues are taught together in a bilingual classroom using the two languages interchangeably. It is expected that in the process, the two language groups will learn each other’s mother tongue in addition to receiving tuition in other learning areas through the medium of both languages … In the southern African context, at least one of the languages may be the learners’ mother tongue (Miti, 2009, p. 163-164).

However, as he puts it:

In the southern African context, since the indigenous African languages have not previously been used as languages of learning and teaching, opting for the Two-way Bilingual Education would further marginalise mother tongue speakers of indigenous African languages. Because educators have been trained to teach in the medium of English or Portuguese, and seeing that there are currently more and better materials in these ex-colonial languages, those learners who are mother tongue speakers of these foreign languages or those who have had better exposures to them at home will have an unfair advantage over learners from relatively poor family backgrounds. Moreover, there can be a tendency to use more English or Portuguese than indigenous African languages (Miti, 2009, p. 164).

Nevertheless, Miti (2009) emphatically emphasizes that there is a need to carefully monitor this process to ensure that IALs are not neglected. He therefore concludes that:

It would appear therefore, that for southern Africa where the use of indigenous African languages in education has been neglected, the monolingual education in the mother tongue is the best option. This, however, should be accompanied if not preceded, by a systematic empowering of these indigenous African languages to level the playing ground, as it were (Miti, 2009, p. 165).

However, advocating monolingual education (albeit in the children’s mother tongue) in this day and age militates against the multilingual character of Africa. Following Banda (2009a), I argue that any move towards mother tongue monolingualism ignores the socio-linguistic realities of Africa. As Banda (2009a, p. 110) states, “… any model that assumes a monolingual perspective goes against the multilingual nature of Africa, where different languages in the repertoire, including what can be termed non-standard languages are used to perform facilitating roles of various sorts”. Furthermore, as Banda (2009b) notes, the very notion of ‘mother tongue’ appears to be problematic in late modern times where urbanization, hybridization and multilingualism are the rule rather than the exception, even in Europe (Appadurai, 1996). As Banda (2009b) puts it, “… in late modern multilingual African societies, rather than ‘a mother tongue’, there are ‘mother tongues’ that constitute speakers’ linguistic repertoires” (Banda, 2009b, p. 4).

Moreover, Banda (2009b, p. 4) argues, “Monolingualism, even mother tongue-based monolingualism, is not ideal. As Banda (2009a, p. 107) aptly observes, “In other words, any model that champions a single language as language of instruction would not be in sync with the linguistic situation and frame of language usage in Africa”. Banda (2017, p. 2) further observes that “At a time when in Africa people necessarily speak at least two languages (an African language and a colonial language) as a necessity, arguments for a singular ‘mother tongue’ education are out of place”. I wholeheartedly agree with Banda (2009a, p. 109) when he states that “… there are problems with the applicability of mother tongue based bilingual model in multilingual contexts as it appears conceptualized and described in monolingual terms”.

66
However, it is important to note that, thus far, no teacher in Namibia has received any formal training on the use of at least two languages as MoI, but most, if not all, have received (their) training to handle one of the two languages. Consequently, as Banda (2009a, p. 111) points out:

There is need for training, equitable funding and resources in at least three languages. Initially, teachers need to be trained to teach and use two languages. This means that teachers need to be able to teach and use two or more languages systematically as LoLT content-matter subjects as a way of enhancing multilingual competencies. The idea is to have learners that are able to speak, read, write and synthesise information at high cognitive level in two or more languages.

Likewise, there is need for multilingual models of education and language policies which are based on natural linguistic repertoires of the speakers concerned. The idea is to build and extend multilingual democratic spaces for speakers as a way of enhancing and taking advantage of multilingualism as a voice for experience and identity performance and hence, as a linguistic resource. This enables material production of multilingualism through local agency and voices across borders, be they ethnic, community-based or national. In this way, multiple languages become tools for socio-political, cultural and economic transformation of Africa, as multilingualism becomes the means for increased socioeconomic and political participation across broad African populations. These considerations lead to the notion of ‘linguistic repertoire-based multilingual models’ (Banda, 2009a, 2009b).

Last but not least, as Banda (2010, p. 231) states, “Since the onset of colonialism, Africans have had to employ at least two languages for translocal and transnational communication needs, and for socioeconomic mobility generally; one of the languages being the colonial language”. Therefore, it can be said that the problem being discussed in this paper is common to Africa and other post-colonial contexts where one has to use more than one language, including the colonial language for communicative and socio-economic mobility (Banda, 2010).

Multilingualism as classroom practice
It is noteworthy that research has started to attend much more closely to the communicative and socio-cultural dimensions of multilingual language use, particularly in school and classroom contexts. In this paper, therefore, the term ‘bilingualism’ is used with a critical recognition of the history of the concept, and of the new view of language which it now represents. It is remarkable to note that MTE and bilingual education in South Africa bear the weight of history (De Klerk, 2002). As Plüddemann (2010, p. 9) notes, “Unlike MTE, bilingual education is a contested term that has at least two meanings”. As Alidou et al. (2006, p. 4) state:

The term originally meant the use of two languages as mediums of instruction. It included, but was not restricted, to the learning of two languages as subjects. Therefore it usually means: the L1 plus an L2 as mediums of instruction. In South Africa, bilingual education is understood as mother tongue instruction (L1 medium) throughout school plus a second language taught as a subject.

Nevertheless, I argue that Plüddemann’s (2010) characterization (of L1 and L2) as mediums of instruction has a West-centric monolingual tone, as it presupposes that all learners are exposed to only one named language or that they have only one single MT/HL, which is not the case in multilingual societies throughout Africa. As Cummins (2003) states:

…bilingual education is generally defined in terms of the means through which particular educational goals are achieved. Two or more languages are used for instructional purposes… However, the term bilingual education is sometimes defined in relation to goals, to refer to educational programmes that are designed to promote bilingual proficiency
among students. When used in this broader sense, bilingual education may entail instruction primarily through only one language (Cummins, 2003, p. 5).

As Plüddemann (2010, p. 9) succinctly summarizes it, “Taken together, the two quotes capture the two traditions of bilingual education in South Africa”.5 In my view, it cannot be denied that the theories on which the models under discussion are based are linked to the Western ideology that learning and teaching are best done in a singular ‘standardized’ language. Nevertheless, these models do not fit the bilingual profile of the African children or the multilingual profile of the continent as a whole. As Banda (2010) notes, Western multilingualism and discourse practices are universalized to African contexts. Consequently, models such as submersion and immersion models, subtractive and additive bilingualism, etc. have been imported to African contexts with uninspiring results as they do not fit the African colonial experiences and multilingual profile (Anchimbe, 2007; Brock-Utne, 2009; Makoni, 1998; Makoni & Meinhof, 2004).

The argument is that language policy and planning in Africa is not only constructed in the image of Western countries (Anchimbe, 2007), but also retains the colonial heritage which directly associates IALs to (ethnic) tradition and culture, rather than socio-economic development and mobility. According to Banda (2009b), three observations can be made. First, African languages are promoted as autonomous and bounded systems linked to equally autonomous homogenous communities, regions and, in some cases, far flung villages. Second, even though there is evidence of multilingual speech patterns throughout Africa, the official doctrine is to promote singular speech patterns in the communities or regions. Third, although English and other colonial languages are part of the multilingual landscape and have become critical components of the linguistic repertoires of Africans (due, in part, to the advent of information technology), the policies favoured by language education scholars are those that restrict instruction in English to later stages of a child’s education (Banda, 2000, 2009b; Williams, 2008; Heugh, 2005, 2006).

Furthermore, as Banda (2010) argues, the new globalized dispensation characterized by translocal and transnational mobility, requires versatile models of education to engender the learning teaching process, and to enable linguistic performative identities. One problem with the models described in this paper is that learners are prescribed a particular identity which they must subscribe to. The argument here is that learners will be better served if the language education models draw and reflect on everyday African multilingual realities of the communities concerned. Consequently, the models examined in this paper, which appear premised on multiple monolingualism, restrict the learners’ use of alternative languages and hybrid codes as academic literacy mediation strategy (Banda, 2010).

Moreover, the notion of bilingualism and what it means to be bilingual in African contexts, in which languages are mostly acquired informally, has not been adequately defined in the Namibian literature. Similarly, in the conceptualization of bilingualism in the Namibian language education policy (LiEP) and curricula documents, only one language is expected to be used as medium of instruction (MoI), the rest are to be taught as first, second, third, etc. additional optional subjects (Banda, 2010). As Banda (2010, p. 223) notes, “It is not clear how teaching a language as an optional subject would lead to bilingualism let alone proficiency in the language”. According to Kosonen and Young (2009, p. 13), “Bilingual/multilingual education means the use of more than one language for instruction and attaining literacy …”. Likewise, Luckett

---

5 Historically, the term bilingual education arose in response to the struggle for political control and economic power between Afrikaans and English. During the Union period (1910-1948), the dominant understanding of bilingual education was dual-medium education, in which Afrikaans- and English-speaking white learners were schooled in the same classes in order to promote not only bilingualism, but political reconciliation and socio-cultural integration after the bitter Anglo-Boer (South African) war (Plüddemann, 2010). When the Afrikaner minority took over the reins of power (in 1948), dual-medium education had been phased out in favour of parallel-stream (known as parallel-medium) and single-medium schools, a process that was accelerated under apartheid. Consequently, bilingual education defined in terms of the means through which educational goals were to be achieved, that is, two media of instruction, increasingly made way for bilingual education understood in relation to the goal, namely of promoting bilingual competence amongst learners (Plüddemann, 2010).
(1993, p. 76) states that “A strict definition of bilingual education requires that both the dominant (e.g. English) and the subordinated languages (e.g. the African languages) are used at some stage in the curriculum as media of instruction”. Nonetheless, Luckett’s definition does not add value to bi-/multilingual education. I therefore contend that Luckett’s argument advocates the teaching through the use of only one language, and not automatically the use of two or more languages as mediums of instruction at the same time depending on the repertoires available to learners.

In view of that, following Aronin and Singleton (2008), Banda (2010, p. 223) defines multilingualism as “the acquisition and use of two or more languages – so that bilingualism is treated as a particular instance of multilingualism”. According to Banda (2010), therefore, multilingual education is one in which two or more languages are used as languages of learning and teaching content matter, not where they are merely taught as a subject (Banda, 2000). I therefore wholeheartedly concur with Mohamed and Banda (2008, p. 96) who put it more succinctly when they point out that “We take bilingual education as one in which two or more languages are used as languages of learning and teaching of content matter, and not one where one is designated medium of instruction and the other a marginal role as subject” (cf. Baetens-Beardsmore, 1993; Banda, 2000).

Furthermore, as they observe, “The latter, which is characteristic of education, not only in Tanzania, but Africa generally, has a monolingual orientation” (Mohamed & Banda, 2008, p. 96). As Banda (2009a, p. 111) succinctly captures it:

…a multilingual model in which two or more languages are alternatively or proportionally used as LoLT throughout the child’s education, would help to do away with the problems associated with transitional models, whether early transition models where learners switch to English as MoI after Grade 3-4, or late transition after Grade 6-7.

Towards heteroglossic multilingualism in Namibia

Although Namibia professes to practice bilingual education, bilingual education in the country has always been (and continues to be) conceptualized using the monolingual habitus. That is to say, the notion of bilingual education is understood as mother tongue instruction in the early years of schooling, and a later switch to EMoI from Grade 4 upwards. Moreover, even though the Namibian constitutional provisions are geared towards societal multilingualism and linguistic proficiency in more than one language, the means and practice to achieve multilingualism are couched in concepts borrowed from Western rather than Namibian multilingual experiences (Anchimbe, 2007; Brock-Utne, 2009; Makoni, 1998).

In view of the above, I fully concur with Banda (2017) when he aptly points out that, even though on paper there appears to be increasing recognition about the need to nurture and promote multilingualism throughout Africa, such sentiments are frequently based on a monoglot/monolingual understanding of multilingualism (Banda, 2010). According to Banda (2017), as a result, multilingualism is seen as a case of multiple monolingualisms (Blackledge & Creese, 2010; García, 2009, 2014; García & Wei, 2014). In this monoglossic conceptualization, Banda (2017) argues, being multilingual is perceived as incremental in the case of “adding” languages or “subtracting” languages (Banda, 2009a, 2009b; Haingura, 2017).

Consequently, García (2009) contrasts the monoglossic ideology of bilingualism and bilingual education (in Africa and beyond) with a more inclusive and plural, heteroglossic view, and paints a rather optimistic view of the development of bilingual education from the more fixed types of the past to the more flexible types of the present. As García (2009) states:

…those [...] that responds to a dynamic bilingual framework … as people increasingly understand the need for bilingualism across groups, for all children, and beyond two languages. Thus, all types of bilingual education are extending towards the last [...] type … as
many groups attempt to develop trilingualism and other more flexible ways of translanguaging multilinguality (García, 2009, p. 385).

The question is: Does Namibia currently practice heteroglossic or flexible bilingualism? Absolutely not! I argue that this could only occur if learners are allowed the use of all the linguistic resources within their repertoire. The bilingual education practiced in Namibia does not at any rate qualify to be a heteroglossic or flexible type, as the use of Namibian African languages as media of instruction is only restricted to the ascribed mother tongues or home languages and English. That is to say, not all knowledge embedded in the speakers’ repertoires is utilized (Banda, 2009b). Namibian learners are restricted to use other linguistic resources available in their repertoires. Thus, MT-English bilingualism in Namibia is a case of double monolingualism (García, 2009), with learners encouraged to keep the two languages (MT/HL and English) separate (Weber & Horner, 2012). This casts a shadow on the label bilingual education in Namibia. The Namibian educational system is maybe only bilingual in name, that is, bilingualism in Namibia is present mainly, probably in the label.

Given the fact that the Namibian LiEP is “… strongly informed by the standard language ideology and strict compartmentalization of languages… one wonders how it could qualify as a heteroglossic or flexible type” (Weber & Horner, 2012, p. 117). As Haingura (2017) puts it, since the Namibian educational system’s language regime appears to be a fixed rather than a flexible one, there is a need for the Namibian education system to move in the direction of greater flexibility, that is to say, towards dynamic bilingualism. Therefore, Namibia must adopt a dynamic or heteroglossic bilingual education model. Adopting a dynamic bilingual framework would mean that the perennial problem about how to differentiate a language from a dialect would fall away, as both language and dialect would constitute part of the linguistic repertoire in heteroglossic linguistic practices in the classrooms.

However, it is notable that the Namibian LiEP recommends that teachers are free to explain difficult concepts using languages familiar to the majority of the learners in the class, particularly at primary level, whenever it is felt that it will facilitate learning. It is argued that:

In these transitional conditions… the use of a language understood by the majority of learners in a class can be permitted temporarily. Indeed, even where resources are satisfactory, experience has shown that the use of such a local language from time to time may help with the understanding of difficult concepts during the primary cycle (MEC, 1993, p. 10).

Consequently, as Haingura (2017) states, the unstructured use of IALs in a supportive role, albeit only at primary level, points towards the fact that the Namibian LiEP embodies some elements of endoglossic models which utilize the resources that learners bring to the classroom. Nevertheless, following García’s (2009) description of the heteroglossic bilingual education model, Namibia would not qualify as practicing bilingual education, in the true sense of the word, as the two languages (MT/HL and English) are not used at the same time as mediums of instruction. Rather, they are used in the form of double monolingualism in which the MT/HL and English are seen as fixed and autonomous systems.

Consequently, I argue that Namibia must adopt the heteroglossic model, in line with the language practices of its citizens, thereby circumventing the monoglossic pressures exerted by the country’s current educational system. As Banda (2009a, p. 111) points out:

…what is required [in Namibia] is [a] multilingual education [model] that takes into account local linguistic diversity and repertoires. This means education authorities need to look at speakers as language practitioners who use linguistic resources to carry out local, national and international communication needs. Monolingual biased education is therefore inadequate to capture this reality.
Thus, in this paper, I join a number of post-structuralist (socio) linguists in calling for a paradigm shift in conceptualizing multilingual models of language education in Namibia, and Africa generally. There is a caveat, though. As Mambwe (2014) succinctly captures it:

…this paradigm shift requires a balance between current sociolinguistic school of thought in which language is conceived as social practice and the structuralist-functional approach in which terminologies needed to explain recent linguistic phenomena can be drawn. For example, the current school of thought argues against language as an autonomous bounded system for language as social practice while the structuralist-functional approach provides us with the terminology as well as analytical tools to be able to explain how the social relates to the form and how the form is influenced by the social and the political (Mambwe, 2014, p. 241).

**Conclusion**

This paper has discussed a number of suggestions on how multilingual models of language education should be appropriately conceptualized throughout Africa. The paper set out to examine a number of issues with regard to the use of languages in education which arise from multilingual contexts, and has contributed to the debate on multilingual education. The paper has shown that some of the problems encountered regarding the implementation of language in-education policies within the African countries arise from conceptions on the classification of languages and the language models to be followed. Furthermore, the paper has also shown that the typological groupings of languages into such categories as major versus minor languages and the multiplicity of education models in multilingual contexts raise problems concerning the choice of education models and the languages to be used in education (Mtenje, 2009). Moreover, the paper has argued that this has influenced progress in the formulation, adoption and implementation of bilingual education policies in numerous African countries.

Following García (2009), the paper has challenged several time-honoured stereotypes that appear to be crumbling against the new realities of globalization. Consequently, the paper has rejected the old, monoglossic interpretation, which treats the first language and the additional language as “bounded autonomous systems” (García, 2009, p. 7), and offers a heteroglossic view of bilingual competence, which emphasizes the dynamic interrelationship of multiple language practices. Last but by no means least, the paper has concludes by supporting a paradigm shift in the conceptualization of multilingual models of language education throughout Africa.

**References**


How Grade-R teachers’ inability to promote a ‘love for books’ influences the acquisition of early literacy skills in Grade-R learners in Zambezi Region, Namibia

Kenneth Nzwala
University of Namibia, Katima Mulilo Campus
knzwala@unam.na

Abstract
Promoting a love for books is key to learning to reading and writing in pre-primary grades. This can only be achieved through the use of qualified human capital at this level of schooling with adequate support from Regional Advisory Services (RAS). Research claims that learners who are regularly exposed to reading materials find a positive basis and impetus for literacy learning. This paper thus reports on a study that investigated the significance of promoting a love for books in Grade-R (in the Namibian context, Grade-R refers to Grade 0) classrooms in the Zambezi region, Namibia. The study also shares the significance of this move as well as what teachers should put in place to promote it as a way to accelerate the emergence of learner early literacy skills in their respective Grade-R classrooms in the Zambezi region. The data were analysed using Vygotsky’s Sociocultural Theory through themes and statistical analysis of emergent Early Grade Reading Assessment (eEGRA) test. Data were collected through interviews, lesson observation as well learner output in the eEGRA test which learners took at the beginning of their Grade One year.

Keywords: emergent literacy, foundational literacy, Grade-R, Zambezi region, pre-primary

Context and literature review
What love for books?
Research reveals that Namibian Grade-R teachers do not promote a love for books (Nzwala, 2018). This was confirmed by their classroom practice as well as absence of book corners in their classrooms (Nzwala, 2018). Important to note however is that what determines children’s early literacy skills development is how much the “child was read to, how much the child has been playing with words and books as a way to develop a love for books, and how much the child pretended to be a reader (through pictures) when they played with language” (Zeiler, 1993, p. 111). A love for books could also be promoted by providing learners with age appropriate books in the book corner where children can choose from as a way to demonstrate that “books are a part of their daily routines” (McMonagle, 2012, p. 15). This implies that Grade-R learners should be subjected to literacy learning enabling environments; environments where they can manipulate or handle books; where they talk about books; and develop stories on pictures during book handling and manipulation.

According to Jalongo, Dragich, Conrad, and Zhang (2012), during these sessions, children get to know how to handle books as well as how a book works. Fang (1996) and Joubert, Bester, and Meyer (2011) further observed that pictures (in books) enable Grade-R learners to learn to associate pictures with their life experiences thus stimulating concept formation in that, as learners discuss a picture, concepts are developed. It is in this context that Namibia MoE (2015, p. 11) states that “learners should link words with pictures by predicting; identifying and matching words to pictures”. Grade-R learners thus only internalize new learning contents after making links with their prior knowledge and experiences thus promoting their higher mental functions (Cohen & Cowen, 2008; Vygotsky, 1978). This can best be achieved in the book corner due to the fact that a child explores the adult world in the book corner by pretending to read picture books, as modelled to them by the teacher (Karpov, 2003). The role of picture
books on early literacy development is also reiterated by Weeks’ (2003) case study which found the contribution of picture books in developing early literacy skills. Weeks concluded that, through picture books, learners interact with graphics thus qualifying picture books as effective semiotic tools which inspire children to love books (Weeks, 2013).

Oral language
Through the above activities; oral language, one of the key drivers of emergent literacy is promoted, discouraging the perception that a culture of reading is fading in our society (Hardy & Hastings, 2016). In a Grade-R class there should be “lots of talk with teacher-initiated conversations with learners aiming at directing their conceptual learning as well as introducing new words into their vocabulary” (Johnson, 2016, p. 130).

Armbruster, Lehr, and Osborn (2003, p. 6) claim that “to be confident readers, children need lots of opportunities to build spoken language by talking and listening, as well as learning about print and books”. Therefore, class environments of children should be avenues for emergent literacy learning where a child interacts with print materials regularly. According to Zygourus-Coe (2001), if children are exposed to reading literacy-related situations before they enter formal school, they will be better equipped to succeed in learning to read in Grade One. In this context, Zeiler advances that “teachers do not make children into readers; they (children) make themselves into readers” (1993, p. 109). The teacher’s role in a classroom is thus to mediate emergent literacy by addressing opportunities to sing, recite, dance, discuss and listen to language. Namibia MoE (2015, p. 1) further states that one of the aims of the Pre-primary curriculum is to “develop children’s language and communication skills with opportunities for all to talk and communicate in a widening range of situations, to listen carefully and to respond to others, and further to practise and extend the range of vocabulary use”.

According to the National Research Council [NRC] (2000, p. 188), an environment that is “well endowed with books has the potential to provide learners with opportunities to pretend to read and to learn to identify and handle books,” thereby promoting oracy. When teachers encourage children to pretend to read, children begin to understand the adult world and start to prepare for its challenges prior to engaging with it (Bodrova, 2008). However, oracy cannot be promoted if it is not consciously mediated by a teacher. Mediation of learning is important for learners not to learn the wrong thing (Wood, Smith, & Grossniklaus, 2001). This is because the child’s learning always “occurs in a social context in cooperation with someone more skillful” (McLeod, 2014, p.6). According to research, teachers should be encouraged to ask questions that offer learners opportunities to explore and apply their critical-thinking skill through discussion (O’Carrol & Hickman, 2012). Therefore, Reja, Manfreda, Hlebec, and Vehovar (2003) suggest that questions should not only be closed-ended but also open-ended. While closed-ended questions only demand one specific answer (yes or no answer, for example), open-ended questions allow learners to freely express their opinion in context, based on prior experiences (Reja et al., 2003).

Research question
The overarching question this article addressed was: What is the significance of promoting a love for books in Grade-R classrooms in Namibia? This key question was further explored through the following sub-questions:

1. What do Grade-R teachers do to promote a love for books in their classrooms in Zambezi region?
2. How are Grade-R classrooms in Zambezi region organized to promote a love for books?

Theoretical framework
The research was guided by Lev Vygotsky’s Socio-cultural theory (SCT) of ‘how children learn’. The theory supports the child’s societal experiences as key to mastering literacy competences in Grade-R (Vygotsky, 1978). Vygotsky, through his SCT claims that the child’s social, cultural and historical backgrounds are integral in any form of learning, and should thus not be ignored. Based on this background, the child is able to understand curriculum related content if linked to their environmental experiences. The SCT thus aligns well with Namibia’s junior primary curriculum which organises learning along cross-curricula themes of social environment, cultural environment, and health, safety and nutrition (Namibia MoE, 2015). The SCT also
claims that the child’s development of critical reasoning is informed by how much the teacher engages their cultural and background knowledge as the child’s background is the basis of new knowledge (Vygotsky, 1978; Bodrova & Leong, 2017). This notion is further advanced by Strauss and Gregory who claim that SCT is “linked to a socio-constructivist understanding of the acquisition of knowledge” (Strauss & Gregory, 2017, p. 59).

Further, SCT is learner centred as it celebrates collaboration and interaction during classroom activities (Vygotsky, 1978; Namibia MoE, 2015), thus aligning well with the progressive principle or ideal of learner-centred education, which is Namibia’s philosophy of teaching and learning (Namibia Ministry of Education [MEC], 1993). Vygotsky (in Bonamigo, 2016), expressed that when learners interact through stories, they enter their Zone of Proximal Developments (ZPDs) and start to think critically about what they are taught with the help of more knowledgeable others (MKOs) like siblings, teachers and elders. The philosophy of learner-centred education recognizes the learner’s existing knowledge as the starting point in the learning process (Namibia. MEC, 1993).

Methodology
Research design and data generating techniques
The study takes the form of a case study and adopts a mixed methods approach, which combines both qualitative and quantitative designs. I chose this approach to address the thesis of this investigation in more depth. While qualitative design is represented, in this research, by qualitative data (of interview and observations); quantitative design is represented by quantitative data of learner scores in the eEGRA test taken by learners early in Grade One. Other than addressing the depth and width of the study in terms of data collected, the significance of a mixed methods approach, to this study couldn’t be overemphasized. Through this approach, the researcher was able to probe the extent of teachers’ promotion of a love for books as a way of mediating emergent literacy skills of Grade-R learners. According to Okeke and van Wyk (2015, p. 209):

Qualitative research is concerned with the understanding of how a particular individual or group of individuals think and the meanings they attach to their actions and in the quest to understand these meanings, qualitative researchers are encouraged to adopt ways that enable them to represent the voices or actual words of the participants in their research reports thus making the qualitative approach thick and descriptive.

The probability that one method cannot provide all of the required data was confirmed by various data sets, for example, quantitative data generated through the eEGRA test which used Analysis of Variance (ANOVA) as the tool of analysis, at the 0.05 significance level. This data showed variation in learners’ performance and the extent of such variance, thus either confirming or rejecting the null hypothesis.

Sampling
Six different schools were drawn (two each) from the urban, peri-urban and rural contexts to participate in this study. This was a way to establish how teachers in different contexts promoted a love for books. Two teachers (one Grade-R teacher and one Grade One teacher) were sampled from each school using purposive sampling technique. A sample of nine learners per school was drawn using stratified random sampling technique. In total six teachers, and 54 learners constituted the sample of this study.

Findings
Findings of this study revealed that Grade-R teachers, despite what they said during interviews, did not demonstrate promoting ‘a love for books’, as there were no book corners in their classrooms where learners could go to and practice to handle books. In this paper Grade-R teachers are referred to as Urban School Teacher 1 (UST¹); Urban School Teacher 2 (UST²); Peri-Urban School Teacher 1 (PuST¹); Peri-Urban School Teacher 2(PuST²); as well as Rural School Teacher 1 (RST¹) and Rural School Teacher 2 (RST²) respectively. In answering the question ‘How do you promote a love for books’ this is what they had to say:
### Dialogue Box 1: Responses to the question: “How do you promote a love for books?”

| UST¹ | I normally encourage my learners to love the books. For example, when they see picture, they love books with pictures. So I normally encourage them that books are good, and books can help them to develop their knowledge. They really love books. |
| UST² | I think I would always tell them stories with storybooks that have large pictures and less content in it because they do not know how to read these words, so I would always use this book to tell them stories. |
| PuST¹ | In order for my learners to love books, I must create a reading corner, put a lot of story books there, sit in reading corner, each learner picks a book only to check pictures, they tell you what is happening in the pictures. |
| PuST² | I use to give them books to read during that reading period. |
| RST¹ | I teach learners to love books; I give learners books with pictures. |
| RST² | Sometimes I use to give the books to learners, like these picture books. |

While one teacher, UST² indicated that she told learners stories with storybooks to develop their love for books, another teacher, PuST¹, motivated learners to love books by creating a reading corner. PuST¹ further said that she made storybooks available to learners to boost their love for books saying that “each learner picks a book only to check pictures”. This is an assumption the teacher makes and not something dictated by the curriculum. The child needs to see words and pictures as well as to use the pictures to interpret the text. The researcher also observed that PuST¹ did not have a reading corner in her classroom at which she claimed learners to go to read. One teacher, PuST² said that she gave learners books to read during reading periods. The teacher’s use of the concept ‘reading periods’ was inappropriate for Grade-R suggesting that the teacher saw Grade-R as a formal grade because what she said only starts in Grade One and beyond and is not part of the Grade-R learning programme, thus failing to recognize the difference between Grade-R, which is informal and the formal Grade One. It also suggests that the teacher is unconsciously showing that she was a former primary school trained teacher, and was not specifically trained for Grade-R. Further, she did not observe the Grade-R daily programme, which did not make provision for formal reading.

The Grade-R programme is a lot loose and therefore the learner should be able to go to the reading corner during fantasy play, structured activity and even before school starts. The Grade-R curriculum suggests that fantasy play is very crucial and that children should be afforded the opportunity to handle books in the reading corner. The researcher also noticed that teachers generally overemphasize the use of pictures as a way to promote a love for books. This may have been derived from their hanging onto the curriculum document which prescribes ‘picture reading’ as a strategy for foundational literacy acquisition. The teachers could have set up an activity in which the children could have made their own books and ‘read’ them to the class or their peers. This way the child is learning about what a book is made up of and developing their language skills in the ‘retelling’ of their story.

While four teachers, UST², PuST¹, RST¹ and RST², expressed that they gave learners books with pictures as a way to motivate them to develop a love for books, one teacher, UST¹ said that books were good, as they helped them to develop their knowledge suggesting that a child handling a book and looking at the contents might develop knowledge, but only if there was someone present who could help mediate learning through the semiotic tool of a book. If this teacher is simply leaving the child to learn entirely through self-discovery there is a risk that they might learn the wrong thing (Wood, Smith, & Grossniklaus, 2001). This style is Piagetian and was criticized by Vygotsky, who regarded social interaction as critical in the development of learners’ critical
thinking and that the child’s learning always “occurs in a social context in cooperation with someone more skilful” (McLeod, 2014, p.6). While there is nothing wrong with a child going into a reading corner by themselves and pretending to read, this must also be offset by regular story times and the teacher sometimes sitting in the reading corner with the children and looking at a book together or answering questions a child might have about a book. Five teachers, UST1, UST2, PuST1, RST1 and RST2 who supported the use of pictures to develop a love for books among children were not explicit whether the learner was making the connection between text and pictures. This is what the teachers assumed the learner was doing. This assumption possibly stemmed from what the curriculum document prescribes. For example, “learners should link words with pictures by predicting; identifying and matching words to pictures” (Namibia MoE, 2015, p. 11).

It should be noted that teachers PuST1, RST1 and RST2 were beginning to acknowledge the fact that learners developed a love for books through exposure to reading corners and to picture books which they could manipulate. However, the teachers did not show any evidence of exposing learners to books during lessons. Furthermore, RST2’s indication (like PuST2’s) that “sometimes I use to give the books to learners, like these picture books” suggested the teacher only gave learners books in the past and not any longer as she was not observed giving picture books to learners during the researcher’s data collection period. As stated earlier, this could be attributed to the fact that none of the teachers observed had a book corner in their classroom for learners to go to and handle books.

Despite the teachers’ not having ‘book corners’ for book handling opportunities of their Grade-R learners, schools demonstrated a very positive output in the eEGRA test on the question that tested learners’ book handling acquaintances or skills establishing no significant difference in performance among the schools. The researcher tested learners’ abilities on each question part as shown in the table below with each question part scoring ten marks.

### Table 1: Scores on how schools performed on Question 1: Handling of a book

<table>
<thead>
<tr>
<th>Question Parts</th>
<th>US1</th>
<th>US2</th>
<th>PuS1</th>
<th>PuS2</th>
<th>RS1</th>
<th>RS2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Learner correctly holding book</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>2 Learner turning pages correctly</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>3 Pretend read</td>
<td>8</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>4 Learner ability to show title of book</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>5 Learner ability to show cover page</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>2</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Mean</td>
<td>6.6</td>
<td>8</td>
<td>6.8</td>
<td>5.8</td>
<td>7.4</td>
<td>8</td>
</tr>
</tbody>
</table>

To compare the mean scores of the schools in Table 1, the researcher formulated statistical null hypothesis ($H_0$) shown below:

- $H_0 =$ There is no significant difference in performance of various schools on Question 1.
- $H_1 =$ There is a significant difference in performance of various schools on Question 1.

The p-value as per the analysis of One-Way ANOVA $a = 0.05$, $df = 5$, is 0.4152 (Appendix 1). Since the p-value (0.4152) is greater than $p = 0.05$, we cannot reject the $H_0$ and thus conclude that there is no significant difference in the performance of the various schools on Question 1. Table 1 shows that PuS2 recorded the lowest mean score of 5.8 points with US2 and RS2 recording the highest mean values of 8 points respectively. The mean score of 5.8 recorded by PuS2 is as a result of question parts 4 and 5 in which learners underperformed, thus calling for support in those areas, such as ability to show both the title of the book and the cover page of the book. It also reveals and suggests that learners were not sufficiently prepared on the question parts in which they underperformed.

Since the focus of this research was also on the learners, the study sought to establish how individual learners at the different schools performed on Question 1 of this study. Each
learner’s mark is expressed as a percentage as shown in Table 2.

### Table 2: Scores on how learners performed on Question 1

<table>
<thead>
<tr>
<th>Schools</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>US¹</td>
<td>80</td>
<td>60</td>
<td>80</td>
<td>80</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>US²</td>
<td>80</td>
<td>60</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>PuS¹</td>
<td>60</td>
<td>80</td>
<td>80</td>
<td>20</td>
<td>100</td>
<td>40</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>PuS²</td>
<td>20</td>
<td>60</td>
<td>60</td>
<td>20</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>RS¹</td>
<td>20</td>
<td>40</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>RS²</td>
<td>60</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Mean</td>
<td>53.3</td>
<td>66.7</td>
<td>83.3</td>
<td>66.7</td>
<td>90</td>
<td>80</td>
<td>100</td>
<td>80</td>
<td>90</td>
</tr>
</tbody>
</table>

The results show a p-value of 0.0194 (Appendix 2). Since the p-value (= 0.0194) is smaller than 0.05, we reject the null hypothesis ($H_0$) and conclude that there is a significant difference in the performance of learners on Question 1. The sources of variance could be attributed to Learners 4 with the highest variance of 1386.667, and Learners 7 with the least variance of 0 (Appendix 2). The table further shows that Learners 1 produced the least mean value of 53.3 marks with Learners 7 at each school producing the highest mean value of 100 marks. This shows a significant difference between the two mean scores. The least mean score of 53.3 points is as a result of the poor performance by Learner 1 of PuS² and Learner 1 of RS¹ suggesting that the two learners had challenges in answering Question 1 as they recorded among other learners the least mark of 20 points each.

### Discussion

**Lack of books and book corners:** Developing a love for books is a curriculum requirement for literacy learning in Grade-R in Namibia (Namibia MoE, 2015). As a result, inculcating a love for books in learners, and using book corners, promote a reading culture throughout a child’s life. Therefore, such behaviour may avert and deter the growing concern that the culture of reading is fading in our society (Hardy & Hastings, 2016). Mediating foundational literacies through learner exposure to books as semiotic tools are key to developing a love for books, which also support literacy learning in Grade-R. Semiotic tools are important as they encourage abstract reasoning which is key to the internalization of learning content and development of higher mental processes (Vygotsky, 1978; McLeod, 2014). Therefore, Grade-R teachers should read many interesting books to learners, introduce learners to picture books, as well as read to them from large-sized books. Moreover, teachers should afford learners the opportunity to handle and pretend to read picture books themselves, from left to right and top to bottom. According to Namibia MoE (2015, p. 11), Grade-R teachers should assist learners to develop skills that will help them to “pretend to read silently and aloud from storybooks”.

While the Namibian Grade-R literacy curriculum advocates that, “learners should read silently and aloud from storybooks” (Namibia MoE 2015, p. 11), silent reading inhibits the learners’ development of vocabulary and self-expression. When Grade-R learners pretend to read from books, they do not only develop a love for books, but also develop critical literacy skills like directionality, recognition of both beginning and end sounds in words, and correct sequencing of pictures, which are essential in promoting the reading skills of children. Learners who are exposed to books get to know how to handle books better than when they are simply exposed to ordinary loose pictures. Jalongo, Dragich, Conrad, and Zhang (2002, p. 168) believe that picture books “teach children how a book works because most children recognize, interpret and express themselves through pictures long before they master print”.

Fang (2006) also supports the notion of exposing children to books by observing that books attract children to pretend to read, thereby promoting children’s love for books. When a child sees a picture in a book, it is easier for him or her to interpret the picture by associating it with the label underneath it than pure text.
Meyer (2011) observed that pictures in books enable Grade-R learners to learn to associate pictures with their life experiences and that pictures stimulate concept formation in that, as learners discuss a picture, concepts are developed.

Though promoting a love for books in Grade-R classrooms in Namibia is a key objective of this paper, findings show that learners were not afforded the opportunity to handle books; they were not afforded time to explore books, despite the Namibian Grade-R literacy curriculum directing that children should demonstrate the “proper way of handling books” (Namibia. MoE, 2015, p. 11). This study further found that teachers did not consciously mediate foundational literacies by encouraging learners to pretend to read, and they did not afford learners opportunities to pretend to read both from ordinary books and from picture books. This was due to the fact that the observed Grade-R classrooms lacked books and book corners where learners could go to manipulate books and pretend to read from picture books. According to Karpov (2003), Vygotsky found that a book corner was key to literacy learning in Grade-R, due to the fact that a child explores the adult world in the book corner by pretending to read picture books, as modelled to them by the teacher.

Weeks’ (2003) case study on the power of picture books found that picture books play an important role in developing early literacy skills. Weeks’ (2003) study also established that, through picture books, learners interact with graphics which points to picture books as effective tools in inspiring children to love books. When children are introduced to books, they get exposed to print, develop skills of book handling and directionality as they page through the books. This is supported by Armbruster, Lehr, and Osborn (2003, p.6) who claim that, “to be confident readers, children need lots of opportunities to build spoken language by talking and listening, as well as learning about print and books”. Through talking, learners share their prior knowledge and experiences which are embedded in their communication with others (Vygotsky, 1978). This study also found that teachers did not challenge their learners’ critical reasoning skills by asking them explorative questions which would have enabled them to give answers based on their prior knowledge and experiences. This is due to the fact that Grade-R learners only internalize new learning contents after making links with their prior knowledge and experiences (Cohen & Cowen, 2008; Vygotsky, 1978).

Although research participants indicated that they promoted a love for books by creating reading corners and equipping reading corners with reading materials, telling learners’ stories by using storybooks, giving learners books with pictures, and availing storybooks to learners, their classroom practice demonstrated the opposite. The study established that teachers did not afford learners the opportunity to handle books, teachers did not read to learners; they did not create opportunities for learners to talk about books as there were no book corners where learners could practise handling books and pretend to read, or story-times in which discussion around books could take place as a way to advance learners’ oral skills. Furthermore, not all the schools had libraries where teachers could take their learners to experiment with books. Thus, this research found that there was a significant deficiency, or a serious lack, of both the reading culture and reading materials in the classrooms of the sampled teachers.

In support of reading materials in Grade-R learning environments, the National Research Council (2000) noted that an environment that has lots of interesting, age-appropriate books will provide learners with the opportunity to handle books and pretend to read. Therefore, when children pretend to read from books, the process should be consciously mediated by the teacher for learners to optimally benefit from the exercise, thereby strengthening both the literacy learning process of children and their explorative skills.

Results of this study revealed teachers’ failure to consciously mediate foundational literacies by encouraging classroom talk about books, reading to learners and encouraging learners to handle books, which discouraged not only a love for books, but also the development of basic literacy skills. Research claims that, “reading ability has to do with the child’s linguistic competencies, his or her experiences, how much the child was read to, how much the child has been playing with words and books as a way to develop a love for books, and how much the child pretended to be a reader when they played with language” (Zeiler, 1993, p. 111). When teachers encourage children to pretend to read,
children gradually start to understand the adult world and prepare for its challenges prior to engaging with it (Bodrova, 2008). It was also established that participant teachers did not offer their learners the opportunity to play with language, owing to teachers not conducting Grade-R lessons in a play-based manner.

**Conclusion**

Children's manipulation of reading materials is key in paving the way to conventional reading in a formal classroom setting. This paper therefore explored this notion as well as its benefit to both children and teachers. This was confirmed by both learners' and schools' overall performances in the eEGRA test. Therefore, despite being untrained to handle Grade-R learners, teachers are encouraged to ensure, with the support of Regional Advisory Teachers, that they introduce learners to books early enough during their pre-primary years as it builds a strong literacy foundation prior to formal learning.

**References**


APPENDIX 1

ANOVA: Single Factor

<table>
<thead>
<tr>
<th>Groups</th>
<th>Count</th>
<th>Sum</th>
<th>Average</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>US^1</td>
<td>5</td>
<td>33</td>
<td>6.6</td>
<td>7.8</td>
</tr>
<tr>
<td>US^2</td>
<td>5</td>
<td>40</td>
<td>8</td>
<td>1.5</td>
</tr>
<tr>
<td>PuS^1</td>
<td>5</td>
<td>34</td>
<td>6.8</td>
<td>2.7</td>
</tr>
<tr>
<td>PuS^2</td>
<td>5</td>
<td>29</td>
<td>5.8</td>
<td>7.2</td>
</tr>
<tr>
<td>RS^1</td>
<td>5</td>
<td>37</td>
<td>7.4</td>
<td>1.3</td>
</tr>
<tr>
<td>RS^2</td>
<td>5</td>
<td>40</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

ANOVA

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>18.7</td>
<td>5</td>
<td>3.74</td>
<td>1.043721</td>
<td>0.4152</td>
<td>2.620654</td>
</tr>
<tr>
<td>Within Groups</td>
<td>86</td>
<td>24</td>
<td>3.583333</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>104.7</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX 2

ANOVA: Single Factor

<table>
<thead>
<tr>
<th>Groups</th>
<th>Count</th>
<th>Sum</th>
<th>Average</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>320</td>
<td>53.33333</td>
<td>746.6667</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>400</td>
<td>66.66667</td>
<td>426.6667</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>500</td>
<td>83.33333</td>
<td>226.6667</td>
</tr>
<tr>
<td>Source of Variation</td>
<td>SS</td>
<td>df</td>
<td>MS</td>
<td>F</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------</td>
<td>----</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>Between Groups</td>
<td>10000</td>
<td>8</td>
<td>1250</td>
<td>2.612229</td>
</tr>
<tr>
<td>Within Groups</td>
<td>21533.33</td>
<td>45</td>
<td>478.5185</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>31533.33</td>
<td>53</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>