e-ISSN: 2789-5661
2024: Vol 4(s1), pp 1-15. https://doi.org/10.38140/ijss-2024.vol4.s1.06
Interdisciplinary Journal of Sociality Studies

Culturally Responsive Pedagogy for the Promotion of Understanding Mathematics: The Case of Rural Situated Primary Schools in Post-Apartheid South Africa

Zingiswa Jojo[1*]

AFFILIATIONS

[1]Department of Secondary and Post School Education, Rhodes University, Makhanda, South Africa.

CORRESPONDENCE

Email: zingiswa.jojo@ru.ac.za*

EDITORIAL INFORMATION
Received: 20 June 2024
Revised: 18 October 2024
Accepted: 19 October 2024
Published: 03 November 2024

DOI: 10.38140/ijss-2024.vol4.s1.06

Abstract: The language of instruction, awareness, and creativity are at the centre of the realities faced by both mathematics teachers and learners, shaped by a socio-political history whose impact and legacy transcend generations in South Africa. Consequently, the dire state of mathematics education in South Africa remains a cause for concern. Recognising the need to conceptualise and develop culturally responsive pedagogy, this paper presents the results from the third phase of a three-year longitudinal study focused on teachers' journeys in infusing indigenous knowledge when teaching geometry to senior primary learners in rural schools. This qualitative study, which followed a case study design, explored several approaches to discussing, teaching, and considering an immediate, perpetual, operative, and discursive approach as culturally disruptive pedagogy used as an indigenous way to promote geometric understanding. Observations and semi-structured interviews were conducted with two purposefully selected participants after their lesson presentations to allow them to clarify, elaborate, and introduce more detail, enriching their explanations of the artefacts used. Results indicated that teachers' references to several artefacts and indigenous activities, such as using straws, wool, and staplers, promoted the understanding of the construction of prisms and pyramids. Recommendations include training mathematics teachers to prepare lessons that incorporate indigenous knowledge and to explore ethnomathematics as a culturally responsive teaching strategy, particularly in contextualising mathematical geometry learning, so that this concept can have relevance and meaning for rural students.

Keywords: Mathematics, geometry, indigenous knowledge, rural primary schools, pedagogy.

1. Introduction

From ancient geometric patterns to Renaissance perspective and modern abstract art, mathematical principles have been used to create aesthetically pleasing and harmonious compositions (Dansu, 2023). This is evident in the works of artists, designers, and architects, who often incorporate mathematical concepts such as symmetry, proportions, and fractal patterns into their creations. South Africa's cultural fabric is woven from a multitude of heritages that can enhance the understanding of concepts in mathematics classrooms. Scholars (Samovar et al., 2006; D'Ambrosio, 1985) define culture as a deposit of knowledge, experience, beliefs, values, actions, attitudes, meanings, hierarchies, religion, notions of time, roles, spatial relations, concepts of the universe, and artefacts acquired by a group of people over generations through individual and group striving. UNESCO has recently articulated the synergies between culture and education in normative action and policy recommendations (Wiktor-Match, 2022). This culminated in the promotion of broad perspectives and deep knowledge about history and society to strengthen heritage protection and transmission, as well as to foster intercultural understanding and appreciation of cultural diversity in the field of culture. In South African education, Padayachee (2022) suggests that through cultural dimensions, learners of all ages should access and benefit from quality education that is contextually relevant, nurturing a greater understanding and respect for all cultures, values, and ways of life. Thus, both globally and locally, there is a call for intersectoral collaboration that draws on the

How to cite this article:
Jojo, Z. (2024). Culturally responsive pedagogy for the promotion of understanding Mathematics: The case of rural situated primary schools in Post-apartheid South Africa. *Interdisciplinary Journal of Sociality Studies*, 4(s1), 1–15. https://doi.org/10.38140/ijss-2024.vol4.s1.06

resources of culture and education in integrated actions towards sustaining more inclusive, agile, and resilient societies. The challenge for practitioners is to assist in establishing common ground for cooperation on how education and culture can be mutually beneficial and supportive, with new initiatives emerging at the intersection of these fields.

Jansens (2019) identifies key challenges in South African mathematics education, including teaching without meaning, fear of failure, curriculum constraints, teacher content knowledge, pedagogical shortcomings, poor numeracy foundations, and a lack of educator enthusiasm. In addition, Mbhiza (2021) highlights several key factors impacting mathematics education in rural South Africa. His study reveals that approximately 40% of rural schools have insufficient learning materials, textbooks, technology, and trained mathematics teachers, which directly affects students' understanding of mathematical concepts. According to Mbhiza (2021), 60% of teachers in some rural schools may not have formal training in mathematics education, leading to gaps in instructional quality. Other factors that negatively contribute to students' poor performance in rural schools include learner performance, socio-economic factors, and infrastructure issues, with many rural schools lacking basic amenities. Over 50% of schools reportedly have no access to electricity or running water (Mbhiza, 2021). Educational disparities in rural schools are further exacerbated by inadequate classroom facilities and inconvenient transportation, which together create a challenging environment for mathematics education in rural South Africa. This situation calls for targeted interventions to improve outcomes for learners in these areas. In this paper, I argue that there is a need to investigate the mathematical ideas embedded in the cultural practices of the ethnic and linguistic communities of rural learners.

Will and Najarro (2022) note that culturally responsive pedagogy (CRT) centres the knowledge of traditionally marginalised communities in classroom instruction, empowering students to be lifelong learners and critical thinkers. Thus, using students' customs, characteristics, experiences, and perspectives as tools for improved classroom instruction is termed culturally relevant teaching (Will and Najarro, 2022). This approach can help learners see themselves and their communities as belonging in schools and other academic spaces, leading to greater engagement and success in education. Gay (2018) identifies five essential components of culturally responsive teaching: (i) teachers' strong knowledge of cultural diversity, (ii) culturally relevant curricula, (iii) high expectations for all students, (iv) an appreciation for different communication styles in class, and (v) the use of multicultural instructional examples. Consequently, using CRT, teachers can connect prior knowledge and students' cultural experiences with new knowledge. It is therefore crucial for teachers to consider the cultural values, traditions, and contributions of various ethnic groups and incorporate that knowledge into their instruction. When issues are contextualised and students' identities validated, they are highly likely to achieve academic success.

Many studies (Nielsen, Nicol, and Owuor, 2008; Sparrow, 2012; and Jett, 2013) report on current perspectives on culturally responsive mathematics pedagogy and explore how complexity thinking can enhance these. Moreover, Nolan & Xenofontos (2023) examined teachers' perspectives on culturally responsive pedagogy (CRP) in mathematics, while Acharya et al. (2020) investigated mathematics educators' views on the cultural relevance of basic mathematics. There appears to be limited literature on culturally responsive pedagogy aimed at promoting understanding in mathematics. This paper addresses that gap and responds to the question: '*How can culturally responsive pedagogy be used to promote understanding of mathematics in rural primary schools?*'

1.1 Problem statement

Recent reports (Maqoqa, 2024; Machisi, 2024) indicate that the poor performance of learners in mathematics, particularly in geometry, is a major concern. The teaching of geometry has been marked by significant pedagogical difficulties in South Africa, despite its importance in honing essential visual, logical, rational, and problem-solving skills required to understand architecture, engineering, and other relevant fields (Tachie, 2020). This is despite the efforts made by the department to supply almost all primary schools with mathematics kits containing instructional materials that can be utilised to enhance students' comprehension and learning abilities, as well as their motivation to understand geometry. Euclidean geometry occupies about 30% of the content required for learners to comprehend in paper 2 of grade 12 mathematics. This implies that learners' failure to grasp geometric concepts negatively affects their overall performance in the subject. The lack of understanding of geometric concepts begins at the primary school level, where a significant portion of new knowledge should be connected to what learners already know.

One of the broader aims of the National Curriculum Statement is to value indigenous knowledge systems by acknowledging the rich history and heritage of our country (Department of Education, 2012). This would assist schools in producing learners who demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation. Harnessing a mathematical way of describing objects found in the surrounding environment of our learners in rural locations can instil pride in them and help them preserve what they know while building on it. The use of culturally responsive teaching strategies is evidenced by activating students' prior knowledge, making learning contextual, and tapping into students' cultural capital (Krasnof, 2016). Hence, this study aims to investigate how culturally responsive pedagogy can be employed to promote understanding of mathematics in rural primary schools.

2. Literature Review

Historically, mathematics is inseparable from culture and the evolution of cultures, as it is deeply rooted in cultural symbols, operational processes, and representations in the arts, crafts, and literature (Archaya et al., 2021). For example, the language of instruction, awareness, and creativity are central to the realities of both mathematics teachers and learners, which are shaped by socio-political history, whose impact and legacy transcend generations in South Africa. Researchers (Sumarto, 2020; Tjahyadi et al., 2019) identified seven elements that define culture: language system, knowledge, social dynamics, technology, economic activity, religion, and art. In mathematics, teachers face cultural challenges, such as when defining concepts like 'fraction' and 'ratio', since different languages may have unique terminologies, resulting in confusion for students. Additionally, knowledge systems can differ; for example, a gable may be interpreted as the same as a parallelogram in some cultures, while in others it may mean a trapezoid. Different forms of art available in various cultures can significantly impact teaching effectiveness and student engagement, especially when teaching geometry.

Furthermore, culture is learned through interaction, observation, and imitation, and is transmitted through symbols, which can include both verbal and non-verbal language, as well as images and icons (Matusov & Marjanovic-Shane, 2017). The language system is used to facilitate instruction in a mathematics classroom. This form of social interaction can utilise mathematics language or any language of instruction. In the lower grades, for example, language is crucial in strengthening and supporting learners' ability to identify and understand the symbolic nature of numerals. Teachers in lower classes are encouraged to code-switch and use the mother tongue to explain certain concepts. However, frequently, the teacher's home language differs from the learners' local language, making code-switching impractical for lesson delivery or explanations.

Barwell (2016) asserts that mathematical discourse has a specialist vocabulary, which includes: (i) technical terms specific to mathematics, such as equilateral, quotient, and probability; and (ii) specialist uses of more general terms, like lines, factors, and frequency, as well as mathematical terms that employ everyday words for unrelated ideas, such as function, expression, difference, and area. Barwell (2016) proposes that language, when used as a source for a dialogic approach, allows for multiple sources of meaning through the incorporation of various languages, discourses, and voices in a mathematics classroom. Thus, it is vital for learners to acquire relevant mathematical vocabulary, especially the syntax used in expressing logical relationships. For example, words such as 'and', 'of', 'or', 'a', 'if', and 'then' are significant in defining mathematical relationships (Barwell, 2016). When used correctly, this syntax may assist learners in understanding (a) mathematical symbols, (b) specialised forms of expression, including both written and spoken mathematical explanations, proofs, or definitions, as well as text types like word problems, and (c) a social dimension that encompasses the dialogue between the learner and teacher in a mathematics classroom. Therefore, it is a challenge for teachers to relate the components of mathematics discourse to the knowledge possessed by the community that learners bring into the classroom. How, then, can the process of forming social groups in society be harnessed to enable social interactions in class?

Bishop (2014) asserts that a cultural perspective on mathematics compels us to examine different mathematical histories and their implications regarding who developed mathematical ideas in various societies. According to Hoyles (2018), the integration of digital technology has the potential to transform activities in mathematics classrooms by engaging students and providing them with opportunities to take ownership of their learning. I believe that learners more readily take ownership of their learning when they are familiar with the context of their lessons. Fouze and Amit (2023) argue that cultural values, traditions, and symbols manifest in the life of every society. To describe the mathematical practices of identifiable cultural groups, which may be regarded as the study of mathematical ideas found in any culture, D'Ambrosio (1985) coined the term ethnomathematics. The author further explains that the prefix 'ethno-' refers to the socio-cultural context, which includes language, jargon, codes of behaviour, myths, and symbols, while the suffix 'tics', with the same root as technique, refers to specific ways used to reason and infer (Rosa & Orey, 2007).

The Curriculum Assessment Policy Statement (CAPS) calls for the use of contextual mathematics problems that incorporate issues related to health, social, economic, cultural, scientific, political, and environmental matters whenever possible (Department of Education (DBE), 2012, p. 8). However, several studies in South Africa (Meeran and van Wyk, 2022; Braun-Wanke, 2017; Govender and Mudzamiri, 2018) report that South African teachers have not made a pedagogical shift, lack the necessary knowledge and skills, and are unprepared to teach culturally responsive classes. This is despite the fact that the curriculum has been revised three times in the past three decades since the country attained democracy. Meeran and van Wyk (2022) argue that for almost three decades of curriculum changes, teachers have been left behind and unprepared to apply culturally responsive pedagogies within the diverse classroom settings across the country. Several studies (Meeran and van Wyk, 2022; Meeran, 2017; Pournara et al., 2015) have investigated mathematics teachers' views on culturally responsive teaching and how they address the phenomenon of cultural diversity in teaching mathematics. This study is distinct and aims to establish how understanding mathematics in rural primary schools can be achieved through culturally responsive pedagogy (CRP). Thus, the main question driving this study is: '*How can culturally responsive pedagogy be used to promote the understanding of mathematics in rural primary schools*?'

2.1 Theoretical framework

This study was conducted through a lens that describes the four essential components of culturally and linguistically responsive (CLR) mathematics instruction, as illustrated in Figure 1. These components are (i) cultural funds of knowledge, (ii) language development, and (iii) gestures and multiple representations (Tran & Schepers, 2023).

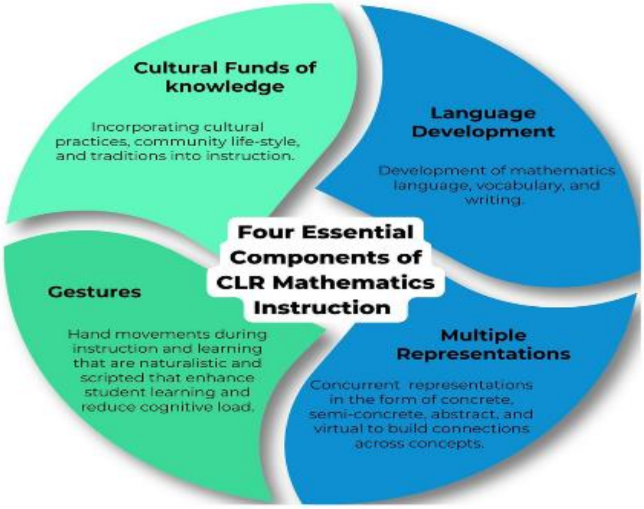

Figure 1: *Four essential components of CLR mathematics instruction (Trans & Schepers, 2023)*

These four essential components in a mathematics classroom should extend beyond implementation within daily instruction. The cultural funds of knowledge encompass students' perceptions of their strengths and contributions in mathematics (Trans & Schepers, 2023). It was important in this study to establish whether the participants drew on the cultural experiences and assets they bring into the classroom and mathematics lessons each day. Language development focused on the use of background knowledge and the current need for mathematics language development in the classroom. The gestures described appropriate and effective strategies for accessing and demonstrating learning in mathematics. The benefit of multiple representations in a mathematics classroom is evident when they are used to represent a single mathematical concept in various ways and demonstrate connections across concepts, thereby strengthening mathematical understanding (Courtier et al., 2021). For example, the nature of three-dimensional structures that students identify in their immediate environments was significant in this study. This notion is echoed by scholars (Ladson-Billings, 1995; Gay, 2018; Tran et al., 2023), who define culturally relevant (CLR) practice as the integration of students' cultural experiences, native language skills, and prior experiences to make learning more relevant and effective while demonstrating respect for students' personal and community identities. Additionally, to ensure that mathematics in the classroom is approached in culturally responsive ways, Kong et al. (2022) suggest the use of: (a) cultural contexts in word problems and examples, (b) culturally relevant resources and connections to cultural artefacts, (c) provision of multilingual support, (d) culturally responsive assessment and personalised learning pathways, and (e) ethnomathematics exploration, including cultural contributions to mathematics. In this study, participants used cultural contexts and examples, attempting to connect mathematics to cultural artefacts while allowing students to provide explanations in their mother tongue.

Thus, the theory of culturally responsive teaching posits that teachers should employ an approach to teaching and learning that facilitates the achievement of all students by recognising that culture is a powerful force in shaping how students perceive themselves and the world around them (Ladson-Billings, 1995). Featuring a review of published research, this paper identifies five findings that encapsulate CRT in mathematics: (1) caring, (2) knowledge of contexts and teaching practices using contexts, (3) knowledge of cultural competency and teaching practices using cultural competency, (4) high expectations, and (5) mathematics instruction/teacher efficacy and beliefs.

3. Methodology

This article reports specifically on the data collected during the third year of the community engagement project 'Bizana Teachers' Journey with Further Education and Training (FET)

Mathematics'. Contrary to the name of the project, I have been working with a population of 126 intermediate and senior phase teachers from the rural outskirts of Bizana, a small town in the Eastern Cape province of South Africa. The project aimed to investigate issues of classroom practice in mathematics at the FET level and to empower teachers with content knowledge, proficiency, and strategies to address the mathematics knowledge gaps that learners bring, facilitating a meaningful understanding of the subject. This was intended to establish a solid foundation for learners' performance and to observe the hierarchical nature of the subject. The two previous phases of this study utilised participatory action research (PAR) design to generate data from the participants. However, this third phase followed a single case study design in which the model of sharing prepared lessons was implemented. This approach was adopted because the teachers in the project had collectively prepared grade 6 and 7 lessons in groups, from which two cases were selected. The lessons were chosen after each group had presented their selected lesson.

3.1 Research paradigm

This qualitative study is situated within the broader context of a transformative paradigm. Samuels (2018) suggests creating spaces for teachers to reflect on their practice and examine their own biases in order to cultivate culturally responsive approaches to teaching and learning. Furthermore, Jackson et al. (2018) assert that the transformative paradigm is a research framework that centres on the experiences of marginalised communities, includes an analysis of power differentials that have led to marginalisation, and links research findings to actions intended to mitigate disparities. The transformative paradigm was deemed suitable for this study because it favours culturally responsive strategies that (i) activate students' prior knowledge, (ii) make learning contextual, (iii) encourage students to leverage their cultural capital, (iv) enable teachers to reconsider their classroom setup, and (v) build relationships between learners and teachers.

3.2 Research design

Moreover, a case study design was found to be relevant in this study since it could accommodate a pedagogy that recognises the importance of including students' cultural references in all aspects of learning. Creswell (2014) asserts that a case study is a qualitative design in which the researcher explores in depth a programme, event, activity, process, or one or more individuals using a variety of data collection procedures over a sustained period of time (p. 241). This was a single case study carried out in a natural setting, where two classes of Grade 6 and 7 learners were taught by the participants during the workshop to reduce the impact of extraneous factors. This also eliminated the pretence of behaving like senior phase learners that teachers would adopt when they taught each other in the workshop.

3.3 Study group

From a population of 126 intermediate and senior phase primary school mathematics teachers in Bizana, only 42 senior phase teachers attended the workshop. Initially, the teachers were divided into seven groups, each composed of six teachers. They were tasked with collaboratively preparing lessons on how to teach 2-D and 3-D shapes to grades 6 and 7 for two hours on the first morning of a two-day workshop. One representative from each group then presented their lesson to the rest of the senior phase teachers attending the workshop. The entire cohort then selected the two best lessons from the seven presented, which were prepared to be taught to chosen grades 6 and 7 at a nearby school by two teachers selected purposefully. This selection was based on the groups' observational judgements of who should present the two chosen lessons.

3.4 Data collection tools

In the first phase, preliminary workshops were held face-to-face with a cohort of intermediate and senior phase teachers to identify the challenges they experienced with mathematics teaching and how these could be addressed. Additionally, an enquiry lesson on the definitions and development of geometric concepts was demonstrated to the teachers using circular papers cut out with circular household utensils. It was during this first phase that teachers were exposed to various indigenous sources of knowledge relevant to their context, which could be utilised in the teaching and learning of mathematics. In the third phase of the study, two teachers were observed teaching Grade 6 and 7 learners from nearby schools, who were assembled in the workshop venue. The duration of the lessons was forty-five minutes each. After the teaching sessions, semi-structured interviews were conducted with each teacher. These interviews took place after all the day's proceedings and lasted approximately 30 minutes. Prior to selecting the teachers who participated in the study, two other teachers took part in a pilot study where they taught lessons on 2-D and 3-D shapes, with the remaining teachers acting as learners. I initially piloted the research instruments by observing two other teachers who did not participate in the main study; data was not collected for conclusions but rather to assess the reliability of the research instruments. This process helped me refine the research question, estimate the time necessary for the main study, and finalise the methods that were best suited to pursue the research.

In this qualitative study, trustworthiness was established through intensive long-term involvement, rich data, respondent validation, intervention, and triangulation, whereas credibility concerns the truthfulness of the inquiry's findings (Cohen et al. 2018). In this study, trustworthiness was achieved by employing observation and semi-structured interviews to support data interpretation across all methods. Triangulation in the study involved interviews and data analysis, while the choice of participants bolstered the credibility of the research.

3.5 Data analysis

Thematic coding was used to analyse the qualitative data collected. Interview recordings and lesson observation schedules were transcribed, and the data were coded into themes. Data analysis, in the form of coding and categorising themes, was aligned with the essential components of CLR mathematics instruction that informed the study's theoretical framework. The analysis resulted in two themes related to the use of culturally responsive pedagogy for the promotion of understanding in mathematics. These themes were (i) the connection of mathematical concepts to lived socio-cultural experiences, and (ii) the incorporation of cultural practices and traditions.

3.6 Ethical consideration

Creswell (2014) and Neuman (2012) assert that ethical issues are a vital part of research and apply to all research designs. Before engaging in the study, I obtained permission from UNISA (Ref: 2019/09/14/90188500/08/MC) and recently from Rhodes University (Ref: 2024-7449-9080). Written permission was also acquired from the Eastern Cape Department of Basic Education, as well as consent from the participants in 2019. Furthermore, the anonymity of participants was guaranteed by assigning pseudonyms to them. Informed consent forms were developed, and participants signed them before taking part in the study. The teachers involved were assured that they could withdraw from the study at any time if they wished to do so. Confidentiality was guaranteed to all participants. The researcher clearly explained the purpose of the research to the participants, as well as the benefits of the study. Additionally, the researcher promised to return to the participants after the completion of the study. The names of the schools and teachers involved in the research are not mentioned; instead, codes T1 and T2 are used to refer to the participants. Lastly, the audio recordings made during interviews were not used in any presentation that could reveal the voices of the participants.

4. Presentation of Results

Results are presented under the two themes that emanated from data reduction. These were (i) the Connection of mathematical concepts to lived socio-cultural experiences and (ii) the Incorporation of cultural practices and traditions.

4.1 Connection of mathematics concepts to lived socio-cultural experiences

Six out of seven groups used readily available materials to teach the properties of both 2-D and 3-D shapes. In one of the selected lessons, T1 brought a box of straws, wool, and a stapler, and divided the learners into groups where each learner assumed a specific role. These dynamic groups were tasked with either constructing and drawing a pyramid or a prism with a specified number of faces. This activity followed an introductory lesson that revised the definitions, differences, and identifications of prisms and pyramids. The activity also required the learners to identify real-life examples of rectangular prisms and cubes. Figure 2 shows Learner 2's examples of rectangular prisms in real life.

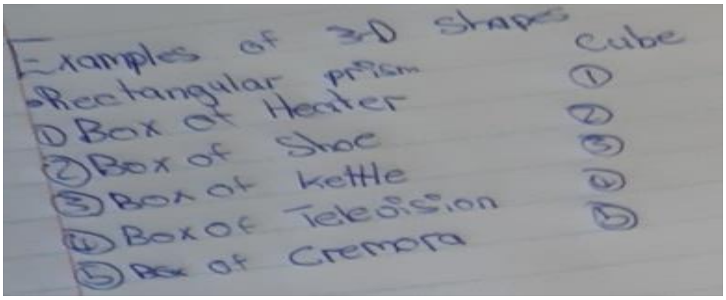

Figure 2*: Learner 2's examples*

During interviews, I asked the T1 why she gave the learner the chalk box from her carboard. She said:

> *I noticed that the learner was only able to identify from home only rectangular prisms, and was only listing them, yet I wanted the learner to see that other boxes are tubes, meaning all their faces are equal, just like the one of the chalk-box.*

Probing further, I asked, "Do you think the learner understood why other prisms are called cubes? I noticed that she did not write any of those examples." T1 replied:

> *You know what? Learners always experience challenges with mathematics language. For example, the shape known as a tube at home is not at all related to prisms, nor does it have any faces, it is something like a pipe, this confuses learners always. This is because in English, a cube and tube are pronounced in the same way, though they are different in spelling and objects.*
>
> *The other issue here is that we talk about faces of each prism or pyramid, and the only face they knew all along was their faces in their bodies. Everything changes because here the edges form the end of each face and join to the other. So as a teacher I need to bring some objects like boxes and point at each of these features so that learners are not confused.*

During the construction activities in the groups, learners were issued with a task similar to Group 6, who had to construct a pentagonal prism and then count the number of edges, faces, and vertices. Group 6's activity is captured in Figure 3.

Figure 3: *Group 6's work*

The learners used the wool that was sucked into each straw to construct the prism. They then had to indicate on the chart the number of faces, edges, and vertices. All the groups were allocated twenty-five minutes to finish the constructions, record, and report their findings. Figure 4 shows Group 4 reporting on the features of the tetrahedron they constructed.

Figure 4: *Group 4 Learners reporting*

When I asked the teacher on the choice of the structure and the of the lesson, she said:

> *I noticed that it is important to give learners a chance to do these activities on their own, such that they experience the theory that a teacher tells them. When you tell all the time, one must always remember that their listening span is limited. When they do the activity in groups, they get a chance to explain concepts in their own language, convince each other on how to successfully construct these objects. They also get a chance to connect their mathematical experiences with their socio-cultural experiences by using all available indigenous materials.*

4.2 Incorporation of cultural practices and traditions

Teacher 2 used the historical hut-building theme as his reference for teaching 2-D and 3-D shapes. When I asked how he decided on this theme, he said:

> *Almost every household has a hut, even those people with big houses still build a rondavel as a room that can be accessible to the public. Usually, in many households this room is used as a kitchen. I felt that if I integrate my lesson with the historical origins of a hut with geometric concepts, it will provide my learners with a comprehensive understanding of how geometry fits within the local context. Also, the traditional huts are often constructed using local materials and techniques, which can be more sustainable and environmentally friendly compared to modern building practices. Thus, even those household that are economically challenged, you find that they have at least on room, which will always be a hut.*

Probed further on the choice of his example, T2 explained that:

> *Huts in this area are much more than mere structures, they are deeply integrated into the cultural and history of our region. Thus, in teaching about 2-D and 3-D shapes, it becomes easy for the learners to recall when I am talking about the fireplace which is usually a two-dimensional circle in the middle of a kitchen hut. This is where unity of the family is strengthened in those households, around those fires and all rituals are done in the hut. So, I deliberately thought they would be interested and motivated to learn about geometric concepts attached to the rondavel. I also anticipated to have an interactive lesson since the lesson are familiar with what I am talking about.*

This teacher's lesson commenced with a question in which T2 asked the grouped learners to name the features of a hut and provide their shapes along with reasons. For example, if a group chose to name a door, they needed to explain that it has three pairs of equal faces and represents a rectangular prism. The group that mentioned more features of the hut with correct descriptions and names would be the winners. When the teacher was asked to reflect on his lesson, he said:

> *In general, I would say the lesson went very well, but this approach showed me the challenges that learners experienced in identifying the different prisms that make a hut. For example, since the door is flat, they knew the rectangular shape, but couldn't realize that it was three dimensional since the third dimension is unproportionally shorter that the other dimensions. In all the groups they easily identified the floor as a circular two-dimensional shape. But it was tricky because it was not continuously flat in huts with a fireplace. There were also some arguments about the shapes of windows since some huts had small oblong openings on both sides of the hut just for the release of the smoke. Others had modern rectangular windows with corresponding panes. What lacked in all groups reporting was the identification of the conical pyramid on top of some rondavels.*

During the classroom observation, when the teacher was making rounds, he tried to ask questions about the roof structure. However, the learners indicated that the roof was closed with mud at the apex of the hut. Typically, the apex of a hut's roof is covered with conical zinc metal. This would resemble a pyramid, but the learners did not mention it as a common feature in a rondavel.

5. Discussion of Findings

It was observed that only one group used computer-assisted teaching out of the seven groups. This was despite the fact that the Department of Education provided all teachers in the district with laptops and monthly data. The geographical location of rural schools in the Bizana area did not allow for network coverage, rendering those devices useless resources for teachers (Cele, 2019). Although the theme of multiple representations of the artefacts used in this study was not explicitly mentioned, it was observed that the participants exposed their learners to different representations of 2-D and 3-D objects. This concurs with Mainali (2021), who defines representation as a sign or combination of signs, characters, diagrams, objects, pictures, or graphs, which can be utilised in teaching and learning mathematics. In both lessons observed in this study, various kinds of representations were used as pedagogical strategies for teaching geometry. Moreover, this is encouraged by researchers (Boaler, Chen, Williams & Cordero, 2016), who assert that when learners are exposed to multiple representations, they are afforded ample opportunities to develop their mathematical creativity. This is because diverse representations of mathematical objects enable students to flexibly adapt their solutions when they encounter new situations (SanGiovanni, Katt, & Dykema, 2020).

Results also revealed some challenges that learners experienced with mathematical language. For example, the instruction to 'circle' a number in a given set with three tens can easily confuse rural primary school learners since the only circle they know is 'o', the shape. This concurs with Barwell (2016), who asserts that mathematical discourse has a specialist vocabulary. This contradicts the primary function of language in mathematics instruction, which, as stated by Mulwa (2015), is to enable both the teacher and the learner to communicate mathematical knowledge with precision. Sadly, one of the four components of CLR in mathematics instruction is the development of mathematical language, vocabulary, and writing. However, it is important for teachers to realise that the process of learning definitions of mathematical terms can be complicated by the abstract nature of the terms and the consequent difficulty of the words used to refer to them (Mulwa, 2016). In this study, it was observed that learners mistakenly thought a cube meant a tube, although these are homophones. It then becomes important for mathematics teachers to write the words on the chalkboard and also provide rough sketches of what they mean or bring artefacts that represent the shape to the lesson, where relevant.

It was clear from T2's lesson that the integration of cultural artifacts in a mathematics lesson not only improves mathematical literacy but also promotes the preservation of cultural heritage (Kurniawan et al., 2023). The results of this research show that exploring local culture can be used as a reference for developing learning plans to enhance mathematical understanding. The use of a common artifact, such as a hut found in each household, was relevant to the lesson. This concurs with Kurniawan et al. (2023), who note that cultural studies as a learning resource are not only for instilling concepts; beyond that, they can be used to develop learners' problem-solving and critical thinking skills. In particular, the teachers' ability to formulate problems, apply mathematical concepts, and interpret mathematical results in various contexts provided abundant experience in completing real-world tasks in mathematics classes, which Hwang and Ham (2021) classify as essential in developing these mathematical skills. In addition, T2's hut example in teaching geometry signified CLR's emphasis on the benefit of multiple representations in a mathematics classroom, which can be used to represent a single mathematical concept in multiple ways and demonstrate connections across concepts, thereby strengthening mathematical understanding (Courtier et al., 2021). The use of the hut example further reinforced learners' identities while enhancing their understanding of the different geometric shapes that comprise it. This has positive influences and implications for promoting understanding in mathematics.

Results also revealed that traditional huts are often constructed using local materials and techniques, which can be more sustainable and environmentally friendly compared to modern building practices, and are familiar to all learners in that classroom. This supports Çakıroğlu et al. (2023), who assert that the importance of developing contextual and meaningful mathematics learning is not only limited to understanding mathematical concepts, but also includes the application of mathematics in everyday life, developing thinking skills, and preparing for a more successful future in various fields. In this study, the learners were observed to be more motivated and developed a stronger personal connection with the lesson taught, using one of the authentic materials related to students' daily lives and culture. It was also observed that CLR was employed in learning scenarios to increase students' sense of connectedness to the material, which improved their conceptual understanding of several geometric concepts found in those artefacts. This encouraged students to use their higher-level thinking skills, such as analysis, reasoning, and evaluation (Kurniawan et al., 2023). Consequently, this can be linked to conclusions made by Tang et al. (2021), who assert that the integration of culture with mathematics significantly impacts the teaching and learning process because mathematics can be viewed as a cultural phenomenon. This integration helps develop a broader understanding of mathematics as a cultural product and deepens the understanding of the cultural values of mathematics (Tang et al., 2021). Additionally, the integration of local culture in mathematics learning during that lesson provided additional meaning to the study of 2-D and 3-D shapes. It is therefore important for mathematics teachers to prepare their teaching materials by considering the cultural context familiar to their students. This aligns with what CLR refers to as incorporating cultural practices, lifestyles, and traditions in instructions as cultural funds of knowledge. For example, it is a known tradition that in the hut, women always sit on the left-hand side of the rondavel, while men always sit on the right. This standing tradition illustrates how women should respect men. It also instils a culture of responsibility in men, since from the right-hand side they are likely to be the ones who see a stranger approaching the hut. The circular shape of rondavels often represents the idea of inclusivity and unity. The round structure ensures that family members are gathered in a manner that promotes togetherness, with no corner or edge separating individuals.

6. Conclusions and Recommendations

In this article, I have attempted to respond to how culturally responsive pedagogy can be used to promote understanding of mathematics in rural primary schools. Specifically, the context of this study highlights how mathematics teachers can utilise cultural artefacts to teach geometry. The CLR in both the case study design and the culturally responsive pedagogy influenced the creativity of learners in the mathematics classroom, with whole group role-playing demonstrating motivation to understand geometric concepts. Findings revealed that the use of culturally responsive pedagogy enhanced the understanding of geometric concepts. It can be deduced that employing familiar contexts and incorporating cultural practices and traditions can be more sustainable and environmentally friendly for learners while enriching their understanding of mathematics. This could further enable learners to relate to and interpret the structures surrounding them mathematically. Although the use of cultural learning resources positively impacted the learners' creativity, the building of mathematics vocabulary was enhanced despite the language challenges experienced by learners.

I acknowledge that the study was limited to a sample of two teachers, which is very small; thus, the findings cannot be generalised as representative of all mathematics teachers. It is therefore recommended that mathematics teachers be trained to prepare lessons that incorporate Indigenous knowledge, use Indigenous teaching aids that vary according to learning styles, and strive to implement a student-centred approach in a timely manner, particularly in contextualising mathematical geometry learning so that this concept can hold relevance and meaning for Indigenous students. In addition, mathematics teachers need training in the awareness and use of culturally relevant artefacts suitable for teaching mathematics, as well as how to foster learning partnerships among their learners and sustain community building for sustainable development.

7. Declarations

Funding: The study received no external funding.

Acknowledgements: The author declares no acknowledgements.

Conflicts of Interest: The author declares no conflict of interest.

Data availability: In accordance with ethical standards and the stipulations outlined in the consent agreement with participants, the data must be maintained as confidential. Nevertheless, individuals seeking further information may contact the corresponding author.

References

Acharya, B. R. (2020). Promoting inclusive mathematics classroom practices in the schools of Nepal: An ethnographic inquiry. *International Journal of Research-Granthaalayah*, *8*(3), 223–237. https://doi.org/10.29121/granthaalayah.v8.i3.2020.146.

Acharya, P., Ranka, S., Sethi, P., Bharati, R., Hu, J., Noheria, A., ... & Gupta, K. (2021). Incidence, predictors, and outcomes of In-Hospital cardiac arrest in COVID-19 patients admitted to intensive and Non-Intensive care units: insights from the AHA COVID-19 CVD registry. *Journal of the American Heart Association, 10*(16), e021204. https://doi.org/10.1161/JAHA.120.021204

Aronson, B., & Laughter, J. (2016). The theory and practice of culturally relevant education: A synthesis of research across content areas. *Review of Educational Research, 86*(1), 163–206. https://doi.org/10.3102/0034654315582066

Barton, B., Poisard, C., & Domite, M. D. C. (2006). Cultural connections and mathematical manipulations. *For the Learning of Mathematics, 26*(2), 21-24.

Barwell, R. (2016). Formal and informal mathematical discourses: Bakhtin and Vygotsky, dialogue and dialectic. *Educational Studies in Mathematics, 92,* 331–345. https://www.jstor.org/stable/24830666

Bishop, D. V. (2014). *Uncommon Understanding (Classic Edition): Development and disorders of language comprehension in children*. Psychology Press https://doi.org/10.4324/9780203381472

Boaler, J., Chen, L., Williams, C., & Cordero, M. (2016). Seeing as understanding: The importance of visual mathematics for our brain and learning. *Journal of Applied & Computational Mathematics, 5*(5), 1–6. http://doi.org/10.4172/2168-9679.1000325

Braun-Wanke, K. (2017). Learning and teaching for a sustainable future. *Handbook of Theory and Practice of Sustainable Development in Higher Education: Volume 4*, 15-29. https://doi.org/10.1007/978-3-319-47877-7_2

Çakıroğlu, Ü., Aydın, M., Bahadır Kurtoğlu, Y., & Cebeci, Ü. (2023). How Instructors' TPACK Developed During Emergency Remote Teaching: Evidence from Instructors in Faculties of

Education. *International Review of Research in Open and Distributed Learning, 24*(2), 162-188. https://doi.org/10.19173/irrodl.v24i2.7177
Cele, Z. E. (2019). *Survival strategies of a rural community: a case study of the Redoubt area in Bizana, Eastern Cape, South Africa* [Doctoral dissertation, University of KwaZulu-Natal]. https://researchspace.ukzn.ac.za/handle/10413/18490
Courtier, P., Gardes, M. L., Van der Henst, J. B., Noveck, I. A., Croset, M. C., Epinat-Duclos, J., ... & Prado, J. (2021). Effects of Montessori education on the academic, cognitive, and social development of disadvantaged preschoolers: A randomised controlled study in the French public school system. *Child Development*, *92*(5), 2069-2088.http://doi.org/10.1111/cdev.13575
Dansu, D. K. (2023). *Changes in the Epigenetic Landscape of Oligodendrocyte Progenitor Cells With Time* [Doctoral dissertation, City University of New York]. https://doi.org/10.1101/2024.02.06.579145
D'Ambrosio, U. (1985). *Ethnomathematics and its place in the history and pedagogy of mathematics.* Sense Publishers. https://www.jstor.org/stable/40247876.
Department of Basic Education. (2012). *Integrated strategic planning framework for teacher education and development in South Africa*. Pretoria: Department of Basic Education.
Fouze, A. Q., & Amit, M. (2023, July). The ethnomathematics of the Bedouin society: Integrating socio-cultural elements into mathematics education. In *Thirteenth Congress of the European Society for Research in Mathematics Education (CERME13)* (No. 6). Alfréd Rényi Institute of Mathematics; ERME.. https://hal.science/hal-04407356v1
Gay, G. (2018). *Culturally responsive teaching: Theory, research, and practice*. Teachers College Press.Glanfield, F., & Sterenberg, G. (2020). Understanding the landscape of culturally responsive education within a community-driven mathematics education research project. In C. Nicol, J. A. Q. Q. Xiiem, F. Glanfield, & A. J. S. Dawson (Eds.), *Living culturally responsive mathematics education with/in indigenous communities* (pp. 71–90). Brill https://doi.org/10.1163/9789004415768_004
Govender, N., & Mudzamiri, E. (2022). Incorporating Indigenous artefacts in developing an integrated indigenous-pedagogical model in high school physics curriculum: Views of elders, teachers and learners. *Cultural Studies of Science Education, 17*(3), 827-850. https://doi.org/10.1007/s11422-021-10076-2
Hoyles, C. (2018). Transforming the mathematical practices of learners and teachers through digital technology. *Research in Mathematics Education, 20*(3), 209–228. https://doi.org/10.1080/14794802.2018.1484799
Hwang, J., & Ham, Y. (2021). Relationship between Mathematical Literacy and Opportunity to Learn with Different Types of Mathematical Tasks. *Journal on Mathematics Education, 12*(2), 199-222. https://doi.org/10.22342/jme.12.2.13625.199-222
Jackson, K. M., Pukys, S., Castro, A., Hermosura, L., Mendez, J., Vohra-Gupta, S., ... & Morales, G. (2018). Using the transformative paradigm to conduct a mixed-methods needs assessment of a marginalised community: Methodological lessons and implications. *Evaluation and Program Planning, 66,* 111–119. https://doi.org/10.1016/j.evalprogplan.2017.09.010
Jansen, J. (2019). Inequality in education: What is to be done? In N. Spaull & J. Jansen (Eds.), *South African schooling: The enigma of inequality* (pp. 355–372). Springer Nature. https://doi.org/10.1007/978-3-030-18811-5_19
Jett, C. C. (2013). Culturally responsive collegiate mathematics education: Implications for African American students. *Interdisciplinary Journal of Teaching and Learning, 3*(2), 102–116. http://www.subr.edu/index.cfm/subhome/36
Jordt, H., Eddy, S. L., Brazil, R., Lau, I., Mann, C., Brownell, S. E., King, K., & Freeman, S. (2017). Values affirmation intervention reduces achievement gap between underrepresented minority and white students in introductory biology classes. *CBE Life Science Education, 16*(3), ar41. https://doi.org/10.1187/cbe.16-12-035

Joseph, G. G. (1987). Foundations of Eurocentrism in mathematics. In A. B. Powell & M. Frankenstein (Eds.), *Ethnomathematics: Challenging Eurocentrism in mathematics education*(pp. 61–82). State University of New York Press. https://doi.org/10.1177/030639688702800302

Kong, J. E., Arizmendi, G. D., & Doabler, C. T. (2022). Implementing the science of math in a culturally sustainable framework for students with and at risk for math learning disabilities. *Teaching Exceptional Children*, 1–8. https://doi.org/10.1177/00400599221127385

Krasnoff, B. (2016). *Culturally responsive teaching: A guide to evidence-based practices for teaching all students equitably.* Equitable Assistance Center at Education Northwest. https://educationnorthwest.org/sites/default/files/resources/culturally-responsive-teaching.pdf

Kurniawan, H., Purwoko, R. Y., & Setiana, D. S. (2023). Integrating cultural artifacts and tradition from remote regions in developing mathematics lesson plans to enhance mathematical literacy. *Journal of Pedagogical Research, 8*(1), 61–74. https://doi.org/10.33902/JPR.202423016

Ladson-Billings, G. (1994). What we can learn from multicultural education research. *Educational Leadership, 51*(8), 22–26. https://doi.org/10.4236/ojpsych.2013.32022

Machisi, E. (2024). An analysis of calculus application questions in grade 12 mathematics exams in South Africa. *Eurasia Journal of Mathematics, Science and Technology Education, 20*(10), em2519. https://doi.org/10.29333/ejmste/15431

Mainali, B. (2021). Representation in teaching and learning mathematics. *International Journal of Education in Mathematics, Science, and Technology (IJEMST) 9*(1), 1–21. https://doi.org/10.46328/ijemst.1111

Matusov, E., & Marjanovic-Shane, A. (2017). Many faces of the concept of culture (and education). *Culture & Psychology, 23*(3), 309-336. https://doi.org/10.1177/1354067X16655460

Meeran, S. (2017). *Influence of new curriculum policies on mathematics teachers' work* [Doctoral dissertation, University of Kwa-Zulu Natal]. . http://hdl.handle.net/10413/15557

Meeran, S., & Van Wyk, M. M. (2022). Mathematics teachers' perceptions of socio-cultural diversities in the classroom. *Journal of Pedagogical Research, 6*(3), 72-87. https://doi.org/10.33902/JPR.202215441

Moyer, P. (2001). Making mathematics culturally relevant. *Mathematics Teaching, 176*, 3–5.

Nicol, C., Archibald, J., & Baker, J. (2013). Designing a model of culturally responsive mathematics education: Place, relationships and story work. *Mathematics Education Research Journal, 25,* 73–89. https://doi.org/10.1007/s13394-012-0062-3

Nielsen, W. S., Nicol, C., & Owuor, J. (2008). Culturally responsive mathematics pedagogy through complexivist thinking. *Complicity: An International Journal of Complexity and Education, 5*(1). https://doi.org/10.29173/cmplct8780

Nolan, K., & Xenofontos, C. (2023). On becoming a culturally responsive teacher of mathematics. *Journal of Mathematics and Culture, 17*, 308-324.

Padayachee, K. (2022). *Integral education for early childhood development: Building values through indigenous knowledge* [Doctoral dissertation, Durban University of Technology]. https://doi.org/10.51415/10321/4753

Pournara, C., Adler, J., Pillay, V., & Hodgen, J. (2015). Can improving teachers' knowledge of mathematics lead to gains in learners' attainment in Mathematics?. *South African Journal of Education*, *35*(3), 1-10. https://doi.org/10.15700/saje.v35n3a1083

Pradhan, J. B. (2017). Mathematical ideas in Chundara culture: Unfolding a Nepalese teaching and learning system. In M. Rosa, L. Shirley, M. E. Gavarrete, & W. V. Alangui (Eds.), *Ethnomathematics and its diverse approaches for mathematics education* (pp. 125–152). Springer. https://doi.org/10.12691/education-12-4-3

Ravn, O., & Skovsmose, O. (2019). *Connecting humans to equations: A reinterpretation of the philosophy of mathematics.* Springer Nature. https://doi.org/10.1007/978-3-030-01337-0

Rosa, M., & Orey, D. C. (2007). Cultural assertions and challenges towards pedagogical action of an ethnomathematics program. *For the Learning of Mathematics, 27,* 10–16. https://www.jstor.org/stable/40248554

Samovar, L. A., Porter, R. E., & McDaniel, E. R. (2006). Approaches to intercultural communication. *Intercultural communication: A reader*, 1-5.

Samuels, A. J. (2018). Exploring culturally responsive pedagogy: Teachers' perspectives on fostering equitable and inclusive classrooms. *Srate Journal, 27*(1), 22-30. https://api.semanticscholar.org/corpusID:55158272

SanGiovanni, J. J., Katt, S., & Dykema, K. J. (2020). *Productive math struggle: A 6-point action plan for fostering perseverance*. Corwin.

Sparrow, P. (2012). Global knowledge management and international HRM. In *Handbook of research in international human resource management* (2nd ed.). Edward Elgar Publishing. https://doi.org/10.4337/9781845428235.00012

Sulistyani, A. P., Windasari, V., Rodiyah, I. W., & Muliawati, N. E. (2019). Eksplorasi etnomatematika rumah adat Joglo Tulungagung. *Media Pendidikan Matematika, 7*(1), 22-28. https://doi.org/10.33394/mpm.v7i1.1537

Sumarto, S. (2020). Forming community culture in advancing education: Study of the Community Ideology Guards Community (KPIB) in higher education. *Prodising ISID, 1*, 28–39. https://doi.org/10.37092/prosidingisid.v1i1.176

Tachie, S. A. (2020). The challenges of South African teachers in teaching Euclidean geometry. *International Journal of Learning, Teaching and Educational Research, 19*(8), 297–312. https://doi.org/10.26803/ijlter.19.8.16

Tang, H., Seah, W. T., Zhang, Q., & Zhang, W. (2021). The mathematics learning attributes valued by students in Eastern China. *ECNU Review of Education, 4*(2), 261–284. https://doi.org/10.1177/2096531120930240

Tjahyadi, I., Wafa, H., & Zamroni, M. (2019). *Buku ajar kajian budaya lokal.* Pagan Press. http://doi.org/10.31943/mathline.v8i4.474

Tran, L. M., & Castro Schepers, O. (2023, November). Making mathematics meaningful for culturally and linguistically diverse students with a mathematics learning disability: A focus on culturally responsive practices. In *Frontiers in Education* (Vol. 8, p. 1276423). Frontiers Media SA. https://doi.org/10.3389/feduc.2023.1276423

Wachira, P., & Mburu, J. (2019). Culturally responsive mathematics teaching and constructivism: Preparing teachers for diverse classrooms. *Multicultural Learning and Teaching, 14*(1), 20160023. https://doi.org/10.1515/mlt-2016-0023

Widyastuti, M. (2021). Peran kebudayaan dalam dunia pendidikan. *Jagaddhita: Jurnal Kebhinnekaan dan Wawasan Kebangsaan, 1*(1), 54–64. https://doi.org/10.30998/jagaddhita.v1i1.810

Wiktor-Mach, D. (2020). What role for culture in the age of sustainable development? UNESCO's advocacy in the 2030 Agenda negotiations. *International Journal of Cultural Policy, 26*(3), 312-327. https://doi.org/10.1080/10286632.2018.1534841

Will, M., & Najarro, I. (2022). What is culturally responsive teaching? *Education Week.* https://www.edweek.org/teaching-learning/culturally-responsive-teaching-culturallyresponsive-pedagogy/2022/04