PRINT: ISSN 0976-691X ONLINE: ISSN 2456-6586
J Communication, 6(1): 57-66 (2015)
DOI: 10.31901/24566586.2015/06.01.23

Learners' Experiences and Knowledge in Indigenous Activities: Opportunities for the Mathematics Classrooms

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KEYWORDS Indigenous Games. String Figure Gates. Mathematical Concepts. Mathematical Analysis. Learners' Demonstrations. Standard Instructions

ABSTRACT Learners bring a variety of experiences and knowledge to mathematics classrooms. These experiences and knowledge are shaped by and contributed by, among others, socio-cultural environments and in which they live and interact with other members of the community. This paper reflects on their experiences on an indigenous game called *Malepa* (String Figure Gates). First, the game is mathematically analysed to reveal the various mathematical concepts that are embedded in it and then followed by a demonstration of String Figure Gate Two by a number of learners. These demonstrations are analysed to determine how this knowledge can be used to enhance the teaching and learning of related mathematical concepts.

INTRODUCTION

A number of studies have been conducted recently on the exploration of the role and use of indigenous materials and activities in the teaching and learning of school mathematics. Examples of work include the incorporation of the indigenous game of Morabaraba in the learning of mathematics (Nkopodi and Mosimege 2009), the ethnomathematical approach to the study on indigenous games from Southern Africa (Mosimege and Ismael 2004); the use of a cultural activity in the teaching and learning of mathematics through the use of twill weaving with a Weaving Board in a Mozambican classroom (Cherinda 2002); the ethnomathematical approach to teaching and learning of some geometrical concepts (Mogari 2002); and the student teachers' exploration of beadwork as a resource for dealing with mathematical concepts (Dabula 2000), among others.

Most of these works reveal that learners have a variety of experiences related to indigenous activities. Their experiences are largely influenced and determined by the socio-cultural milieu and the environments in which they live and interact. These are made up of playing and interacting with siblings and friends; lessons taught by parents and grandparents and other members of the community; engaging in daily activities at home and surroundings; observing others engage in a variety of socio-cultural activities; etc. Masingila (1995) specifically refers to mathematical knowledge that students bring to school in relation to knowledge gained from everyday situations that the students have experienced. Malloy (1997) adds the historical context (in addition to the socio-cultural context) in which the learners live as defining these experiences. These experiences which occur to a greater extent outside the classroom, which may not necessarily be mathematical in nature, can be brought to bear on activities within the mathematics classroom. The use of such experiences in mathematics classes give learners 'a new insight about themselves in relation to mathematics' as stated by Loet al. (1996). These authors found that the learners did not only see themselves as contributing to the discovery of new mathematics (in this case Geometry) but their interest towards mathematics was renewed. Unfortunately these experiences and knowledge do not always find much use by the educators in the classroom. Some educators may not only find any use for it, but they may even consciously and intentionally discourage it (Lester 1989) and in the process the students come to regard their experiences and knowledge as less important or not relevant at all. This creates an impression and strengthens the view that what they learn in their mathematics classrooms has got nothing to do with the environments in which they live and function. In the same way, many experiences that learners have gone through outside the classroom are largely viewed as having no relevance to what happens in the mathematics classroom.

Relevance of such experiences is a major area of concern in any classroom activity that brings everyday experiences to bear upon such classroom activity. If all there is to relevance is for pupils to enjoy the activities, then one wonders what mathematical competences are being derived from the activities (Nyabanyaba 1999:13). Here Nyabanyaba joins many people who have criticised the use of games (and other daily experiences) as serving to a greater extent the affective component of fun. However, if we redefine the role of both learners and teachers when such activities are used in mathematics classrooms, then this problem will become less of a factor.

One of the activities that can be introduced into mathematics classrooms are games, more specifically indigenous games. Nkopodi and Mogege (2009) elaborate on the exploration of the indigenous game of Morabaraba in the teaching and learning of mathematics. They also give examples of the use of various kinds of games in enhancing mathematical understanding (2009: 379-382). This paper reflects on the use of Malepa (an indigenous Setswana game), particularly the knowledge of learners about the game and how this knowledge can be integrated in the teaching and learning of various mathematical concepts that are relevant to the school curriculum.

Malepa: An Indigenous Game

Malepa (this is the Setswana name for String Figure Game) is a game which is popular with children in many parts of South Africa . The International String Figure Association has been gathering and distributing string figure knowledge from different countries since 1978. The different bulletins of the Association have a record of the different string figure activities from different countries, confirming the knowledge of these figures. Although the knowledge of string figure games is well spread, the emphasis seems to differ from country to country, or more specifically, from different parts of the world. Whereas in a particular community knowledge and emphasis may be on making gates, in another the concentration is on different figures which may be made by using strings. Keith (1994: 5) refers to the knowledge of string figures that his parents had, which they had forgotten but were triggered by the figures he made for them. His father could even remember what Keith knows as 'Jacob's ladder', which his father knew as 'Job's coffin'. This is similar to the experiences that the researcher encountered in some of the workshop which were conducted on string figures as part of an ethnomathematical project in South Africa (Mosimege 1997:533) and other ethnomathematical materials. The two instances illustrate not only the knowledge of string figures in different cultures, but also that string figures are a part of different cultures, although the focus or emphasis differs from one culture to another. For instance, Keith refers to Jacob's ladder which he is familiar with, and the researcher refers to '*diheke*' (also known as diamonds) which the researcher learnt as a small boy. Some of the children who took part in the study in which the demonstrations below were done did not know any 'diamonds', but were able to make 'monatlana' (chicken legs or even affectionately called 'run-away' by some learners) with ease. This gives an indication of the specificity and different emphasis of the games, where the game, although it may be known from one place to another, is either played differently that is rules differ and possibly even versions of the same may be different, or the same game may have a different meaning and names attached to it, or even played under different socio-cultural circumstances.

Mathematical Concepts in the Game of Malepa

The mathematical concepts that are mentioned here were arrived at through an analysis of the different String Figures Gates. (for analysis of more indigenous games and other games see Nkopodi and Mosimege (2009: 384-385) and Mosimege (2012: 71-74)). The analysis would involve a process in which the String Figure Gate is looked at from the mathematical point of view, looking out for geometric figures where such exists and using other forms of mathematical knowledge to make meaning of the activities in which patterns and generalisations thereof are possible. The analysis process also included making meaning of the statements that are made when the gates are performed, or looking at the implication of the steps taken in performing a particular gate.

(i) Variety of Geometric Shapes and Figures

In any string figure gate the following geometric figures may be identified: Angles, triangles, quadrilaterals (particularly rectangles and squares). The number of the geometric figures increases as the number of gates increases.

(ii) Patterns, Relations and Functions

An analysis of the String Figure Gates reveals a variety of relationships between the triangles and quadrilaterals, quadrilaterals and intersecting points, and the generalisations that result from these relationships. The generalisations between the different geometric figures are:

- triangles and quadrilaterals: $y = 2x + 2$
- quadrilaterals and intersecting points: $y = 3x + 1$;
- quadrilaterals and the number of spaces (spaces are given by the combination of triangles and quadrilaterals): $y = 3x + 2$

(iii) Symmetry

Working with gates, a variety of symmetry types may be identified. Most of the gates show bilateral symmetry, particularly even numbered gates. Some of the gates exhibit reflection symmetry, for example Gate 2, while others have rotational symmetry, for example Gate 1. It is also possible to show radial symmetry; translational symmetry; and antisymmetry. After making a specific gate, disentangling the string along a specific line of symmetry also ensures that the string does not get entangled. An interesting classroom activity could be to investigate which types of symmetry are associated with which String Gates.

Gibbs and Sihlabela (1996: 26) have examined the geometric figures similar to the ones identified in (i) above and suggest that the loop of a string can be manipulated even further to create a variety of other geometric shapes. For instance, how the loop of the string can be manipulated to create an isosceles and equilateral triangle out of the existing one. In the same way, the string can be manipulated to create a kite or rhombus from the identified square or rectangle. This work would provide interesting explorations in secondary school mathematical explorations.

The Use of Malepa Games in Mathematics Classrooms

The trial of the Malepa game in the mathematics classroom followed a number of steps that were designed to serve different purposes in the use of this game. The procedures reported here are those that relate specifically to what the learners actively took part in.

Free Play

During the first classroom visits the researcher had a suspicion that some of the learners knew a variety of forms of the Malepa game, possibly even more than the researcher knew or even different string activities than those the researcher knew. The only way of finding out about this knowledge was to give the learners an opportunity to engage in the games. This process led to the period of free play which took place at the beginning of the lesson. The exact manner in which the free play took place is as follows:

- Each learner was supplied with a piece of string approximately l metre in length;
- All learners were given a period of about 10 minutes to try any of the String Figure Activities that they were able to do. During this period learners who knew a variety of String Figure Activities were identified to give a demonstration to the whole class at a later stage during the lesson. On average, 4 learners from each of the Grades ranging from Grade 8 to 11 were then selected from a cohort of those who knew the activities and requested to demonstrate these to the whole class;
- The researcher then called on any of those learners who had been identified to give a demonstration on the particular activity that they had performed in class. Although the learners were allowed to give a demonstration of a variety of activities, the emphasis was on String Figure Gates (Malepa) which were the main focus of the study. The order in which the learners were called to give the demonstrations was based on the number of gates that they could make, starting with the demonstration on the least number of gates to the highest.

Demonstrations by the Learners

The three demonstrations below were selected from the demonstrations that were given by learners in three high schools in the town of Polokwane and neighbouring areas in the Limpopo Province, South Africa. The schools were selected as follows:

- School A from a predominantly rural area 30 kilometres from the town of Polokwane
- School B from an urban township 10 kilometres from the town of Polokwane
- School C from one of the suburbs in the town of Polokwane

These schools were selected to determine whether there is any difference or significant variation in terms of the understanding of indigenous activities in relation to the location of the school and the composition of the student population.

From the activities that each of the learners engaged in in the period of about 10 minutes a number of learners were identified. These learners knew a variety of String Figure Activities. In some instances, some of the learners selected did not necessarily know many different types of activities, but knew a specific activity well. In instances where one particular learner knew a variety of String Figure Activities or even a variety of String Figure Gates, the learner would be requested to perform the most complex of the activities that other learners could not perform. For instance, demonstrators selected from this knowledgeable group of learners were likely to give a demonstration of String Figure Gates 4, 5, or even 6, or even generate more Gates (7, 8, etc.) from these and leave the other activities for those learners who could perform only lower number of Gates like 1, 2 and 3. All the identified learners were then given an opportunity to demonstrate a specific activity to the whole class. The instructions to the learners were that the demonstration should be performed twice. The first time the demonstration was given without any explanation. This was intended to assist the learner to perform the activity without the accompanying difficulty of explaining it to the whole class. This decision was arrived at after some of the learners who had been called upon to give demonstrations publicly experienced some difficulties in giving their demonstrations in the presence of other learners and had to repeat some of the steps or the whole demonstration. Giving the demonstration twice assisted the learners giving the demonstration to review their knowledge of the activity. This was then followed by a similar demonstration accompanied by the related explanation of the steps involved in performing the particular activity.

In giving the explanation the learners were allowed to use a language of their choice, as long as it was a language which they were comfortable to use and could be understood by all the learners and the researcher. The following purposes of the demonstrations given by the learners in the study on Malepa game can be looked upon as opportunities that are created when learners are given an opportunity to share their knowledge and experiences:

(i) To affirm the learner's knowledge and experiences outside the classroom as relevant in mathematics classrooms.

(ii) To give the learners who knew some string activities an opportunity to share this knowledge with other learners.

(iii) To allow the learners an opportunity to interact among themselves without domination or prescription by the researcher, although occasionally the researcher asked the demonstrator to repeat either a particular step or the whole procedure.

(iv) The purpose of the repetition of the same String Figure Gate by the learners was intended to familiarise the demonstrator with the activity and recall all the steps to be demonstrated and reduce the anxiety of trying to recall how to perform the activity while explaining to other learners.

Five Distinct Groups of Learners in the Knowledge of Malepa

During the period of free play described earlier in the paper, different learners became engaged in a variety of string activities that they knew. As the learners became engaged in these activities, it was possible to notice that they did not have the same levels of knowledge of activities in strings. A further analysis of the involvement of learners in these activities led to the identification of five distinct groups:

(i) Learners who did not know any String Figure Activity (String Figure Gates or String Figure Configurations).

(ii) Learners who did not know String Figure Gates but other String Figure Constructions such as the Saw, Cup and Saucer or even Magic that is disentangling of the string around a mouth.

(iii) Learners who knew only one String Figure Gate. The majority could only construct one String Figure Gate especially String Figure Gate 2. Some of the learners could construct only one of the following Gates – Gate 1 and Gate 3. However, they were fewer than those who could construct Gate 2. An even a smaller number could construct String Figure Gate 4.

(iv) Learners who were able to construct a maximum of two String Figure Gates. This group also includes learners who could use more than one method to make the same gate and these methods differ from those used by most of the learners or the standard method for constructing the gate.

(v) Learners who can construct more than two gates and other String Figure Configurations. They were also able to generate other String Gates from those already made. The numbers here are extremely low, at most two learners in each school.

The five distinct groups of learners show that the learners bring different levels of knowledge from experiences outside the classrooms. It becomes an impossible task to make any intervention without knowing the learners' level of knowledge. In fact there is no way of making any appropriate use of this knowledge without knowing what it is. The learners' roles and the teachers' roles can best be defined after this knowledge has been identified.

Demonstrations by Learners of String Figure Gate 2 (Malepa a Bobedi)

The demonstrations are of String Figure Gate 2, the gate that the study showed to be known by most learners in most classrooms. The demonstrations are included here to reveal the following about the learners' experiences and knowledge in the Malepa game:

(i) The extent of the learners' knowledge in String Figure Gate 2 of the game.

(ii) The similarities and differences about the language, terminology, number of steps, explanation of knowledge, and interaction with other learners during the demonstration.

(iii) The mathematical concepts that each learner uses or lack thereof in the demonstration.

All the demonstrations were video recorded, so it was possible to review and analyse further what the demonstrators did without an explanation. This is given in {…} in the demonstrations below. The English translation for the third demonstration is given in […].

Demonstration 1

This demonstration was done by a male learner in a Grade 8 mathematics classroom in School B (see Fig. 1)

1. You put the string on your thumb and on your small finger. {The learner looks at the right

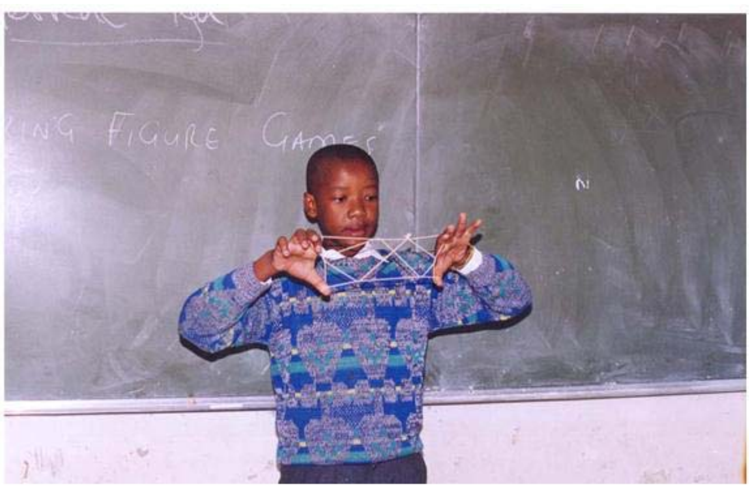

Fig. 1. Male learner giving a demonstration of String Figure Gate 2

hand as he explains, moving first the fourth finger and then the small finger as he refers to them. By this time the string is already hooked on the thumbs and small fingers of both hands, so he merely explains what has been done on one hand that is he does not really start from the beginning but after the first step had been made. He seems to be assuming the use of the left hand in making the gate}

2. Then you take your fourth finger and take the string in the left hand side and do the same on the right hand side. {As the learner talks about the fourth finger, he moves it a bit to indicate what he meant by the fourth finger. He then uses this fourth finger to pull the string, starting with the right hand and then following this with the left hand. He does not explain nor clearly indicate that the string to pull is on the palm of the left hand}

3. Then you put out the thumb on the string. {Both thumbs removed at the same time}

4. You take the...the string on the bottom and put it on your thumbs. {The learner first picks up the string with the right hand thumb and follows with the left hand thumb. Before he picks up the string with the right hand thumb, he first uses the thumb to show the string at the bottom and then uses the thumb to pick the string up}

5. Then you take the string next to the, to your thumb and put it on your thumb. Do it on the other side. {He uses the left hand fourth finger and thumb to pick up the string on the right hand side although this is not said explicitly. By the other side he is referring to using the right hand side to put the string on the left hand side}.

6. Put out the, this one must meet in the finger and the one that was on the finger must go out. {Going out here means releasing the string at the back of the thumbs to remain with one string on the thumb. He starts with the right finger again. By finger the learner is referring to the thumb}

7. Then on the other side you do the same. {Referring to the left hand}

8. Then you put your fourth finger on the hole next to the thumb and do it on the other side. {He starts again with the right hand}

9. You put out the string on the...on your first small fingers. {This time the learner starts with the left hand.

10. Then you will have something like this. {The learner shows the class the two gates}.

Demonstration 2

This demonstration was done by a female learner in Grade 10 mathematics classroom in School C (see Fig. 2).

Fig. 2. Female Learner giving a demonstration of String Figure Gate 2

1. And then take this one {at the start of the recording of the demonstration the learner had already put the string on the index and small fingers that is had Basic Opening. The learner was using the left index finger to pull the string on the right hand side}

2. And the other finger too this side {using the left index finger to pull the string on the right hand side resulting in Opening B}. Did you do this?

3. Then take out this one {the learner pointing to the thumbs), whatever you call it (responding to the other learners comment about the thumbs}

4. Then take these two thumbs and do this {referring to the using the thumbs to hook up the string on the small fingers. The presenter repeated this step for the sake of those who were not sure about what to do}

5. Do I have to start again {when the other learners seemed to be lost at this stage}

6. Okay, take this one {referring to the string on the right index finger to be put on the thumb}. You did this okay?

7. You will have to take this one and put it around the thumb

8. Then you take out the two thumbs.

Demonstration 3 (see Fig.3)

This demonstration was given by a female learner in Grade 10 in School A:

1. *Re tsea string se ra se lokelamomonwaneng o mogolo le o monnyane.[*We take this string and put it in the big and the small fingers]

2. *Ra gogakamonwanawaboseven* [We pull with the seventh finger]

3. *Ra ntshamomenwaneng e khi e megolo.[*We remove on the big fingers]

4. *Ra goga e khi ka mo mafelelong ka e khi e megolo... Ja.[*We pull these ones at the end with the big ones]

5. *Ra tsea e khi mo monwaneng wa boseven ra e lokela mo o mogolo.* [We take the one on the seventh finger and put it in the big finger]

6. *Le kamo* [And this side]

7. *And then ra isa e khi e megolo ka fatshe*. [And then we take the big ones to the bottom]

8. *Ra lokela e khimosquareng, go naledisquarenyanamogauswi le menwana e megolo*.[We put these ones in the square, there is a small square near the big fingers]

9. *Ra entsha mo menwaneng e khi e mennyane.* [We remove on the small fingers]

Standard Instructions for Making String

Figure Gate 2

The following instructions are the standard instruction for String Figure Gate 2 that appear in most of the literature on String Figures (see Fig. 3)

1. Place the string over the thumbs and the little fingers.

2. Put the right index finger under the left hand palm string.

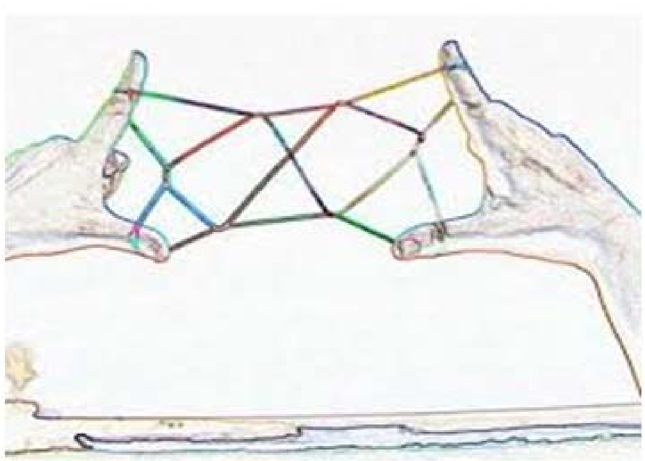

Fig. 3. Regular figure of String Figure Gate 2 from standard instructions

3. Put the left index finger under the right hand palm string.

4. Release the string on the thumbs.

5. Use the thumbs to pick up the string on the little fingers from the front that is the thumbs must go over all the strings on other fingers to pick up the string on the little fingers.

6. With the right hand index finger and the thumb pick up the string on the left index finger and put it on the left hand thumb.

7. With the left hand index finger and the thumb pick up the string on the right index finger and put it on the right hand thumb.

8. Remove the string at the back of the thumbs (you may use your mouth to assist in removing the string).

9. Put the index fingers in the triangles underneath the thumbs.

10. Release the little fingers.

11. Turn both hands to face away from you.

The figure that is made is called String Figure Gate 2 and it is made up of 2 quadrilaterals and 6 triangles.

Similarities and Differences in Learners' Demonstrations of String Figure Gate 2 and Comparison with Standard Instructions for Making Gate 2

Even though all the learners' demonstrations are based on String Figure Gate 2, there are similarities and differences that are evident among the three demonstrations and with the Standard Instructions for making String Figure Gate 2.

Start of Explanation: The first two demonstrations do not start with the explanation at the beginning of making the gates, but start after the first few steps have been performed, unlike the third demonstration which starts at the beginning. In the two demonstrations in which explanation started after a few manipulations of the string had been done, the demonstrators realized after they had started that they had to explain the steps involved in making the gate for the sake of the learners. However this realization did not make them start from the beginning. They merely continued with their explanation at the step at which they were.

Number of Steps in Demonstration: Despite the fact that the first demonstration skips the first few steps, his demonstrations involves 10 steps, more than demonstrations 2 and 3 and just one less than the standard demonstration. This is a learner who is in Grade 8 as compared to the other 2 learners in Grade 10.

Repetition of Step: The only learner who repeated a step in the procedure for making Gate 2 is the second learner. This was done after the realization that some of the learners were experiencing difficulties with this particular step. However, this repetition has not been recorded as a different step as no verbalization occurred but just the performance of the step.

Language: All the learners giving demonstration were given the latitude to use a language in which they were comfortable to give their demonstration. The learner giving the first demonstration chose to use English, and the third decided to use her mother tongue (North Sotho). The second learner decided to use English as some of the learners in her class could not follow the demonstration in her mother tongue. This happened in the second demonstration in which the learners were predominantly Black and Indian

Numbering of Fingers: The only fingers that the second learner refers to are thumbs, while the other fingers are not numbered. The numbering used by the first learner is the same as that used in the Standard demonstration, although he uses the fourth finger instead of index finger. However using the fourth finger is equally correct. As the third learner is using her mother tongue, she refers to thumbs as big fingers which is correct in her language. However, she refers to the index finger as the seventh finger, meaning that she is counting the fingers from one hand, proceeding to another hand.

Mathematical Concepts Mentioned By the Learners in the Demonstrations

The only reference to specific mathematical concepts in the demonstrations is by the third learner who refers to small squares underneath the big fingers (Step 8, Demonstration 3). She incorrectly refers to them as small squares as they are in fact triangles.

Implied Mathematical Concepts

The learner giving the first demonstration refers to doing something on one side and doing it on the other side. This is done in Steps 2 and 7. The learner giving the third demonstration refers to the same in Step 6. This implies the concept of symmetry in which what is done on one side is a reflection of what is done on the other. This also involves the idea of an equation in which an introduction of something on one side of the equation has got to be done on the other to maintain the balance of the equation.

Role of Teachers in Exposition and Development of Related Mathematical Concepts

The generalisations of the patterns among triangles, squares and intersections are only possible to observe and discuss after a particular String Figure Gate has been made. As can be seen from the three demonstrations, none of the demonstrators said anything about the patterns which resulted from the completion of Gate 2. In fact, the learners are not only saying anything about the patterns and relations at the end of the Gate, but rather do not say anything else about the completed Gate. This is an instance where the teacher should be observant about and be on the lookout for. Where the learners' activities in the Gates provide an opportunity to link any step of the gate to a mathematical concept, this should become an important role of the teacher – to identify such moments which may either be followed upon immediately or later on. The moment for following them could be determined by the purpose that is intended in a specific mathematics lesson. Therefore, instances that the teacher needs to be on the lookout for during a lesson that involves String Figure Gates are:

Steps in the procedures for making gates that demonstrators do not comment about, and yet such steps are necessary for understanding how to make the gate or identification of a related mathematical concept .

Steps which demonstrators decide to repeat and reasons for the repetition.

Explicit mention of mathematical concepts that accompany any step.

Steps in which mathematical concepts are implied but are not explicitly mentioned by the demonstrators.

Steps at which demonstrators get stuck and are not able to proceed.

CONCLUSION

The three demonstrations recorded above are just a few of the many examples of the different kinds of experiences and knowledge that learners bring with into the mathematics classroom. There are a variety of ways in which this knowledge can be made use of. The example of the use given above exploits this knowledge to allow the learners to actively participate and share their knowledge with other learners. As they are called upon to give a demonstration, they get the first opportunity to share their knowledge and in the process gain in confidence about the level and value of their knowledge and experiences. The second opportunity in which the learners demonstrate their knowledge, although not as easy for the learners as the first, still allows them to share their knowledge with the whole class. The third opportunity in which teachers can play a role is to compare these learners' demonstrations against established standard procedures that are recorded in the literature to show that the learners knowledge is not necessarily far removed from the recorded, but compares, in many instances, closely if not exactly with the established rules. This has got a desired effect of affirming the learners knowledge and empower them to relate it to other classroom experiences. As these demonstrations are given, learners use a variety of terms in the game. Some tend to refer to various geometric shapes as they do so - at times incorrectly refer to a small hole or circle or square when actually a triangle is involved. Here is an opportunity in which the teachers can use to correct, introduce, and also highlight some of the mathematical concepts that are part of the game that is being used. This shows an important role that teachers can play to elevate games from being an activity for mere fun to be activities that can be related to a variety of mathematical concepts for the benefit of mathematics teaching and learning.

RECOMMENDATIONS

It is recommended that mathematics educators analyse a variety of games for the mathematical concepts that are either embedded in them or mathematical concepts that can be taught through the use of these games. The analysis and identification of related mathematical concepts should not be done without the socio-cultural implication of the games. The socio-cultural aspect is an essential ingredient that makes this game a special activity that can contribute in a variety of ways in a mathematics class.

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