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Black Students' Rich Mathematical Experiences: Mathematics Concepts and Xhosa Cultural Games for Reception Class

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Abstract

Poor mathematics performance and low socio-economic status variables in South Africa are skewed towards a black child due to the history of colonization and apartheid. These variables then become labels that nurture assumptions that mathematics is for the elite and belongs to the West, and therefore these students' mathematical prior knowledge and experiences are ignored. Mathematics is a problem-solving tool. Disregarding mathematics learnt from cultural artefacts and community engagements due to socio-economic status is disempowering. Such symbolizes power of privilege that recognizes Western culture versus lack of property ownership experienced by Africans, which unconsciously translates to lack of confidence in their own heritage. This paper presents and explores cultural games played by these students during playtime and in their communities with the aim of eliciting mathematics embedded and attained while engaging in the game. The paper recommends cultural relevant pedagogy that integrates mathematics learning with students' cultural artefacts for ownership of knowledge and recognition of pluralism for economic and development initiatives globally.

Keywords: cultural games, inclusion, cultural relevant pedagogy, critical race theory, ownership, esteem

1. Introduction

Distancing mathematical knowledge to a certain group of children and human beings has history. Mathematics in the past was only learnt by monks and noble-men. With time, traders participated due to discoveries they observed in different cultures and because of status they obtained through trading [1]. Even then, some cultures' mathematics were recognized and documented, while others were labelled as applied mathematics giving them a lower status than pure mathematics. This discriminatory behaviour still exists in the field and continues to exclude. South African black children like all children in the world experience mathematics from their mother's womb, where they explore and navigate such space to a level where they know and feel safe in it. The loud cry they make during birth is caused by the realization that the new space is cold as they feel the temperature, they also feel that it is big as they are unable to touch, and then as soon as they are picked up and

wrapped, they feel safe again. This indicates the exploratory nature of the human being and their spatial abilities. However, the society enters this life and starts undermining and discriminating what is already there by grouping children according to their geographical existence, race and socio-economic status.

It is difficult not to align these discriminatory behaviours with entitlement, privilege and property ownership [2]. These mathematical intuitions develop naturally for children; they start engaging in games that use mathematical abilities. Ref. [2] uses critical race theory to analyse these experiences of exclusion adjourning from land rights and ownership of land. Landson-Billing proposes using US law that ownership of land goes a long way in developing one's identity in the society. Land ownership seems to be physical; however, it contributes heavily on the psychological being and esteem of human beings. Hence, black children's games are excluded in the society because this group of human beings has no privilege, no property ownership nor esteem. Since, they are already excluded these games are never brought into class because whose games are they, matters in the discriminatory society. This is a global issue because cultural games that are recognized are those from the West such as chess because of white privilege, while on the other hand, there are African games like "umrabaraba," a logical game that was used during trade in Africa. There are other logic games such as stick fighting of the Xhosa boys and girls in South Africa. Their character is similar to those that are globally recognized but carry no property right with them and therefore excluded. This exclusion translates to classrooms where children enter classrooms labelled by default that they have no mathematical skills and knowledge from their communities and therefore learning provided to them is not connected with their mathematical knowledge they bring to school.

Hence, only if they are resilient will they succeed in mathematical learning; otherwise their self-esteem and identities are not integrated with mathematical creation [3]. This paper aims to bring forth the cultural games played by Xhosa children with their mathematical skills and the knowledge they develop.

2. Mathematical exclusion

Ref. [4] gives detail account on mathematics exclusion of young black children in South Africa. In her paper she revealed that classrooms are not resourced for mathematics stimulation for young children rather they are boring formal classrooms for adults. In addition, her paper highlights that teacher qualifications are informal and vary in terms of quality with high learner-teacher ratio. These findings are supported by [5] revealing that learners from low socio-economic backgrounds attend schooling in low socio-economic schools with no resources and teachers with inadequate qualifications for mathematics teaching. Ref. [3] list a number of "vulnerabilities" South African black and coloured students possess that hinders success in learning mathematics such as homes with no resources, schools with no resources, peers with similar challenges and language of instruction not the same as home language (p. 355). These studies show how exclusion in mathematics learning is systemic.

A commissioned review of early childhood provision in South Africa revealed that the history of segregation played a significant role in excluding young children in quality mathematics instruction [6]. In addressing this injustice post 1994, the South African government through social development opened preschools for black children with a focus of care and social development. This provision did not provide for mathematics stimulation but focused more on welfare addressing poverty. The positive outcome from this review were the universality of the reception class which assured that all 5- to 6-year-old students receive stimulation to date. The current

challenge though is that teachers who teach these students are informally trained with varied quality of training by non-governmental organisations; hence, their classroom practices lack quality and purpose [4, 7, 8]. This indicates that education system drags itself in addressing issues of inequities in the education. This slow movement is resulting to graduates of poor quality that are also unemployable. This issue is an emergency as it is an economic factor that will scar the system for a long time and lead to more poverty experiences; currently the job losses per day are increasing, and the buying power is decreasing heavily.

It is important to note that the poor quality of teaching students receive is not the only factor of exclusion. Their cultural experiences also are not regarded as contributing knowledge to the mathematical learning experiences. Furthermore, English continues to have power over learning in general; hence, mostly language is becoming a barrier towards excellent performance for those who learn in language different than their own. A summary of literature that discusses the language exclusion in mathematics teaching and learning is discussed and shared below.

2.1 Language exclusion

Trends in International Mathematics and Science Study (TIMSS) 2015 results indicate clearly that students who write test in their spoken language at home perform far better than those who are tested in a foreign language. [9] revealed a significant difference of ($p = .008$) that was observed between a group of students whose proficiency in English was nurtured in an intervention and those who were in the control group, an indication that English holds a key towards successful access to mathematics learning for students. These findings reveal already that students with home language other than English are automatically excluded from learning; hence, an added challenge to them is to be proficient in English. This relationship between English language of instruction and students' proficiency in English has been highlighted in the US research too for students whose home language is not English [10–13]. Student participation and comprehension in mathematics learning are hindered by poor English fluency, and it impedes engagement with mathematical ideas [14, 15]. Hence, poor fluency in English excludes students from mathematics successful experiences. Ref. [16] asserts that language is a socio-cultural tool that allows students to gain access to ideas. This socio-cultural tool develops as an external tool while the child is born. Through interaction and observations with adults, the child begins to internalise vocabulary s/he hears; in doing so this, vocabulary becomes an internal tool to use to engage. Vygotsky then argues that when this vocabulary is used, it is no longer an external tool but an internal one. All children gather this language tool from their immediate environments and from their homes, and this tool becomes their cultural capital [17]; they use to make sense of the world. [18] highlights the importance of language in teaching and learning mathematics; they mention that the use of sociocultural theory in teaching mathematics is highly important as it embraces the language of the student and make connection for successful learning.

South Africa is one of the countries that has tried to address the language issues of multilingualism. However, the country struggles to align its language policies with the practice for the benefit of the students. [36, 28] revealed how South African young children get exposed early to English numeracy. This creates challenges to the teaching as educators who teach these students also lack foundational mathematics language in their own home languages similar to the students [36]. These are the results of the South African apartheid system that created deeper wounds to the education of the black child. The identity of teachers that has been determined by fluency in other people's languages such as Afrikaans and English

has created teachers who are not proficient in any language as their home languages were never used as cultural capital. Research cannot only focus on students when addressing language proficiencies; teachers also need intervention that can develop their esteem and pride of their home languages too.

2.2 Racial exclusion

Ref. [19] asserts that race is overlooked when discussing challenges observed in mathematics performance. This paper supports this assertion by supporting it with empirical evidence. For example, South Africa started participating in the TIMSS study in 1999 observing the trends of reporting the challenges of poor performance that were aligned with disadvantage learners, overcrowded classrooms and lack of resources [20]. However, revisiting these findings the students who were in overcrowded classrooms, disadvantaged and in schools with no resources were all black. The next trend of reporting this participation again highlights inequities and lack of foundational knowledge due to poor early mathematics exposure [21]. Again who were the learners who were mostly affected by the inequities, who lack foundational knowledge and also are exposed to poor mathematics instruction? The response is again black students. The 2011 and 2015 TIMSS findings did not bring anything different; although again race is not mentioned, the same black students are the ones who continue to perform poorly. Ref. [22] argue that within mathematics learning and research, there is a silent privilege that needs to be exposed. Critical race theory unravels and unpacks how white privilege continues to close access and opportunities to those who are non-white. Also it unravels how this privilege prevails through entitlement and unfounded generalisations that align whiteness automatically with success.

In the context of South Africa, research is taking too slow in unravelling racial issues that are highly embedded on educational practices including methodologies used to address educational issues. South Africa has top performing students in the National Certificate that come from low social backgrounds studying in under- or unsourced schools. However, these students repeatedly demonstrate that resilience is innate to them and therefore poverty, and discrimination cannot impede their performance. Research needs to tap on these students' traits and learn from them the qualities that they possess to be able to nurture other students from similar backgrounds.

Therefore, this racial exclusion demands more research to be conducted. This paper will only contribute by exposing black children's cultural games that have potential to nurture and influence black learners' identities within mathematics learning and experiences. By doing this it is encouraging more exploration of cultural artefacts and practices that influence mathematical growth and thinking.

2.3 Economic exclusion

Students reject a school science that is disconnected from their own lives, a depersonalized science, where there is no space for themselves and their ideas (p. 13).

The UNESCO [23] shared the above quote with the aim of asserting educators and researchers that scientific knowledge that does not align with one's experiences and thought has no place in students' conceptualization of the world they want to conquer. The global community faces challenges of attrition of scientists due to the fact that only the elite and the haves receive quality stimulation, while the majority who lives under poor socio-economic situation are deprived from such experiences.

Socio-economic variable has rooted itself in the centre to obstruct or allow quality mathematics experiences. Internationally, research has revealed how the socio-economic variable plays a significant role in the provision of quality

mathematics instruction. Lack of resources generally indicates economic exclusion. This economic exclusion begins from home where parents are sometimes jobless or earn below poverty levels. Ref. [24] states that this variable is a cruel unjust variable. Lack of resources for learning influences the quality of mathematics instruction negatively [25–27]. In addition, [28] reveal that quality educators highly influence mathematics learning of students from low socio-economic homes. This finding argues for quality human resources to be provided to all students for mathematical experiences that are successful. Refs. [29, 30] describe quality mathematics teachers as teachers with excellent content knowledge of mathematics, who have insight into mathematics progression and who are able to develop self-regulation in students.

The best performing countries in the world make sure that they choose the best performing graduates to join teaching [31]. This also means that these teachers will earn equally with their colleagues in other fields. Countries that perform poorly do the opposite. If providing students with high-quality education has the gains, research has already been proven. Why do systems continue treating education as a “Cinderella” of the systems? Economies need engineers, scientists, innovators and inventors who will produce those high-skilled citizens if the teacher in the classroom is not a high performer him- or herself. Educational systems need to be reflective and truthful to themselves if growth is the agenda of their missions. Otherwise, the current practices look like they are planned and have a purpose that is negative to the societies.

3. Capital-/asset-based approach in teaching and learning of mathematics

Refs. [24, 32, 33] have proven that young students have demonstrated that they have high capabilities in mathematics regardless of their socio-economic background, ethnicity and geographical origins. These researchers propose the use of students' capital/assets in nurturing mathematics knowledge. Capital/asset refers to their ways of knowing and communicating and experiences that are mathematical and have been ignored. Ref. [34] indicates that there are diverse mathematical experiences from different cultures that nurture mathematics in early ages. Some cultures develop spatial reasoning first through hunting, while others develop measurement concepts through construction, and others develop diverse concepts through games, etc. If this is the case, tapping into these diverse mathematical experiences and heritage is more capacitating for students from these cultures. It develops ownership of mathematical knowledge and allows for more creation and activity. Ref. [35] argues that drawing knowledge from the students' languages and cultural-rich knowledge when teaching them creates healthy nurturing learning environments. Such environments will create spaces where mathematical creation of knowledge belongs to all, and the disadvantaged groups of students will take active participation in such creation and bring forth diverse-rich innovations in mathematics. This chapter focuses on exploring the cultural capital of Xhosa students in the Eastern Cape of South Africa. While doing so it also presents the mathematics embedded in the cultural games explored.

A lot of research has been conducted under ethnomathematics trying to find cultural experiences with mathematics. However, mathematics knowledge was not exposed, and that resulted in integration that had some flaws. The focus was the cultural practices than the mathematics embedded in them [17]. Teacher empowerment becomes very important in understanding play with a purpose. Games are fun and occupy students longer developing their concentration abilities; they need structure and reflection. Amount of skills and knowledge attained from them has

to be assessed and evaluated. Some games allow for developmental levels and that needs to be integrated in the games played in the classroom. Games develop interest and pleasure to students something that lacks in current classrooms.

This chapter contributes in bringing fourth cultural games into the learning and teaching of mathematical concepts in the classroom and proposes that researchers use these games in their interventions.

4. Research design

This paper is a qualitative inquiry paper with a purpose to observe and gain insight on students' games inside and outside schools. Therefore, the data was collected and analysed qualitatively.

4.1 Context

Six primary schools in the Eastern Cape of South Africa were visited during playtime. Two of them were rural schools and four were township schools. All six schools provide education to black students from low socio-economic backgrounds; in the South African language, they are quintile 1 schools, fully funded by the government. Grade R/Reception year students' informal play during playtime was observed and documented and some pictures taken. The researcher engaged with students sometimes playing with them to get clear understanding of the games and the rules and procedures of the games.

In addition, the researcher made visits to one of the townships where the schools are situated during weekends to observe children play and document their games with the aim of triangulating with games observed from schools following similar procedures to collect the data.

4.2 Consent

Parental consent in the township was negotiated differently through engaging with parents and asking for voluntary participation of their children. This forced the researcher to only observe children from one street as in the possible second street, some parents were unavailable for consent. The children were made aware that the researcher is interested to learn their games and negotiated with them and got their ascent. The agreement was that children should play games they wish to play and be free. It was emphasized that when they lose interest in playing, they should feel free to stop playing anytime.

4.3 Rapport

Before the researcher could be able to collect data, she first needed to develop trust with the parents of the children by visiting the homes of 5- to 6-year-old children in the streets and talk to the parents about what she plans to learn from the children. The engagement with the parents who were mostly mothers made them to revisit their childhood games and compare them with what they see as children play. Issues of safety were also discussed. In a way the time the researcher was going to spend observing their children became the safest time. This made their children's cousins to join during the researcher's visits. The advantage for the researcher is that some of the parents knew her as she grew in the same township. Some parents trusted her when she introduced herself; as they always listen to a radio programme, the researcher leads in discussing about

educational challenges in the South African Broadcasting Corporation (SABC) “Umhlobo Wenene” radio station.

4.4 Duration

This data was collected over a period of 6 weeks, each school visited three times a week during the 30 minutes break time. This consisted of 9 hours spent on schools and 6 hours spent on the street in the townships on weekends. In total 15 hours was spent collecting data.

4.5 Analysis

The data from schools and the township consisted of field notes, pictures and audio of students' discussions. The field notes were typed, while the audio was transcribed and typed; the pictures were saved for reference and presentation. For each setting the data was organized in the separate file for analysis. The researcher analysed each data teasing out the game, rules and procedures. Once the structure was there, the researcher teased out the mathematical activities that were observed from each game and listed them with observed skills. This data was analysed continuously after each observation to make sure that if there are challenges, the researcher is able to address them during the next visit. A structured analytical memo was developed for each game observed. All analytical memos were developed for each game from the school setting and also to the township setting. The data was then triangulated making confirmations and checking for differences if they were any. The differences were then discussed with the students during the visits for confirmation and identifying if the setting influenced the differences.

After data collection, the structured analytical memos from school data were triangulated with the structured analytical memos from the township. This data was then shared with teachers to try the games and elicit all skills they observed and knowledge from the games. Their notes were then triangulated with the researcher's notes to write the final report. Students were frequently interviewed for clarity and consensus during triangulation time. It is important to share that due to the excitement of being observed, students went overboard to play many games; some were not experts at playing. This required the researcher to only focus on the games that students mastered in their age group and focus on analysing those; hence, only nine games were documented properly and analysed properly during this study. Also the purpose of this paper was to highlight the games that develop their mathematical knowledge and skills during early years. The other observed games had a lot of potential, but young children have to master them first before they could make the mathematical contribution embedded in them.

5. Findings

The findings had nine games that were discovered when they were grouped according to skills and concepts they developed. In avoiding repetition only one game per group is presented especially the games that cover most skills in a group. Each game is presented with knowledge gains and skills it develops (**Figures 1–4**).

5.1 Upuca

Upuca, the name of the game, is a traditional game among Xhosas as well other Africans in the Southern African countries with different names per culture. The

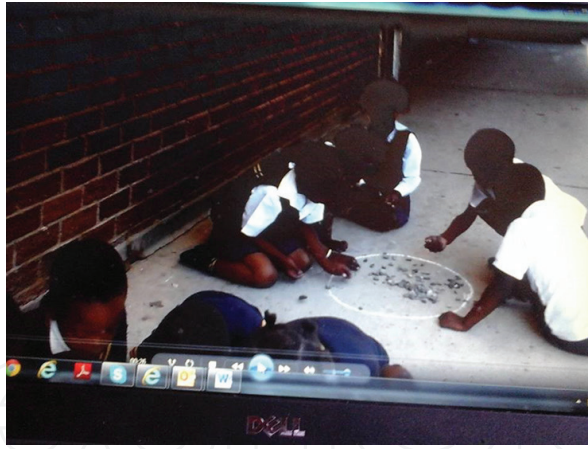


Figure 1.
Young children playing with stones and circles drawn on the floor.



Figure 2.
Young children playing with tins and a ball.

game uses small stones and can be played by a number of children taking turns; the smaller the group, the better. A circle is drawn on the ground where these stones are put in. The surface has to be smooth on the ground to be able to play. A player has to have one bigger stone, a spherical stone called “ingqanda” in his/her hand.

5.1.1 Procedure

The game starts at the beginning in ones until stones are finished. Then the second round will be in twos led by the winner, then threes, fours, until tens. The winner is always the one with many stones during counting time when stones are finished:

1. The player throws the spherical stone vertically while moving stones out of the circle fast and catch the stone on its way back.
2. The next step is to throw the stone again vertically while pushing back to the circle, the stones leaving only one outside the circle.
3. The player continues until s/he did not catch the stone back or left more stones than required outside the circle or unable to leave one stone outside. A good player might play until all the stones are finished.

Then they will move to the next round of playing in twos repeating the procedure. To move to the next round, all players should have at least managed to collect



Figure 3.
 Young children playing with a board with squares and a die.



Figure 4.
 Young children holding each other's shoulders forming a train.

ten stones not less. If less, you still stay in the previous round of collecting ones, while others move to collecting twos.

5.1.2 Mathematical concepts and skills that can be learned

5.1.2.1 Concepts

The game develops the following:

- Object counting—one to one correspondence.
- Skip counting in ones, twos, threes, fours, fives to tens sequentially.
- Subitising is nurtured automatically as the player needs to spot groups of numbers before selecting with the hand.

5.1.2.2 Skills

It is a good game for developing the following skills:

- Eye and hand coordination
- Time control
- Hand motor skills

5.2 Black toti

Black Toti is a children game played in South Africa; its popularity to other African countries is not known. A square is drawn with a small chord in each right angle of the square. Tins of different sizes are collected and put on top of each other so that they balance at the centre of the square to form a pyramid. There is also a ball to play with. It is important to note that the tennis ball is not a favourable one for this game as it runs too far. Most children prefer the plastic ball for this game, or they create their own with plastic bags. In some cases, they use the tennis ball.

5.2.1 Procedure

The game is played by three players in a team with ten cans in different sizes and a plastic ball/homemade ball/tennis ball. One player must have a ball and stand along the border of the square and hit the cans with the ball. S/he starts running to the chords counting as she/he reaches each chord around the square. S/he has to run fast as to reach 24 in counting. At the same time, the opponents' role is to run after the ball to pick it up to hit other players who are trying to rearrange the tins. The runner has to count to 24 before the tins are balanced; if not, they lose the game; if they finish 24, the game is over, and they have a point as a team.

5.2.2 Mathematical concepts and skills that can be learned

5.2.2.1 Concepts

- Develops sorting
- Counting and balancing
- Logic
- Time management

5.2.2.2 Skills

- Running fast
- Concentration

5.3 Umrabaraba

Umrabaraba is an African logic game that can be adapted according to the age group of players. A 3 by 3 square is drawn. One vertical and one horizontal line are drawn inside the square and meet at the centre. Two diagonal lines are also drawn inside the square to meet at the centre.

5.3.1 Procedure

Only two players at a time play as opponents. Each player plays with three counters of the same colour different from the opponent. Each player takes turn to place the counter. It is each player's role to block the other player from placing the

three counters to form a straight line whether it is diagonal. The winner is the player who manages to place his/her counters on a straight line first.

5.3.1.1 Concepts

- Logic
- Probability
- Prediction

5.3.1.2 Skills

- Concentration
- Internal logical thinking

5.4 Itreyini

Itreyini is a cultural game that is called train in English. This game is played by 22 children. Two of these children are heads of two different carriages. The heads of the carriages secretly give each carriage a name. For example, the other might be a chocolate and the other a biscuit, and these names are kept secretly.

5.4.1 Procedure

All 20 children wait to be called to the heads of the train. Each child is whispered to choose between a chocolate and a cake. Once the choice is made, the child goes behind the head s/he has chosen. This continues until all 20 children have selected the head they belong to. Once the choices are made, the carriages are made of the children that have chosen each head. The time now to create a bridge by drawing a line on the floor comes. Each head together with their carriages try to pull each other; the ones that crossover the line belong to the group on the other side. There is a strategy implemented during the pulling time. Those children who are stronger are the ones who must always be directly pulling the head, and the tiny ones are always at the back until the game is over.

5.4.2 Mathematical concepts and skills that can be learned

5.4.2.1 Concepts

- Adding
- Subtracting
- Balancing

5.4.2.2 Guessing

- Motor skills

6. Conclusion

Generally African cultural games explored in this paper develop logical thinking, numeracy, problem-solving skills, measurement and spatial reasoning. The “umrabaraba” game challenges the mind into making predictions and look at probability. Numeracy that develops from “black toti and upuca” nurtures meaningful counting, and concepts such as one-to-one correspondence, cardinality and skip counting, an indication that the numeracy levels observed by [35, 36], can be aligned with this exposure. The “black toti” game demands planning, motor skills, self-regulation, teamwork and time management. These games together with others are a cultural capital to African students. When cultural capital becomes a vehicle in accessing knowledge that knowledge is owned, and the esteem of the individual is elevated [33]. Ref. [2] indicates that ownership is the key to access and esteem in learning mathematics. This paper recommends that cultural relevant pedagogy is employed if mathematics access and knowledge are really universal. Pluralism in mathematics learning is dragging, while the society is currently challenged economically in providing jobs and increasing economies. The current challenges of the globe need citizenry that uses logical thinking so as to create innovative ideas in dealing with the emerging unique challenges of the globe. All mathematics curriculum expectations for Grade R are covered and beyond in these games. The way forward is inclusion of ideas and ways of learning and teaching mathematics. Students’ cultural capital should be capitalized in their learning of mathematics experiences [33].

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Conflict of interest

I have no conflict of interest to declare and have followed ethical procedures in conducting this research.

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