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Exploring Zimbabwean Mathematics Teachers' Integration of Ethnomathematics Approaches into the Teaching and Learning of Geometry

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Abstract: This article reports on a study that explored how a group of in-service mathematics teachers integrated ethnomathematics approaches into the teaching and learning of geometry. The study used a convergent parallel mixed-methods design, which combined both quantitative and qualitative methods, to provide a deeper understanding of how the participants integrate ethnomathematics approaches into the teaching and learning of geometry. The data for the study were gathered from 40 in-service mathematics teachers through the use of questionnaires and focus group discussions. Results showed that the in-service teachers integrate ethnomathematics approaches into the teaching and learning of geometry as learning materials, resources, and the learning context. Based on the study, it is suggested that teachers should consider the incorporation of ethnomathematics approaches into the teaching and learning of geometry using technological means such as the internet, TV, and films. The findings have implications for continuous teacher professional development in the forms of workshops for the teachers involving the use of ethnomathematics approaches.

Introduction and Background

Currently, in Zimbabwe, geometry is one of the more difficult topics in secondary school mathematics syllabus (Mashingaidze, 2012). Many learners perform poorly in geometry (Examiner report, Zimbabwe School Examination Council (ZIMSEC), 2016, 2017 & 2018). Jones (2002) asserts that the learners' problems with geometry are merely pedagogical, and poor performance can be attributed to the teaching approaches being used, among other factors. Scholars have argued that teaching mathematics in general and geometry, particularly as a culture-free discipline, is one of the major causes of the decline of learners' inspiration as well as their difficulties in learning geometry in particular (Bishop, 1988; Gerdes, 2011). To bridge the gap between school mathematics and the learner's background, the teaching of mathematics should be culturally contextual and relevant to the learner (Bishop, 1988; Rosa & Orey, 2010, Mogari, 2014). Therefore, teachers should make use of learners' cultural background and experience as a way of augmenting their skills in teaching mathematics (Gerdes, 1998; Rosa & Orey, 2010; Mogari, 2014).

Ethnomathematics is a field of mathematics that deals with various forms of mathematics emanating from diverse cultures. Ethnomathematics comprises mathematics that is experienced, practiced, or integrated into the cultural practices or activities of diverse groups in the world (Mosimege & Ismael, 2004; D'Ambrosio & Rosa, 2017). Geometry lies at the epicenter of ethnomathematics and culture (Gerdes, 2005; Zhang & Zhang, 2010). "Geometry provides a culturally and historically rich context within which to do mathematics" (Jones 2002, p.125). Examples of ethnomathematics include geometrical motifs and cryptograms in embroidery work. These are produced by the Ikalinga tribe in India in which parallel lines, connected triangles, and zigzag patterns exemplify the mountainous surroundings of the tribe and the ridged farming on the mountain slants (Abbacan-Tuguic, 2016). Another example is fractals in African design ((Brandt & Chernoff, 2015) and shapes and designs in drawings from hip-hop culture in the United States (Eglash, 2012). Learning mathematics through the integration of cultural values instills basic concepts and expertise by linking various subject areas to mathematics concepts.

Consequently, teaching geometry very well includes an appreciation and a comprehension of the history and cultural context of geometry, the ability to come up with fascinating geometrical problems and theorems, as well as geometry content knowledge, proficiency, and expertise (Jones, 2002). The Zimbabwean mathematics syllabus (ZIMSEC, 2015) suggests that geometry teaching should connect to the learners' cultural background and environment, which is consistent with the social constructivist theory of learning. This entails using ethnomathematics approaches, which are learner-centered and activity-oriented and put emphasis on teaching mathematics using relevant, everyday cultural activities that the learners are familiar with (Mogari, 2014). Ethnomathematics approaches focus on the learners' background, their experiences, and immediate environments incorporated with the school mathematics in a practical way as required in the teaching of geometry concepts. Learners' construction of mathematical knowledge would be based on their general experience, which is connected to their culture and environment.

As such, the objective of this study was to provide insight into how in-service mathematics teachers integrate ethnomathematics approaches into the teaching and learning of geometry at the secondary school level. Specifically, the study intends to provide answers to the following question:

How are in-service teachers integrating ethnomathematics approaches into the teaching of geometry?

Ethnomathematics and Social Constructivism

Social constructivism theory is connected to the ethnomathematics approaches, which put more emphasis on the importance of culture in the teaching and learning process and the significance of the learners' interaction with social values and essentials for the purpose of acquiring the essential geometry knowledge. From the social constructivist theory perspective, learners initially attain societal mathematics ideas from their surroundings, which act as a mediator between the learners and the social values and ideas, and continue to acquire and consolidate them in school, which logically processes and manages knowledge. Ethnomathematics approaches and social constructivism share similar views on two major enlightening assumptions that influence how mathematics should be taught in schools (Matang, 2009). Firstly, learners socially construct knowledge through their social interactions with the immediate environment. Secondly, learning occurs through realistic and contextualised activities that provide the appropriate contextual meaning to what is being learned or taught in the classroom. Although ethnomathematics and social constructivism share similar views, ethnomathematics specifically deals with mathematics teaching and learning.

In contrast, social constructivism is a lens to view teaching and learning of various areas, including mathematics. According to Vygotsky (1978) and Woolfolk (2010), learning cannot occur in vacuity. This has some implications for geometry teaching in the sense that teachers should connect their teaching to the learners' experiences and environments. Both ethnomathematicians and social constructivists support this view. These implications may have beneficial effects if suitable instructional approaches are utilised in tapping into the ethnomathematical knowledge that might be used as a starting point in the teaching and learning of geometry/mathematics (Matang, 2009).

Possibilities of Integrating Ethnomathematics Approaches in the Mathematics Curriculum

Researchers have suggested more cultural activities, practices, and ideas to be integrated into the formal mathematics curriculum (D'Ambrosio, 1985; Adam, 2004; Mogari, 2014; Fouze & Amit, 2018). The integration is essential in the approach to mathematics learning, the mathematics content, its epistemology, and the classroom culture (Adam, Alangui & Barton, 2003). For pedagogical reasons, there has been increasing interest in how ethnomathematics approaches can be integrated into the school mathematics curricula (Adam, 2004; Gerdes, 2005; Paraide, 2015). Adam (2004) identified five options for an ethnomathematical curriculum. All the options are grounded in an understanding that an ethnomathematical curriculum is one in which the social facets of the learners' backgrounds are holistically integrated into the teaching and learning environment (Adam, Alangui & Barton 2003).

The first option for an ethnomathematical curriculum is regarded as "mathematics in a meaningful context" (Adam, 2004; Fouze & Amit, 2018). Such a curriculum presents mathematics as a social reaction to human desires (Fouze & Amit, 2018). This kind of an ethnomathematical curriculum draws examples from the learners' own experiences or practices that are common in the social surroundings of the learners (Adam, 2004). It is postulated that a curriculum of this kind would influence the learners' thinking about mathematics instead of what or how they learn (Bishop, 1988; Mogari, 2014).

The second option is the one that views ethnomathematics as a specific social content that is distinctive from the universal mathematics theories/concepts taught in the classroom, such as distinct designs or ornamental arrangements, for example, those displayed in weaving (Adam, 2004). Such ethnomathematical content could include mathematical concepts, activities, and practices drawn from a specific cultural or social group. It could also include the historical development of mathematics in diverse ethnic groups as well as incorporating culturally diverse mathematics resources into the teaching and learning process. It is acknowledged that such a curriculum would have motivational learning benefits for the learners (Gerdes, 2011, Hunter 2013).

The third option is based on the notion that ethnomathematics consists of developmental stages in mathematics related to the contextual thinking that learners go through in their mathematics education (Adam, 2004). Such an ethnomathematical curriculum is psychological, in the sense that mathematical thinking develops concretely from practical situations. Vygotsky, cited by Fouze & Amit (2018), reported that language determines the development of thought. Hence the learning atmosphere consists of the learners, the learning resources and procedures, as well as collaborative communication. The integration of ethnomathematical practices into the learning environments classrooms can be achieved through the use of indigenous language (Fouze & Amit, 2018). The teaching of mathematics, in an indigenous language that the learners are familiar with, makes learning more meaningful and improves understanding of the concepts grasped (Paraide, 2009; 2014). A good reason for using such a curriculum is that mathematics should begin with what the learners are familiar with, then make links to their culture, and then relate to the world of mathematics (Fouze & Amit, 2018). Such a curriculum would benefit learners in terms of them becoming aware of the mathematics that exists in their own culture and viewing mathematics as a living and developing discipline (Hunter 2013; Meaney & Lange, 2013; Rosa & Orey, 2016).

The fourth option is based on the view that all the learning environments or classrooms are positioned in a cultural context, comprising social values, principles, and culturally detailed learning philosophies (Adam, 2004; Fouze & Amit, 2018). Such an approach to the curriculum was proposed by Bishop's (1988) work on "Mathematical enculturation," where he focussed on aspects such as visualization and geometry and social and cultural facets of mathematics teaching and learning that have a potential of improving learners' understanding of mathematics. The curriculum was intended to help learners, as they learn in an environment that is compatible with their societies. According to Rosa and Orey (2016), mathematics is everywhere, and mathematical ideas exist in every culture. Mathematics and daily life activities are connected.

Accordingly, Brandt and Chernoff (2015) suggested that mathematics teachers must incorporate components of ethnomathematics in lesson preparation to take advantage of a culture that is dominated by technology. Learners live in multicultural environments, where their relationships are intercultural, and their everyday lives are imbued with available technology. Various technological instruments such as TVs, calculators, computers, films, cellphones and the internet that permit a pictorial, auditory, and sensory learning practice that can result in learners solving problems they come across in daily activities (D'Ambrosio & D'Ambrosio, 2013; Fouze & Amit, 2018). Using such technological tools will allow the learners to learn in a more straightforward way that will increase their likelihood of understanding the mathematical concepts as well as their drive to learn mathematics (Fouze & Amit, 2018). Technological tools can transform techniques for dealing with natural, social, cultural, political, and economic and environmental problems. The integration, of technological tools, in the teaching and learning of mathematics that the learners are familiar with might help learners to make connections between school mathematics and everyday life mathematics, as well as developing the skills of solving real-life problems.

The fifth option is based on the notion of integrating mathematics activities, concepts, and practices instigating from the learners' culture, with those of conventional, formal academic mathematics (Adam, 2004). Learning begins with the learners' experiences from their environment. It builds on those mathematical notions, in the long run, to grasp and understand such things as the need for the correctness and the use of procedures in mathematics, as well as in realistic situations. The understanding of the mathematics taught in schools would then give feedback and help in the knowledge of culturally-based mathematics. It postulates that such a curriculum might motivate learners to view mathematics as an essential component of their daily life, improve learners' capacity to make significant mathematics relations, and deepen their understanding of all kinds of mathematics (Adam, 2004, Mogari, 2014). The work of Adam (2004) is an example of such a curriculum. Adam (2004) researched the implementation of an ethnomathematical unit in the Maldives with Grade 5 teachers and learners. That research involved measurement concepts such as perimeter, area, and volume. Teachers and learners visited different places, for example, markets, carpentry, and boat-building shed to research the mathematical features of those activities. Teachers and learners welcomed and appreciated the use of the ethnomathematical approach in the teaching and learning of measurement.

Research evidence showed that both teachers and learners managed to recognise cultural activities and experiences in Maldivian culture, displaying measurement systems, and they also managed to connect the exhibitions to the academic mathematics in their school syllabus (Adam, 2004). For example, perimeter and area used in carpentry and boat-building sheds. The benefits resulting from such activities include motivation and interest, being able to link school concepts on measurement to real-life situations, and to understand that humans develop mathematics as a response to specific problematic situations. Adam's (2004) study showed that it is possible to integrate ethnomathematics approaches when teaching mathematics. Adam's research focused on a topic on measurement. The current research is on how the in-service mathematics teachers integrate ethnomathematics approaches into the teaching and learning of geometry.

In another study in California, Rosa and Orey (2009) investigated the symmetrical designs found in quilts, making associations that involved geometry and the craft and art of quilting. During their analyses of different symmetrical freedom quilts, Rosa and Orey (2009) developed a teaching unit for geometrical transformations. The unit comprises of comprehensive work on symmetry, reflections, rotations, and translations. Those were captured in lesson plans that enable teachers to design geometry activities that would help learners to comprehend geometry, particularly concepts of transformations and symmetry. The learners first observed the quilts in their environment and then made their quilts before the study. Geometry concepts were viewed as abstract by learners; however, analysing real symmetrical freedom quilt patterns, as in Figure 1, enabled them to change their views about geometry and to see the relevance of learning geometry (Rosa & Orey, 2009).

Figure 1: Freedom Quilt Displayed on Window-sill (Adapted from Rosa & Orey, 2009, p. 58)

Their particular patterns identify quilts that bear them specific names; for instance, the quilt in Figure 2 is known as the Bowtie, while the other one in Figure 3 is called *Shoofly* (d'Entremont, 2015).

Figure 2: Bowtie

Figure 3: Shoofly

(Adapted from d'Entremont, 2015, p. 2820)

On the whole, quilts provide "real world" examples of geometry concepts since the design of quilts includes the use of symmetry, translations, rotations, and reflections. That study demonstrated how to link school geometry to the learners' environments and culture. The quilts may be used as models by teachers to teach numerous geometrical concepts such as shapes, perimeter, area, symmetry, measuring, and transformations that include rotation, translations, and reflection. However, that study focused only on one concept, which is a geometrical transformation. The current research is about in-service teachers' incorporation of ethnomathematics approaches into the teaching and learning of geometry.

Research Methodology

Research Paradigm and Design

Pragmatism is acknowledged as the guiding theory in mixed methods research, which was employed in this study to investigate in-service teachers' integration of ethnomathematics approaches into the teaching and learning of geometry. The pragmatists believe that education must be practical and come through experience (Creswell & Plano Clark, 2011; Creswell, 2015). According to Cohen et al. (2015), the pragmatist paradigm draws on and combines both qualitative and quantitative methods to meet the needs of the study and to provide complete answers to the research questions. Pragmatism suggests that "what works to answer the research questions is the most useful approach to the problem" (Cohen et al., 2015, p.23) under study, be it a combination of focus group discussions, questionnaires as was done in this study to enhance the quality of the research (Creswell & Plano Clark, 2011). As this study intends to find out in-service teachers' integration of ethnomathematics approaches into the teaching and learning of geometry, it fits nicely into the principles of pragmatism.

To achieve the purpose of the study, the mixed-methods design investigated how the in-service teachers integrate ethnomathematics approaches into the teaching and learning of geometry. A convergent parallel mixed-methods design in which quantitative and qualitative data was gathered and analysed concurrently (Creswell & Plano Clark, 2011) was employed to conduct this study. According to Creswell and Plano Clark (2011), in a convergent parallel mixed-methods design, the gathering of quantitative and qualitative data is done both simultaneously. Then the findings are amalgamated in the analysis and the interpretation phases. The questionnaire gathered both qualitative and quantitative data simultaneously through closed and open-ended questions. Focus group discussions gathered qualitative data that was merged with the data from the questionnaire during analysis. The basis for collecting both quantitative and qualitative data, through questionnaires and focus group discussions, was to gain a deeper understanding of the problem under study; teachers' integration of ethnomathematics approaches into the teaching and learning of geometry. The two data sets were merged (Creswell, 2015).

Participants

The participants in the study were the 2017 second-year cohort of Bachelor of Science Honours degree in mathematics in-service teachers. In-service mathematics teachers are admitted into the program with minimum teaching qualifications, such as diplomas/certificates in education attained from teachers' colleges or universities and a minimum of two years of teaching experience. The in-service mathematics teachers have the requisite knowledge in the teaching and learning of geometry since they were all trained to teach mathematics up to the Ordinary Level ('O' Level). In-service teachers graduate with a degree in mathematics education and are qualified to teach mathematics up to Advanced level ('A' level).

Sample and Data Gathering Methods

The cohort comprised 50 male and 30 female in-service mathematics teachers. A total of 40 in-service secondary school mathematics teachers (25 male and 15 female) were selected through proportional stratified random sampling to complete the questionnaires. The purpose of using stratified random sampling was to ensure that the participants were a representative of the group to be studied in terms of gender. Research-based recruitment was used to select the same participants who were recruited to complete the questionnaires to participate in focus group discussions. This is in line with Creswell (2015), who suggested that in the convergent parallel mixed-methods design, data can be gathered from the same number of participants on both the qualitative and quantitative methods, to resolve the issue of sample size in these two methods. The selection of group members was random. Five groups were formed; each group consisted of three female and five male in-service mathematics teachers.

All the 40 in-service teachers were diploma holders, with 15 of them teaching Form 1 and Form 2, while 25 were teaching Form 3 and Form 4 classes. Geometry is taught from Form 1 up to Form 4. Regarding their teaching experience, 15 teachers had 2-5 years of teaching experience, 20 had 6-10 years of teaching experience, and 5 had between 11-15 years of teaching experience.

The questionnaires consisted of a 5 point Likert scale with questions such as 'I design geometry learning activities that are adapted to learners' cultural background' and open-ended questions such as 'Explain how you include cultural/ contextual examples when teaching.' As a result, the questionnaire gathered both qualitative and qualitative data concurrently.

A focus group discussion is an interactive discussion, where a focus group facilitator keeps a small and homogeneous group of 6-12 participants concentrated on the problem under study (Christensen et al., 2015). The focus group discussions comprised questions such as

'Explain how you integrate ethnomathematics approaches into the teaching of geometry.' The focus group discussions were for approximately 55 minutes, with five groups. The discussions were held in a lecture room during lunch hour for five consecutive days. Each focus group discussion started with an explanation of the purpose of the study and it was made clear that the participants' answers were neither right nor wrong. Participants were also informed that they should feel free to have a conversation with group members, as well as giving others a chance to participate and share ideas. Debriefing meetings were held immediately after each focus group discussion to check whether the focus group discussion was providing the information necessary to meet the objectives of the study. The audio recorded voices were played back with a tape recorder to make sure that what they had said was captured correctly.

Data Analysis Procedures

Descriptive Statistics

In terms of data analysis, descriptive statistics, which included the frequencies and percentages, were used to analyse the quantitative data. The responses to the questionnaires were presented on a 5 point Likert scale, with SA (strongly agree) taking the highest score of 5. In the current study, the developed questionnaires and focus group discussion items were given to three mathematics educators involved in data gathering instrumentation validation for research at the university where the study was done.

Inductive Analysis

Inductive analysis leading to categories and themes that emerged from qualitative data (open-ended questionnaire questions and focus group discussions) was framed in this study. Inductive analysis is a process where patterns, categories, and themes are developed through organizing into units (Creswell, 2015). Data with similar meanings were categorized together under one theme. For example, using a catapult to demonstrate the concepts applicable to a shear from an open-ended question was classified under learning materials and resources as a theme. Audio-taping, that produced data, through recording contextualised verbal data (Creswell, 2015), was used to record the focus group discussions. One of the purposes of recording the focus group discussion, was to allow the researchers to replay the tapes throughout, when presenting and analysing the data (Sarantakos, 2013), as a way of confirming the findings. Member checking was used to ensure the accuracy of the transcriptions of focus group discussions (McMillan & Schumacher, 2010). In this study, member checking was achieved by taking the findings back to the participants for confirmation and validation purposes. The two data-gathering instruments were used for the rationale of improving the validity of data and attaining processes of reliability (Creswell, 2015). Pseudonyms were used in place of participants' real names. Five groups were used in this study, each group comprising 5 males and 3 females, to ensure a representative composition in terms of gender. However, gender was not an issue in this study. Pseudo names such as A, B, C, D, and E were also used for each of the five groups, and codes were used for each in-service teacher from IST1 to IST40.

Findings

Research results are presented and summarised using tables according to themes, with categories, mainly through direct quotations and verified by discussions with the aim of re-contextualising them within appropriate literature. The data from closed-ended questionnaire questions in Table 1 shows the teachers' integration of ethnomathematics approaches.

Item	Statement	SA N (%)	A N (%)	N N (%)	D N (%)	SD N (%)
1	I design geometry learning activities that are adapted to learners' cultural background.	5 (12.5)	18 (45)	9 (22.5)	6 (15)	2 (5)
2	It is not possible to link geometrical concepts to learners' social environments.	3 (7.5)	3 (7.5)	5 (12.5)	13 (32.5)	16 (40)

Table 1: Teachers' integration of ethnomathematics into the teaching of geometry

The findings in Table 1 (item 1) show that 57 percent of the participants agreed (inclusive of those who agreed or strongly agreed) that they designed geometry learning activities that are adapted to learners' cultural background. The majority of the teachers (72.5%) were of the view that it was possible to link geometrical concepts to learners' social environments (see Table 1, item 2).

The closed-ended questionnaire data in Table 1 was supported by the open-ended questionnaire data, which showed that 60 percent of the teachers made provisions for the use of cultural/ contextual examples in geometry lesson planning. They also responded to the question of how they used cultural/ contextual examples when teaching geometry. How they did, was categorised into two, as learning materials and resources (see Table 2) and learning context, as indicated in Table 3, including the representative quotes for each category.

Representative quotes
Through the use of media such as indigenous fruits (IST3)
Learners are asked to bring in learning aids such as circular tops to draw circles (IST12)
By using available environment resources (IST20)
I engage the environment and the readily available objects (IST33)
To demonstrate shear l use using a boy pulling a catapult (IST26).

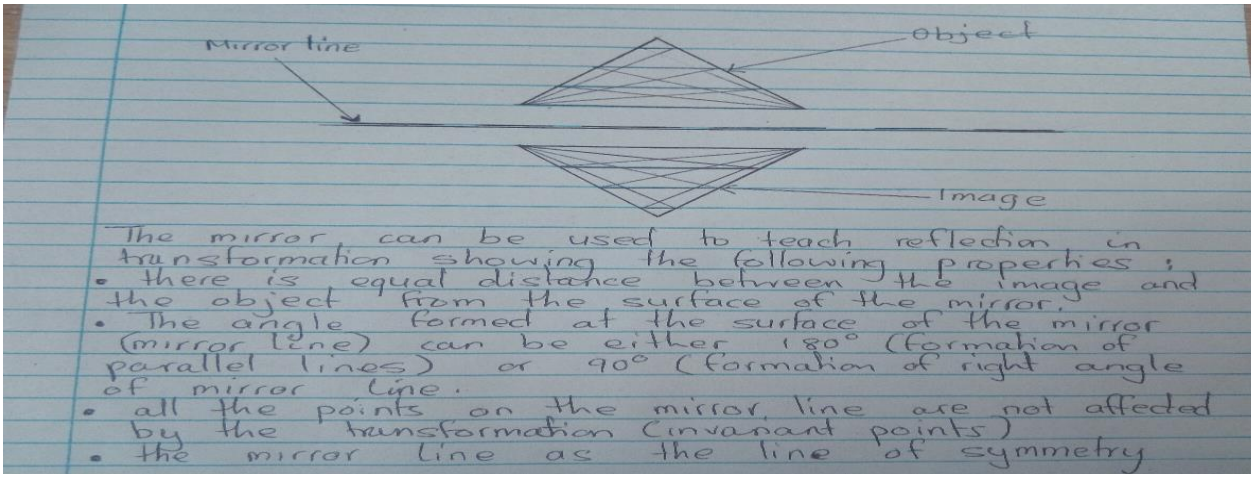
Table 2: Teachers' inclusion of cultural examples in geometry lesson planning as learning materials and resources

The teachers' responses indicated that they used cultural/contextual examples as learning materials and resources in the teaching of geometry (see Table 2).

Data from the focus group discussions also confirmed the teachers' use of cultural examples as resources and materials in teaching geometry. Substantiation for this is presented in the teachers' voices below.

> *We also relate to what the learners' already know, from their everyday life, when teaching transformation. For instance, when teaching the concepts on reflection and symmetry, we use a mirror. Each learner, is asked to bring a mirror, which is used to teach concepts on reflection and symmetry. For reflection and symmetry, learners, are asked to stand before their mirrors and they will see their images. Group A*

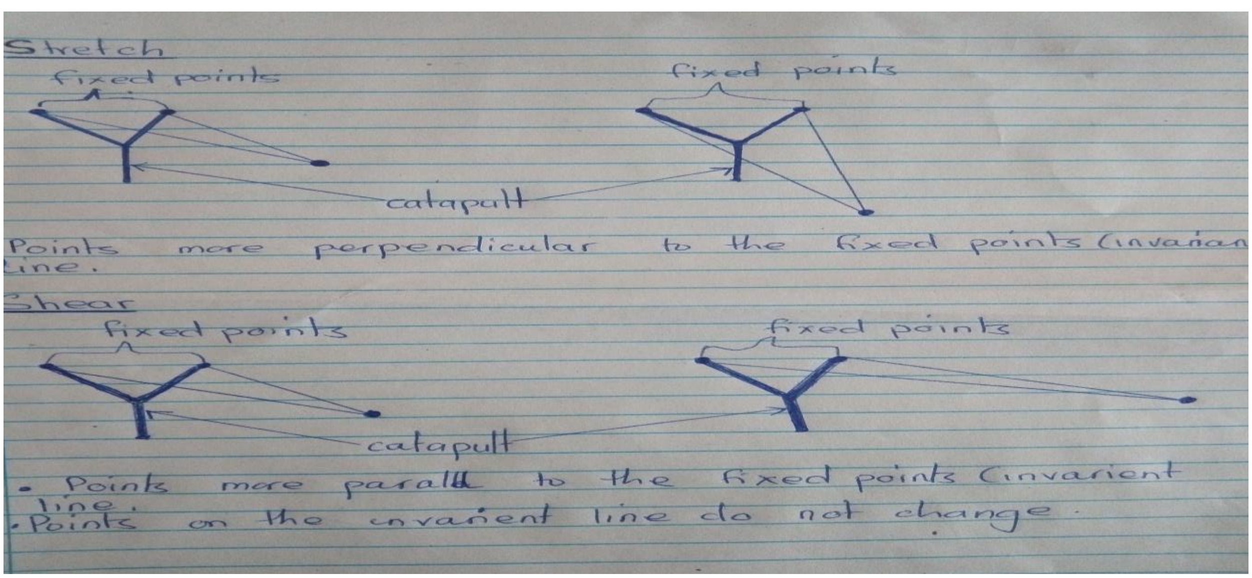
When using the mirror, this will look like this: (Group A teacher then wrote, see Extract 1):



Extract 1: Group A's response

The mirror can be used to teach reflection in transformation showing the following properties:

- *There is equal distance between the image and the object from the surface of the mirror.*
- *The angle formed at the surface of the mirror (mirror line) can be either 180^0 (formation of parallel lines) or 90^0 (formation of right angle of mirror line)*
- *All the points on the mirror line are not affected by the transformation (invariant line)*
- *The mirror line as the line of symmetry. Group A*

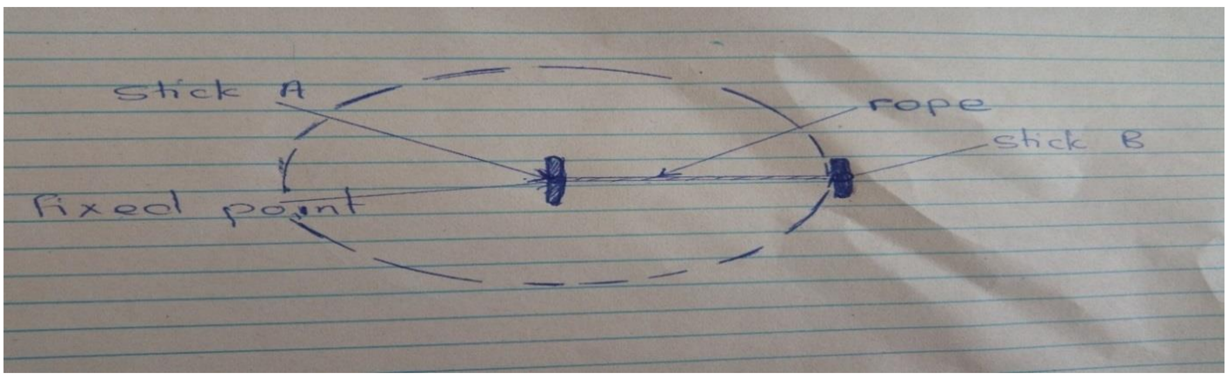


Extract 2: Group B's response

'We teach geometry concepts such as shear and stretch using a catapult'. Group B
You know if you have a catapult, this will look like: (Group B teacher then wrote, see Extract 2):

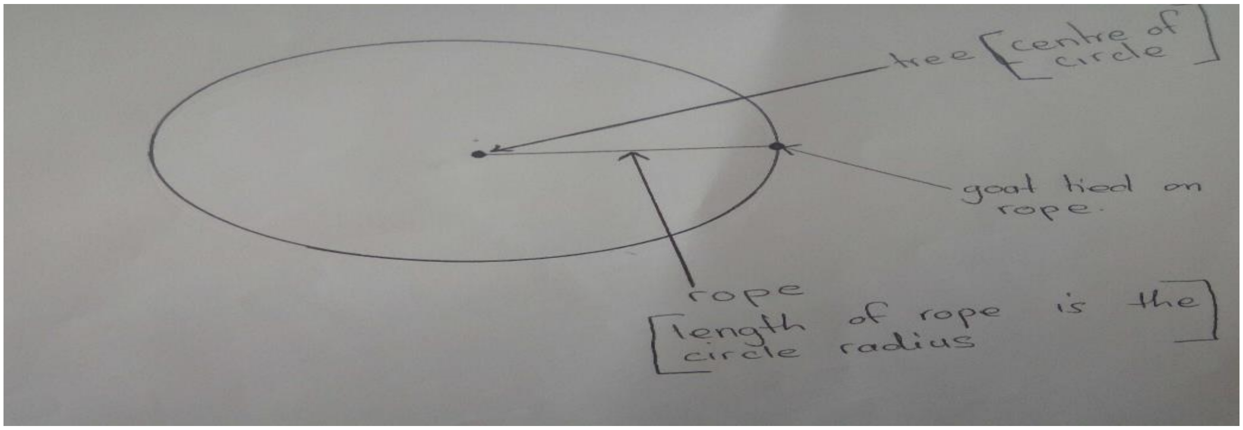
- *Points more perpendicular to the fixed points (invariant line).*
- *Points more parallel to the fixed points (invariant line).*
- *Points on the invariant line do not change. Group B*

Yes, for example, two sticks and a string, can be used to explain how to draw a circle from a fixed point with a certain radius, r. A string of a certain radius, suppose r, is attached to the two sticks. In rural areas, this is the idea that is used in the foundations of the huts. This can be used to teach circle geometry concepts such as the radius, circumference of circle and the locus of points equidistant from a fixed point. Group C
When doing this in the class, in practice, it will be like this: (Group C teachers then wrote, see Extract 3):



Extract 3: Group C's response

Sometimes, examples on drawing the circles when building round huts. An example of a goat tied on a tree where the total grazing area is the area of a circle, which is determined by the length of the string equal to the radius, r. The locus of point's r from a fixed point can be taught by considering the boundary a goat can graze whilst tied with a rope of length r from a tree. The example can be used to explain how to draw a circle from a fixed point with a certain radius as well as the locus points equidistant from a fixed point. Group D
The diagram will be like this: (Group D teachers then wrote, see Extract 4):



Extract 4: Group D's response

The teachers' responses (Extracts 1, 2, 3 and 4) illustrated how they used cultural examples in teaching geometry.

Representative quotes
To demonstrate translation l use examples from the construction of buildings (IST13)
Use examples from different cultures (IST2)
Examples such as circumference of the base of the hut (IST31)
All the learners are given the opportunity to give examples from their environment (IST21)
I make use of the round tank to explain circle geometry (IST11)
Use materials from learners' daily experiences (IST37)
For example in transformation many cultural examples are available (IST40)
Say in circle geometry many cultural examples are available (IST4)
By linking each concept to the immediate environment (IST8)
Use of real life examples, for instance, relating to how the rural hut is built (IST10).

Table 3: Teachers' inclusion of cultural examples in geometry lesson planning as learning context

Apart from using the cultural /contextualised examples, as learning materials and resources, from the environment, in teaching geometry, some of the teachers (60%) reported that they teach geometry through several activities carried out in the society (see Table 3). They used cultural /contextualised examples as a context for learning. They referred to outdoor activities done outside the classroom. The teachers believed that they could relate the geometry that they teach to culture and environmental situations. For instance, connecting the teaching of circle geometry to round tanks and huts. Teachers' use the cultural /contextualised examples as a context for teaching geometry, was supported by the following data from the focus group discussions:

> *We do, when we relate geometry to the learners' home activities and culture. To demonstrate, the relationship between circumference and diameter, learners can use clay pots of different sizes, and then measure the circumference, by aligning strings around the pots, then compare the diameter with the measured circumferences, thereby deducing that the diameter is proportional, to the circumference with π as the constant of proportionality. Group A*
>
> *We do, especially when dealing with circles, we use circular objects in the environment, and you may refer to such examples. Houses, both in rural and urban areas, are built at a certain distance from the road, for precaution*

measures. This example, can be used to teach locus of points equidistant, from a line. Group B

We use objects that learners are familiar with, to teach geometry concepts. For instance, if we show the learners a photograph and its large enlargement, this could be used to introduce the concepts of enlargement. Photographs, can be used, to explain the negative scale factor, since the image is smaller than the object. Some real-life examples are, house plans and maps that can fit on A4 pages. Group C

The teachers' examples above showed how they used the cultural /contextualised examples as a context for teaching geometry.

The findings from the focus group discussions also showed that some of the participants (20%) reported that they used the Shona language when teaching geometry. This is what the teachers from Group A said:

We use Shona language when introducing geometry concepts to make learners understand better. We start by explaining in Shona, then move to English. Shona is part of the learners' culture and is their first language hence we do integrate. Shona language is rich with multiple meanings contained in a single word, for example denga ("roof", "the sky" or "on top"). *Group A*

The participants from Group A's intention was to present geometrical content in a local language, Shona, so that learners can understand the concepts of geometry.

Discussion

The findings showed that the majority of the teachers were of the view that it was possible to relate geometrical concepts to learners' social environments. This finding is consistent with Jorgensen et al.'s (2010) opinion that many teachers use cultural activities, including learners' prior knowledge, in their lesson planning and delivery. The teachers used various cultural materials and resources in their geometry lessons, planning to help the learner develop the envisioned geometry knowledge and skills. The findings are consistent with results from earlier studies (Hunter 2013; Meaney & Lange, 2013), in terms of including cultural/contextual examples when planning for geometry lessons and using them as learning materials and resources. Rosa and Orey (2016) assert that teachers needed to use culturally specific examples in teaching geometry by exposing learners to a range of cultural contexts.

Also, the findings showed, that some teachers were using the local language when teaching geometry. The findings are in line with the view held by Fouze and Amit (2018), who pointed out that indigenous languages can be used in the teaching and learning of mathematics. However, the participants were also quick to point out that some Shona words have several meanings. For example, *denga* in Shona can mean the roof, the sky, or on top. This implies that the different meanings of the word *denga* pose challenges for the effective integration of ethnomathematics approaches into the teaching of geometry. Geometry language includes terms specific to geometry, and the everyday language has different meanings when used in geometrical contexts (Cangelosi, 1996). Therefore, teachers should be made aware that some geometrical terms might not translate well into indigenous languages, thus leaving the learners with the challenge of trying to understand the geometry content taught.

The integration of cultural examples and activities into the teaching and learning of geometry is in line with the social constructivist theory, in the sense that new knowledge is scaffolded by previous experience. However, integrating ethnomathematics approaches into the teaching and learning of geometry to the in-service mathematics teachers was limited to representations, objects, and problems that replicate everyday life activities. There is a need for teachers to consider the incorporation of culture in teaching and learning resources, using technological means. For example, the internet, TV, and films, that enable a pictorial, audio, and sensual learning procedure as suggested by Fouze and Amit (2018). In so doing, learners could learn in a simpler way that will enhance their likelihood of understanding geometry concepts as well as their desire to learn geometry. Teachers also need to enhance their ethnomathematical knowledge. That could be achieved by training in ethnomathematics approaches that embrace the use of technological tools in the teaching and learning of geometry. The inclusion of technological tools that the learners are familiar with in the teaching and learning of mathematics generally and in geometry specifically will improve learners' understanding of geometry concepts.

Conclusions

The purpose of this study was to investigate how in-service mathematics teachers integrate ethnomathematics approaches into the teaching and learning of geometry. The study findings showed the participating teachers (60%) used cultural examples and activities in geometry teaching, as learning materials and resources, as a context for teaching geometry. For instance, a mirror is used to teach geometrical reflection in the classroom. The findings of this study concur with results from earlier studies (Matang, 2002; Gerdes, 2005; Rosa & Orey, 2009; 2010; Fouze & Amit, 2018) in terms of linking geometry concepts to the learners' cultural activities and experiences. Teachers also indicated that they used learners' indigenous language to enhance their comprehension of the geometry concepts. The teaching of geometry, in a language that the learners were used to, is in line with Paraide (2009, 2014), who concluded that the use of indigenous languages, when teaching, makes learning more meaningful and improves understanding of concepts learned. As indicated by Vygotsky (1978) and Woolfolk (2010), learning cannot take place in a vacuum. Learning occurs when learners interact with more knowledgeable peers or teachers in the classroom; for that reason, language is essential for communication and any form of interaction in the classroom. Ethnomathematics approaches are a means of improving learners' achievement in geometry. Teachers are in charge of the teaching and learning process, which consists of the development of syllabi, and teaching and learning approaches, based on the incorporation of cultural essentials and principles, in the geometry classroom. The incorporation of learners' cultural values and prior knowledge in geometry classrooms might contribute significantly to the learners' learning process; enhance their understanding of geometry concepts as well as retention.

Even though the study findings were limited to only one university, the implications of the study, for further mathematics curriculum development, are propitious in Zimbabwe and even other countries in similar situations.

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