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The Teaching of Mathematics in Rural Learning Ecology Using Morabaraba Game (Board Game) as an Example of Indigenous Games

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Abstract. The paper will focus on enhancing problem solving skills in Grade 10 Mathematics classroom using indigenous games which address certain topics which Grade 10 learners do not perform well in. These topics which Grade 10 learners do not fare well in include amongst others: patterns, functions, trigonometry in two and three dimensions, and analytical geometry. The Department of Basic Education Report (2009) shows that the very same topics mentioned above are those that Grade 12 learners also do not perform well . (Mosimege, 2000) states that games are usually viewed from the narrow perspective of play, enjoyment and recreation. However, there is more to games than just the three aesthetic aspects. Indigenous games reveal mathematical concepts associated with the games; and possibilities and implications for general classroom management.

The study will utilise the participatory action research method. Participatory action research recognises community members as experts and it is empowering for communities who are enabled to find their own solutions to local issues (Moana , 2010). The researcher put together team of community members, school population and education district officials as participants in the study. These participants are determined to enhance problem solving skills in Grade 10 Mathematics classrooms by using indigenous games. Different participants have expertise in various indigenous games and some have understanding of mathematical concepts.

Keywords: indigenous games, problem- solving

1. Introduction

South Africa, like many other countries has a problem of producing scientists and technology professionals due to a high failure rate in Mathematics. Most research in South Africa has been done in social Sciences, but minimal attention has been given to the role of African indigenous knowledge in the teaching and learning of Mathematics . This paper will focus on enhancing problem solving skills in a Grade 10 Mathematics classroom using indigenous games that apply to certain topics which Grade 10 learners do not perform well. Nabie & Sofo(2009:1) indicate that although this idea of using indigenous games to teach Mathematics is not familiar to some teachers, teachers need to be encouraged to utilise learners' culture as a vehicle for learning to make education culturally relevant and meaningful to learners. Gerdes (2009:11) emphasis that exploring educationally mathematical ideas embedded in, and derived from technologies of various African cultural practices may significantly contribute to close the gap between home and school culture. Furthermore, Thomson & Chepyator-Thomson (2002:49-50) point out that unless the African continent do something, indigenous educational systems of endangered cultures are faced with extinction.

One can suggest that, Mathematics practitioners need to take the initiatives to integrate the teaching of Mathematics with indigenous cultural morals and values. This will help to add value to the education offered in our learning ecologies. Thus, Education researchers are faced with the responsibility to promulgate educational diversity before thousand years of valuable educational knowledge is extirpated. Indigenous knowledge systems and values should be recognised as global resources rather than as being viewed as antiquated and localised primitive liabilities. In addition Jorgensen, Sullivan, & Youdale (2009: 1) point out that in order for effective teaching to occur in a multi-dimensional learning ecology, a variety of factors need to be taken into account. Factors such as , culture and background of the learners, the Mathematics they already know, the Mathematics they need to learn, the nature of the desired learning, the experiences that

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might support that learning; the pedagogies that can support the experiences, and the processes that can be used for assessing learning and evaluating teaching. One could realise that in the teaching and learning of Mathematics, these factors are to a large extent not considered. As the result learners may view Mathematics as not relevant to their daily experiences, and end up resorting to rote learning in an effort understand Mathematical content knowledge, skills and principles.

The paper strives to elucidate that African indigenous cultures has the potential to develop Africa or local indigenous inhabitants. This notion is further illustrated by Thomson & Chepyator-Thomson (2002:49) who cite the Keiyo of Kenya who have a rich education system. Its focus is on the indigenous game, Kechui (using calculations to sharpen your mind), based on cattle raiding, and the Keyos'use of the game for learning mixed strategy-based probabilistic problem-solving.

2. The role of African indigenous knowledge in the teaching and learning of Mathematics

In classroom situations the teaching and learning of Mathematics is not aligned to African cultures. There are artificial barriers that exist between culture and Mathematics. The paper will suggest ways to forge the link between Mathematics and African indigenous knowledge. Mathematics should be viewed as human activity practiced by all cultures, developed and contested over time through both language and symbol by social interaction and thus, open to change. Mathematics has the roots in culture and it is advisable that Mathematics practitioners take examples from cultural contexts (Department of Basic Education, 2003:9, Gerdes, 1998:36 & Barton, 1996: 201-233). Furthermore, Lebakeng (2012:304) points out that indigenous knowledge is cultural knowledge in its broadest sense, including all social, political, economic, technical aesthetical and spiritual aspects of an indigenous community's way of life. Indigenous knowledge has the potential of providing the basis for problem-solving strategies for local communities and indigenous knowledge represents an important component of global knowledge on development issues. It helps to leverage other knowledge so that poverty and other ills can be addressed jointly with the poor. Moreover, Agrawal (1995:416) suggests that indigenous knowledge is local knowledge that has value not only for the culture in which it evolves, but also for scientists and planners striving to improve conditions in rural localities.

New teachers receive their education and training based on Eurocentric Approach, whereas their learners are from African cultural background. This fact is clearly illustrated by Gerdes (2009:12) who cites the Kpelle in Liberia who attended western-oriented schools where they were taught things that have no meaning within their culture. As such, it was difficult to comprehend the Mathematics taught. At times this can result n the development of negative attitudes towards the subject, because it has no relevancy to learners' environmental experiences. Barton (1996) points out that the dilemma faced by Mathematics teachers is that the culture of the teachers differs from that of students. Most of these teachers are using Mathematics textbooks which are written in European languages, style and illustrations. Some of the examples given in school textbooks are not easy to understand because the context in which they are written is unfamiliar to both the teacher and the learner. Some of these Mathematics teachers fail to come up with the strategies that can help learners to understand Mathematics concepts, principles and problem- solving, hence the high failure rate in Mathematics. It is for this reason that Mathematics teacher educators should attend to the culture of their students and use that culture as a means of enhancing the teaching and learning of Mathematics. Gerdes (1998) also point the need for mathematicians in Africa to write textbooks to reflect cultural background, and ensure that Mathematics is firmly grounded within their environment (Gerdes, 1998 & 2009). Furthermore Thompson (2008 :) suggests that teachers should capitalise on the background of learners for performance to be enhanced; children meet mathematical concepts every day and operate in rich mathematical contexts even before they set their eyes on a Mathematics worksheet.

Van De Walle (2008) points out that Mathematics knowledge content grounded in an experience familiar to students supports the development of advanced mathematical concepts and provides students with access to meaningful mathematical reasoning, and thus they are able to learn it successfully. On the other hand culture is seen as a set of beliefs and understandings, which serve as a basis for communication within a community of people (Barton, 1996). Moloi (2012) states that some of these problems in Mathematics emanated from the fact that under the apartheid era, indigenous knowledge systems were marginalised suppressed and subjected to ridicule. These sentiments are echoed by Lebakeng(2012 : 299) who suggests that colonialism introduced western knowledge systems, as an attempt to destroy indigenous knowledge systems. Odora-Hoppers (2002:6) argues that the major threat to indigenous knowledge is the erosion of peoples knowledge, and the low value attached to it. This is evident in most rural communities, as they look down upon their culture and feel ashamed of it. Arguably the effect of Western hegemony has been achieved at the cost of silencing, parochial legitimation procedures, and most of all, the deterioration n social status for most humanity, including women and non- Western cultures. The ideal is that indigenous and western (mainstream) knowledge systems must complement each other for reciprocal volarisation.. Furthermore, Odora- Hoppers(2002:5) and Agrawal(1995:418) illustrate that indigenous knowledge systems(IKS) is the process of creative and transformative change and a counter-hegemonic tool.IKS is not merely local crafts and folklore but it is exploring indigenous technological knowledge in agriculture, medicine, knowledge transmission systems, architecture and Mathematics etc. One of its key features is that indigenous knowledge requires a commitment to the local context, unlike western knowledge which values mobility and weakens local roots. Odora-Hoppers and her collaborators sternly voice that colonisation of Africa dispossessed Africans their knowledge and voice. They further argue that Africa's problems must be solved by Africans and that the only way to do this is to reclaim, restore and revitalise indigenous knowledge. Furthermore, Thomson & Chepyator-Thomson (2002:50) contend that in Africa, remnants from the colonial period and a general lack of viable research that can inform educational and social transformation continue to challenge the continent as we embrace the 21st century. This paper gives a new look at the perception of teaching and learning of Mathematics capitalising on learning experiences of the child.

The new outlook of the teaching and learning of Mathematics is observed in the National Curriculum Statement (NCS) policy document that the inclusion of indigenous knowledge in the teaching and learning of Mathematics is important (Moloi, 2012 :). Most importantly, the national curriculum is the culmination of efforts over a period of seventeen years to transform the curriculum bequeathed by apartheid (Department of Education, 2011: iv). All the good things which were eroded by colonialisation and apartheid era need to be brought back and knowledge viewed from African perspective. The National Curriculum Statement (NCS) is liberating education and Mathematics practitioners from the bondage of colonisation. It is not the kind of education system, which Baturo, Cooper &Norton (2004:88) explain as the education system that have devalued indigenous culture and marginalised it as primitive, simplistic and insignificant with respect to Mathematics education, leading indigenous people to believe that they must become "white" or westernised to succeed in Mathematics.

3. Conceptual Framework of the paper

The paper is viewed through the lens of community cultural wealth theory. Community cultural wealth focuses on and learns from the array of cultural knowledge, skills, abilities and contacts possessed by socially marginalized groups that often go unrecognized and unacknowledged (Yosso,2005:). Within the cultural-historical context, Mathematics can be defined as a cultural activity that emerged somewhere in man's cultural history and went through a rich and remarkable cultural–historical development to end up in the multifaceted and highly sophisticated discipline as we know it today (Van Oers ,2009:). It is clear that Mathematics cannot be divorced from the culture; even the teaching and learning of Mathematics has to reflect the cultural context. Lebakeng (2012: 30) shows that indigenous knowledge is indispensable for environmentally and ecologically sensitive activity. This statement supports the idea that teaching and learning of Mathematics needs to be contextualised within cultural practices. Moreover, Baturo, Cooper &Norton (2004:88) view contextualisation of Mathematics" *as a relatively new strategy aimed at bringing relevancy into Mathematics education for Indigenous students. Fundamentally, it involves incorporating aspects of indigenous culture and Indigenous perspectives into pedagogical approaches to Mathematics education and in turn, instils a strong sense of pride in the students' indigenous identity and culture. Essentially the contextualisation process attempts to develop links between the two knowledge systems [Western and Indigenous] that on the surface seem light years apart*". In this paper, the focal point is on the understanding of mathematical content areas found in cultural games. Baturo et al. (2004) further indicate that in other indigenous communities, cultural Mathematics includes the use of money, sport and gambling.

4. Methodology

The study used the participatory action research method. Participatory action research recognises community members as experts and it is empowering for communities who are enabled to find their own solutions to local issues (Moana, 2010). In the study, the researcher and participants utilised indigenous knowledge systems to solve mathematical problems and identify mathematical concepts embedded in cultural practices. Yosso (2005) argues there is huge capital in our communities, which is not adequately utilised. Indigenous knowledge systems are seen as the huge wealth which communities possess and it is not effectively used. On the other hand Lebakeng(2012: 305-306) points out that the threat caused by colonisation of Africa or Western powers was not socio-economic but more importantly was on destruction of natural wealth-plants,anmals, insects, clean air and water- and human cultural wealth.Yosso,2005 human wealth principles, which Lebakeng sees as important in indigenous knowledge

4.1. Learners Activity illustrating interplay between Mathematics and African indigenous games

Mosimege (2000) illustrates that indigenous games are usually viewed from the narrow perspective of play, enjoyment and recreation, and there is more to them than just these three aesthetic aspects. Children are likely to be creative when they use ideas and experiences; and make new connections through play (Thompson,2008).Nabie & Sofo(2009:1) reveal in a study carried in Ghana that 22.44% of teachers incorporated traditional African games into Mathematics lessons. The most common used traditional African games involved jumping, hopping, and rhythmic activities. The indigenous African games used addressed Mathematical content areas such as number and number operations, measurement, shapes and space, problem solving and investigations, and collecting and data handling. Gerdes (2009:11-12) cite the cultural practices of storytelling, basket making, salt production, and mat, trap and hat weaving as potentially rich in Mathematics content areas. Moreover, he alludes to the fact that mathematical concepts are involved in playing traditional games of memory, calculating games, checkerboard games and games of chance, and analyses ways to integrate these concepts n the teaching of Mathematics. One of the games in which the teacher involved in this study interacted with learners is the Cultural game in fig. 1: Morabaraba (board game).It is the board game played by two people, with 24 tokens and 12 for each player. The aim of the game is to create rows of three cows (tokens), being vertical, diagonal or horizontal. The following mathematical concepts: area, ratio, proportions, geometric figures, numerical patterns and similarity will be addressed. Mathematical skills also targeted are logic, reasoning, construction, accuracy on calculations, interpretation and identifications.

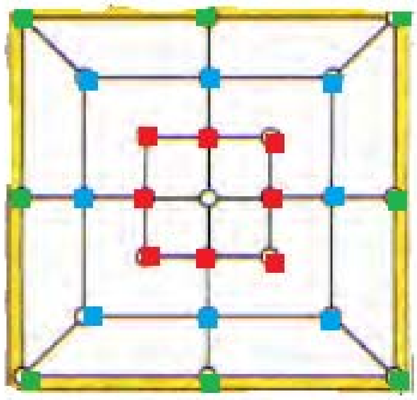

Fig. 1: Morabaraba board

Refer to Fig. 1 to answer the following questions:

- Question 3.1: Name all the shapes or figures (where corners are indicated in red, blue and green colours) in the board game.
- Question 3.2: To justify the answer in question 3.1 measure (in cm) the dimensions of the above shapes and compare your response with question 3.1.
- Question 3.3: How do the shapes or figures in question 3.2 relate?
- Question 3.4: Calculate the area covered by the shapes or figures and the perimeter of the shapes.
- Question 3.5: What deductions can you make from question 3.4?

Suggested responses:

These responses which follow are a guide that the facilitator of the lesson will expect from learners. Although there can be a quite number of responses which will be raised by learners.

- Question 3.1: The shapes or figures shown by the board games are squares.
- Question 3.2: To justify the answer in question 3.1 measure (in cm) the dimensions of the above shapes and compare your response with question 3.1

Table 1

Figures	$Length\ x\ Breadth$	$Perimeter$	$Area$
$figure1$, $where\ corners\ are\ in\ red$	$1{,}4\ cm\ x\ \ 1\ cm$	$4{,}8\ cm$	$1{,}4\ cm^2$
$figure1$, $where\ corners\ are\ in\ blue$	$2{,}6\ \ cm\ x\ \ 2\ cm$	$9{,}2\ cm$	$5{,}2\ cm^2$
$figure1$, $where\ corners\ are\ in\ green$	$4\ cm\ x\ \ 3\ cm$	$14\ cm$	$12\ cm^2$

After measuring the figures, it appeared that the figures shown by the board games are rectangles, not squares. From the onset (question 3.1) the figures appeared to be the squares. The centre rectangle with red corners is partitioned by the squares, which agreed with the actual measurement performed.

If the learners follow the patterns observed in Table 1 above, it is possible that they come up with the following observations, in Table 2 below:

Table 2

Figures	$Length\ x\ Breadth$	$Perimeter$	$Area$
$figure1$, $after\ figure$ $4\ cm\ x\ \ 3\ cm$	$5{,}6\ cm\ x\ \ 4\ cm$	$19{,}2\ \ cm$	$22{,}4\ \ cm^2$
$figure\ 1$, $after\ figure$ $5{,}6\ cm\ x\ \ 4\ cm$	$7{,}4\ \ cm\ x\ \ 5\ cm$	$24{,}8\ cm$	$37\ cm^2$
$figure\ 1$, $after\ figure$ $7{,}4\ \ cm\ x\ \ 5\ cm$	$9{,}4\ cm\ x\ \ 6\ cm$	$30{,}8\ cm$	$56{,}4\ \ cm^2$

- Question 3.3: How do the shapes or figures in question 3.2 relate?
- Question 3.5: what deductions can you make from question 3.4?

The observations made on the breadth are, the breadth of the rectangle with blue corners, is twice that of the rectangle with red corners. The breadth of the rectangle with green corners is three times that of the rectangle with red corners. Generally the breadths increase by 1 cm every time. The length of the rectangle with blue corners is $1{,}2\ cm$ more than the length of the rectangle with red corners. The rectangle with green corners is $1{,}4\ cm$ more than the length of the rectangle with blue corners. Generally the pattern followed by the lengths can be described as follows: $l_n = (0{,}1)n^2 + (0{,}9)n + 0{,}4$ (where l indicates the lengths of rectangles and n indicates the number of rectangles). The general pattern of perimeter and area of the rectangles can be illustrated as follows: $P_n = (0{,}2)n^2 + (3{,}8)n + 0{,}8$. (where P indicates the perimeter of the rectangles and n indicates the number of rectangles) and Area pattern is as follows: $A_n = (0{,}1)n^3 + (0{,}9)n^2 + (0{,}4)n$ (where A is the area of the rectangles and n is the number of rectangles). See Appendix A, as to how the formulas are derived.

- Question 3.4: Calculate the area covered by the shapes or figures and the perimeter of the shapes. See table 1 and 2 above and Appendix A for detailed calculations.

As the study uses participatory research, various ways of getting the solutions are discovered. This is emphasised by Agrawal (1995:417) who argues that indigenous knowledge is of crucial significance if one wishes to introduce a cost-effective, participatory and sustainable development process. The participants are fully engaged as they work cooperatively on something they know, and practise culturally. These solutions showed that indigenous games, particularly Morabaraba games can help develop the teaching and learning of mathematical concepts. The mathematical concepts discovered here are the patterns, between the dimensions, that is lengths and breadths. The pattern displayed the areas and the perimeters were observed. The relationships of these dimensions and the relationship between areas and perimeters were established. Gerdes (2009:15) points out that board games or tchadji board game can be used to teach learners geometrical pattern recognition and probability theory.

5. Conclusion

Odora-Hoppers (2002:3) argue that authentic change requires authentic engagement. In this context the authentic change can be viewed as the operationalisation of indigenous knowledge system, which in turn brings in the authentic engagement on how indigenous games can be incorporated in the teaching and learning of Mathematics. Agrawal (1995:414-415) illustrates that the focus of indigenous knowledge publicises the long overdue move, and that indigenous knowledge has brought a positive contributions in the fields of Ecology, Social sciences, Agricultural Economics, Rural Sociology , Mathematics and many more fields. New international, and national institutions sponsor inquiries into indigenous knowledge, this further signifies the importance of indigenous knowledge.

In this way indigenous games are used as an endogenous knowledge, which demonstrates that mathematical concepts are not exogenous, is our cultural practices. The new look, as suggested earlier in the paper will be easily realised in the teaching and learning of Mathematics. The Morabaraba games emphasised the fact that, given the pattern, when the second difference is common, in order to determine the general formula we use the quadratic formula, given as $(x) = ax^2 + bx + c$. They also emphasise the fact that when the first difference is common, generally, the linear function is used to find out the last term, where the linear function is defined as $(x) = bx + c$. The Curriculum and Assessment Policy Statement Grades 10-12: Mathematics (2011:12) states the following in the curriculum statements for Grade 10: "*Investigate number patterns leading to those where there is constant difference between consecutive terms, and the general term is therefore linear*". The following is stated for Grade 11: "*Investigate number patterns leading to those where there is a constant second difference between consecutive terms, and the general term is therefore quadratic".* Thus the Morabaraba games are clearly aligned to. The Morabaraba game further discovered that when the third difference is common, to determine the general formula, we will use the cubic general formula shown as $f(x) = dx^3 + ax^2 + bx + c$.

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