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Using Indigenous Games to Teach Problem-solving in Mathematics in Rural Learning Ecologies

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Abstract

This article explores the use of *morabaraba*, a board game, as an example of indigenous games to teach problem-solving in mathematics. This approach is part of a rural learning ecology informed by the theory of community cultural wealth that posits community members as experts and empowers communities to find their own solutions to local issues. It is based on the existence of knowledge which learners possess but is not used in the teaching and learning of mathematics; there is no deficiency in the marginalized knowledge of the excluded people (Yosso 2005: 79). The author tapped into the marginalized knowledge of subaltern communities to teach problem-solving using participatory action research in generating data, hence the involvement of community members (parents, traditional leaders), education experts (teachers, mathematics subject advisors, lecturers from institutions of higher learning) and learners themselves. The primary data was generated using a tape-recorder and video camera, analysed using Van Dijk's (2001) critical discourse analysis to identify instances of 'discursive injustices' in text and talk, and to acquire deeper meanings of the text. It signifies a form of resistance to unethical and unjust social power relations.

Résumé

Cet article examine l'utilisation du Morabaraba, un jeu de plateau, comme un exemple de jeux autochtones utilisés dans l'enseignement de la résolution des problèmes mathématiques. Cette approche s'inscrit dans un environnement d'apprentissage rural se basant sur la théorie de la richesse

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culturelle communautaire qui considère les membres de la communauté comme des experts et qui habilite les collectivités à trouver leurs propres solutions aux problèmes locaux. Elle est basée sur la prémisse selon laquelle les apprenants possèdent des connaissances qui ne sont pas utilisées dans l'enseignement et l'apprentissage des mathématiques; les connaissances marginalisées des personnes exclues sont utiles (Yosso 2005: 79). L'auteur a puisé dans les connaissances marginalisées des communautés subalternes pour enseigner la résolution des problèmes en utilisant la recherche-action participative dans la génération des données, d'où l'implication des membres de la communauté (parents, chefs traditionnels), des experts de l'éducation (enseignants, conseillers sur les disciplines mathématiques, conférenciers provenant d'institutions d'enseignement supérieur) et les apprenants eux-mêmes. Les données primaires ont été générées en utilisant un magnétophone et une caméra vidéo, analysées grâce à la technique d'analyse critique du discours de Van Dijk (2001) pour identifier les cas d'« injustices discursives » dans le texte et les paroles, et obtenir des sens plus profonds du texte. Cela signifie une forme de résistance aux rapports de forces sociales injustes et contraires à l'éthique.

Introduction and Background

That mathematics results in South African secondary and primary schools are poor, especially for grade 9 learners, was confirmed by the Annual National Assessment (ANA) Report (Department of Basic Education 2014: 43, 60), which showed the average performance of learners stood at 13 per cent in 2012, 14 per cent in 2013, and 11 per cent in 2014. Also, the Department of Basic Education (DBE) Reports of 2012 and 2013 illustrated that nationally grade 12 mathematics results stood at 54 and 59 per cent respectively. Moreover, Yang and Manizade (2010) have illustrated that the rote learning approach of teaching should be replaced by more application, modelling and real life problems. Mathematics should be more intuitive, interesting and accessible to a larger population of diverse learners. In this study, the teaching and learning of mathematics using the *morabaraba* (indigenous board game) helped overcome the challenges faced by learners as they realized that mathematical content was within their reach; that is, daily play contains concepts which are not viewed as too complex to comprehend. Teacher-oriented methods were influenced by an assumption that learners are empty vessels to have knowledge poured into their minds, and the lack of engagement of parents who separated teaching from the home environment and learners' backgrounds, which are actually rich in mathematical content. As Mosimege (2000: 427) and Pramling-Samuelsson (2008: 630) assert, when playing, children learn mathematical concepts more easily.

The lens

The paper is framed by community cultural wealth theory, which validates and recognizes the knowledge that learners bring from rural learning ecologies. Lynn (2004: 156) and Yosso (2002: 98,100,102; 2005: 69) argue that an array of cultural knowledge, skills, abilities and contacts possessed by socially marginalized groups often go unrecognized and unacknowledged. In this research article, *Morabaraba* is used as an example of indigenous games in teaching problem-solving skills in grade 10 mathematics classes to recognize and acknowledge the cultural practices of various communities. Van Oers (2010: 23, 26–27) introduced the cultural-historical theory of Vygotsky, which views learning as a process of qualitative change of actions that may take place when people participate in cultural activities and receive guidance for improving or appropriating actions. Within the cultural-historical context, problem-solving can be defined as an activity that emerged and underwent a rich and remarkable development to culminate in the multifaceted and highly sophisticated discipline it is today. Leonard (2008: 59, 60) contends that mathematical problem-solving, like other forms of knowledge, is situated within a cultural context; consequently, counting can be conceptually understood as both a knowledge form and a cultural practice that enables learners to organize their world. Engaging cultural norms in the classroom is at the heart of teaching cultural relevance.

Yosso (2005: 78–79) argues that community cultural wealth theory has various forms of capital, such as aspirational, navigational, social, linguistic, familial and resistant, which draw on the knowledge of learners from homes and communities being taken into the classroom. The researcher draws on the theories of Yosso and Van Oers to argue that using indigenous games to teach mathematics problem-solving skills is a way of bringing the immediate environment and experiences of the learner to the classroom.

It is evident that the teaching and learning of problem-solving should be viewed from a humanistic point of view through lived experiences of marginalized groups regarding many mathematical concepts that are formulated (Barker 2012: 20; Bush 2005: 3; Vilela 2010: 249). The use of *morabara* in the teaching and learning of mathematical content portrays the human element and human activity. Problem-solving meanings are not fixed or predetermined, and meanings are not indifferent to linguistic practices (Lynn 2004: 154; Vilela 2010: 347; Yosso 2005: 80). Therefore, the link between mathematical content and cultural practices, such as playing indigenous games, helps learners to see and appreciate the relevance of problem-solving skills in their day-to-day activities (Chikodzi and Shumirai 2010: 4).

There are many other representations and interpretations which could improve the understanding of mathematical concepts. As such, learners need to be exposed to a variety of concept representations. Maharaj et al. (2007), citing Witherspoon (1993), suggested representations to concretize mathematics, including concrete models, real-life situations, pictures and spoken language. The use of *morabaraba* is within the reach of learners and subaltern communities, and so encapsulates these representations, encouraging a learner-oriented approach by which the learners discover mathematical concepts through practical play and use of their home language, found to be rich in mathematics vocabulary (DBE 2011).

Methodology and Design

The study utilized participatory action research (PAR), which recognizes community members as authorities and specialists in their fields and is empowering for communities in enabling them to find their own solutions to local issues (Moana 2010: 10). In the context of this study, the researcher and participants were empowered in using indigenous games to solve problems and identify mathematical concepts embedded in them. Everyone had a significant role to play in the learning of problem-solving, rather than simply expecting all activities to be handled by the teachers and/or research coordinator in the team. Hitherto, marginalized cultural capital was explored to understand problem-solving by using cultural games, particularly indigenous ones.

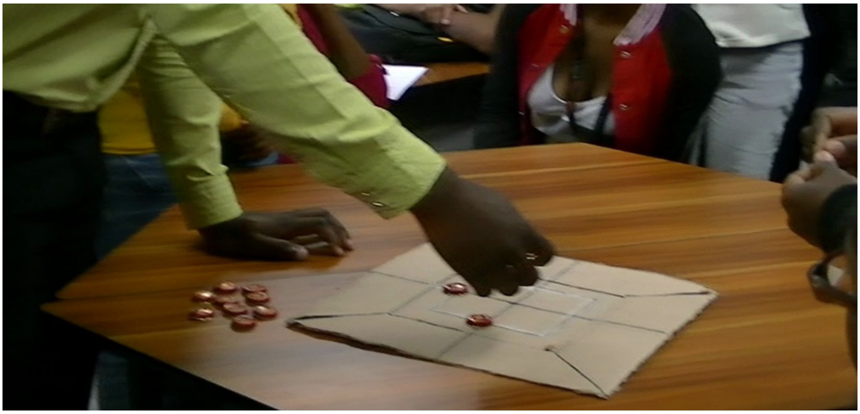
The research coordinator assembled a team of grade 10 learners in one school located in the rural area of QwaQwa, Free State Province, in Thabo Mofutsanyana Education District. This comprised one deputy principal, one head of department (HOD), three grade 10 mathematics teachers, two Life Orientation teachers, two district officials from the Department of Basic Education (DBE), one in the sports section and two mathematics subject advisors, ten parents with knowledge of various indigenous games, two members of the royal family who were custodians of cultural games, and a lecturer in the school of Mathematics, Science and Technology Education from the university.

Bungane (2014: 33) and McGregor and Murnane (2010: 423) recommend that the researcher and the participants be seen as central to the research process, and act as equals throughout the teaching and learning processes. The approach of using a board game to teach problem-solving was followed. For confidentiality and anonymity, the school and participants were given pseudonyms and, to stimulate debate, free attitude interviews (Buskens 2011: 1) were conducted, thus also ensuring that they were central to the study and their voices heard, rather than being seen as objects to be manipulated and controlled in a setting removed from the real world of their lived experiences (McGregor et al., 2008: 199; Stinson and Bullock, 2012: 46).

Findings and Discussions

According to Lynn (2004: 154) and Yosso (2002: 162), the teaching of problem-solving should draw on the strengths of learners nurtured at home. Thus the subject matter presented in mathematics class will make sense to them, with no deficit in their language, culture or lived experiences. It is important for the teachers to consider this capital wealth if the teaching and learning of problem-solving is to be simplified and meaningful. The lived experiences of learners can include storytelling, family histories and indigenous games. The DoE (2003: 2), Haylock (2010: 3) and Van de Walle et al. (2010: 13) agree that teaching of problem-solving must be learner-centred, in support of the ontological and epistemological stance of community cultural wealth theory which posits that knowledge and the nature of reality do not reside within one powerful individual, but rather that there are multiple realities shaped by a set of multiple connections that human beings have with the environment, and that the nature of knowledge is subjective (Chilisa 2012: 40). The teacher should not take centre stage, trying to explain everything for learners. As Van de Walle et al. (2010: 13) citing Schifter and Fosnot (1993) argues, no matter how lucidly and patiently teachers explain the subject matter they cannot *understand* it for their learners. If the teacher explains everything to learners their potentialities are oppressed and marginalized. The research team used indigenous games, such as *morabaraba*, to teach problem-solving in mathematics, allowing learners, teachers and parents to unearth mathematical content contained within the board game.

Figure 1: Learners playing morabaraba (board game)



As learners played they reflected on the lessons learnt in groups, reporting under various headings on mathematical concepts, skills or knowledge observed, and mentioned any information they deemed fit to share with the whole class.

> [ext] Group 1: Rona ha re shebile straturale neitjha sa morabaraba,re bona rektengele e nyane, ho latele e kgolwanyane, e kgolo, (lebella Figure 1) jwalo-jwalo. rektengele tseo di entswe ka dilaene. Ha papadi e bapalwa re bona tsena, re beha dikgomo tsa rona ka ho fapanyetsana, o lokela ho nahana ka kelo hloko pele o beha kgomo ya hao, hore o tsebe o hlola enwa wa direng. O menahana mokgwa wa ho hlola papadi ena. (As we view the structural nature of *morabaraba* we see rectangle of various sizes, the big one, the bigger one, and the biggest one (refer to Figure 1*)*. These rectangles are made out of lines. On the actual playing of the game, these are apparent; we play by giving a chance to each opponent to place his/her token cow on the board. You have to think strategically before you place the token cow on the board, so as to maximize the chances of winning the game, and also anticipate the movement that the opponent might take.) [ends]

The above extract shows that learners were able to interact freely among themselves. The teacher had given them freedom to think of problem-solving skills embedded within the board game so they were able to design a lesson plan which included those mentioned by learners. In this way, it was flexible as one plan, and accommodated the prior knowledge of learners.

The learners were empowered to decide on the content to be taught, and as such the content was infused with the context with which they were familiar. As a result, the teacher packaged the content raised by learners in the class activities to be presented; for example, patterns, which the teachers elaborated on by showing that there were ascending or descending orders in the game. In this way, learners used problem-solving skills they mentioned such as sequences (orders), rectangles, lines, and chances of winning the game that also fell within the parameters of their syllabus. The playing of *morabaraba* resuscitated concepts which they knew from their home experiences, so that as the teacher went into detail it was easier for them to relate new knowledge to what they previously knew.

As learners or teams, members interacted with the various groups to share their reflections and so demonstrated that they possessed social capital. The navigational skills were illustrated as they performed analysis and interpretations of the mathematical concepts or skills they had observed from the playing of the game. As the extract 'we see rectangle of various sizes, the big one, the bigger one, and the biggest one' indicates, what they conceptualized was true. They saw patterns or sequences of rectangular shapes, which differed according to size. The power of linguistic capital enabled learners to use words such as 'big', 'bigger' and 'biggest' to describe the pattern of rectangles they observed. The ability of linguistic skill helped them to understand mathematical concepts, not only ascending and descending order, but also concentric geometric patterns. These are the problem-solving skills (algebraic expressions, equations, number patterns and geometric figures) that are featured in the grades' 9 and 10 mathematics curriculum and Curriculum Assessment and Policy Statement (CAPS).

The learners used linguistic capital to describe the shapes properly, revealing how the geometric figures were arranged in a particular sequence and explaining how they were related. Mathematically, it shows that they realized that these geometric figures were ordered concentrically. The extract also shows that they were able to perform the high cognitive skills of analysing and synthesis. The teaching and learning of problem-solving has to include such skills and assess them. From the perspective of cultural wealth theory, learners already possessed these rich skills, but it is the responsibility of the teachers and community members at large to nurture and develop them further.

Consequently, the teaching of this problem-solving in mathematics had helped learners to see the relevance of the subject matter in authentic situations. All group members were actively involved in the presentation.

In order to stimulate further discussions, Mr Debako crafted worksheet 1 (see below), and distributed it to various groups.

WORKSHEET 1

1. Name all the shapes or figures shown in *morabaraba* game.
2. To justify the answer in question 1 measure (in cm) the dimensions of the above shapes and compare your response with question 1.
3. How do the shapes or figures in question 2 relate?
4. Calculate the area covered by the shapes or figures and the perimeter of the shapes.
5. What deductions can you make from question 4?

The worksheet gave learners a chance to use their background knowledge to discover mathematical content on their own. They were in small groups working on the activity, structured in such a way that they had to use various methods to reach an answer, not only taken from the teacher or person presenting but also arrived at through class interaction.

Linda, the leader from group B, presented solutions as follows:

> [ext] Linda: we really enjoyed to work on the activity. Lots of answers came out, but finally we agreed on one solution. We will present our solutions, thereafter we can take questions and comments from the floor.
> Linda: Question 1, the figures are squares, but after measurement were performed in question 2, we realised that the geometric figures showed are rectangles. Remember the properties of square and rectangles. That is what we provided as our motivation, and the table below. [ends]

The table below shows how Linda's group framed their responses.

Figures	Length & Breadth	Perimeter	Area
Picture 1 above showed th big shape	1.4 cm x 1 cm	4.8 cm	1.4 cm^3
The bigger figure, following the big one	2.6 cm x 2 cm	9.2 cm	5.2 cm^3
The bigger shape, following the bigger one	4 cm x 3 cm	14 cm	12 cm^3

After the questions and comments were entertained, group D was given a chance to give feedback on questions 3 and 4.

Tshepiso, the group leader took the platform to give their responses:

> [ext] Tshepiso: Thank you group B, we really enjoyed your presentation, the excellent way you did the presentation. We hope our presentation will match yours.
> Tshepiso: (see table above), generally the breadths of big shape increase by every time. The length of the bigger figure is more than the length of the bigger rectangle. The biggest rectangle is more than the length of the biggest rectangle. Generally the pattern followed by the lengths can be described as follows: $l_n = (0,1)n^2 + (0,9)n + 0,4$ (where indicates the length 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).

The extracts above show that learners are empowered to determine mathematical concepts to be taught in class. This method of teaching problem-solving using *morabaraba* elevated learners' self-esteem and confidence. Also, their voices were respected when deciding the content to be presented in class, illustrating teaching from learners' perspectives. Also, learners are empowered to be aware that integration of problem-solving skills and concepts happens spontaneously; that is, they were aware that problem-solving in mathematics does not occur as separate entities but as linked concepts. The above activity and learners' responses showed that algebra, Euclidean geometry (shape, space and measurements) and mathematical processes (e.g., critical thinking, communication) are interconnected.

Worksheet 1 above indicates that the class activities are learner-centred, with learners having to argue before reaching the decision on the answer. This worksheet (class activity) encompasses the social capital which learners demonstrated excellently by freely sharing and networking on ideas to reach solutions. The response 'we really enjoyed to work on the activity' shows hope for a brighter future in the learning and comprehension of problem-solving in mathematics in the form of aspirational capital. Even when the learners face real and perceived barriers in problem-solving skills they are determined that they will overcome them. Using the navigational skills they helped to manoeuvre through the patterns observed in the class activity, and managed to come up with general formulae, such as , $l_n = (0{,}1)n^2 + (0{,}9)n + 0{,}4$ $l_n = (0{,}1)n^2 + (0{,}9)n + 0{,}4$ and $A_n = (0{,}1)n^3 + (0{,}9)n^2 + (0{,}4)n$ for lengths, perimeters and areas of concentric rectangles in the board game respectively.

The findings above concur with Ewing (2013: 135) in that learners recognize problem-solving skills such as patterns when they sing, dance, weave and play. Su et al. (2013: 2) add that the preliminary or background knowledge that learners possess is foundational to understanding more sophisticated problem-solving. The process of learning problem-solving skills is sustained if owned and framed by learners and school communities. Vankúš (2008: 106) points out that if learners are actively involved in the learning of problem-solving skills they tend to develop self-reliance and become more creative. This is also evident when learners managed to discover the formula for the perimeter as $P_n = (0{,}2)n^2 + (3{,}8)n + 0{,}8$, given the rectangle with dimensions and . They did not use the usual formula, $P = 2(l + b)$, used by most of the textbooks, which showed the creativity and critical thinking they had developed in learning problem-solving skills using *morabaraba*.

Conclusion

In conclusion, the argument made in this paper confirms those of the DoE (2003: 29), Provasnik et al. (2012: 1,4) and TIMSS and PIRLS International Study Centre (2009: 24) that in the teaching of problem-solving, reasoning skills such as analysing, selecting, synthesizing, generalizing and conjecturing are important attributes for learners to have, also as life-skills for survival. The empirical evidence (SACMEQ Report by Moloi and Chetty 2011: 7; Su et al. 2013: 2, 3) evinced that the wealth of marginalized knowledge learners possessed enabled them to unearth mathematical content imbued in *morabaraba* and relate them to the problem-solving skills addressed by the CAPS.

In this article, it has become evident that learners were assisted in deciding on the mathematical content to be taught in the classroom, infused within the context with which they were familiar. Engaging learners in the playing of *morabaraba* resuscitated mathematical concepts which they knew from their home experiences. Learners experienced patterns or sequences of rectangular shapes, alternative formulas of the perimeter and area of rectangle. The power of linguistic capital enabled them to use words such as ‘big’, ‘bigger’ and ‘biggest’ to describe the pattern of rectangles they observed. Linguistic ability helped them to understand mathematical concepts, such as ascending and descending orders, and concentric geometric patterns. Also, they were assisted in understanding mathematical concepts such as algebraic expressions, equations, number patterns and geometric figures.

Moreover, it was encouraging to realize that learners were able to discover the general pattern of the lengths of rectangles within the *morabaraba* described as*:* $l_n = (0{,}1)n^2 + (0{,}9)n + 0{,}4$ (where indicates the length of rectangles and n indicates the number of rectangles). Again, further observations were made by learners that 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 the general pattern of the Area 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*)*.

Finally, the above activity and learners’ responses showed that algebra, Euclidean geometry (shape, space and measurements) and mathematical processes (e.g., critical thinking, communication) are interconnected.

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