Journal of Popular Education in Africa
January, February & March 2020, Volume 4, Number 1, 2 & 3
ISSN 2523-2800 (online)
Citation: Madusise, S. (2020). Developing Positive Mathematics Identity for Students: Competence, Performance and Recognition as Dimensions of Mathematics Identity. *Journal of Popular Education in Africa.* 4(3), 93 – 110.

Developing Positive Mathematics Identity for Students: Competence, Performance and Recognition as Dimensions of Mathematics Identity

By

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Abstract

Utilising culturally-relevant pedagogy as the main theoretical framework, this article explores the potential of culturally-relevant pedagogy for influencing learners' mathematics identity. The qualitative study from which this article is premised examined the impact of culturally-relevant mathematics lessons on learners' mathematical identity. Three Grade 9 mathematics teachers and their learners from one rural middle school in South Africa's North West Province participated in the study. In this Province cultural villages are being used as centres for preserving the communities' indigenous knowledge systems. The study's intention was to connect mathematics education to indigenous knowledge systems. Through mathematising culturally-based activities, the research team indigenised (i.e. adapted to local culture) two Grade 9 mathematics topics. A teaching and learning unit on the indigenised topics was designed and implemented in five Grade 9 classes at the same school. In the discussion in this article, I consider mathematics learning as a process of developing a mathematical identity. I address how Grade 9 learners' practices in mathematics classroom communities shape learners' perspectives of themselves. The paper analyses learners' narratives of mathematics classroom practices to demonstrate dimensions of identity in the activity of mathematics learning. I view identity in two ways: how individuals know and name themselves, and how individuals are recognised and looked upon by others. The findings revealed that culturally-relevant pedagogy can facilitate the development of learners' mathematical identities by rationally using learners' cultures to serve as a bridge between the learner and the subject. Competence, Performance and Recognition were found to be interrelated dimensions for describing learning as an identity. I argue that culturally-relevant pedagogy can facilitate the development of learners' mathematical identities.

Key words: Culturally-relevant pedagogy, identity, mathematics classroom community

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Background to the Study

Many researchers and theorists have considered how mathematics is learned, each foregrounding different aspects of the learning processes and viewing it from a range of theoretical frameworks. Learning mathematics can be viewed as building skills, using algorithms and following certain procedures. Another view focuses on students' construction or acquisition of mathematical concepts (Anderson, 2007). This study focuses on the view that learning mathematics in schools involves becoming a certain type of person with respect to the practices of a community. In this view, learning occurs through social participation (Wenger, 1998, p.4): learning changes who we are by changing our ability to participate, to belong and to negotiate meaning (Wenger, 1998, p.226). According to Wenger all learning eventually gains significance in the kind of person we become. This article addresses how Grade 9 learners' practices within mathematics classroom communities shape learners' sense of themselves - their identities. Learning transforms our identities: it transforms our ability to participate in the world by changing all at once who we are, our practices, our communities, learning is a matter of engagement: it depends on opportunities to contribute actively to the practices of communities that we value (Wenger, 1998, p. 227).

Therefore, learning mathematics also involves the development of each learner's *identity* as a member of the mathematics classroom community. In this article I view identity as how individuals know and name themselves and how an individual is recognised and looked upon by others (Grootenboer et al, 2006, p.612). Identity refers to the way we define ourselves and how others define us (Sfard & Prusak, 2005; Wenger, 1998). Thus, identity is socially constituted, that is, one is recognised by self and others as a kind of person because of the interactions one has with others.

Putman and Borko (2000) stated that, how a person learns a particular set of knowledge and skills, and the situation in which a person learns becomes a fundamental part of what is learned (p.4). With this in mind, the impact of culturally-based mathematics lessons were determined through analysing learners' narratives. Identity was then seen as a set of reifying, significant and endorsable stories about a person (Sfard & Prusak, 2005). Learning events and forms of participation are thus defined by the current engagement they afford. Problems of disengagement and non-participation in mathematics have tenaciously persisted for many years (Bishop, 2001). It is hoped that an investigation of mathematical learning as identity development through engaging in culturally-relevant mathematics lessons may offer some new insights into how these issues can be ameliorated.

Statement of the Problem

Some mathematics education reform policies indicate that mathematics should be connected to learners' cultures. However, teaching in schools rarely brings this interconnection between

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mathematics and culture in pedagogically informed ways. This article explores the potential of culturally-based lessons in Grade 9 mathematics for influencing learners' mathematical identities.

Theoretical framework: Culturally-Relevant Pedagogy

Various theorists have outlined pedagogical strategies which incorporate students' cultural backgrounds and prior experiences. The belief that the pedagogy can empower learners intellectually, socially, emotionally and politically by using cultural referents to impart knowledge skills and attitudes is an important framework for this study. Ladson- Billings (1994) asserts that culturally relevant teaching is designed not only to fit the school culture to the students' culture but also to use students' cultures as a basis for helping students understand themselves and conceptualise knowledge. Culturally relevant pedagogy has been defined as a means to use students' cultures to bridge cultural knowledge and school knowledge (Boutte and Hill, 2006), to validate students' life experiences by utilising their cultures, histories as teaching resources (Boyle-Baise, 2005), to recognize students' home cultures, promote collaboration among peers, and connect home life with school experiences (Neuman, 1999). It would appear the proponents of this pedagogy generally contend that culturally responsive teaching acknowledges the legitimacy of the cultural heritages of different ethnic groups as legacies that affect students' dispositions, attitudes and approaches to learning. Studies based on the concept of cultural differences make an assumption that students coming from culturally diverse backgrounds will achieve academic excellence if classroom instruction is conducted in a manner responsive to the students' home culture (de Beer, 2010; Madusise, 2013). Culturally relevant pedagogy is a teaching style that validates and incorporates learners' cultural background, ethnic history, and current societal interests into teachers' daily instruction.

Many mathematicians, mathematics teachers and students possess only a limited understanding of what and how [cultural] values are being transmitted through the discipline (Bishop, 2001, p.234) to develop a positive mathematics identity. Culturally relevant mathematics lessons work against this ignorance by reversing the trend in traditional mathematics curricula to divorce mathematics from its cultural roots (Troutman & McCoy, 2008).

Ladson-Billings (1995) documented the success of innovative lessons that appeal to diverse cultures in improving students' attitudes towards classroom subject matter. Teachers who participated in her study developed lessons that incorporated the knowledge students gained from their lives outside of class and demonstrating the value of students' home cultures and languages. By so doing the participating teachers positively influenced student test scores, engagement in the classroom community, and overall attitude towards school and learning (Ladson-Billings, 1995). Thus, this leads to the development of a positive mathematics identity.

Lloyd (2001) conducted a five-year study aimed at showing teachers alternative classroom practices to better meet the needs of students. The study focused on encouraging schools to promote the learning by all students through lessons that showed connections between mathematics and students' lives. The most successful educators were those who fully embraced innovative and culturally relevant lessons. The study reported in this article aimed to connect the

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teaching and learning of mathematics to cultural contexts, checking on the potential of culturally-based mathematics lessons for influencing learners' mathematical identities.

A possible mathematics identity model

In this section, I describe my mathematics identity model developed to provide analytical direction for data analysis and interpretation. The model was adapted from Carlone and Johnson (2007)'s Initial Science Identity Model which is premised on both practical and theoretical sources of data. In this model a person who has a strong mathematics identity is described as someone who is competent; who demonstrates meaningful knowledge and understanding of mathematics content, who can perform for others her competences with mathematical practices/activities, and finally, someone who can recognise herself / himself, and gets recognised by others as a mathematics learner. These aspects of mathematics identity are captured in the following interrelated dimensions: *competence, performance and recognition.* Any one of the three dimensions illustrated in the diagram in Figure 1 can *be used to describe* mathematical identity. However, the intersection of either two or all the three sets can represent an even stronger mathematical identity.

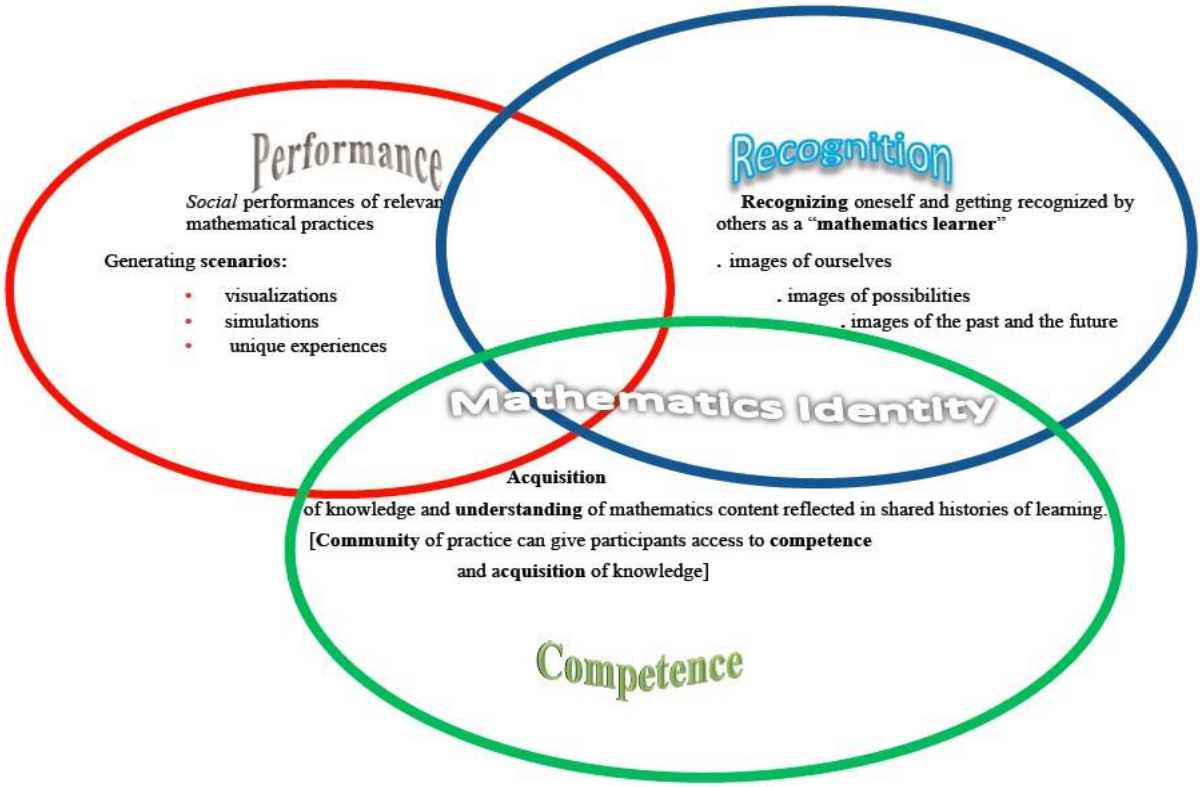

Figure 1**:** Model of mathematics identity

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Research question

This article addresses the following central research question: *What is the potential of culturally-based lessons in Grade 9 mathematics for influencing learners' mathematical identities?*

Methodology

To address the above question, data sources included learners' pre and post questionnaires, teacher and learners' interview transcripts, learners' lesson journals, lesson observations, teachers' reflective forms and transcripts from reflective meetings. These multiple data sources (Merriam, 1998; Yin, 2003) served as corroborating evidence to enrich the picture of teaching practices presented in the study and the stories learners tell about their engagement in the mathematics learning communities. The multiple sources of data provided convergent lines of evidence to enhance credibility of assertions (Yin, 2003).

Quotations from learners' questionnaire responses and interview transcripts were used as narrative stories told by learners evaluating their participation. Excerpts from teachers' interview transcripts and reflective meetings were used to find out how teachers recognised learners as a part of the mathematics learning community (Boaler, 2000; Wenger, 1998). Therefore, the excerpts were used to determine learners' mathematical identity, using the identity-as-narrative construct (Sfard & Prusak, 2005). Sfard and Prusak clarify that the identity-as-narrative construct assumes identity to be human-made rather than God-given (p.17). They assert that narrative is not a window onto identity, rather narrative is identity (p.14). Thus, they suggest, identity is a discursive construct where identities are considered as discursive counterparts to lived experiences (p.17) limiting their definition to linguistic signs that index or represent a person's lived experience. In agreement with this definition I used linguistic data from learners' experiences to count as admissible evidence in constructing an account of identity.

In my model I considered identity as one of those self-evident notions that, whether reflectively or instinctively, arise from one's first-hand experience. This is linked to the work of Lave and Wenger. According to Lave and Wenger (1991, p. 53) learning… implies becoming a different person… learning involves the construction of identity. Therefore, being a kind of person remains the centrepiece of the definition of identity. The motif of a person's own narrativization recurs in the description proposed by Holland et al. (1998):

People tell others who they are, but even more importantly, they tell themselves and they try to act as though they are who they say they are. These self-understandings, especially those with strong emotional resonance for teller, are what we refer to as identities (p.3).

Samples and Sampling Procedures

The sample in this study consisted of three mathematics teachers from one middle rural school in the North West Province of South Africa and their Grade 9 learners. Purposive and convenience sampling was used to select the research sites (Patton, 1990). Merriam (2009) identifies purposive sampling as one appropriate sampling strategy in case-study design. Merriam (2009) further adds that purposeful sampling is based on the assumption that one wants to discover, understand, gain sight; therefore, one needs to select a sample from which one can learn the most. In this case, a cultural village was identified as the research site and mathematics teachers

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who teach at a school very close to the selected cultural village were focused on. 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)

A cultural village was selected with the belief that it is where the community's indigenous knowledge is preserved. The intention was to make the cultural village a mathematics teaching resource centre. A school close to the cultural village was chosen with an assumption that its members (including learners) are quite familiar with the activities taking place at the cultural village.

Grade 9 was chosen based on the argument that it is a transitional grade from GET to FET where students after Grade 9 are to choose between Mathematics and Mathematical Literacy. At Grade 9 students are learning mathematics which combines aspects of both Mathematics and Mathematical Literacy. At Grade 9 learners have more experience with mathematics than learners at earlier grades. Doing the study at FET level would have limited the number of participating learners as some learners might have perceived it as being linked to Mathematical Literacy and would therefore withdraw since everyday examples are usually associated with Mathematical Literacy.

Intervention Teaching Context

Two Grade 9 topics were taught using culturally-based activities in five Grade 9 classes. The Setswana step dance, a cultural dance practised at a cultural village near the school, was used as a context for teaching number patterns. A group of Grade 9 learners demonstrated the dance. These learners used to participate at the cultural village. A number pattern was observed involving the number of dancers and the number of foot-steps they were making (see table below). The second row shows the total number of steps made by all the dancers if each dancer is making five steps.

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

Some tasks were formulated using the artefacts from the cultural village. Step dancing was again used to teach substitution using number of dancers as input and number of steps as output. In another topic, artefacts from the Ndebele paintings and beadings, (see Figure 2 & 3 below) were used to teach properties of shapes and transformations.

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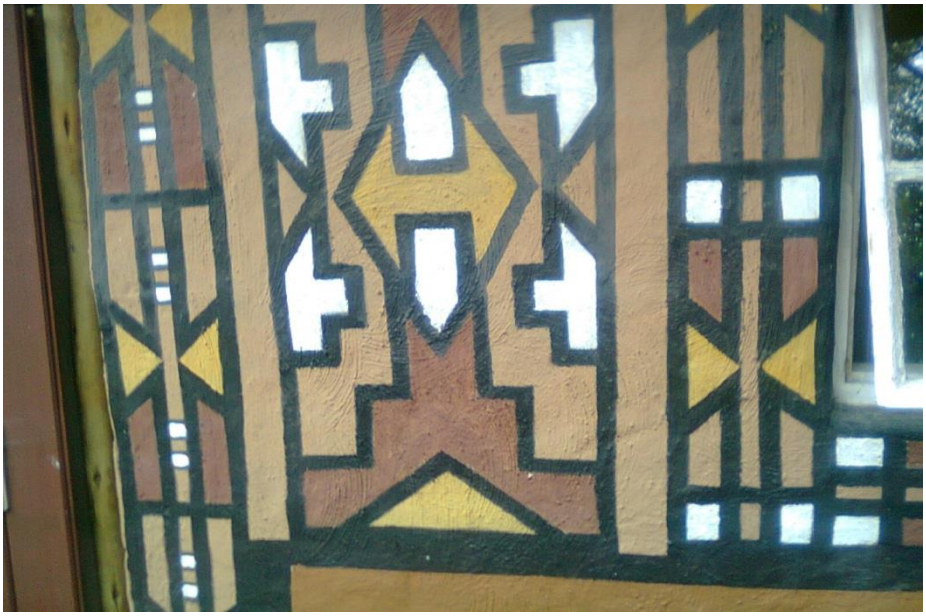

Figure 2: Ndebele paintings
Source: From field data

Figure 3: Ndebele beadings
Source: From field data

Nature of data and data analysis

The data collected in the study on which this paper is premised included seventeen video recorded culturally-based lessons from five Grade 9 classes, learners' responses from pre and post questionnaires, learners' lesson journal entries, audio-recordings from learners' group post-lesson interviews, audio-recordings of teachers' pre and post interviews, notes from post-lesson reflective meetings with teachers and teachers' lesson reflective forms. In this article I focused on learners' narrative stories, on their perspectives of culturally-based lessons, triangulating data from lesson journal entries, post-lesson questionnaire responses and post-lesson interview transcripts. I also used teachers' narratives from the post-lesson reflective meetings and the post-

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interview transcripts to check on how they recognised learners' capabilities as mathematics learners.

Learners were asked to complete journal entries after every lesson, to reflect on their learning. Questions for the post-lesson questionnaire were constructed to check on learners' views about the importance of learning mathematics and their perspectives on how the incorporation of culturally-based activities in mathematics lessons impacted on their mathematics learning. Interviews were carried out to probe learners' responses from journal entries and post-lesson questionnaires as well as checking on learners' perceived learning trajectories. In analysing the data, the narratives were accordingly coded using the themes; competence, performance and recognition – the dimensions of identity (see Figure 1). The approach to analysis involved identifying the words learners used to represent their experiences and how social relationships and practices produced confidence and pride in the learning leading to the development of a positive mathematics identity. When analysing learners' responses, expressions like: I feel good, happy, excited, educated, impressed, cool, amazed etc., were categorised as indicating learner satisfaction. Thus, an indication of a positive identity. Narratives depicting the same theme were grouped together into a vignette and commented on in detail.

Data Presentation and Discussion

To begin the analysis, completed questionnaires were given identity codes that represent the type of questionnaire, the class of the learner and the number of the questionnaire. This was also applied to the learners' journals. For example, a questionnaire completed by a learner in Grade 9A was identified as Q1LA01, Q1 denoting first questionnaire and Q2 denoting the final questionnaire, LA denoting learner from Grade 9A, and 01 denoting student identification number. 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.

In the following sections, vignettes are presented and commented on to identify and demonstrate aspects of learning as identity.

Vignette 1: Factors which contribute to the difficulty of mathematics

This vignette contains extracts from learners' responses on the question: *What factors do you think may contribute to the difficulty of mathematics? Please explain.* This question was designed to understand learner's participation as well as non-participation and of inclusion as well as exclusion in the mathematics classroom community. Learners were asked to answer the above question prior the intervention teaching.

Q1LA02: In mathematics you work with numbers when in other subjects you work with words, there are no notes or scenarios

Q1LA08: Equations are difficult, you need to do all your steps correctly. If you miss some steps you get wrong answers.

Q1B39: The way teachers teach. Other teachers explain very fast, others do not know how to teach and they say we do not know mathematics.

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Q1LC14: The difficult of mathematics is to work with algebra and equations. Things we do not understand give us stress or headache.
Q1LD24: The difficult factors for me are when you do things which you do not talk about every day e.g. prime factors because we do not talk about them every day.
Q1LD06: Mathematics needs more time than other subjects.
Q1LD41: Strict teachers contribute a lot to the difficult of mathematics because sometimes you are afraid of them especially when you do not get the required answer.
Q1LE08: The difficult of mathematics is that you cannot calculate the answer without following some steps. I just do not like going through each and every step without my own shortcuts.
Q1LE27: Unlike other subjects, it is difficult to read mathematics.

Comment/Analysis

Learners' comments on the question were divided into seven categories as follows: teaching and learning styles, nature of mathematics, insufficient resources, anxiety, procedures, language barrier, and insufficient time. However, the way teachers teach was cited as the major contributing factor to the difficulty of mathematics. Eighty-one (81) out 157 (52%) learners cited factors related to this category. Reasons like missing notes and scenarios (See Q1LA02; Q1LD24) were given. In the vignette above, Q1LA02 expressed dislike of learning mathematics without using related scenarios and Q1LD24 emphasised that lack of connections to everyday life makes mathematics difficult. Learners who do not have the opportunity to connect with mathematics at a personal level may fail to see themselves as competent at learning mathematics (Boaler & Greeno, 2000). According to Q1LB39 the treatments they get from their teachers contribute to their non-participation in the mathematics lessons. Learners who do not see themselves or are not recognised as contributors to the mathematics classroom may not consider themselves to be capable mathematics learners, leading to a negative mathematics identity.

One way learners come to learn who they are relative to mathematics is through their engagement in the activities of the mathematics classroom. This idea of following laid down procedures without own creativity does not go down well with some learners (Q1LE08). When learners are able to develop their own strategies and meanings for solving mathematics problems, rather than following laid down procedures, they learn to view themselves as capable members of a community engaged in mathematics learning (Boaler & Greeno, 2000). Therefore, the types of mathematical tasks and teaching and learning structures used in the classroom contribute significantly to the learners' mathematical identities.

The nature of mathematics as a contributing factor to the difficulty of mathematics was cited by 40 learners (~ 25%). Comments like, it is difficult to read mathematics (Q1LE27), in mathematics you work with numbers when in other subjects you work with words (Q1LA02), in mathematics there are some required answers (Q1LD41) were emphasised. Learners who are not the quickest to get the required answers may see themselves as not capable of learning mathematics. Insufficient time (Q1LD06) and lack of resources like calculators was also emphasised as contributing to the difficulty of mathematics. For these learners the availability of learning resources is an important prerequisite for mathematics learning. The use of English language in mathematics was also cited as another contributing factor to the difficulty of

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mathematics since mathematics is a language which is being taught in their second language (English). Therefore, learners are struggling to understand these two languages simultaneously. Learners with problems in English language may not see themselves as capable mathematics learners.

The above vignette highlights that, before the intervention, lack of good teaching strategies, good treatment by teachers, and connections to everyday life may have contributed to learners' weak mathematical identities (low capability of doing mathematics). Use of procedures and the nature of mathematics may also contribute to a weak mathematical identity.

Vignette 2: Competence as an identity dimension

In this vignette the following narratives have been cited to show learners' comments on their acquisition of mathematical knowledge and understanding of the mathematics content learnt after participating in culturally-based lessons.

Q2LA05: I feel very amazed because I can see that other cultures, they do mathematics in their own way which makes it easy to know number patterns and transformations

Q2LA28: I like the fact that I understand the whole topic (referring to number patterns), so I am excited when I get questions based on the topic. I am proud of my work.

J1LA21: Today I have learnt the following things in the number patterns; forming a number pattern from the Tswana dance, getting the position of the term in the number pattern, getting the general term and the rule connecting the terms.

Q2LB02: I feel that number patterns are simple when we use the Setswana dance or any other dance from our culture. Because we listen and look, count their steps when they are dancing and get some mathematics

Q2LC02: I like using our culture because it made me understand maths

Q2LD26: I feel very impressed because I did not know number patterns but_I now know them very well and I hope they can put them in the examinations.

Q2LC09: I feel like I can now handle anything in mathematics, mathematics is not all that difficult.

Q2LE06: I liked these two topics because there is something in my mind now that I have learnt about – it reminds me that in the olden years in my culture, our elders used powerful mathematics also.

Comment/Analysis

The above quotations from learners overwhelmingly point to the success of learners in their engagement and understanding the concepts that were part of the culturally-based lessons. Out of 169 learners who responded to the questionnaire, 163 (96%) expressed satisfaction and 44% of the learners felt satisfied with the way they learnt the two indigenised topics because they gained a good understanding in these topics. Some learners (e.g. Q2LD26) even wish to see questions on the covered work in the examinations. This indicates a very high degree of competence and confidence. This is further epitomised by Q2LC09 who feels competent to handle anything in mathematics. Q2LA28's competence is indicated by his/her sentiments that s/he understands the whole topic (number patterns), excited to get questions based on the topic and proud of her/his

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work. Most learners expressed more or less explicitly their pleasure to learn mathematics and a satisfaction in completing a task. In the lesson journals almost every learner was able to express explicitly what s/he learnt during the intervention lessons (JILA21). This fluency in mathematics talk demonstrates meaningful knowledge and understanding of the experienced mathematical content – a positive mathematics identity.

Some of the learners in the study experienced the aha! moments and joy of mathematical discovery, discovering a link between mathematics in the classroom and the mathematics used in the cultural activities. Their expressions (Q2LA05) revealed surprise in this gain of knowledge. Grootenboer and Zevenbergen (2007) asserted that such personal responses, describing mathematics in terms of wonder, beauty and delight provide motivation in terms of continued engagement and fuel a passion for the discipline of mathematics. On the other hand, statements like those expressed by Q2LA05 and Q2LB02 suggest that, for them, the culturally-relevant lessons did address Ladson-Billings' (1995, p. 160) requirements for this kind of teaching where learners are expected to experience academic success, develop and/or maintain cultural competence. Interestingly, knowing that even their fore fathers were also doing what they termed powerful mathematics (Q2LE06) may spur them to acquire a strong mathematical identity. Their admission that they did not know the possibility that some mathematical concepts might have evolved in their cultures, not knowing that people in their cultures were also doing mathematics in their cultural activities, prior to the lessons, suggests that the lessons encouraged the development of their cultural competence as mathematics learners leading to a positive mathematics identity.

However, six out of 169 learners who responded to the post-lesson questionnaire expressed that they were unsatisfied with the way they learnt the indigenised topics. Such learners had this to say:

Q2LA32: I was feeling so boring because I do not love mathematics.

Q2LB29: I feel nothing because I don't like mathematics.

For these learners, any innovative method introduced may not have had a positive impact on them because they do not like mathematics. They attend mathematics lessons because mathematics is a compulsory subject. Given a choice they would drop the subject.

Vignette 3: Performance as an identity dimension

Below are some narratives from learners which indicate how they valued their social performances in the culturally-based lessons which were referred to as participation in a project during group interviews.

JILD01: I liked sharing my ideas with my teachers and other learners.

J3LE12: I really liked the introduction using cultural songs and dance.

Q2LE17: It was interesting. I was learning something now.

Q2LE29: I learnt number patterns by the things that I could understand and doing number patterns is very easy, you can even do them without using a calculator.

Q2LE04: It was very, very interesting because I was watching the Ndebele drawings, they used transformations and they are good.

Q2LE03: I feel very good when they teach a lesson showing me how it works.

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R: Do you think the way you are thinking about mathematics now is different from the way you were thinking about mathematics before the project?
G1LE03: Yes! Mathematics, I thought was very tough. But now because of the project I just see it as a subject which everyone is doing even outside school.
R: Do you think that the way you have been asking questions about mathematics before the project is different from the way you can ask questions now?
GILE03: It has changed. Before I used to think of questions like … Does this work? How does transformation work? Where do we use transformations and so forth? Yeah, but now I won't think or ask myself such questions. I will start thinking or looking for places where such things can be applied in our cultures. Yeah, I now know our cultures use such mathematics.

Comment/Analysis

Although using the identity-as-narrative construct may sound valid, when it comes to performance, there is a need for triangulation. Because of this need, learners' narratives were cross-checked against observation data, i.e. checking how learners participated in the culturally-based lessons. Lesson videos were replayed. This then entailed rigorous validation of data procedures.

Learners valued sharing of ideas with their teachers and classmates (J1LD01). Being part of a group and working collectively enabled learners to share their indigenous mathematical knowledge. This sharing of knowledge stated in the narratives was observed during lessons when discussing cultural incidences where number patterns can be observed (Venda clothes, Zulu baskets and different cultural dances). The mathematics classroom can also be organised to encourage discussion, sharing and collaboration (Boaler, 2000). Group activities were satisfactorily and actively done. The fact that the learners liked the sharing of ideas, this active participation included not only thoughts and actions but also membership within a mathematics classroom community.

Learning mathematics involves the development of each learner's *identity* as a member of the classroom community (Wenger, 1998). Learners were observed being central to the community of practice. Through the observed warm relationships and valued experiences with their peers and teachers, it can be concluded that these learners came to know who they are relative to mathematics. Due to the non-threatening and supportive environment, learners could actively engage in the activities at levels that met their understanding. This ethos has been documented in Boaler's studies (Boaler, 2002a, 2002b) as being one that enables learners to participate without threat and hence open up opportunities for participation and learning.

Learners also valued the unique experiences of using cultural contexts in teaching and learning (J3LE12; Q2LE04). These experiences were unique in the sense that mathematical knowledge was constructed out of culturally-based activities. I know how to dance and I now know how to draw a number pattern from a dancing style (J1LD02). This contention shows the learner's capability to construct mathematical knowledge from a culturally-based activity- a dance, sending a message that culturally relevant pedagogy can provide a worthwhile learning experience (see Q2LE17; Q2LE29). The idea of involving learners in practical activities was positively received by learners (Q2LE03) who seem to like the visualisation involved. The same

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statement by Q2LE03 was observed by Teacher A during lessons and reiterated in the last interview*: "Personally I have realised learners understand more easily when the lesson is practical. Yeah… when learners are involved in a lesson they participate with interest"* [emphasis placed]. The practical work provided a range of affordances and issues related to mathematics and mathematics learning – a positive learners' mathematical identity. Some learners are now thinking of searching for mathematical knowledge from cultural activities (GILE03). Therefore, identities get formed in practice (Lave & Wenger, 1991).

Vignette 4: Recognition as an identity dimension
Self-recognition
GILE03: I see myself as a whiz-kid in mathematics
GILE01: I see myself as a whiz-kid because I can now understand mathematics.
GILE02: Me, I can see myself as a champion because I understand everything we learnt in the project.
GILB02: Mathematics is now simple to me.
GILB01: I can now understand mathematics better when mathematics examples from our South African cultures are used.
GILB03: 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.
GILE02: Yes, before the project I used to consider mathematics as tough. Even when we were given some work to write, I used not to write, but now I am so happy. I did not like mathematics; I hated it so much but now …
GILB04: In future we will try to use the same method we used in the project to learn mathematics, thinking about how the same mathematics is being used in our cultures.

Comment/Analysis
Most learners in the study described themselves as capable mathematics learners; they began to imagine themselves as fitting into this community of practice. Imagination involves the creative process of producing new images and of generating new relations through time and space that become constitutive of self (Wenger, 1998, p. 177). One hundred and sixty-four out of 171 (95%) learners positively acknowledged culturally-relevant pedagogy as enabling them to understand mathematical topics taught in the lessons better. Some learners emphasised that their engagement in culturally-relevant lessons will significantly influence their future mathematics learning (GILE02; GILB04)). However, this may depend on the nature of the mathematical concepts, providing possible connections to cultural knowledge. Culturally relevant lessons also afforded learners with the opportunity to see themselves as mathematics learners even when they are away from the classroom (GILB03). Learning is being viewed as a trajectory. As trajectories, our identities incorporate the past and the future in the very process of negotiating the present. Community of practice is a living context that can give newcomers access to competence and also invites personal experience of engagement by which to incorporate that competence into an identity of participation (Wenger, 1998, p.214).

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Recognition by Others

TR B: The funny thing is that the learners were able to make their own explanations from what they saw, they could visualise everything and could deduct their explanation from that.
TR A: Learners were involved because they actively participated in the discussions and at least they understood the lessons easily.
TR A: I realised that practically, it is the way to go and learners can do better when their cultures are involved.
TR B: In my previous lessons only three or four learners participated, but in these lessons almost all learners participated. In groups I could see they were sharing ideas. I also observed that almost all the learners submitted the given tasks unlike in my previous lessons. Most learners do not write home work.

Comment/Analysis

This recognition of learners by their teachers, as becoming capable mathematics leaners due to their engagement in the culturally relevant lessons happened repeatedly especially when reflecting on the lessons. According to the observation by TR B, learners were involved in mathematical thinking because they could come up with their own explanations. Learners also made an effort to complete and submit given tasks. Shannon, (2007) posits that a realistic context will facilitate student success by intrinsically motivating students and thus increasing the likelihood that they will make a serious effort to complete given problems. This is another indication of successful participation in the mathematics classroom community. All learners *can* become mathematics learners, identifying themselves and being recognised by others as capable of doing mathematics (Anderson, 2007, p.13).

Learning from Learners' Narrative Stories

The majority of the learners in the study expressed their experiences in culturally-based lessons in terms of competence, performances and recognition. Their engagement in the lessons led to the definitions of their actions as competent members of the mathematics classroom community. Contrary to their initial thinking that the way teachers teach contribute to their non-participation in the mathematics classroom community, learners perceived culturally relevant pedagogy as an enabling pedagogy which can provide access to mathematics. They valued their experiences in the culturally-relevant lessons as unique, where mathematical knowledge was pulled out of culturally-based activities (Ladson Billings, 1995, p.479) and the construction of knowledge was part of the learning experiences. They recognised themselves and were recognised by their teachers as now capable mathematics learners. What then can we learn from their stories?

The dimensions of identity reflected in this article can be used to understand how learners label themselves as members of the mathematics community in relation to teaching and learning strategies. Thus, these findings interrogate a strategy for drawing learners into mathematics, stimulating their interests, enthusiasm, competence and confidence. Learners' experiences may not necessarily reflect only one of the three dimensions of identity described in this article. All the three or two dimensions can be intersected, therefore leading to an even stronger and positive mathematical identity. One learner can label himself/herself as good in mathematics due to the

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experienced competence through participating in some unique experiences. Teachers can provide learners with opportunities to see themselves as mathematics learners away from the classroom (Anderson, 2007). The various images learners have for themselves and of mathematics extending outside the classroom - in the past, present, or future may change over time (learning trajectories) and this change may be influenced by the espoused pedagogies.

Conclusion

Through consistent and sustained efforts by mathematics teachers to develop positive identities in their learners, I argue that more learners can improve their identities as mathematics learners. As pointed throughout this paper, identities are socially developed in relationships with others, including teachers and peers in the learning community. I designed a mathematics identity model which enabled me to look at what happened within culturally relevant mathematics lessons. This model highlighted competence, performance and recognition as interrelated dimensions for describing learning as an identity (Wenger, 1998). The use of culturally- relevant pedagogy positively impacted on learners' mathematical identities since the learning trajectories reflected in the learners' narratives show that learners were drawn more centrally into their community of practice, recognising themselves as competent mathematics learners basing on the two topics taught in the study and their perceived future anticipations.

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