EXPLORING HOW MODERN SCIENCES IMPEDE THE DEVELOPMENT OF INDIGENOUS KNOWLEDGE (IK) [ETHNO-SCIENCE AND ETHNO-MATHEMATICS] IN THE KAVANGO EAST REGION: A CASE STUDY

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Abstract

The analysis of this research paper is drawn from theoretical framework that indicates the relationship between modern science and Indigenous Knowledge (IK) in their different environments. The focus of this study was to establish the relationship between modern science and indigenous knowledge (IK), particularly how modern science has become dominant over IK. This seems to have resulted in many IK systems becoming extinct and redundant. The significance of this study is to contribute to the existing scientific body of knowledge since there seems to be dearth of IK documented information. It also creates awareness on the existence of traditional methods and skills that were used and still being used in their livelihood.

In addition, the research paper provides explanation on the importance of the IK in relation to modern science. In the same vein the research paper draws parallel lines among the ethno-sciences, ethno-mathematics and modern science. Since the paper focuses on ethno-sciences and ethno-mathematics, learning systems of imparting knowledge were meticulously investigated. This paper places IK at the center of the knowledge creation instead of being an obstacle to the development of contemporary science and mathematics.

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The study involved 15 informants, 5 adults and 10 teenagers, from different age groups regardless of their gender. For the purpose of cross checking ideas, observation and focus group discussion were used as research instruments.

The findings in this paper point at the followings factors: rapid change in the natural environment and fast pacing economic, political, and cultural changes on a global scale. Furthermore, the intrusion of modern technologies or development concepts is detrimental to IK systems. This seems to have resulted in IK practices vanishing as they became inappropriate for new challenges, or they are adapting too slowly. Lastly, in this paper the concept teachers are referring to mathematics and science teachers/educators.

Introduction and background

The Kavango East region is located in North-East Namibia, sharing borders with Angola and Botswana. This region is found in the woodland savannah alongside the Kavango River. Indigenous knowledge (IK) seems to be viewed as old fashioned compared to the modern sciences, even though no existing knowledge system can be legitimately viewed as backward or primitive. Equally, the term IK is used to describe knowledge systems developed by a community whereas this may not be the case with modern science (Ajibade, 2003). Modern sciences and mathematics are normally preferred over IK. This has resulted in the loss of indigenous practices as people often embrace modern sciences and pure mathematics as the only true sciences. It is against this background that this study was carried out and aims at investigating how modern science and mathematics have hindered the practice of IK in communities. The local inhabitants within the area under study seem to be losing grip on the traditional practices as a result of modern sciences and mathematics.

Since IK is essentially transmitted orally, through stories, and/or by simulation and demonstration, whilst modern sciences and mathematics are mainly written down, IK is based on observation and experiences as opposed to modern science and mathematics which are taught and learnt. Because of the observational and experiential nature of IK, and the fact that it is not documented, it can easily be overshadowed by modern science and mathematics, which are taught and learnt at home or at school. This study has demonstrated the hegemonic position given to modern science and mathematics over IK. IK systems are viewed as inferior cognitive systems that can be improved by systemisation and rationalisation in accordance with the logic of the superior modern sciences, but there is growing awareness that traditional people have knowledge about properties of the natural world that are important and valuable, even to the modern sciences. This awareness is behind the efforts of, for example, pharmaceutical companies to make contact with traditional healers in order to learn about healing properties of medicinal plants, their cultivation, storage and collection. Major seed companies and genetic engineers also realise the need to learn about traditionally cultivated varieties from indigenous farming populations around the word. A binary opposition between modern sciences and IK systems should not be constructed; Instead a transformation of traditional beliefs should be strived for in order to preserve traditional values.

The realisation that traditional beliefs and practices are not confined to the supernatural has led to the emergence of "ethno-science" because it is seen as essentially rational and rooted in a process of empirical research and scientific testing over many generations. It is "ethno-science" because it is context-specific inasmuch as it is expressed in the everyday practices of the people who developed the knowledge and it is shaped by their particular ways and cognitive maps.

Recent research has shown that the relationship between mathematics, sciences and culture has been of concern to researchers in the last decades. According to Bishop (1991) children from minority cultural groups in Britain had problems in learning mathematics. While in South Africa, Adler (1991, as cited in Schäfer & Dabula, 2002) found that out of every 10 000 black students who register for Sub A (Grade 1), only one eventually matriculated with a high enough mathematics symbol to gain entry into a university. A similar pattern is seen in the outcomes in Namibians schools, despite the fact that representatives of industries said that Namibia needs high-grade scientists, technicians and engineers if Namibia is to successfully compete in the technology-intensive global market by 2030 (Utete, Ilukena & Simasiku, 2016, p. 66; Ilukena, Simasiku, & Musiba, 2016), while Mateya, Utete and Ilukena (2016. p.108) and Ilukena, Simasiku and Musiba (2016) also found that performance of learners in mathematics since independence was not impressive at all school levels. The high failure rate at the Upper Primary phase (Grade 5-7) is conspicuously evident in the Southern African Consortium for Monitoring of Education Quality (SACMEQ, I & II, 2004), and Namibia's Standardised Achievement Tests (SATs) results (Mateya et al., 2016).

The apparent crisis might be caused by factors, such as alienation, demotivation, and fear of the related subjects. Researchers such as Adler, Brombacher and Shan (2000), Utete, et al. (2016) and Mateya, et al. (2016) advocated for the incorporation of contexualised knowledge as strategy towards addressing the issue of alienation, for example (Mawere, 2015, p. 63).

Education in Namibia started long before colonisation. In 'old Namibian societies' the purpose of education was a preparation for adulthood. It was not the responsibility of a specialist labour force, called teachers, principals, coordinators, consultants, or "supervisors" (Auala, 1989 as cited in Ilukena, 2008). Instead it was the responsibility of all parents to teach, correct, or even punish a child who did something wrong. The roles and skills of adult society were learnt through poetry, riddles, proverbs, storytelling, memory tests, racing, wrestling, demonstrations, as well as through traditional songs, dance and games (Ellis, 1984; Ndilula, 1988, as cited in Ilukena, 2008). In addition, there are various activities children took part in to learn traditional skills. For example, they did carpentry, made drums, built houses, and weaved mats and baskets. This traditional education involved a life-long process, where individuals passed through different learning processes in various phases of their lives. It aimed at transmitting the people's cultural heritage, beliefs, behavioural patterns, attitudes, values and skills from one generation to another.

Literature review

The paper addresses two major views on ethno-mathematics: Firstly, the D' Ambrosio-Gerdes model, which explains that ethno-mathematics in third world countries bridges the gap between home culture and modern sciences. Secondly, the Zaslavsky-Ascher model explains that ethno-mathematics in first world countries bring the world into the classroom, and propagates an appreciation of mathematics of other cultures (Scott, n.d., as cited in Gerdes, 1995). The models thus complement each other.

The term *ethno* describes "all of the ingredients that make up the cultural identity of a group which include language, codes, values, jargon, beliefs, food, dress, habits, and physical traits "(Arismendi-Pardi, 1999). Furthermore, Powell and Frankenstein (1997) stated that "ethno" does not only refer to a specific ethnic nation or racial group, gender, or even professional group, but also to a cultural group defined by philosophical and ideological perspectives (p. 179). The social and intellectual relations of individuals to nature or the world and to such mind-dependent, cultural objects as productive forces influence products of the mind that are labeled mathematical ideas. With the assertion above, the teaching of ethno-mathematics and ethno-sciences should incorporate economic, social, and cultural issues (Ilukena et al., 2016; Utete et al., 2016). The incorporation was necessitated due to the fact that mathematics and science were seen as subjects that had no relationship with peoples' cultural values. However, it can be argued that cultural aspects contribute to the recognition of mathematics and science as part of daily life, enhancing the ability to make meaningful connections, and deepening the understanding of mathematics and science.

Western mathematics, science and IK are frequently perceived as two different competing knowledge bodies hence they are treated as two different entities, separable from each other in space which impedes the development of IK. Researchers such as (Agrawal, 1995) argued that western mathematics and science seem to be open, systematic and objective, dependent very much on being detached center of rationality and intelligence, whereas IK is seen to be closed, unintellectual, primitive and emotional. They further argued that whereas western knowledge systems are part of the whole notion of modernity, IK is part of a residual, traditional and backward way of life, with too little to offer, a view which may be reinforced by the concentration of work on IK on people of low and middle income countries (Kundiri, Jarvis, & Bullock, 1997, p. 206, in Briggs, 2005) discuss farmers as having very subjective methods of identifying and describing the different soils. It should be noted that the word 'subjective' is a non-rigorous connotation of IK. Similarly other scholars such as Pretty (1994) went even further and claimed that participatory methods of data collection in IK lack the rigour and accuracy assumed to be more formal positivist approaches. Western science has retained its resilience in development debates over IK because of its perceived 'substance', something which IK apparently does not possess. It is against this postulation that this paper tries to demystify. IK is entirely situational and characterised by adaptability as opposed to modern science that requires hypothesising and experimentation. In the same vein IK is anchored on the epistemological foundation characterised by experience and observation.

There is a need to study the logic and efficacy of traditional IK practices especially those that are overshadowed by modern science and mathematics. Some of the traditional IK practices seem to act as a fundamental foundation for understanding modern science and mathematics. As Kawagley and Barnhardt (2007) observed that indigenous people throughout the world have sustained their unique worldviews and associated knowledge systems for millennia. They further argued that students in indigenous societies around the world have, for the most part, demonstrated a distinct lack of enthusiasm for the experience of schooling in its conventional form. The Namibian education system lacks the connection of IK concepts in the mathematics and science curricula. This is evident in the Kavango East region where current mathematics and science teaching seem to have dwarfed ethno-mathematics and ethnoscience. It should equally be understood that modern mathematics and science education seems to emphasise on formal knowledge which is always taught in a structured setting of classrooms, while the indigenous people in the area under study seem to have traditionally acquired their knowledge through direct experience in the natural environment.

It is against this background that modern mathematics and science should be anchored onto ethno – mathematics and science to enhance the understanding of science and mathematics. The inhabitants of Kavango East seem to engage in mathematics and science when they practise farming, build houses, make bows and arrows, crosses rivers in dugout canoes, catch fish, cut down trees, collect herbs, and brew alcohol such as Kasipembe (Traditional Whiskey). However, there seems to be little information available on these activities in terms of mathematics and science documentation. The inhabitants in the area under study will feel motivated to study when the subject content is based on IK concepts that they already know and are useful to their situations and livelihood.

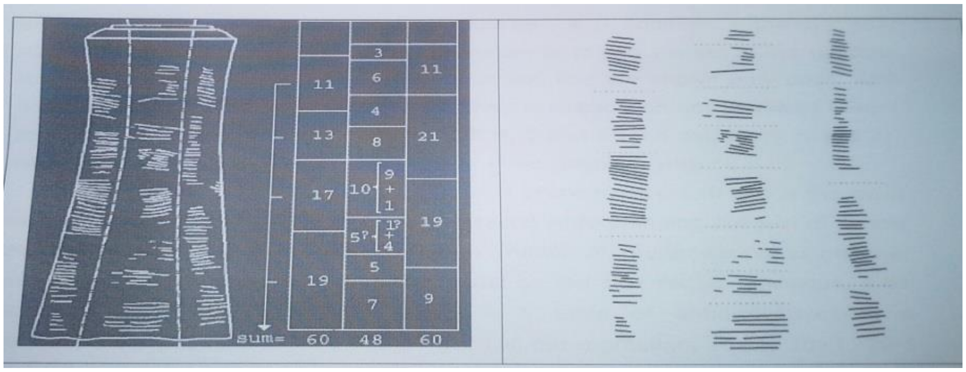
In support of the assertion above, Mukonyora (2007) observed that brewing of Kachasu (Traditional Whiskey) in Zimbabwe was an activity that women brought to the urban wilderness from the villages (p. 65). The Kachasu was provided for entertainment during the harvest and winter months. White settlers in Zimbabwe later discovered that Kachasu was special to Africans. They then started to compete for the market by manufacturing refined brews such as Chibuku, Castle, Lion and building special pubs to sell them. This development complicated life for the women of urban wilderness as their clientele were reduced. However, women who were skilled at brewing, especially those who knew the secret recipe to produce Kachasu similar to vodka or gin, could afford to live in towns.

In defence of the Kachasu or lituka, Zambian Economist (2008) revealed that alcohol can vary significantly, depending on the strength of the brew. This emerged after a research on the composition and safety of Kachasu was conducted by the University of Zambia (UNZA) in 2001. The researchers found that the brew contained about 20% to 30% ethanol-pure alcohol while other studies found that the strength can be as high as 70%. They also discovered that the brew contained no major contaminants but added that basic hygiene was crucial. The brew could be made less potent by flavouring it with fruits. Malawi is another country where Kachashu is brewed, but alcoholic percentages in the liquor are doubled that of Zambia (Chisamba, 2015).

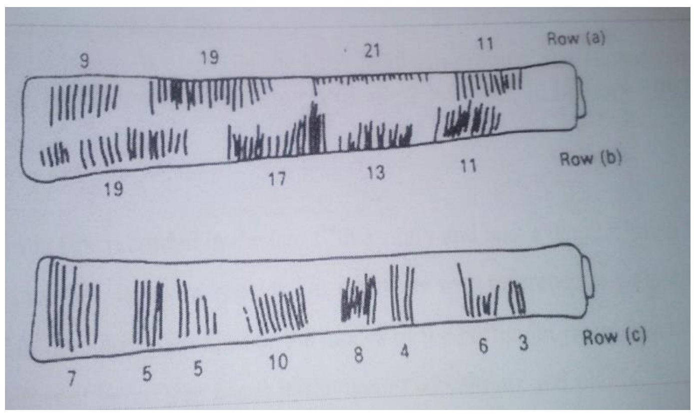
Recent research revealed that policies on modern mathematics and sciences are mainly situated in western culture definitions and descriptions, thus marginalising IK, which is misconceived as primitive and illogical. In addition, the learning of modern mathematics and sciences generally lacks Africanness and African rationality, which alienates people from their traditional beliefs.

There seems to be a gap between modern mathematics and sciences, and IK though an intersection between them is possible. Modern mathematics and sciences focus on facts that are brought about by hypothesising, experimentation, prediction and can therefore be easily documented, whereas IK seems to be less transferable than modern mathematics and sciences given its completely socio-cultural and spiritual dimensions, because the source of knowledge production of IK is the community, instead of written material that can be studied removed from the community.

The paradigm shift at the end of the twentieth century, where the global trends have been marked by substantial challenges as to what constitutes knowledge (Welch, 1998) has inevitably led to major curriculum reforms as education began restructuring towards new concepts of knowledge (Schafer & Dabula, 2002). As Raw (cited in Gerdes, 1999) contends: one of the principles of good teaching emphasises the importance of understanding the cultural background of learners and relates teaching in school to these cultural backgrounds (p. 911). Mathematics and Science teachers and educators need to incorporate learners' background experiences into their lessons to help scaffold learning. Therefore there is a need to seek mathematics and science connections with societal backgrounds. For such development to happen, teachers need to broaden their horizons and look for connections in other disciplines, such as history, cultural anthropology, cognitive psychology, early childhood education, physical education (Marewe, 2015; D'Ambrosio, 1990; Bishop, 1997; Walkerdine, 1990; Wright 1998; Arismendi-Pardi, 1999). It is evident that studies carried out in history of mathematics and science show that European mathematics and science were actually developed and refined through the interaction of Greeks with the Arab world, Egypt, Babylon, India, China and other countries (Briggs, 2005; Schäfer & Dabula, 2002; Arismendi-Pardi, 1999; D'Ambrosio, 2001). Furthermore, it emerged in literature that sub-Saharan countries such as the Democratic Republic of Congo (DRC), Uganda, South Africa and Zimbabwe have also contributed immensely to the history of mathematics (Chadenga, 2015; Huylebrouck, 2006; Gerdes, 1994; Keller, 2015; Zalslavsky, 1976, in Ilukena, 2015). This is supported by the early fifties' discovery along the borders of the modern day DRC and Uganda, of the Ishango bone which is one of the oldest mathematical artifacts, which had incised marks that signify numbers as identifiable properties and relationships as shown in the images below.



De Heinzelin's detailed drawing of the Ishango bone above and below (source: Vladimir Pletser, European Space Agency, The Netherlands) with its three columns ("left", "middle" and "right")



The mathematical interpretation, row (a) has group of 9, 19, 21 and 11 carvings. This suggests a number system based on 10, since 10 – 1 = 9, 20 – 1 = 19, 20 + 1 = 21 and 10 + 1 = 11 respectively, while row (b) shows groups of 19, 17, 13 and 11 incisions, all the prime numbers between 10 and 20 presented in descending order. Meanwhile, row (c) has groupings of 7, 5, 5, 10, 8, 4, 6 and 3. From the right to left, 3 carvings are doubled to 6; thereafter 4 carvings are doubled to 8; after that the process is reversed and 10 carvings are halved to 5. According to De Heinzelin (2006, as cited in Chadenga, 2015; Keller, 2015), the sequence reveals the multiplication and/or division by 2. Other observations include the fact that all the numbers on the first and last columns are odd, and that each of these columns adds up to 60 while the middle column adds up to 48. Since these totals are 5 x 12, and 4 x 12 respectively, De Heinzelin suggested that this was a calculator for arithmetic on base 2 and base 10. Simple addition, subtraction and multiplication reveal a plethora of other less imposing relations.

In addition, the African diversity in number names, gestures and systems include the base 2 (Binary) of the KhoiKhoi of South Africa, who had two number words 'a' and 'oa' as one and two respectively. They also noted the discovery of a bone during the excavation of a border Cave in the Lebombo Mountain between South Africa and Swaziland. The bone dates approximately 35 000 B.C., which resembles calendar sticks of today by San clans in Namibia. It is also evident that the Shona people in Zimbabwe utilised geometry to construct the elliptical tower and the walls of the Great Zimbabwe ruins.

The Great Zimbabwe ruins
Retrieved from: www.google.com.na/search zimbabwe+ruins+image

It should not surprise learners in the Southern Africa Development Community (SADC), particularly in Namibia, to find that different mathematical and scientific manifestations are found in all cultures. Studies conducted in the history of mathematics and sciences reveal that the models of D' Ambrosio-Gerdes and Zaslavsky-Ascher complement each other in the sense that both industrialised and third world countries are confronted with the need to multi-culturalise the mathematics and science curricula (Mawere, 2015; Briggs, 2005; Gerdes, 1995). There is a gap in the Namibian education system, and with a view to bridge this gap, there is a need to reconstruct and analyse both mathematics and science in African cultures in general and in Namibian cultures in particular. Research has also shown that Chinese mathematicians discovered the Pythagorean theorem, but Pythagoras was given credit for it, even though it appeared in a Chinese documentary by Chu Shikie, dated 1303 (Stewart, Redin, & Watson, 2012, p. 822), before Pythagoras was born. Furthermore, Gerdes (1988) found that women in Mozambique unknowingly applied the Pythagoras theorem in their basket designs.

On the scientific aspect, the brewing of Kachasu is similar to the brewing of Whisky, vodka or gin, but the difference is that Kachasu is not a legalised brew as it lacks modern brewing procedure and it is brewed under unhygienic conditions, such as the bush where the brewers hide from law enforcement agents in fear of being arrested as the brew is highly intoxicating and illegal because it contains a lot of impurities that are detrimental to the human health. To restore the dignity of the losers, the winners and losers should move into both ethno-mathematics and science to be able to help both sides.

Findings and discussions

Traditional brewing of Kasipembe (Scientific Name)

The process of brewing Kasipembe is similar to the modern brewing processes, except that the traditional brewing technique is unhygienic and does not involve a methodical approach to the brewing processes, which include alcohol content testing, the measurement of temperature, the percentage of hydrogen or potential of hydrogen (pH), and the presence of oxygen gas. The procedure in brewing of Kasipembe as is as follows: Mangette fruits were collected and rinsed in water and then boiled for approximately two hours at high temperature. The boiled mangette fruits were taken out of the pot, placed in a mortar and then, using a pestle, they were delicately pounded to extract the pulp. The pounded mangetti fruits were then placed in dishes and water was added to separate the pulp from the seeds.

Picture taken by Mathews Ngunda, 16 July, 2016

Picture taken by Mathews Ngunda, 16 July, 2016

The thick liquid which remains after the seeds have been removed, was then poured into barrels and stirred in order to get a homogenous mixture. The mixture was then left to ferment outside in the sun for two days. During the fermentation of mangetti pulp, alcohol was produced as a byproduct through the release of carbon dioxide gas. Factors that can affect this process are temperature, salt concentration, pH, oxygen availability and nutrient availability. After fermentation the mixture was poured in another container to boil. The container into which the mixture was poured was then covered with an improvised lid which had a clay mold on top to prevent evaporation.

Picture taken by Mathews Ngunda, 16 July, 2016

Picture taken by Mathews Ngunda, 16 July, 2016

A pipe was connected from the container to an elevated dug-out canoe as illustrated below.

Picture taken by Mathews Ngunda, 16 July, 2016

The container had water that would cool the vapour for condensation to take place. The pipe ran along the length of the dug-out canoe to the end where the cooled vapour, which was in liquid phrase by then, oozed out into a collecting container. The collected liquid was known as Kasipembe. The procedure in brewing Kasipembe is similar to the western brewing of whisky. The whisky brewing procedures are as follows:

- Malting: barley contains starch and it is this starch which needs to be converted to simple soluble sugars (glucose). For this to occur, barley must undergo germination;
- Mashing: ground down malt, is now added to warm water to begin the extraction of soluble sugars;
- Fermentation: the yeast is added to the mash and fermentation begins (the yeast converts the sugar to alcohol-ethanol);
- Distillation: taller stills with longer necks will give finer, lighter spirits while shorter and fatter stills produce a richer and fuller spirits;
- Maturation: the spirit is stored in oak casks. It must mature in the casks for a period of three years before it is legally allowed to be called whisky.

Kasipembe distillation equipment revealed shabby unhygienic set-ups, but the principles and the products are similar to those brewed in the shiny copper vats of the modern industrial breweries. The researchers also observed that, although the procedures are similar, the maturation stage is not recognised in the traditional brewing of Kasipembe because of the high demand by consumers, and because of the brewers' financial gain. In addition, it emerged that the mathematical components that are involved in the procedure are the duration of each phase in the process, the length, width, and height of the dug-out canoe, and the capacity of containers which determined the quantity of end product. The dug-out canoe is elevated so that the end product can easily flow and drop into the collecting container.

Drying of meat using salt

The informants revealed that in the absence of a fridge they dry meat using salt since salt draws out moisture from the meat and thus prevent bacterial growth, which leads to decomposition. This is similar to osmosis, where water molecules move from a high water potential (meat) to a low water potential (salt) through a selective membrane. In this case, water molecules move from the meat or fish into the salt drying the meat out. The informants know the right dimensions according to which the the meat has to be cut and the correct quantity of salt to apply on particular cuts. They know that if the salt is too much the meat will not be edible and if it is too little it creates a more hospitable environment for bacterial growth. However, the informants did not know the mathematical and scientific relationships involved in the process of preserving.

The method seems to be more popular in rural areas than in urban areas where people use fridges to freeze the meat. Needless to say, even in the rural area where preserving food using salt is popular, people tend to use fridges where electricity is available, instead of using salt to preserve their meat. It looks like the method is becoming extinct, except in areas where people have no access to electricity.

Bows and arrows (Projectile weapon system)

A bow is a flexible arc that shoots arrows. The two ends of the bow are joined by an elastic string. When the string is pulled back the bow ends are flexed. Upon releasing the string the potential energy stored in the flexed bow is transferred into the arrow and that is why it is sent flying at terminal velocity. The arrows have feathers at the back to maintain constant speed so as to achieve terminal velocity and for the arrows to move straight to the target. There is also a mathematical component involved, whereby distance and angles are measured so that the target cannot be missed. The further the target, the more likely the shot is going to be inaccurate as the speed of the arrow reduces because of gravitational forces. The arrow also accommodates marginal errors.

Traditional dancing gear

The mathematical and scientific concepts illustrated on these artifacts below are equaling symmetry (Translational and Rotational); Tessellation (Rhombi, Triangle), repetitive cycles for the purpose of adding similar deigns or creating a similar pattern, counting-counting of layers or turns before making other patterns, circles, cylinders, rectangles, volume, sizes, elasticity, chemical composition of the beads, and paint mixtures.

Traditional dancing attire



Female head gear | Female front cover | Female back cover

Male bottom cover

Cultural Specific Games and Ethno-mathematics

The term “game” brings to mind a variety of notions, which include recreation, competition, sportsmanship, winning, losing, and enjoyment, to mention but a few. The term “games”, according to Ascher (1991), encompasses a variety of activities which children and adults can play, such as puzzles, board games, dice games … and international competitions (p. 85). A game is an activity in which one or more people may be involved, following a set of rules, and the players engaged in such activities arrive at certain outcomes. The outcomes may be the completion of a particular configuration or winning of the game. According to Mosimege (2000), specific terminology and language used within different cultural groups, categorise a game as a culturally specific game (p. 31).

Picture of the Weraboard taken by C. Utete, 5 July, 2016.

Research by Zaslavsky (1999, in Ilukena, 2008) indicates the two board games that are most commonly played in various parts of the world are two-row and the four-row versions. The focus on the research is on the two games of Werawongombe and ondota in the Kavango regions. *Werawongombe* is played on the four-row board of at least eight holes per row. The two research sites (known as popular hot spots) that were visited by the researchers indicate 20 and 26 holes respectively, but not more than 32 holes and always an even number, which concurs with the findings of Itamalo (2016, p. 8). *Owela* should always be in even numbers but not more than 32 holes. The game Wera, as it is referred to in the Kavango regions, is also known as //hỦs in the central and southern regions of Namibia. Owela has other names, such as xoros, ogoro, onjune, otjitoto, mulabalaba and lochspiel. A number of tribes in Namibia, Damaras, Namas, Ovaherero, Kwanyama, Ndonga, Kwangali, Mbukushu, Shambyu, Subia, Mafwe, and He//om play the games. They use counters such as pebbles or Sclerocaryabirrea (Marula or Mulula) /Schinziophyton rautanenii (Mungongo or Mangetti) seeds that they place in holes. Players must outwit their opponents in addition, subtraction, division and multiplication; this enhances the mental computations as they have to calculate the number of counters with reference to the holes. Other mathematical concepts that emerged from the game Werawongombe, are rectangular Prisms (Cuboid), 3-Dimension shapes, edges, faces, vertices, circles, lines, perimeters (horizontal, vertical & parallel), semi-circles, breadths, lengths, heights, spaces between holes, polygons, triangles, rectangles, and formulae.

WeraKukiketa/Kulizanga/Wakukuyanga/Piyo

This is a traditional game where 12 pebbles (Mamanya or Mawongo) are placed in a small hole dug in the ground. A larger stone is tossed in the air as players attempt to scoop a certain number of pebbles out of the hole, and then catch the larger stone before it hits the ground. The mathematical and scientific concepts emerging from the game are counting, multiplication, multiples, groupings, additions, arithmetics, even and odd numbers, factors, divisors, dividends, quotients, and velocity, gravity, distance, estimation, and time.

Artifacts

Recent research has shown that artifacts made by indigenous people exhibit mathematical and scientific knowledge (Utete et al., 2016; Ilukena et al., 2016; Mosimege, n.d.). Artifacts investigated are pottery, wood carvings, grass baskets, grass brooms, bead ornaments, traditional hats, traditional axes, traditional sieves, plaited ropes, and fish traps, such as cylindrical drum traps, funnel and pyramid traps, vertical slit traps and spring traps (Utete et al., 2016, Ilukena, et al., 2016; Fisheries & Aquaculture Department, n.d.). For the purposes of this paper, the following artifacts have been used to illustrate mathematical and scientific concepts embedded in them:

Clay pots (Vapoto) – the process of molding and the end products exhibit mathematical and scientific concepts such as mixing, the application of pressure, symmetry, geometrical shapes (circular, cylinder, cone, arc) volumes, temperatures (heating and cooling), chemical reactions, estimations, counting, lines, classifying, ordering, and angles.

Pottery (Pictures taken by Ms L Luwango and Ms C Ausiku, 2015

Fish traps and **Axes** – there are various types fish traps, as mentioned above. Illustrated below is the funnel trap, which exhibits mathematical and scientific concepts such as estimation, geometrical shapes, tension, aeration, and measurements. **Axes –** the handle is shaped in such a way that mathematical and scientific concepts are exhibited, such as angles, lines, shapes, arcs, circles, triangles, circumferences, edges, cones, pyramids, rectangles, areas, volumes, and radius, diameter, ellipse, and heating (temperature, expansion and contraction).

Fish Traps (Pictures taken by L Luwango and C Ausiku, 2015); Axe (Picture taken by John, 2014)

This shows that indigenous people are (maybe unwittingly) knowledgeable about a variety of mathematical and scientific concepts that are regularly used in their work. In order to harmonise IK and modern mathematics and science concepts, the knowledgeable indigenous people can showcase their products at schools so that teachers and learners can analyse them in order to reveal the mathematical and scientific concepts embedded in artifacts. This ensures that the always present gap between home knowledge and school knowledge is bridged.

Conclusion and recommendations

This research paper challenges the inequity, superciliousness, and bigotry exhibited by the Eurocentric bias that impedes on both ethno-mathematical and ethno-scientific contributions and rigor of other cultures. In the same vein, there is no way to deny some successes and contributions made by the Greeks and others, as explained by D'Ambrosio (1999, p. 3). Furthermore, it presents findings which concur with other authors in the literature and unfolds the history of mathematics and sciences in the Sub-Saharan African countries. It is the responsibility of mathematics and science teachers, education officers, and curriculum planners and implementers to include ethno-mathematics and ethno-science in their multicultural teaching with a view of harmonisation and creating awareness in learners that mathematics and science did not only originate from Europe. Ethno-mathematics and Ethno-science present a realistic history of mathematics and science pointing to a variety of examples used to solve problems emerging in the every-day lives of various cultures. In addition, there is recognition that the learning of mathematics and science is a unique process for each individual learner because of their individual living conditions, upbringing, background, and chores with a variety of skills and interests acquired from home education. The ramifications of both ethno-mathematics and ethno-science bring various benefits to the curriculum of education systems, such as an awareness that mathematics, science and culture are interwoven with knowledge that manifests itself in symbols, jargons, codes, myths, and ways of reasoning and making inferences (Arismendi-Pardi, 1999). Furthermore, it also creates awareness in learners that all people, whether literate or illiterate, are contributors to the development of mathematics and sciences as cultural products.

We therefore recommend the following:

- Mathematics and science teachers should be appropriately trained and placed according to their areas of expertise so as to be able to create linkages between home education and modern mathematics and science concepts.
- The IK concepts embedded in artifacts and traditional activities should be used in classrooms to link home education with classroom activities, especially in the context of the new mathematics and science curricula, which lack IK concepts.
- Curriculum and textbook authors should include IK with modern mathematics and science concepts in their writing.

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