The historical development of number systems in Namibia

[1]Mbonabi Alex Ilukena, [2]Frans N. Haimbodi and **[3]Reuben A. Sirinji**
[1,2&3]University of Namibia, Rundu Campus
[1]milukena@unam.na, [2]fhaimbodi@unam.na and [3]rsirinji@unam.na

Abstract
This research paper focuses on the historical development of number systems in Namibia. The research uses a qualitative paradigm to explore the number systems used by several ethic groups in northern, north-eastern and eastern Namibia. The data was collected from a sample of 76 students at the University of Namibia (UNAM), Rundu Campus, who were asked to write the traditional counting numerals from their places of origin. Data revealed that most of the ethnic groups in the studied regions used base 5 (Quinary Numeral System) counting system and a few base their counting on the fingers. The study recommends that research be conducted to look into the effects of the base 5 system used traditionally on the performance of learners in primary schools.

Keywords: *numerals, counting, number systems, number, digits*

Introduction

The Namibian Government attaches great significance to the teaching of Mathematics in Namibian schools. "Mathematics is indispensable for the development of science, technology and commerce" (National Institute for Education Development [NIED], 2010a, p. 18). The value attached to Mathematics led to the reform policy that Mathematics was to become a compulsory subject for every child in Namibian schools (NIED, 2010b; Ilukena, 2011), at the beginning of 2012.

The teaching of Mathematics in Namibia has been a challenge since independence in 1990 as the learners' performance in Mathematics has been unimpressive (NIED, 2009; Iyambo, 2010). Studies on Mathematics performance in Namibian schools indicated unimpressive learners' performance in Mathematics particularly at Upper Primary Phase (Sichombe, Tjipueja, & Nambira, 2013). Sichombe et al. further add that efforts on promoting the status of Mathematics nationally and improving learners' performance are of great importance. This can happen if a solid foundation is properly laid at lower grades.

Background of the research

Numbers origins

A numeral system, or system of numeration, is a writing system for expressing numbers, that is, a mathematical notation for representing numbers of a given set, using digits or other symbols in a consistent manner. Numeral systems are sometimes called *number systems*, but that name is ambiguous, as it could refer to different systems of numbers, such as the system of real numbers, the system of complex numbers, the system of *p – adic*, etc. For this study, such systems are not the topic for discussion.

However for the purpose of this study, a number system should be seen in the context that allows the symbols "11" to be interpreted as the binary symbol for *three*, the decimal symbol for *eleven*, or a symbol for other numbers in different bases. The number, the numeral represents is called its value. Because ideally, a numeral system will:

- *represent a useful set of numbers for example integers, or rational numbers;*
- *give every number represented a unique representation (or at least a standard representation); and*
- *reflect the algebraic and arithmetic structure of the numbers.*

Moreover, the focus is basically on the simplest numeral system, the unary *numeral system*, in which every natural number is represented by a corresponding number of symbols. If the symbol is chosen, for example, then the number *three* would be represented by ///. The tally marks represented on such system are still commonly used all over the world, Namibia not being an exception. Although the *unary system* is only useful for small numbers, it still plays an important role in theoretical computer science, Elias gamma coding, which is commonly used in data compression, expresses arbitrary-sized numbers by using *unary* to indicate the length of a binary numeral.

Historically, whole numbers began with the ancient Egyptians who built up a powerful structure of numerals with discrete hieroglyphs from *1* up to *10*, and all the exponents of 10 up to over 1 million. For instance, using the original hieroglyphic script of Egyptian numerals where | = 1 as indicated earlier. A place-value system with foundation fundamentally on the numerals was used by the Babylonians between 2000 BCE and 1000 BCE and their place value system were based on base 60 rather than base 10. This Babylonian system lacked a symbol for zero, although the Babylonians began thinking about the concept of zero in 2000-1800 BCE, it was not until about 200-300 BCE that the concept of 0 as a placeholder and 0 as a number were associated with one another in India much earlier than in Babylon (Reno, 1999; Erwee, 2007 in Ilukena, 2014). The concept *zero* was developed, to avoid much ambiguity about written numbers, for example if the symbol for 6 was written down, there was no way of distinguishing between 6, 60 and even 60, 000 (Ilukena, 2005; Erwee, 2007 in Ilukena, 2014). Due to these ambiguities, zero was them introduced as a placeholder.

Numbers and counting have become an integral part of our everyday life, especially when we take into account how the computer and other programmable systems make use of numbers. These words you are reading have been recorded on a computer using a code of ones and zeros. It is an interesting story how these digits have come to dominate our world. With the need to count, keep records and solve problems, every nation designed its own numeral system, with unique characters. History has revealed origins of numbers in several nations such as Egyptian, Babylonian, Greek, Chinese, Mayan, Hindu and Roman (Ilukena, Haimbodi, & Sirinji, 2015; Smith, 2012). These nations used various base systems ranging from base 10 (Denary), base 20, and base 60 (Sexagesimal) as alluded to earlier.

Therefore it is not surprisingly that the Namibian numeration system is a consistent base ten system that facilitates mental and written notational forms of number for both whole number and decimal fractions. The numeration system allows us to allocate words for numbers in a pattern that follows a base ten system where the multi-unit conceptual structures used involve the powers of ten.

Problem statement

Research has revealed the historical development of numbers in different nations. This research was triggered by these researches and the fact that only few researches have been carried out on the historical development of number system in Namibia, if any. Furthermore, the current education system in Namibia encourages parental participation in their children's learning. This is coupled with the concern that counting in vernacular languages or dominant languages used in the community collates with one used in schools, especially at lower grades. This paper focuses on exploring numeral systems in the northern, north-eastern and eastern Namibia. It, thus, seeks to address the following research questions:

- *What are the traditional numeral systems used by Namibian ethic groups?*
- *What are the challenges encountered by teachers teaching mathematics using base 10?*
- *How do traditional numeral ethic groups incorporate the concept of zero?*

Theoretical framework

The study draws upon the Expectancy-Value Theory of Motivation by Hodges. This is a general notion that learners expect certain outcomes from certain behaviours and the more learners value behaviour, the more they are likely to perform well in it (Hodges, 2004). Learners want to obtain good grades and when motivated tend to study comprehensively and perform well. It is further argued that expectancy-value theory depends on the self-esteem of learners and is assured through valuing the expected results of the activities.

Literature review

Western education comes with the art of writing and symbolic expression, it is evident that before that, different races in Africa had different systems of counting, that is, they had their own different number system. The development of numeration in any particular society ultimately depends upon the economic development of that society. The much celebrated number system with modern mathematics is as old as life in Africa (David – Osuagwa, Anemelu, & Onyeozili, 2000 in Ilukena, 2014). Northern Africa participated in the flowering of Arabic scholarship from the eighth to the fifteen centuries and many of their manuscripts of that period, written in the Arabic language by scholars of various ethnicities have been analysed and translated contributing to mathematics knowledge. Among those who made such original contributions are the Egyptian Abü Kámil (circa 850 – 930) with his work on Algebra, and Ibn al – Haytham, who contributed to discoveries in optical geometry (Zaslavsky, 1979).

One of the most interesting numeration systems is that of the Yoruba people, of south – west Nigeria, a nation of urbanized traders and farmers, not only is it based primarily on 20, with 10 as subsidiary base, but it relies on subtraction to a great extent. For example, 45 was expressed as “five from ten from, three twenties” illustrated as $45 = (20 \times 3) - 10 - 5$) some numbers in symbolic notation in the Yoruba as indicated by Zaslavsky (1979) in David – Osuagwu, Anemelu, & Onyeozili, 2000, p. 57) are:

$$106 = (20 \times 6) - 10 - 4$$
$$300 = 20 \times (20 - 5)$$
$$525 = (200 \times 3) - (20 \times 4) + 5$$

In addition, the Igbos counted in quinary (base 5) and vigesimal scale (base 20). Moreover in Sierra Leone, the two major ethnic groups, the Temne and the Mende had a “toes – and - finger” counting system; they grouped objects in fives then in twenties. The Mende, defined 20 as “*one man finished*” (Ohuche, 1979 in David – Osuagwu et al., 2000), this is due to the utilization of all toes and fingers on one person.

Southern – African societies have also developed mathematical concepts and practice to serve their needs and one can apply ethno-mathematics principles to analyse them. Gerdes (1988) speaks of ‘hidden’ or ‘frozen’ mathematics, meaning that when an artisan discovered a production technique, she or he was thinking mathematically for example activities on house building and basket–weaving in Mozambique. The Tschokwe/, Cokwe of South – West Africa draw in the sand to illustrate the folklore of their people and instruct the young and such knowledge is passed down from one generation to the next by word of mouth and by example.

Furthermore, mathematical ideas are evident in games of chances and games of strategy for example the two board games that are common in various parts of the world are two-row and the four-row versions Owela (Oshiwambo) or *Mulavalava* (Subia). Players must outwit their opponents in addition, subtraction, division and multiplication. Other games are *Oodoota or Kudota* played in Namibia which involve multiples, counting and addition. It should further be noted that the Hottentots of Southern African were the first people to use the binary scale (David – Osuagwu et Al., 2000). They had only two number words; “a” as one and “oa” as two, most people thought this scale was primitive and only meant for those of low mental development, or those who were incapable of forming any other number scale worthy to be called the name. This was only realized after the invention of computers, arguments changed drastically as computers are based on electrical circuitry. An electrical principle is based on “On” and “Off” which agrees with two digits of the binary system. This is how the binary scale has become so popular worldwide today.

As alluded to in this research paper, the level of a society’s mathematical knowledge depends to a greater extent on the culture and technological level of that society. Although we cannot describe the mathematics they used, there is evidence that the Dogon people of Mali plotted the orbits of the Sirius star – system on the basis of knowledge acquired seven centuries ago (Adams, 1983); for what seems to have been an astronomical observation in north – west Kenya dating back over 200 years (Lynch & Robbins, 1978); for the practice of advanced metallurgy in central Africa at about the same time (Schmidt & Avery, 1978) that Africa reached the New World long before the voyages of Columbus (Van Sertima, 1977) and lastly, eight centuries ago southern Africans constructed the massive complex of stone building called "Great Zimbabwe" (Garlake, 1973). It is not surprisingly that all people count. Numeration systems may range from a few words to the extensive vocabulary of nations with a history of centuries of commerce. Among the ethnic group of West Africa, numeration systems usually based on grouping of twenties, with five and ten as subsidiary bases, while in southern and Eastern Africa ten is the most common base. Frequently number-words are borrowed from neighbouring peoples or from Arabic and European languages. A characteristic of African counting is a standardized system of gestures to accompany, or even replace, the number-words. Familiar to the whole number digits written in standard form or standard notation is our number system, the denary or decimal scale (base 10) the most familiar number system in the whole world that resulted from counting of human fingers and toes used as a matching device, and accepted by the international community; people now count in groups of 10s. This number system has ten symbols, 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9 which we are very familiar with right from primary school.

Lastly, research has shown that any numeral system can be expressed as:

$$number_b = [d_N \dots d_2 d_1 d_0]_b = \sum_{n=0}^{N} d_n b^n = d_0 b^0 + d_1 b^1 + d_2 b^2 + \dots + d_N b^N$$

Where:

b = numeral system base

d_n = the nth digit

n - can start from negative number if the number has a fraction part.

$N + 1$ = the number of digits

Research methodology

Research design and research instruments

This study was situated in the qualitative paradigm as it sought to obtain an in-depth understanding of the traditional numeral systems (Gay, Mills and Airasian, 2009). The researchers, being lecturers at the University of Namibia, engaged their students in collecting traditional numeral systems from their ethnic groups. The data was then categorized based on the tribes. The data was recorded in tables and analysed based on emerged themes of tribal counting.

Population and sample

The population of this study consisted of 50 year 3, and 26, year 4 B. Ed. student-teachers, respectively enrolled at UNAM Rundu Campus in 2015.

Results and discussion

The findings show that the mother tongues used by our students enrolled in the B. Ed. programme doing mathematics at upper primary phase were Nyemba (10), Rumanyo (11), Rukwangali (18), Oshindonga (4), Oshikwanyama (3), Umbundu (3), Thimbukushu (2), Subia (2), Chokwe (1), Setswana (1), Otjiherero (1) and Afrikaans (1). It was further established that Nyemba is divided into three dialects namely; Nkangala Nyemba, Masaka Nyemba and Ngangela Nyemba. Rumanyo has two dialects which are Rusambyu and Rugciriku. The one Oshindonga student spoke Oshimbalantu at home. Due to cultural diversification, these participants were either taught through their mother tongue or a predominant local language of the area as per school language policy of 1993. Table 1 shows mother tongue languages taught at lower grades in Namibian schools.

Table 1: Languages and mother tongue languages taught at lower grades in Namibia

Language	School	Mother tongue	Not mother tongue	Other language
Rumanyo	11	8	3	Thimbukushu
Rukwangali	20	19	1	Umbundu
Thimbukushu	4	4	0	-
Silozi	2	0	2	Subia
Oshindonga	8	4	4	Oshimbalantu Rukwangali Oshingandjera
Oshikwanyama	6	3	3	Oshimbandja
Otjiherero	3	3	0	-

Setswana	3	3	0	-
Afrikaans	7	1	6	Rukwangali Chokwe Rumanyo Oshikwanyama

The questions were aimed at finding out if these student-teachers expected to be proficient after completing their studies and teach mathematics proficiently with the changes in the new curriculum, where the mother tongue as medium of instruction was from Grade 0 to 5. What challenges could be encountered after being trained in English at University level, and what needs to be done to remedy the situation? Will they be able to publish or write teaching and learning materials in those mother tongues – or predominant local languages or not, if they are assigned to handle grade 4 to 5 classes? Table 2 gives the different counting strategies in mother tongue of the students who took part in this study.

Table 2: Numeration in Indigenous languages included in the school syllabus at primary level

Numeral	Hindu-Arabic	Rumanyo	Rukwangali	Thimbukushu	Silozi	Oshindonga	Oshikwanyama	Otjiherero	Setswana
0	Zero	-	Euta	-	-	Owala	-	Ouriri	Sepe
1	One	Mwe	Zimwe	Thofotji	Ṅwi	Yimwe	Imwe	Imwe	Ngwe
2	Two	Mbiri	Mbali	Yiwadi	Peli	Mbali	Mbali	Imbari	Pedi
3	Three	Ntatu	Ntatu	Yihatu	Talu	Ndatu	Nhatu	Indatu	Tharo
4	Four	Ne	Ne	Yine	Ne	Ne	Nhe	Ine	Nne
5	Five	Ntano	Ntano	Yikwoko	Tanu	Ntano	Nhano	Indano	Tlhano
6	Six	Ntano-nayimwe	Ntazimwe	Kwoko noThofotji	Silela	Hamano	Nhano naYimwe	Ihambo-umwe	Thataro
7	Seven	Ntano-nambiri	Ntambali	Kwoko noYiwadi	Supa	Heyali	Nhano naMbali	Ihambo-mbalri	Shupa
8	Eight	Ntano-nantatu	Ntantatu	Kwoko noYihatu	Loba-Peli	Hetatu	Nhano naNhatu	Ihambo-ndatu	Robedi
9	Nine	Ntano-nane	Ntane	Kwoko noYine	Loba-ṅwi	Omugoyi	Nhano na Nhe	Imuvyu	Robongwe
10	Ten	Murongo	Murongo	Dikumi	Lishumi	Omulongo	Omulongo	Omurongo	Shome
Base	**10**	**5**	**5**	**5**	**10**	**10**	**5**	**5**	**10**

It emerged (see Table 2) that the eight mother tongue languages used different number base systems in counting. Five languages, Rumanyo, Rukwangali, Thimbukushu, Oshikwanyama and Otjiherero, used base five while three namely the Silozi, Oshindonga and Setswana languages used base 10. , This finding concurs with the reviewed literature that a variety of bases are used in counting by different ethnic groups in Namibia. We also found that Silozi and Setswana used advanced subtraction methods, as indicated in the Table 3. Reflecting on numeral 7, the Silozi and Setswana ethnic groups say *Supa* (Silozi) and *Shupa* (Setswana) which is the finger we use for pointing at objects or things. Mathematically, it means fold three fingers below the pointing finger; $10 - 3 = 7$, while at *loba* (means break or fold), *Peli* (means two), therefore *Loba – Peli* (means break two from 10); $10 - 2 = 8$; *Loba - ṅwi*; $10 - 1 = 9$. Furthermore, statistically 5 out of the 8 (62.5%) of the languages used base 5 and only 3 of the 8 (37.5%) used base 10 which is used in Namibian schools. This shows that it is viable for Namibian schools to adopt the base five numeration system for the languages that use base five. There are other languages in Namibia which are not used as media of instruction in schools, but used by our students at home. Their use in schools may enhance the learning of mathematics in our schools.

Table 3: Languages found in Namibia and not used as a media of instruction in schools

Numeral	Hindu-Arabic	Nyemba (Nkangala)	Nyemba (Ngangela)	Nyemba (Mashaka)	Umbundu	Subia	Oshimbalantu
0	Zero	*Livunda*	*Livunda*				
1	One	*Yimo*	*Cimo*	*Yimo*	*Mosi*	*Kamwina*	*Yimwe*
2	Two	*Vivali*	*Yivali*	*Yivali*	*Vali*	*Tobele*	*Mbali*
3	Three	*Vitatu*	*Yitatu*	*Yitatu*	*Tatu*	*Totatwe*	*Nhatu*
4	Four	*Viwana*	*Yiuana*	*Yiwana*	*Kuala*	*Tonee*	*Ne*
5	Five	*Vitanu*	*Yitanu*	*Yitanu*	*Tanlo*	*Iyaza*	*Nhano*
6	Six	*VitanunaCimo*	*Pandu*	*Hambowomwe*	*Epandu*	*Iyaza ni Kamwina*	*Hamano*
7	Seven	*VitanunaVivali*	*Panduvali*	*Hambombali*	*Epanduvali*	*Iyaza ni Tobele*	*Heyali*
8	Eight	*VitanunaVitatu*	*Tjinana*	*Hambondatu*	*Epandutatu*	*Iyaza ni Totatwe*	*Hetatu*
9	Nine	*VitanunaViwana*	*Tjela*	*Muvyu*	*Epanduguala*	*Iyaza ni Tonee*	*On'ngoyi*
10	Ten	*Likumi*	*Likumi*	*Likumi*	*Equi*	*Ikumi*	*On'longo*
Base	**10**	**5**	**10**	**10**	**5**	**5**	**10**

The findings from Tables 2 and 3 reveal that eight languages use base 5 while six languages use base 10. The findings further reveal that ***analysis of Numerals system*** used for counting numbers by different ethnic groups in Namibia in are given in Table 4.

Table 4: Contrasting the Decimal and the Quinary Base systems

Decimal Numeral System - Base-10	Quinary Numeral System - Base-5
0	0
1	1
2	2
3	3
4	4
5	10
6	11
7	12
8	13
9	14
10	20
11	21
12	22
13	23
14	24
15	30
16	31
17	32
18	33
19	34
20	40
30	100

Table 4 shows the numerals for counting in groups of 5 and 10. It emerged in this study that only the digits less the base number system can be used. For example, in base five only the following digits can be used, that is: 0, 1, 2, 3, and 4 while in base 10, digits such as 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 can be used. This implies that base five has 5 characters and base 10 has 10 characters. Furthermore, we found that in order to differentiate the number bases we usually use subscript notation. For example, 23_5 read as two, three base 5. Meaning; $2\times5^1+3\times5^0$ that is 2 fives and 3 ones Equals $10_{10}+3_{10}=13_{10}$. *Working out the addition and subtraction operations in*

Base 5 (Quinary System). A number system defines how a number can be represented using distinct symbols / characters. An example of addition and subtraction in base 5 would be:

1. Addition

- *Augend*: The first of several addends, or the one to which the others are added.

$$\begin{array}{r} 1\,3\,4_5 \\ +\,4\,2\,3_5 \\ \hline 1\,1\,1\,2_5 \\ \hline\hline \end{array}$$

Steps:

- Add right to left; 4 +3 = 7 (value bigger than base value). Hence

  divide 7 by 5 = 1 rem 2. Write remainder down and carry a 1.
- 3 + 2 + 1 (the carried number) = 6, 6 ÷5 = 1 remainder 1. Write remainder 1 down
- and carrv the 1.

2. Subtraction

- *Minuend:* The number from which another number is subtracted
- Subtrahend: The number being subtracted

$$\begin{array}{r} 4\,3\,1\,2_5 \\ -\quad 3\,0\,3_5 \\ \hline 4\,0\,0\,4_5 \\ \hline\hline \end{array}$$

Steps:

- Subtract right to left. Since 2 < 3, borrow a 'five' from the next place value. Now value in first column is 7, minus 3 = 4.
- Second column now has zero in the minuend. 0 – 0 = 0.
- Third column, 3 – 3 = 0.

It also emerged that it is common practice to count articles like oranges, eggs, vegetable leaves and cassava in groups. Most such articles are often displayed for sale in piles. Counting is usually done in groups of twos, threes, fours or fives. Traders count in groups because it is faster. It also emerged that the base number should be smaller than the digit in use for that particular base; this is further illustrated in Table 5.

Table 5: Base Number and System digits

Ten	Two	Three	Four	Five	Six	Seven	Eight	Sixteen
0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	10	2	2	2	2	2	2	2
3	11	10	3	3	3	3	3	3
4	100	11	10	4	4	4	4	4
5	101	12	11	10	5	5	5	5
6	110	20	12	11	10	6	6	6
7	111	21	13	12	11	10	7	7
8	1000	22	20	13	12	11	10	8
9	1001	100	21	14	13	12	11	9
10	1010	101	22	20	14	13	12	A
11	1011	102	23	21	15	14	13	B
12	1100	110	30	22	20	15	14	C
13	1101	111	31	23	21	16	15	D
14	1110	112	32	24	22	20	16	E
15	1111	120	33	30	23	21	17	F

16	10000	121	100	31	24	22	20	-
17	10001	122	101	32	25	23	21	-
18	10010	200	102	33	30	24	22	-
19	10011	201	103	34	31	25	23	-
20	10100	202	110	40	32	26	24	-

The Octal Numeral System - Base-8 uses digits from 0 to 7 while Hexadecimal Numeral System - Base-16. Hexadecimal numbers use digits from 0 to 9 and capital letters of alphabets from A to F. The H denotes *hex* prefix as B denotes binary prefix which uses digits 0 and 1 only.

Conclusions and recommendations

In this research paper, we critically analysed and reviewed various number systems embedded in home languages used in teaching mathematics in lower primary schools. We found that there are more home languages in Namibia than those used in schools. The switching of languages may contribute to difficulties in learning mathematics. The teaching and learning of mathematics is subject to challenges emanating from translations across languages and number systems. While some numerals like inne (*fou*r), and imwe (*one*), tend to remain consistent across several dialects, they drastically mutate, as language hieroglyphics continue shifting. We further found that graduates of UNAM may face challenges in teaching mathematics at grass roots level because some of the concepts may be lost in the translation of numeral systems. We therefore recommend that:

- teachers of mathematics should be sensitive to the transition of number sense across home languages and from English;
- further research should be conducted to look at the implications of the traditional number systems on classroom settings which use base 10; and
- research should be carried out in computation in base 5 to establish the difficulties learners encounter when using the four basic operations in mathematics.

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