Cultures Meet in Mathematics: Illustration with the *Adinkrahene* Symbol of Akans of Ghana and the *Waterhole* Symbol of Australian Aboriginals

Mavis Okyere
Catholic University College of Ghana
Faculty of Education
okyere@ualberta.ca
mavisokyere020@gmail.com

Abstract

A central theme of the ethnomathematics program is that all societies/cultures use mathematics in their daily activities and that activities and practices of different cultures could be brought to the classroom for mathematics teaching and learning. This paper presents similarities between two cultural symbols: 1) the *Adinkrahene* symbol of Akans of Ghana and 2) the *Waterhole* symbol of Aboriginals of Australia as an opportunity for teaching mathematics in a multicultural context, not only because students can learn mathematics from the symbols, but the values the symbols represent are also worth learning. Using the two symbols in mathematics activities could promote students' tolerance and respect for each other and their cultures. Therefore I recommend that the ethnomathematics community begins to identify similar cultural objects from different cultural groups and study them together for their potential use in a multicultural mathematics curriculum.

Introduction

Massarwe et al. (2012) recognized that mathematics education reform must aim at adapting to reality, meeting the needs of economic and cultural progress in modern society, and building a school culture based on the principles of justice, pluralism, and harmony (see also D'Ambrosio, 2017). In my research study about the Adinkra symbols of Ghana (Okyere, 2021), I recognized the striking resemblance between the *Adinkrahene* symbol and the Australian Aboriginal *Waterhole* symbol as an opportunity for a multicultural mathematics education that could help promote justice, pluralism, harmony, and multicultural understanding, and reduce racism.

Many practices and traditions are common among different cultures: examples include marriage and funeral rites, farming methods, architecture, art, etc. Mathematics concepts are believed to be embedded in most cultural practices of different ethnic groups. From the

ethnomathematics perspective, mathematics is seen as a human and cultural knowledge activity, and mathematics is embedded in human activities (D'Ambrosio, 1990). The human desire to understand what is happening, and to explain what is seen and felt, contributes to the construction of knowledge, including knowledge of mathematics (D'Ambrosio, 1990).

Ethnomathematics education researchers have demonstrated that mathematics concepts exist in every culture (see D'Ambrosio 1990; Bishop, 1988). Bishop (1988) asserts that traditional mathematics, or mathematics as cultural knowledge, is developed based on six universal activities: 1) counting, involving tallying and the use of number words, 2) locating, encoding, and navigating in the environment, 3) measuring, including measurement of units and methods, 4) designing methods for objects, artifacts, and technologies, 5) playing and how to play, including games and activities, and 6) searching for and explaining a theory or model of connection. Thus, mathematics is an integral part of all human activities and is an integral element in every culture. Massarwe et al. (2010) are of the view that the relationship between ethnicity and mathematics is strongly expressed in visual art and geometry in all cultures. They observe that geometry is the essence of every culture and is inherent in every human mind. Many geometric ideas have been established from different indigenous cultural practices and artwork.

Gerdes has shown that many concepts of the school mathematics curriculum, as expressed in the European context, exist in the practices of different ethnic groups in Africa (See Gerdes, 1988, 1998, 2012). He demonstrates how the Pythagoras theorem can be derived from a widespread decorative motif of the basketry designs of the Salish Indians of British Columbia (they call it '*star* pattern'), the Porno Indians of California (they call it '*deer-back* or *potato forehead')* and on plaited mats of Angolans *(*they call the motif *'T*chokwe- Tortoise') (Gerdes, 1988). Various mathematics concepts can be identified in artifacts and practices of different

ethnic groups which can be investigated for their mathematics concepts and brought to the classroom. Gerdes also encourages mathematics teacher educators to consider their students' culture and use it to improve teachers' (preservice teachers) ability to teach mathematics. This paper presents the result of a study into the mathematics concepts of the *Adinkrahene* symbol and illustrates how this symbol is similar to and applies to the Australian Aboriginal *Waterhole* symbol.

The Study

This study involved three junior and two senior high school mathematics teachers investigating the images and creation processes of selected Adinkra symbols for the possibility of using them for teaching purposes. The teachers first observed the images of the symbols, and then visited an Adinkra craftsman to observe their creation to identify the mathematics principles applied in the creation processes. The teachers then used this knowledge to create mathematics lesson activities for Grade 8 and 11 students.

The *Adinkrahene* symbol (Figure 1) was investigated for its related mathematics concepts, and teachers designed a task for a Grade 8 class based on the symbol. The class consisted of students from six ethnic groups in Ghana who were born and grew up in the same cultural environment (the research site) and were all familiar with the Adinkra symbols. The interest in studying cultural symbols for their related mathematics concepts led to the discovery of the *Waterhole* (Figure 2) also known as the *Campsite* symbol of Aboriginals of Australia.

Figure 1

Image of the Adinkrahene Symbol

From Adinkra symbols & meanings, by Well-Tempered Web Design, 2001-2007 (https://www.adinkra.org/htmls/adinkra_index.htm). In the public domain.

Figure 2

Image of the Waterhole/Campsite Symbol

From Aboriginal art symbols – Waterhole/Campsite, by Artyfactory. (https://artyfactory.com/aboriginal-art/aboriginal-art-symbol-campsite-waterhole.html). In the public domain.

The rings of the *Waterhole* symbol (Figure 2) may be read as a *Waterhole* by some Indigenous groups*, or* as a *Campsite* or *Rockhole* by other Indigenous groups in Australia (Brazil, 2000).

The Cultural Meaning of the *Adinkrahene* and the *Waterhole* Symbol

The two symbols are strikingly similar in what they represent for the people of these two cultures. The *Adinkrahene* symbol is used by the Akans to indicate greatness, creativity, and leadership which are all attributes of God. The Akan craftsman, who was involved in Okyere's (2021) study, shared that the circle is used to represent infinity, because it has no beginning or end, and it is associated with the saying: "Only the one who created the 'circle' knows its beginning and its end". This saying signifies that only God knows the beginning and the end of creation and so the circle is used by the Akans to describe the creator of the universe and to signify attributes of God. Arthur (2017) has also described how the circle in Akan culture signifies the presence and power of God, and the sanctity of the male aspect of society. Similarly, in the Aboriginal culture, the circle represents 'never ending', 'ever evolving', and the 'creation story' (Jones, 2013).

The *Waterhole/Campsite* symbol is a series of concentric circles representing the principal source of life, or sacred sites, where people meet for physical and spiritual sustenance (https://artyfactory.com/aboriginal-art/aboriginal-art-symbol-campsite-waterhole.html). Aboriginals recognize the significance of water for human existence and believe that water cannot be separated from human life (Toussaint et al., 2005).

It can be noted from the meanings of the symbols that the two cultures have similar concepts about the circle as something infinite and representing creation or the one who created the universe. Akans use the *Adinkrahene* symbol to communicate attributes of God that they want the community to emulate and Aboriginals use the *Campsite* symbol to represent a sacred site where they meet the one who gives life or the *Waterhole* symbol to indicate "water as a source of life". The lessons for the students in Okyere's study also required the students to talk

about the meanings of the *Adinkrahene* symbol and relate the meanings of the symbols to their personal values.

In terms of the meanings of the *Adinkrahene* symbol and the *waterhole* symbol, there is a slight difference in the connotation of the use of circles in the two cultures (Akans and Aboriginals), however, the same idea of the *Waterhole* of the Aboriginals is used by Akans in the cloth pattern called *Nsu bura*. The African print design in Figure 3, originating from Ghana is called *Nsu bura* which means "well of water" or "waterhole" connoting the same meaning of *Waterhole* of Aboriginals, recognizing water as the source of life. These patterns are similar to the *Adinkrahene* symbol and the *Waterhole* symbol (Figures 1 and 2) I presented earlier.

Figure 3

The Nsu Bura cloth pattern of Ghana

Photo source: Okyere's research data

We know that a circle is formed from the locus of points at a given distance from a given point. That is, mathematically, the pattern in Figure 3 shows a circle as a locus of points (different from the images in Figures 1 and 2). The *Nsu bura* pattern in Figure 3 demonstrates the locus of the points that form the different concentric circles.

Mathematics Concepts that Could be Related to the Symbols

The *Adinkrahene* symbol, the *Waterhole/campsite* symbol, and the *Nsu bura* pattern are all made up of concentric circles which are equally spaced. The *Adinkrahene* symbol is made up of three concentric circles while the *Waterhole/campsite* symbol is made up of five concentric circles, as in Figure 2 or a series of concentric circles, as in Figure 3.

Arthur (2017) notes that the *Adinkrahene* symbol has a radial symmetry in its appearance, thus we can infer that the *Waterhole/Campsite* symbol and the *Nsu bura* symbol also have radial symmetry. What are radial symmetries and how are they formed? The idea of radial symmetry can be explained using the *Nsu bura* pattern in Figure 3. In the design, we see that the points (loci) appear to be regularly arranged from the centre. The loci of the different circles are radiating from the centre. In Okyere's study, two mathematical concepts were identified with the *Adinkrahene* symbol: 1) ratio and proportion and 2) linear growth.

Ratio and Proportion

Mathematics teachers in Okyere's (2021) study observed that the circles are evenly spaced in the *Adinkrahene* symbol so that the radius of the central circle is twice the radius of the inner circle, and the radius of the outer circle is three times the radius of the inner circle. Therefore, the radii of the circles are determined in a ratio of 1:2:3 and are proportional to the sum of the radii of the circles. This was investigated by drawing different sizes of the *Adinkrahene* symbol provided that the distance between successive circles is equal to the radius of the inner circle. Three teachers' drawings in Figure 4 revealed that the radii of the circles relative to each other were in a ratio of 1:2:3, starting from the inner circle. This ratio was used to draw more *Adinkrahene* symbols, and it was decided that this ratio should exist in each *Adinkrahene* symbol, regardless of size.

Figure 4

Three Different Sizes of Adinkrahene Symbol Illustrating the Ratio of 1:2:3 in the Radii of the Circles

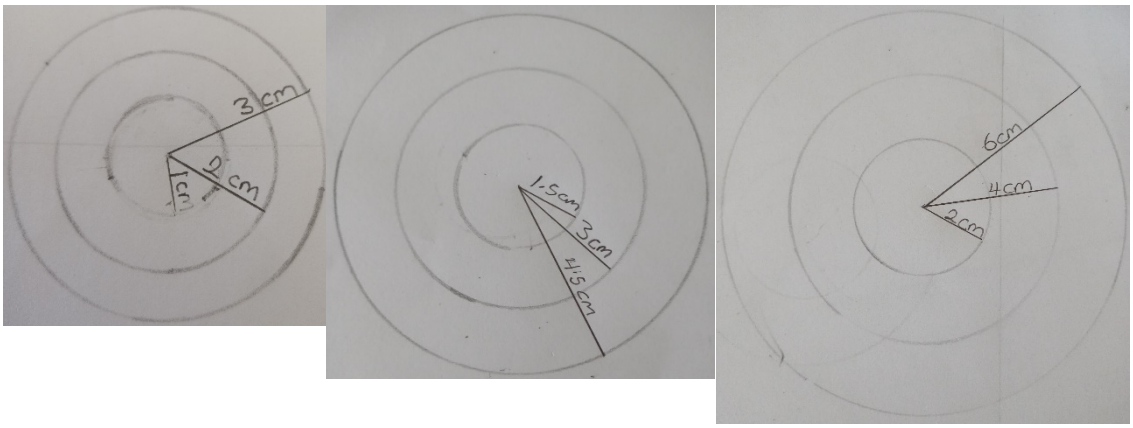

Photo source: Okyere's research data

For example, if I start with an inner radius of 3cm, since in the *Adinkrahene* symbol, the distance between the circles is equal to the radius of the innermost circle, the radius of the second circle will be 6cm and that of the third circle 9cm. Comparing these radii gives 3:6:9, which simplifies to 1:2:3. This mathematical idea about the symbol was used to create a problem for junior high school students using the *Adinkrahene* symbol. The mathematics problem teachers developed around the *Adinkrahene* symbol has been transferred to the *Waterhole* symbol as shown below:

In drawing the *Waterhole* symbol, the ratio 1:2:3:4:5 is observed to split the total radius among the five circles:

a. If a *Waterhole* is drawn such that the sum of the radii of the five circles is 25cm, what will be the radius of each circle?
b. A *Waterhole* is drawn such that the radius of the innermost circle is 3cm. What will be the radius of the outermost circle?

c. Draw a *Waterhole* such that the sum of the radii of the five circles will be 20cm
    - Now, if you are to extend your *Waterhole* to seven circles what will be the radius of the seventh circle? How did you obtain it?

d. How does the meaning of the *Waterhole* symbol apply to your personal values or the social values of your community?

Linear Growth

The *Adinkrahene* symbol was extended to include two more circles, with the condition that the distance between successive circles must be equal. Figure 5, below, led to the conclusion that arithmetic, or linear sequence, could be related to the *Adinkrahene* symbol. Teachers form the *Adinkrahene* symbol with five concentric circles, that is how the *Waterhole/Campsite* symbol of Aboriginals was formed. In the teachers' illustrations, as in Figure 5, we see that the circles are growing. In the drawing in Image A, the teacher drew the concentric circles with an unknown radius, but with the spaces between them equal to the radius of the innermost circle, so he got the pattern: a, $2a$, $3a$, $4a$, $5a$.

Figure 5

Teachers' Illustrations of Linear Sequence in the Adinkrahene Symbol

Image A Image B

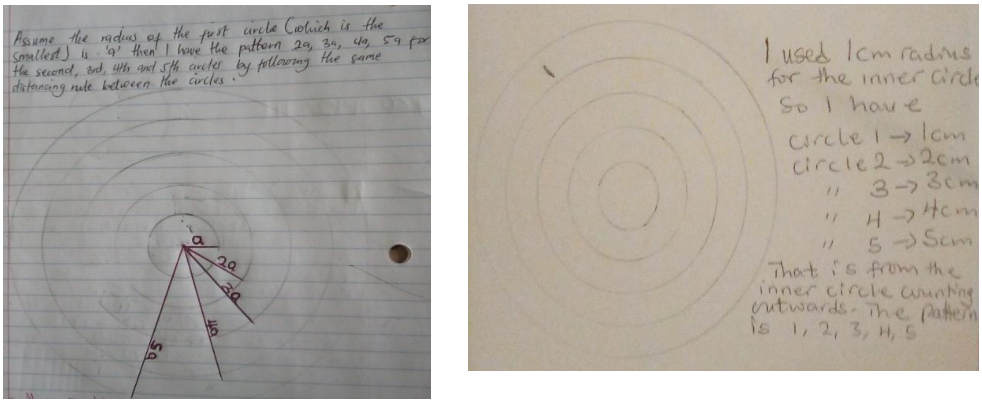

Photo source: Okyere's research data

The Image B symbol used a radius of 1cm to draw the innermost circle with a pattern of 1, 2, 3, 4, 5. Both patterns gave a linear sequence with a common difference of 1. That means that the *Adinkrahene* symbol can be used to illustrate linear patterns. From this discussion, and the similarities observed between the *Adinkrahene*, *Waterhole,* and *Nsu bura* symbols, it can be said that these symbols or designs, can be used to support the teaching of ratio and proportion, and linear patterns in the classroom.

Using these Symbols for Designing Multicultural Mathematics Curriculum

One of the goals of critical mathematics education is to provide students with the knowledge, skill, and behaviour necessary to build democratic communities that embrace social justice inside and outside the school (Tutak et al., 2011). Acquiring academic mathematics knowledge is important, but educators must also educate students to seek social justice. Although Okyere's study involved using the Adinkra symbols in mathematics lessons, the lessons could incorporate symbols from other cultures. Using and comparing the *Adinkrahene* and the *Waterhole* symbols in a mathematics discourse brings two cultures of two different continents

together, thereby creating the possibility of fostering students' appreciation of each other's culture. Orey and Rosa (2008) believe that the ethnomathematics perspective provides students and teachers with transformational space and enables them to view diversity as a necessary feature of life in a globally interconnected world. Culturally responsive pedagogy perspectives also encourage students to have competence in the knowledge and understanding of their own culture (language, traditions, histories, culture, etc.), and to develop competence in at least one other culture (Ladson-Billings, 2021). Through the use of multicultural artifacts, students are given the opportunity to realize that, though we are different, we are similar in many ways, including our use of mathematics knowledge. D'Ambrosio (2007) believes that intrinsic to ethnomathematics is the ethics of diversity, which constitutes, a) respect for the other (the different), b) solidarity with the other, and c) cooperation with the other (see also D'Ambrosio, 2017). The use of such multicultural symbols in a mathematics curriculum could help promote ethics of diversity in the following ways:

a. Students would begin to develop respect for each other's culture when they begin to learn about the cultural values of each other. By using symbols from the different cultures and discussing their social values, students will get to learn about what each culture upholds and why they uphold those values, which could prevent cultural intolerance among students.
b. Students' harmony with each other is supported if students are aware of the differences and similarities between their cultures and accept the differences. The acceptance of such differences could be promoted through the use of multicultural ideas in the mathematics classroom. For example, using the *Adinkrahene* and the *Waterhole* symbols, we can discuss with students how Akan and Aboriginal cultures

have similar concepts about the 'circle', but at the same time, differ in their use of the two symbols (*Adinkrahene* and *Waterhole*) involving circles, but then again, the two cultures coincide in their use of circles as in the *Nsu bura* of Akans and the *Waterhole* of Aboriginals. Again, though the symbols differ in their appearance, they are similar in terms of the mathematics concepts they are based on.

c. Cooperation with each other would be enhanced only when students have learned to respect each other's culture and accepted to live in harmony with their differences. I believe mathematics educators could contribute to achieving harmonious relations in human living, not only by making use of their students' cultural referents but by making use of multicultural ideas (ideas from different cultures).

Discussing the values of different cultures and using their cultural symbols could increase students' awareness that their cultures have similar values and beliefs, thereby enhancing their tolerance for each other and helping to eliminate racism and cultural intolerance. Such work promotes social justice through the building of tolerance and sensitivity, thereby eliminating racism (D'Ambrosio, 2007, 2017); awareness and respect for each other can be strengthened through mathematics by using different cultural ideas in the classrooms. That is to say that using cultural symbols to define cultural values and beliefs could enhance tolerance for others and eliminate cultural intolerance.

There is also an opportunity for students to learn moral values in mathematics by discussing what the symbols stand for in different cultures. The class activities in the Okyere (2021) study included a discussion of the symbol's social values and the meaning of the symbol: greatness, leadership, and creativity. They discussed who is considered a leader or a great person, the character of good leaders, and how they (personally) should live their lives to be recognized

as leaders or great people. A group of students identified creativity, in a mathematically productive way, when they wrote: "*We are creative because we have created Adinkrahene with mathematics*".

Just as it was possible to discuss the values the *Adinkrahene* symbol represents, we could also discuss the values of the *Waterhole/Campsite* symbol. As mathematics teachers investigating cultural symbols to de-complexify them for instruction, we cannot ignore the cultural aspects of the symbols. What are the possible moral values students could learn from the meaning of the *Waterhole/Campsite* symbol? Aboriginals recognize water as being more than physical, it is sacred, and waterholes served as meeting places for Aboriginals (Brazil, 2000). Aboriginals place great importance on water bodies. I would argue that discussing the meaning of the *Waterhole*, which is "water is a source of life" is as important as discussing the Pythagoras theorem in the mathematics classroom. In respect of Aboriginal recognition of land as "mother" (Brazil, 2000), what about considering the classroom, the school, the community, and probably the entire earth as a "*Campsite – a sacred site for physical and spiritual nourishment*" and therefore should be considered and treated as such? D'Ambrosio (2007) states "Mathematicians and math educators look into the most universal problem facing mankind as the most urgent problem to be dealt with" (p. 25). In my opinion, moral decadence and environmental pollution are some of the universal problems currently facing mankind, increasing the importance of studying the cultural values of such symbols. Studying the social values of the *Adinkrahene* and *Waterhole* symbols in schools could contribute immensely to curbing these social cankers.

Recommendations

The ethnomathematics and culturally responsive pedagogy positions encourage the use of students' cultural referents in the mathematics curriculum. The two positions also promote the

development of a multicultural mathematics curriculum. I am of the view that to develop a multicultural mathematics curriculum, similar artifacts and symbols can be identified with different ethnic and cultural groups and be brought together in the curriculum.

I recommend that the ethnomathematics community begins to look for common artifacts among different ethnic/cultural groups and to investigate them for incorporation into the mathematics curriculum. We should investigate cultural artifacts from different cultural backgrounds to be associated with the same mathematics concepts in the mathematics curriculum. I believe that we should not use only one artifact from one cultural group to represent a concept. If we wish to develop a multicultural curriculum, then concepts must be presented with multicultural artifacts.

Using a group of students' cultural referents for mathematics learning would help them appreciate their culture, but it will not influence their views about other people's cultures. If we wish to promote cultural tolerance through a multicultural curriculum, then there is the need to consider representations of mathematics concepts in a multicultural way.

I also recommend that, as we investigate cultural artifacts and symbols for their mathematics concepts, we should regard them as cultural objects by discussing their uses in the cultures and the values they communicate to the members of the cultural groups to help students to appreciate their own cultures and that of others.

References

Artyfactory (n.d). Aboriginal art symbols – Waterhole/Campsite. Retrieved from https://artyfactory.com/aboriginal-art/aboriginal-art-symbol-campsite-waterhole.html

Arthur, G. F. K. (2017). *Cloth as metaphor: (Re)reading the Adinkra cloth symbols of the Akans of Ghana* (2nd ed.). Bloomington: iUniversity.

Bishop, A. J. (1988). Mathematics education in its cultural context. *Educational Studies in Mathematics, 19*(Special issue), 179-191. https://doi.org/10.1007/BF00751231

Brazil, J. (2000). Dreamtime superstore, *Third Text, 14*(50), 61-72. https://doi.org/10.1080/09528820008576837

D'Ambrosio, U. (2017). Ethnomathematics and the pursuit of peace and social justice. *Educação Temática Digital, 19*(3), 653-666. https://doi.org/10.20396/etd.v19i3.8648367

D'Ambrosio, U. (2007). The role of mathematics in educational systems. *ZDM Mathematics Education, 39*(1-2*)*, 173–181. https://doi.org/10.1007/s11858-006-0012-1

D'Ambrosio, U. (1990). The role of mathematics education in building a democratic and just society. *For the Learning of Mathematics, 10*(3), 20-23. Retrieved from https://www.jstor.org/stable/40247989

Gerdes, P. (2012). Old and new mathematical ideas from Africa: Challenges for reflection. In S. Oesterle, D. Allan, & P. Liljedahl (Eds.), *Proceedings of the 2012 annual meeting of the Canadian Mathematics Education Study Group* (pp 13-33). Burnaby, BC: CMESG/GCEDM.

Gerdes, P. (1998). On culture and mathematics teacher education. *Journal of Mathematics Teacher Education*, *1*(1), 33-53. Retrieved from https://link.springer.com/content/pdf/10.1023/A:1009955031429.pdf

Gerdes, P. (1988). A widespread decorative motif and the Pythagorean theorem. *For the Learning of Mathematics, 8*(1), 35-39. Retrieved from https://flm-journal.org/Articles/5DCEAD955842E7083DAFE196CAB78.pdf

Jones, C. (2013, October). *What do circles represent in Aboriginal art.* https://www.youtube.com/watch?v=qyUxxgwHK8Q

Ladson-Billings, G. (2021) I'm here for the hard re-set: Post pandemic pedagogy to preserve our culture. *Equity & Excellence in Education, 54*(1), 68-78. https://doi.org/10.1080/10665684.2020.1863883

Massarwe, K., Verner, I., & Bshouty, D. (2012). Ethnomathematics and multi-cultural education: Analysis and construction of geometric ornaments. *Journal of Mathematics and Culture*, *6*(1), 344-360.

Massarwe, K., Verner, I., Bshouty, D., & Verner, I. (2010). An ethnomathematics exercise in analyzing and constructing ornaments in a geometry class. *Journal of Mathematics and Culture*, *5*(1), 1-20.

Okyere, M. (2021). Culturally responsive teaching through the Adinkra symbols of Ghana and its impact on students' mathematics proficiency. [Unpublished doctoral dissertation]. University of Alberta.

Tutak, F. A., Bondy, E., & Adams, T. L., (2011). Critical pedagogy for critical mathematics education. *International Journal of Mathematical Education in Science and Technology, 42*(1), 65-74, https://doi.org/10.1080/0020739X.2010.510221

Toussaint, S., Sullivan, P., & Yu, S. (2005) Water ways in Aboriginal Australia: An interconnected analysis. *Anthropological Forum, 15*(1), 61-74. https://doi.org/10.1080/0066467042000336715