# Using School Mathematics to Understand Cultural Activities: How Far Can We Go?

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***Abstract***

*Mathematics and culture are often interconnected, making school mathematics intimately linked to the society in which it is taught. In response to this connection, mathematics educational reform policies indicate that learners should be getting an education which is connected to their cultures. Contexts are seen to be useful insofar as they provide access to school mathematics. This article focuses on the reverse, that is, using school mathematics to deepen our understanding of cultural activities, largely based on the notion that the mathematics content learnt in schools will be transferred by learners to use in their daily lives. We propose that this reverse practice calls for learners who are mathematically, socially and epistemologically empowered through mathematics education. We argue that mathematics classrooms rarely establish mathematics as an essential tool for understanding and changing the world. Critical pedagogy is not being valued as an emerging pedagogic agenda in mathematics education. Also the advanced nature of cultural practices need more advanced mathematical knowledge possibly to respond to the complexity of the practices. The qualitative study from which this article emerges worked with three mathematics teachers and their Grade 9 learners from one rural school (situated very close to a cultural village). An attempt was made to try and connect mathematics concepts to cultural activities. Based on the analysis of data collected over an extended period of ethnographic and participant classroom observation, we argue that school mathematical knowledge can be used to read and understand cultural practices deeper.*

***Keywords:*** *critical pedagogy, cultural activities, indigenous knowledge, mathematics education, teacher practices.*

## 1. Introduction

Current reforms in mathematics education emphasise the need to empower learners mathematically, socially and epistemologically (National Curriculum Statement Grades R-12, DoE, 2011a). Mathematical empowerment concerns the gaining of power over the language, skills and practices of using and applying mathematics. Social empowerment through mathematics concerns the ability to use mathematics for social betterment. The South African National Curriculum Statement (NCS) advocates for the use of mathematics to enable individuals to participate more fully in society through critical mathematical citizenship. Epistemological empowerment concerns the individual's growth of confidence and personal power over the use, creation and validation of knowledge (Ernest, 2004).

In South Africa, education and curriculum have an important role to play in establishing a society based on democratic values, social justice and fundamental human rights (National Curriculum Statement Grades R-12, DoE, 2011a). Mathematics education is not spared from this democratic and social role. The teaching and learning of Mathematics aims to develop a **critical** awareness of how mathematical relationships are used in social, environmental, cultural and economic relations (Curriculum and Assessment Policy Statement Mathematics Grades 7-9, DoE, 2011b). Relationships, hence connections, are an underlying principle of mathematics education.

Studies which advocate for the use of out of school mathematical practices in mathematics education (ethnomathematics as a teaching tool) highlight the necessity and benefits of such connections in bridging academic and cultural mathematics (e.g. Rosa & Orey, 2009; Adam, 2002; Arismendi-Pardi,2001). Rosa and Orey (2009) explored the symmetrical patterns found in quilts, making connections between mathematics and the craft and art of quilting. Through analysing different symmetrical freedom quilts, Rosa and Orey designed a module for teaching transformations. The module covers detailed work on reflections, translations and rotations captured in lesson plans which can allow teachers to develop classroom activities that help learners to understand geometry, especially concepts of symmetry and transformations. "Geometry concepts, when standing alone, can be seen as abstract concepts for learners, but by

analysing actual symmetrical freedom quilt patterns and being surrounded by examples, learners are able to see their relevance to the study of geometry" (Rosa & Orey, 2009, p.23). In general, quilts provide "real world" examples of geometry concepts because they often use translations, reflections, rotations and symmetry. Their study demonstrates how connections can be made between academic mathematics and learners' personal lives and cultures.

Adam (2002) investigated the implementation of an ethnomathematical unit in mathematics classrooms at two primary schools in the Maldives involving Grade 5 teachers and learners. The designed unit was on measurement (area, perimeter, volume) and was implemented in Grade 5 classrooms. Sites such as carpentry, boat building sheds, and markets were visited to explore mathematical aspects of these activities. The reaction of teachers and learners indicated that the ethnomathematical approach appeared to be welcomed, appreciated, and understood by both teachers and learners. "Teachers and students were able to identify activities and experiences in Maldivian culture exhibiting measurement systems, and were able to link this to the conventional mathematics that is part of Grade 5 measurement syllabus" (Adam, 2002, p. 7). The study provides empirically based data to support the claim that ethnomathematics is a possible way of learning mathematics.

Most studies which motivate for the incorporation of ethnomathematics as a teaching tool in the mathematics classrooms argue that ethnomathematical approaches to mathematics curriculum are intended to make mathematics more relevant and meaningful for learners promoting the overall quality of their mathematics learning. Little is known or established about the reverse process that is using school mathematics to deepen understanding of the cultural activities, and hence the article. This article intends to address the question: To what extent can school mathematics be used to understand cultural activities?

The article first establishes the need for critical mathematics pedagogy in mathematics classrooms. However, there is literature which argues that this pedagogy is faced with some implementation problems. The implementation problems are discussed in the article. The discussed problems were then used to direct the study focus.

### *1.1 The critical mathematics classroom*

The critical mathematics classroom establishes mathematics as an essential tool for understanding and changing the world. It connects mathematics with learners' cultural and community histories, and assists learners (and teachers) in understanding the power of an active, democratic citizenry, while, in turn, motivating learners to engage in learning significant mathematics (Stinson, Bidwell & Powell, 2012). On the whole, critical mathematics pedagogy centres mathematics instruction specifically around issues of social and political justice and reform (Skovsmose, 1994). It assists students to achieving a greater awareness of the extent to which mathematics is involved in day-to-day life and to prepare them for democratic citizenship, Skovsmose examined projects focused on mathematics, relevant to Danish students' lives, and related to important processes in society. He used each project to highlight particular aspects of critical mathematics education aimed at promoting social justice. Gutstein (2006) sees one of the goals of mathematics pedagogy as that of changing learners' (and teachers') orientation to mathematics, thus, to understand mathematics not as a series of disconnected, rote rules to memorise and regurgitate, but as a powerful and relevant analytical tool for understanding complex, real-world phenomena. This, he argued can be achieved by grounding mathematics instruction in the learners' languages, cultures, and communities, while providing them the mathematical knowledge needed to survive and thrive in the dominant culture (critical pedagogy). This also helps learners to develop positive cultural and social identities.

Bartolomé (1996), delving into conceptualising critical pedagogy, argues that it is a humanizing pedagogy that values learners' (and teachers') background knowledge, culture, and lived experiences, moving learners (and teachers) into their own ever-expanding interpretations of their lived worlds (Greene, 1996). Critical pedagogy therefore supports a problem posing pedagogy in which the subjects – who know and act, "develop their power to perceive critically *the way they exist* in the world *with which and in which* they find themselves" (Freire, 2000, p. 83). Critical mathematics pedagogy is most often framed as teaching mathematics for social justice (Stinson, et.al, 2012). Gutstein's (2006) social justice pedagogical goals in mathematics education are; reading the world with mathematics, writing the world with mathematics and developing cultural and social identities. From this observation we argue that school mathematics can be used to interpret and understand cultural activities, thus, building on the scholarship of culturally relevant pedagogy (Ladson-Billings, 1995).

"Another aspect of providing access and affirmation for learners of Mathematics is to look at examples of Mathematics in the variety of cultures and societal practices in our country" (DoE, 2003, p. 62). This statement in the NCS refers to the importance of reflection upon and inclusion of a variety of examples from cultural and social practices

to enable access and affirmation for learners of mathematics. This flexibility allowed by the curriculum also promotes the incorporation of local practices as starting points for applications or investigations, thus promoting critical mathematics pedagogy. Therefore the NCS refers to ethnomathematical activities in the classroom as empowering contexts for mathematical and contexts understanding. By using ethnomathematics as a teaching tool we believe this helps to stress that mathematics originated in cultures other than Greek, and that it continued to be developed by many societies other than European, thus developing cultural and social identities. Gonzalez (2009) draws on the scholarship of Paulo Frere (1970/2000), claiming that when mathematics is understood as a tool to further social change and emancipation of the oppressed communities, it is being viewed as the pedagogy of liberation. However, there are some scholars (Horsthemke and Schäfer, 2006) who claim that the use of ethnomathematics to teach academic mathematics is absurd because it localises and isolates mathematical thought. To them this contributes to the exclusion of learners' access to mathematical knowledge because ethnomathematical ideas in the mathematics curriculum contribute to the creation of a lighter school curriculum based on learners' cultural backgrounds. Indeed they are arguing for a critical interrogation of ethnomathematics as a teaching tool.

### *1.2 Implementation problems*

Although these new understandings of mathematics teaching and learning may sound very appropriate, the implementation and impact of explicit instructional strategy may not be widespread and unproblematic. The major challenge has been how to convert this vision of teaching mathematics for social justice from the written curriculum into the taught curriculum. In South Africa, teaching in schools rarely grounds mathematics instruction in learners' cultures and communities (Mosimege, 2012), it rarely brings the interconnection between mathematics and culture in pedagogically informed ways. In his plenary address on 'Mathematical connections and contexts' at the Institute for Science and Technology Education (ISTE) 2012 International Conference at Kruger National Park in South Africa, Professor Mosimege (ibid) reiterated that mathematics teachers lack the ability to make connections in their mathematics classrooms; their indigenous (local) content knowledge is shallow. Also, an evaluation of the implementation of the NCS carried out in 2009 by the Task Team for the Review of the implementation of the National Curriculum Statement revealed that some teachers had problems of converting the NCS vision of mathematics teaching from the written into the taught curriculum. Some teachers face challenges when using social/cultural contexts to reveal the underlying mathematics while simultaneously using the mathematics to make sense of the contexts themselves. In so doing they are hindered from developing in their learners the ability to read and understand their world mathematically.

There is widespread agreement that improving teaching and learning requires that teachers participate in high-quality professional development (Elliot, & Kazemi, 2007). Such professional learning communities are largely linked to teacher learning in and from practice. Adler (2009) has suggested that such models should consider "a range of orientations… all of which cohere with the conception of teaching as knowing-in-action-in-context: learning to teach requires the study of the act of teaching". Effective teacher professional development has been characterised as being long-term, collaborative, school-based and focused on student learning (Hiebert, Gallimore & Stigler, 2002). Little (1993) describes professional development as an activity that is intended partly or primarily to prepare teachers for improved performance in present or future roles in their schools (Desimone, 2009:182). It is from the above observations that we saw a need for engaging in a deeper exploration of how mathematics and culture connect at a classroom level. We engaged with mathematics teachers in a school-based professional learning community. The key aim of the professional development was to base the teaching of mathematics on the cultural background of the learners, using out-of-school, culturally-based activities.

### *1.3 The study focus*

The study from which this article emerges linked the mathematical knowledge being taught in a school (close to a cultural village) to the knowledge and activities of the cultural village[1] itself, interrogating connections between mathematics and indigenous knowledge systems. Apart from enabling learners to access and understand school mathematics, we also hoped this would equip the participating teachers and their learners with personal power over the creation and validation of knowledge (epistemological empowerment). Where applicable, we also hoped to equip the participants with the power

[1] *A cultural village is a tourist establishment where tourists can view aspects such as the homestead, traditional clothing, food and food-related practices, history and societal structures as well as song and dance routines of one or more of South Africa's cultures (Mearns & du Toit, 2008).*

and ability to apply their school mathematical knowledge in participating in and understanding cultural activities.

This article raises the question of the extent to which school mathematics can be used to understand cultural activities. This, we argue, has a bearing on the teaching and learning of mathematics where mathematical connections enable the recognition and application of school mathematics to contexts outside of mathematics - the links between mathematics and other disciplines or the real world (Blum et.al, 2007).

In literature, there is a predominant focus on connections targeted at using cultural activities to understand school mathematics. Contexts are useful insofar as they provide access to school mathematics. However, learners' ability to make connections in mathematics itself is crucial for conceptual understanding (Antony & Walshaw, 2009) as well as for application outside the discipline. This article focuses on using school mathematics to deepen our understanding of cultural activities, largely based on the position that the mathematics content learnt in schools should be transferrable to learners' daily lives. This view considers mathematics as relevant and practical. Mathematics has a utilitarian value and can be applied to many aspects of everyday life. From this orientation, teachers play a crucial role; they must apprentice learners into ways of investigating mathematics, and to be 'exemplars' and 'conveyors' of school mathematical knowledge (Graven & Venkat, 2007). Teachers must teach lessons in ways that will enable learners to recognise and make sense of these mathematical connections (Mhlolo, Venkat, & Schäfer, 2012).

## 2. Methodology

The study (from which this article emerges) with its focus on critical theory and constructivism paradigms needed hermeneutic methods seen as involving dialogue with participants as sources of information. We then relied on qualitative data using a case study approach or style of inquiry in search of understanding the extent to which school mathematics could be used to understand cultural activities.

### *2.1 Samples and sampling procedures*

The sample in this case study consisted of three mathematics teachers from one middle rural school in the North West Province of South Africa and their Grade 9 learners (218 learners in all), cultural dancers (these included some of the 218 learners) and the trainer of cultural dancers. A cultural village was identified as the research site and mathematics teachers who teach at a school very close to the selected cultural village were invited to participate. A cultural village was selected with the belief that it is where the community's indigenous knowledge is preserved. It was further considered that activities at a cultural village could assist teachers and learners in understanding condensed cultural ways of living. There is tremendous potential for cultural villages to act as custodians of indigenous knowledge (Mearns, 2006). Visitors and workers at cultural villages interviewed by Mearns (2006) expressed that cultural villages conserve respective cultures they are representing. A school close to the cultural village was chosen with an assumption that its members (including learners) could be quite familiar with the activities taking place at the cultural village. This assumption was supported by the school principal's comment that they were using the cultural village in Arts and Culture activities and that some learners were participants of activities at the cultural village.

### *2.2 Data collection procedure*

The first author visited the cultural village several times to familiarise herself with the activities at the cultural village. Videos of the cultural activities were recorded. The performers of cultural activities and the trainer of cultural dancers were interviewed to check on the extent to which they were using mathematics in understanding the cultural activities. A group of Grade 9 learners[2] demonstrated a Setswana step dance, a cultural dance practiced at a cultural village near the school. It was observed that the dancers were following a certain dancing style where each dancer was making five footsteps forward, backward and sideways. The modeling of the dancing style, through class discussions, produced a number pattern involving the number of dancers and the number of cumulative foot-steps made in one direction before change of direction (see **table 1** below).

[2]*These learners had previously participated in cultural dances at the Cultural Village near the school.*

**Table 1:**

| | | | | | |
|---|---|---|---|---|---|
| Number of dancers | 1 | 2 | 3 | 4 - - - - | n |
| Number of foot-steps | 5 | 10 | 15 | 20 - - - - | nx5 |

The second row was used to introduce a sequence. Through deductive reasoning the rule connecting the terms of the sequence was generalised. Learners managed to explain their understanding of a sequence leading to its definition. However, there was a heated argument on whether 'n' could take any value. Realistic considerations were recruited. Making 'n' = 0 meant no dancer, therefore no dance and making 'n' too large meant too many dancers dancing at the same time making it difficult to follow the dance. At higher levels the depicted scenario can be used to introduce bounded sequences. Given the periodic nature of the cultural dance – going forward, backward and sideways, the implied mathematics involved is periodic in motion since the steps were repeated over time. This led to another sequence - a constant sequence: 5, 5, 5, 5, …whose $n^{th}$ term is 5.

During class discussions, some learners reiterated that they could use their knowledge of number patterns to design different dancing styles. Besides enabling learners to access mathematics through the dance, school mathematics was used to understand the dance deeper through linking the dancing style to a number pattern. Some artefacts collected from the cultural village were also used to enact critical pedagogy in the mathematics classrooms. All in all, seventeen mathematics lessons were taught. The lessons were co-planned and co-taught by the first author and the class teachers. Lesson reflective meetings were held with the teachers. Teachers were pre and post interviewed individually. All the interviews were semi-structured to allow the exploration to create meaning-making through open-ended questions. The open-ended questions allowed flexibility to pursue responses that were relevant but initially not expected.

Learners were interviewed and asked to complete a questionnaire after the intervention teaching. This was aimed at understanding the impact which the critical mathematics pedagogy used in the study had on learners. This enabled us to explore learners' views about the use of cultural contexts in mathematics education. In the questionnaire learners were asked to state what they liked about the way they learnt the topics taught in the culturally-based lessons. We designed a learners' journal entry to allow learners to describe the lessons where culturally-based activities were summoned. The major concern was to determine what learners foregrounded in their lesson descriptions. The trainer of cultural dancers who also happened to be the cultural village manager was interviewed. For this article, we basically checked for statements suggesting the use of mathematics to understand cultural activities. Due to the nature of case studies, one cannot generalise the findings beyond the studied case. However, consistent with the objective of the study, the findings could lay principles for making high quality mathematical connections in practice.

At both school and individual levels, the researchers maintained the participants' anonymity and confidentiality by using pseudonyms (TR A, B and C). The Department of Education granted the researchers permission to carry out this study in one of their schools. We received informed consent from the principal, head of mathematics department, teachers and parents of the learners who participated in the study.

### *2.3 Data analysis*

Excerpts from learners' narratives, teachers' interview transcripts and comments on reflective meetings were analysed in order to describe the views of the participants on the use of mathematics in understanding cultural activities. The trainer of the cultural dancers' views on the extent to which school mathematical knowledge is needed in training the dancers were analysed using excerpts from the interview transcripts. Also the first author's observational data from cultural activities was used to determine the extent to which one can successfully model (mathematically) cultural activities.

In the sections that follow, we present the results of the analysis that captures the following aspects:

- The dancers' perspectives on the use of school mathematical knowledge in dancing.
- Participating teachers' perspectives on the connection between school mathematical knowledge and cultural activities.
- Learners' perspectives on the connection between school mathematical knowledge and cultural activities.
- Our perspectives on the use of school mathematics in modelling cultural activities.

The article then examines issues related to the analysis and concludes that the extent to which one can use mathematical knowledge to understand cultural activities depends on one's level of mathematical, social and epistemological empowerment and awareness of this empowerment.

*2.3.1 The dancers' perspectives on the use of school mathematical knowledge in dancing*

To understand the use of school mathematics in cultural dances, the first author interviewed the cultural manager who was also a trainer of cultural dancers. According to the trainer, school mathematics was only useful when training new dancing styles. This is illuminated by the following remarks by the trainer: (M = training manager, R = researcher)

> *M: The one who is mathematically literate when it comes to training has an edge over the illiterate one because there is a lot of counting of steps involved. They have to count certain number of steps going forward, backward, and sideways. The mathematically literate one catches faster, whereas the other one might miss out because of the mathematical language involved and he/she is sometimes slow, but not impossible as he/she will eventually catch up.*
> *R: So the mathematical knowledge is only useful when training?*
> *M: Mathematical knowledge is only useful when training something new. When they all get it chances are, from my experience, the one who was initially slow may even be a better dancer. It comes with passion.*

The above remarks trigger the question: what is mathematics for? Can we use mathematics to understand cultural activities? It is argued, in literature, that mathematics education for "critical citizenship" needs to emphasise a diversity of situated, social, cultural, and political mathematical practices, giving important attention to the mathematical knowledge that helps to describe and explain those practices – with mathematics as a critical tool to analyse and develop awareness of reality (Agudelo-Valderrama, 2008). The fact that, according to the trainer of cultural dancers, the one with knowledge of mathematics enters quickly into the dance, suggests that "school" mathematics is necessary for understanding the cultural dances. This then suggests that mathematics can be used for social empowerment. According to Ernest (2002), social empowerment through mathematics concerns the ability to use mathematics to better one's life chances in study and work and to participate more fully in society. Thus it involves the gaining of power over a broader social domain, including worlds of work, life and social affairs (p.2).

Each culture has got some basic styles which are applied in all dances and mathematical knowledge is basically needed when training these basic styles.

> *M: There are some basic styles which are used in each and every dance which can help to move to other complicated styles and as I have mentioned before, every culture has its own such basic movements for all its dances.*
> *R: Ok, suppose we go deeper to complicated styles; does it mean the mathematics being used is also getting deeper?*
> *M: Hmm… (Silence for a while). Maths, like I said before is only needed at basic levels. Like I said before, once the illiterate one catches up at that basic level, even if they get to complicated steps he can even manage faster than the literate one. In these dancing styles, after catching up with the basic steps it's even simpler to move to complicated styles.*

It seems the manager does not quite answer the question about whether deeper dancing styles also implied deeper mathematics.

> *R: Suppose someone is coming from the classroom, say a mathematics teacher, does his/her mathematical knowledge help him/her to understand the dances?*
> *M: The problem is, even our dancers, when they are dancing the concept of Mathematics is not even with them. They are simply dancing. To them it is just a dance not even related to mathematics at all.*

Not quite answering the question again. Answers to such questions may need someone who is very good at the dance and also very good at the Mathematics or someone who has been exposed to a pedagogical agenda (we argue) which encourages viewing the world with mathematical lenses. On the other hand, it is very rare to get a trainer who is very good at dancing and also very good at mathematics because it looked like the prerequisite for being a trainer is knowledge of the cultural dances. From the trainer's responses they do not really value knowledge of mathematics much because even the one who is mathematically illiterate will eventually catch up and even excel. In addition to not really valuing the use of mathematics, the trainer also may not be aware of the mathematics when performing the dances.

*2.3.2 Participating teachers' perspectives on the connection between school mathematical knowledge and cultural activities*

Before the collaborative implementation of critical pedagogy in their mathematics classrooms teachers reiterated that they were familiar with the activities at the cultural village. (TR A = Teacher A; TR B = Teacher B; TR C = Teacher C). All

the three teachers were teaching Grade 9 mathematics; TR A and TR B had two classes each while TR C had one class.

> *TR B: We are familiar with the activities at the cultural village; even our learners are also familiar with the cultural activities which take place at that village. Some of our learners participate in the cultural activities such as dancing, at the cultural village. (TR B, Notes of meeting, 23/01/2012)*

It is clear from the above remarks that teachers indicated familiarity of cultural activities. However, were the teachers and learners also aware of the possible use of mathematics in the cultural activities? In the first meeting teachers indicated that they were familiar with the activities at the cultural village. But at the conclusion of the study, they contended that the way they were now going to see these activities was completely different.

> *R: Do you think the way we used activities at the cultural village will shift the way you will see these activities the next time you visit the cultural village?*
> *TR A: Definitely sure because now I will be very observant to understand activities using mathematics. Since I now know their paintings contain a lot of mathematical ideas, some observed in the lessons. I will also try to be very observant and look for some more mathematical ideas to integrate in my teaching.*
> *TR B: Yes now we are going to see activities differently, because we are now going to see different kinds of shapes, number patterns, different colours and how they are used to create patterns and all these are included into mathematics and can be incorporated when teaching.*

When commenting on one of the lessons TR C made the following comments:

> *TR C: Learners were able to identify different shapes (mathematical shapes) from paintings used by different cultures e.g. Ndebele. They had a constructive debate in groups when identifying the involved types of transformations. Learners showed understanding. They participated well in the lesson. I liked that learners were able to discover that the mathematical skill - transformations is also applied in our cultural activities, meaning they can use transformations to study the paintings at the village. Ndebele people use mathematical patterns, lines, shapes, reflections, translations to design their houses.*

The above statements by teachers suggest a new way of seeing and understanding cultural activities, thus seeing them with a mathematical lens. In the past although the teachers emphasised that they knew activities taking place at the cultural village, knowing them and understanding them now appear to be two different things. The use of mathematical knowledge adds more appreciation of the cultural activities. TR B emphasised that she was going to appreciate the decorations and the colours through using her mathematical knowledge, thus reading the cultural activities with mathematics. This sends a message that one's mathematical knowledge can assist him/her to read and understand cultural activities that is, reading the world with mathematics (Gutstein, 2006). The deeper the mathematical knowledge one has, the deeper he or she will get to understand the cultural activities. For example knowledge of bounded sequences was (in the study) used (by the authors) to understand the need for limiting the number of dances in each dance. According to TR C the knowledge of properties of shapes and different transformations can be used to read and understand the decorations on Ndebele paintings and beadings and Venda traditional clothes. For example, from the pictures below learners identified shapes representing different transformations. This led to deeper understanding of the paintings and beadings.

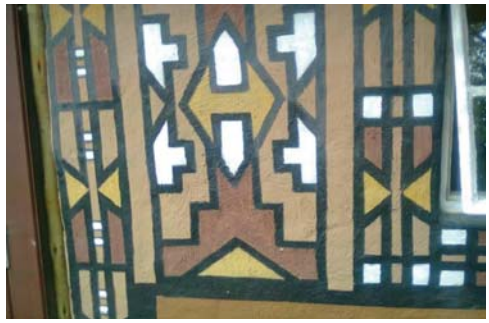

**Figure 1:** Ndebele paintings

By applying their school knowledge of transformations and shape properties, learners managed to describe the patterns and transformations on pictures of the Ndebele huts used during the lessons. This led to an appreciation and understanding of the mathematical skill(s) being applied by the painters.

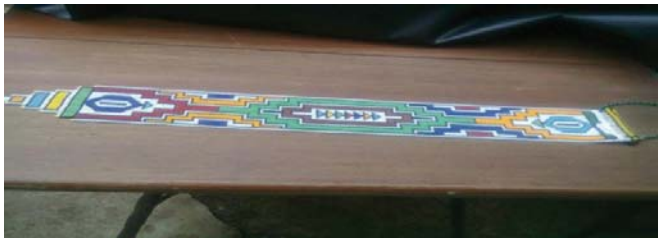

**Figure 2:** Zulu beadings

Through applying their school mathematical knowledge on translation, reflection and enlargement, learners had constructive group discussions on how the beads were sown. This led to a deeper understanding of the beading activities as well as the involved mathematics. Through measuring (in some cases counting beads in a line) the real artefacts learners came up with the used enlargement scale factors, the translation vectors and reflection mirror lines (axis of symmetry). Some learners reiterated that they were going to use their school mathematical knowledge in coming up with their own different beading designs without being coached.

*2.3.3 Learners' perspectives on the connection between school mathematical knowledge and cultural activities*

In the analysis, a questionnaire completed by a learner in Grade 9A was identified as Q2LA01, Q2 denotes the final questionnaire, LA denoting learner from Grade 9A, and 01 denoting the number of the questionnaire. For J1LA01, J1; J2; and J3 denote Lesson Journal 1, 2 and 3 respectively and LA01 with the same representation as above. For GILA01, GI denote group interview.

Learners also evaluated their knowledge of school mathematics as enabling them to understand cultural activities better. This is illuminated in some of the learners' remarks below: (All the underlining was done by the authors to add emphasis)

> *Q2LC26: I feel good because I have learnt how mathematics can be used to change the rhythm of the dance. I now understand the Tswana dance better than before. I can even design my own dancing styles using my knowledge of number patterns.*
> *J1LD02: I now know how to dance and how to draw a number pattern from a dance. I understood mathematics from that dance. I understand how mathematics and traditional dance work.*
> *J1LA16: We watched the Tswana dance checking their steps so that we can understand what they are doing when they dance.*
> *Q2LC08: I got interested because when we go to the cultural village we can learn more about number patterns.*
> *Q2LA05: Mathematics has very important applications outside of class which can help you to understand the subject and the activities. All you need to do is to talk about maths in front of others if you don't talk you will find it hard to know mathematics.*
> *LB3GI: I think much has changed because I used to see cultural activities as activities which just ended at the village but now…now I can use the activities to understand the mathematics we learn at school, to simplify my work and also use mathematics to understand these activities.*
> *LE3GI: When I go to the cultural village I will focus on finding the mathematics they will be using. I think I will spend more time trying to find that mathematics.*

According to Q2LC26 his/her mathematical knowledge helped him or her to read the dance and learn more about the traditional dance. Q2LC26's comment also illustrates the power of mathematics: "mathematics can be used to change the rhythm of the dance". Thus suggesting that the more mathematics one knows the more one can understand the cultural activities. JILD02's comment (I now know how to dance) in the excerpt indicates competence and confidence gained as a result of participation in the mathematics community of practice. Learners such as JILD02, who access mathematics through authentic cultural contexts, become doubly advantaged in that they gain access to both

mathematics and practical aspects of the recruited context itself.

The learners (e.g. LB3G1 and LE3G1) seem to be suggesting that the research activities developed in them a skill to read the world mathematically, which they thought they would use when they visit the cultural village in future. Learners valued and appreciated the gained knowledge which would enable them to understand and experience cultural activities from a mathematical point of view. Their participation in the study equipped them with a mathematical lens which they said they were going to use to view and read the world mathematically.

*2.3.4 Our perspectives on the use of school mathematics in modelling cultural activities*

In the study the first author was a participant researcher. From the first author's observation, the basic dancing styles in most dances were using constant sequences, for example the sequence 5;5;5;5; …. where 5 was representing the number of footsteps made by each dancer before changing direction. This led to convergent sequences. However, as the dances got more and more advanced and complex, modelling them got more and more complex as well. The advanced nature of the dance needed more advanced mathematical knowledge possibly to respond to the complexity of the practice. The required mathematical knowledge needed to be scaffolded by familiarity and deeper understanding of the activity. Some advanced styles led to periodic sequences where dancers were making a different number of steps forward, backward and sideways, leading to periodic sequences such as 4;5;3;4;5;3;… in some cases. However, to come up with the sequences the researchers had to replay the videos taken at the cultural village several times to familiarise themselves with the dances. This suggests that, as the cultural dances get more complex, the extent to which one can successfully model the dance mathematically depends on at least two things, that is, awareness of more advanced mathematical knowledge and familiarity with the dance or the cultural activity. We can use the mathematics we learn in school to actually go back to our communities and understand more of the activities taking place in those communities/activities.

## 3. Issues Arising from the Analysed Data

Our data analysis highlights some benefits of engaging critical pedagogy in a mathematics classroom. The trainer of cultural dancers indicated that he had passed Matric but could not clearly answer questions on whether or not deeper mathematical knowledge was required to understand cultural activities deeper. Does this failure to give clear cut answers reflect a possible lack of advanced mathematical knowledge to see the embedded mathematics in the dances? Or does it reflect the absence of pedagogical experiences (during his schooling) which emphasised meaningful engagement with contexts? In order to induct learners into thinking mathematically and viewing the world through mathematical lenses, mathematics pedagogy should explore contexts/scenarios to both deepen understanding of mathematics and understanding of the contexts/scenarios involved (Stinson et al., 2012).

Throughout the aforementioned narratives, the participating teachers articulate connections between school mathematics and cultural activities. TR C reiterated that learners could use knowledge on transformations to read and understand cultural paintings at the cultural village. "I liked that learners were able to discover that the mathematical skill – transformations is also applied in our cultural activities, meaning they can use transformations to study paintings at the village". These remarks by TR C suggest that learning can be transferred from one context to another. However, we are aware that from the situated cognition perspective, transfer of knowledge from one context to another is not unproblematic (Lave, 1988). However, transfer can occur when the transformed situation contains similar constraints and affordances to the initial context that are perceived as such by the learner (Bracke, 1998; Corte, 1999 cited in Bossard et al., 2008). TR A and TR B articulated their participation in the study as developing a new way of looking at cultural activities, rather than learning a mere method of teaching. They indicated that they were going to use their mathematical knowledge to read and understand activities at the cultural village. "I will be very observant to understand activities using mathematics" (TR A). In their remarks, knowledge of the subject matter – in this case, mathematics is to be used to examine and make better sense of the lived worlds (Gutstein, 2006).

Culturally-based lessons encouraged learners to recognise hidden ways in which school mathematics is used within everyday life (epistemological empowerment). LB3GI reiterated, "I used to see cultural activities as activities which just ended at the village but now…now I can use the activities to understand the mathematics we learn at school (mathematical empowerment), and also use mathematics to understand these activities" (social empowerment). As learners become more aware that they are using mathematics more than they previously recognised, learners may determine that they know more mathematics than they had thought (Frankestein, 1990). Learners in the study, after

recognising the ways that school mathematics is being used in the cultural activities, they became more confident in their mathematical understanding and understanding of the cultural activities. This is illuminated by the following remarks.

> *Q2LA05: Mathematics has very important applications outside of class which can help you to understand the subject and the activities. All you need to do is to talk about maths in front of others. If you don't talk you will find it hard to know mathematics.*

The underlined phrase in the above excerpt indicates the importance of talk – talk is providing entry to mathematics education. It also indicates the need for dialogue in critical mathematics pedagogy. The dialogical educator creates pedagogical spaces for epistemological curiosity where learners become apprentices in the rigors of exploration (Freire & Macelo, 1996).

The connection between learners' own lives and the school mathematics content may allow learners to develop a stronger mathematical identity (Leonard et al., 2010). As Ladson-Billings (1997) points out, it is not necessary to mathematise every topic but instead to allow learners to see, compare, and evaluate the link between the real world and mathematics. This, we argue, will assist learners to understand both the mathematics more and the real world. Through being able to describe, analyse and understand the world with mathematics, learners may see their everyday lives in a way they would have never anticipated. This helps learners to realise that mathematics can be used as a tool in society (Gutstein, 2003). From the identified learners' narratives in the context, "read the world with mathematics" (Gutstein, 2006), learners stepped out of the culturally-based lessons with a new outlook on how mathematics can be an effective tool in their lives – viewing mathematics as a tool to understand the world in which they live.

## 4. Limitations of Critical Pedagogy

Our experience in the study revealed that learners need to be apprenticed into ways of investigating mathematics and to be 'conveyors' of school mathematical knowledge. Therefore educators should make meaningful connections to learners' cultures in their mathematics classrooms. However, teaching in schools rarely brings the interconnection between mathematics and culture in pedagogically informed ways. The participating teachers, before the implementation of culturally-based lessons, indicated they were not making connections to learners' cultures due to lack of the required cultural mathematical content knowledge. This suggests the need for quality professional development on ways of making explicit connections to learners' cultures in mathematics classrooms. The challenge is: Who will in-service or teach the teachers? Many teacher educators may themselves be in need of similar in-service. They may also face great difficulty with pedagogic competences as espoused in this study.

Also our participation in the study revealed that successful mathematisation of cultural activities required adequate and relevant mathematical content knowledge. As the activities become more and more advanced and complex, more advanced mathematical knowledge is also needed to respond to the complexity of the practice. Limited mathematical content knowledge limits the intricate and flexible use of school mathematics to read and understand the cultural activities. More successful modelling also depends on one's level of mathematical empowerment and awareness of this empowerment.

## 5. Conclusion

In terms of the question raised in this article: To what extent can school mathematics be used to understand cultural activities, we conclude that the extent to which one can read and understand cultural activities depends on one's level of mathematical, social and epistemological empowerment and awareness of this empowerment. The focus of culturally relevant pedagogy brought with it sound pedagogical practices which participating teachers and learners perceived as empowering them into ways of reading and understanding cultural activities with mathematical lenses. If mathematics education continues to fail to connect mathematics to learners' cultures, it will continue to fail to socially empower learners (and teachers) into ways of examining real-life activities. Therefore, in order to best address these pitfalls and create individuals which most intended mathematics curricula claim to be producing, teachers need to embrace, implement and share ideas that promote critical pedagogy. Does one need the social phenomena first in order to produce/create or learn mathematics? In this article we put forward that one might need mathematics first in order to be able to identify/create it in/for given social phenomena. By so doing it will help that individual to read and understand the social phenomena deeper. However, this opens a debate about which comes first; the mathematics or the context. So it is like a chicken and egg problem which requires more engagement with, given the content-dependent metaphors that it

evokes.

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