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Re-enacting Mathematics Values through Cultural Symbols

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ABSTRACT

More attention and concentration are paid to cognitive and psychomotor than affective learning of mathematics. The problem may have arisen from the symbolic nature of mathematics values which makes it difficult to understand. Another loophole could have popped up from teachers' perceptions that mathematics values have little relationship with cultural symbols in the classroom, as well as in affective values. In this study, the researcher explored five prominent mathematics values of 'respect', 'commitment to excellence', 'truth and integrity', 'teamwork', and 'equity' through cultural symbols, called 'Adinkra'. With a case study design involving ten student teachers, the researcher assembled over 60 Adinkra symbols. The student-teachers then selected and matched at least five of the symbols that fall into each of the five values and analyzed their values. In five separate tables, the results showed that 'respect' ranked highest, and was closely followed by 'commitment to excellence', and 'truth and integrity'. The least values were 'teamwork' and 'equity'. Having given this culturally responsive pedagogy, it was recommended that many more cultural symbols should be explored to equip teachers and students to apply mathematics values for life-long learning.

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INTRODUCTION

Culturally responsive pedagogy is the use of simulations to allow students to explore indigenous and vernacular knowledge spanning both mathematical topics as well as computational thinking. For example, in one study, African fractals were introduced in an ethnically diverse high school computing class in New York City: This intervention group showed statistically significant improvement on pre/post comparisons relative to a control group which received similar instruction without any cultural connections. Despite this evidence for efficacy, there has been little serious adoption in most curricula; even when cultural connections are introduced, the overwhelming tendency is to only superficially represent indigenous knowledge. While the "culture" side of ethnomathematics can vary

widely-including topics from the vernacular culture such as graffiti, working-class skills such as carpet laying, and even investigations of cultural influences in professional mathematics--indigenous math plays a special role, as it directly contradicts the pernicious myths of genetic determinism (Babbitt et al., 2015; Seah, 2019).

Babbitt et al. (2015) bemoan that when students are convinced that there is a "math gene" enjoyed by Asian and white students but denied to students of African or other indigenous heritage, it becomes a self-fulfilling prophecy. Indigenous ethnomathematics or ethnocomputing directly contradicts that myth. Similarly, the colonial legacy introduces a myth of cultural determinism: African American students perceive a forced choice between black identity and high scholastic achievement. There is statistical evidence supporting the contention that high-achieving African American students are often accused of "acting white" by their peers. This means that culturally responsive educational interventions should always be conscious of the difficulties some students face when reconciling their own identities (Babbitt et al., 2015).

National and international assessment results consistently indicate that a few (< 25%) of our basic school pupils possess the mathematical proficiency needed to access the opportunities that the 21st century offers them. The low performance is largely a result of an education system that appears to direct focused attention on preparing students for passing examinations, at the expense of helping them to develop core skills such as critical thinking, creativity, digital literacy, reflection, and evaluation they will need to participate fully in society. Teachers often tend to present mathematical concepts, work several examples on the board, and then assign exercises in which learners practice whatever has just been presented, that is, an approach thathas been widely criticized (MoE, 2019).

Teachers and students do not appear to appreciate the varied uses of mathematics in different local contexts to amplify the beauty of mathematics in solving real-life problems nor do they take account of learners' different language and literacy abilities, accessibility, and inclusivity issues. In addition, respect for culture and diversity as well as allowing learners to make connections between local and global contexts and then share their understanding with others appear limited in most of our mathematics classrooms. Given the incredible power that teachers hold to make a difference in pupils' mathematical development, a reasonable point of entry for changing the narrative is a teacher education curriculum that inspires and develops highly competent, reflective teaching professionals committed to the holistic development of their pupils and the improvement of society. This course plays animportant role in this regard. Specific attention is given to topic areas that have consistently been flagged up in chief examiners' reports for senior high school core mathematics as difficult (MoE,2019)

The Concept of Values

Values represent the socially mediated qualities that are considered important to us. Of recent, values have extended to valuing as a motivating force with which one gets what one wants. The deep rootedness of values in asserting that values, including ethics and morals, refer to the deep, 'personal truths' or commitments cherished by individuals. They help motivate long-term choices and shorter-term priorities. They may also be highly structured, forming value systems. The constructs of values and beliefs are sometimes used interchangeably. However, they refer to different qualities. Beliefs are "what people consider as facts, opinions, hypotheses, as well as faith" (Seah, 2019). On the other hand, "when we

think of our values, we think of what is important to us". The essence within these two quotes is commonly reflected in other definitions of beliefs and values as well. That is, beliefs reflect what is true (or false), and are thus contextualized, whereas values reflect what are personally important (or not important), and exist in a context-free manner. Neither is there a one-to-one relationship between beliefs and values; any belief might be an expression of two or more different values. For example, one may believe that the four-function calculator is a useful pedagogical tool in early primary mathematics lessons. Yet, the value(s) underlying this belief may be efficiency (one gets the answer quicker) or it may instead be processed (having the answer computed by the calculator allows us to focus on the process of the mathematics work). Thus, values form a strong driving force for an individual, community, or culture (Seah, 2019).

Mathematics Values

The concept of values is not new in mathematics anthropology. Values have strongly been linked to culture (Hill & Hunter, 2023)). Values in mathematics education emphasize three constructs, namely rationalism-objectivism, control-progress, and openness-mystery. *Rationalism* entails abstractions, explanations, and theories that have been guiding principles of mathematical development. Therefore, student teachers must be aware and appreciative of the theoretical aspects of mathematics as well as be able to explain the significance to their students in the future. Without an understanding of the abstractness and logic of mathematics, language, and symbols would be meaningless and foreign to students in that culture. In that sense, logical connections should be developed through mathematical ideas involving proofs, examples, counterexamples, and generalizations (Haciomeroglu, 2020).

It is also essential to reduce the theoretical nature when teaching the essential components of mathematics. When this is accomplished, students develop strong feelings of control, security, and mastery. These complementary pairs control and progress as the attitudinal values drive the mathematical development. For instance, the solution to a mathematical problem can be explained by the abstract nature of mathematics. In some cases, solutions can be generalized for other problems. But sometimes generalization cannot be applied when progress occurs (Haciomeroglu, 2020).

In addition, two sets of values, *openness, and mystery* acquire the mathematical knowledge of the students. Openness involves truths, propositions, and ideas about mathematics. This means the students could examine and verify the truth about any mathematical propositions both theoretically and practically. Although both openness and mystery rely on the abstract nature of mathematics, the mystery is associated with students who generate knowledge and ideas. It is vital for the students to feel that mathematics is important to develop 'good' values. A good teacher should encourage students to demonstrate and explain, "why mathematical truth is so, rather than merely accepting a reason such as it looks as if it is true". To develop 'good' values in the students, the teacher should be able to create alternative and rational solutions to mathematical problems (Haciomeroglu, 2020).

Mathematics Education Values

Values are central to education and mathematics education has positioned itself as a universal subject transcending culture and values (Hill & Hunter, 2023). In this regard, mathematics has many educational values which determine the need to teach the subject in

schools. Dushi (2023) has put mathematics education values into practical, cultural, and disciplinary. The practical values are our everyday encounters with mathematics. These include buying and selling, measurement, money, and taxes. The cultural arena involves music, fine arts, poetry, and painting. And the d*isciplinary values* development of the power of concentration, development of inventive faculty, and patience and perseverance.

Traditionally, mathematics was regarded as both value and culture-free (Hunter, 2021). In recent times, the heart of any curriculum is the belief in nurturing honest, creative, and responsible citizens. As such, every part of this curriculum, including the related pedagogy should be consistent with the following set of values.

Respect: This includes respect for nations, their institutions and laws, and the culture and respect among its citizens and friends.
Diversity: Every nation is a multicultural society in which every citizen enjoys fundamental rights and responsibilities. Learners must be taught to respect the views of all persons and to see national diversity as a powerful force for national development. The curriculum promotes social cohesion.
Equity: The socio-economic development across the country is uneven. Consequently, it is necessary to ensure an equitable distribution of resources based on the unique needs of learners and schools. Learners are from diverse backgrounds, which require the provision of equal opportunities to all, and that all strive to care for each other both personally and professionally.
Commitment to achieving excellence: Learners must be taught to appreciate the opportunities provided through the curriculum and persist in doing their best in whatever field of endeavor as global citizens. The curriculum encourages innovativeness through creative and critical thinking and the use of contemporary technology.
Teamwork/Collaboration: Learners are encouraged to become committed to team-oriented working and learning environments. This also means that learners should have an attitude of tolerance to be able to live peacefully with all persons.
Truth and Integrity: The curriculum aims to develop learners into individuals who will consistently tell the truth irrespective of the consequences. In addition, be morally upright with the attitude of doing the right thing even when no one is watching. Also, be true to themselves and be willing to live the values of honesty and compassion. Equally important, the ethos or culture of the workplace, including integrity and perseverance, must underpin the learning processes to allow learners to apply skills and competencies in the world of work (MoE, 2019).

Adinkra Symbols

Semiotics, the study of signs and symbols of a particular language and society; and the interpretation of symbols and their impact on people, may vary from culture to culture (Ali, Davis & Agyei, 2021). Language itself is a system of symbols as stated by Aristotle; The Great Philosopher working in language some 2500 years ago stated that ‘‘spoken words are the symbols of mental experience and written words are the symbols of spoken words’’. Symbols are the replica of the meanings of words, things, actions, emotions, behavior, and ideas of a people within a particular culture. People’s actions can be motivated and guided by symbols and their meanings (Kuwornu-Adjaottor, Appiah & Nartey, 2015).

Traditional symbols are the forms in indigenous Ghanaian art that are primarily a usual translation of thought and ideas, expressing and symbolizing the values and beliefs of the people among whom they occur. In several cases, these images have become symbolic by having certain ideas or proverbs arbitrarily imposed on them. Several traditional symbols have definite explanations, however, the significance of others is a matter of opinion, while of quite, nothing atall seems to be known. The objects that are represented in symbolic art forms among the traditional ethnic groups in Ghana are textiles, pottery, stools, umbrella tops, and linguist staff(Kuwornu-Adjaottor, Appiah & Nartey, 2015).

Theory of Culturally Responsive Pedagogy

The theory of culturally responsive pedagogy, also known as culturally sensitive pedagogy, postulates that the discontinuity between the school culture and the home and community cultures of students is an important factor that affects their academic achievement. Bridging the gap between students' home culture and school culture, by reflecting and drawing on the students' culture, will consequently increase the academic achievement of these students. It is also referred to as culturally relevant pedagogy. She defined it as a pedagogy that empowers students intellectually, socially, emotionally, and politically by using their cultural references to convey knowledge, skills, and attitudes to them. There are other variations of culturally responsive pedagogy such as cultural regenerative teaching and cultural restorative teaching. Cultural regenerative pedagogy seeks to reclaim educational practices that indigenous people have lost by reinstituting such practices (Okyere, 2021).

The culturally responsive pedagogy or culturally relevant pedagogy defined as the use of culturalknowledge, past experiences, frameworks, and performance styles of various ethnic students that constitute the class to make learning encounters more relevant and effective for them is the approach that best fits this study. Ladson-Billing (1995a) also acknowledged that culturally relevant teachers use student culture as a vehicle for learning. The Adinkra symbols were not artifacts that were originally used to teach mathematics but rather; they exist as part of the Ghanaian culture—used to communicate ideas and values; Ghanaian students already know about them, and they can describe most of them. Hence, in this study, students' knowledge about the Adinkra symbols was drawn to support the teaching and learning of mathematics concepts that were found to be related to the Adinkra symbols (Okyere, 2021).

The Research Problem

Mathematical symbols are the means of representing mathematical concepts as well as communicating mathematical meaning. Mathematical concepts or objects do not have a tangible existence and are not directly accessible to perception. They are only accessed through symbolic representation. However, the symbolic nature of mathematics makes it difficult to understandand challenges students. The symbolic language of mathematics is meaningful to teachers but presents challenges to students. Students have difficulties in verbalizing, reading, understanding, and writing mathematics to express their mathematical thoughts (Mutodi, 2021).

Values, moral values, and democratic values are attracting the attention of education researchers in general and mathematics education researchers in particular. Little research has studied pre-service teachers' perceptions of values in the classroom, their perceptions of the relationship between the different variables of values in the classroom, as well as their

relationship with the democratic society. The present research attempts to do so (Daher, 2019; Hunter, 2021).

Decades of mathematics education research interventions and initiatives have failed to bring about significant improvements in students' learning of mathematics. Perhaps, we have not paid enough attention to the role of conation in facilitating learning and teaching, and in particular, to the variable of values. That is, students' learning outcomes are not only linked to cognitive and affective processes but also to how these processes have been considered important– and thus, valued–by students and other stakeholders. In this context, valuing refers to an individual's embracing of convictions in mathematics pedagogy which are of importance and worth personally. It shapes the individual's willpower to embody the convictions in the choice of actions, contributing to the individual's thriveability in ethical mathematics pedagogy. In the process, the conative variable also regulates the individual's activation of cognitive skills and affective dispositions in complementary ways (Davis et al., 2021).

The following research questions guided the study:

1. What mathematics values are there in the Adinkra symbols?
2. How do Adinkra symbols showcase the values of affective mathematics?

METHOD

The Research Design

With a case study design involving ten student-teachers pursuing a Master of Education in Mathematics Education, over 60 Adinkra symbols were assembled. The student-teachers then selected and matched to each of the five values and analyse their meanings. (Agbo, 2020).

The 10 student-teachers pursuing a Master of Education in Mathematics Education were involved in this study. They were put into five groups and each group contained two student-teachers. They were so purposely selected to reflect the cultural nature of the study and their experiences as teachers in mathematics at the pre-tertiary level (Ali et al., 2021).

Two instruments were employed. The first was documents on Adinkra symbols. The student-teachers searched and assembled the various Adinkra symbols in their communities. The second part was an interview. The student-teachers were called one after the other to identify the meanings and interpretations of the Adinkra symbols. The interviews helped to examine the student-teachers perceptions of the Adinkra symbols on the five mathematics values in the curriculum (Davis et al., 2021).

The researcher analysed the data based on the five cases. These cases were respect, equity, commitment to excellence, teamwork/collaboration, and trust and integrity. In each case, the student-teachers provided the symbol, the name in the Ghanaian (Akan) language, the meaning in the English language, and its interpretation, the researcher analysed every group concerning the mathematics values in the curriculum. These analyses were also compared with existing literature on mathematics values internationally. The inter-rater reliability of the data was compared and found to be more than 0.75 (Haciomeroglu, 2020).

RESULTS

In this section, there are five tables representing the five values in mathematics. In each table, the Adinkra, its name in the Akan language, its meaning in English, and its interpretation in themathematics value have been provided.

In Table 1, it was discovered that as many as 12 symbols out of the 60 stand for 'respect'. This implies the value of respect ranks high in mathematics teaching and learning (Hill, & Hunter, 2023). Feeling respected in the mathematics classroom extends to student-teacher relationships, calmness, self-efficacy, and fellow feeling (Averill & Clark, 2012). Secondly, the interview collaborates with the essence of participants' responses and the voice of literature is ample evidence to drum home the significance of 'respect'.

Table 1. Adinkra Symbols and the mathematics value of respect

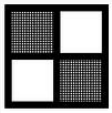
Symbol	Name	Meaning	Interpretation
	Gye Nyame	'Except God'	This symbol expresses the omnipotence of God. Probably the most popular Adinkra symbol has even been featured on Ghana's largest-denomination banknote, the 200 cedi note.
	Adinkrahene	'King of the Adinkra symbols'	This symbol stands for authority, leadership, and charisma. Also a symbol of qualities associated with kings. Adinkrahene is reportedly the inspiration for the design of the other symbols.
	Dwennimmen	'Ram's horns'	This symbol stands for strength (in mind, body, and soul), humility, wisdom, and learning. This symbol features prominently in the logo of the University of Ghana.
	Denkyem	'Crocodile'	This symbol stands for adaptability and cleverness.
	Aban	'Fortress (or castle)'	This is a symbol of strength, seat of power, authority, and magnificence
	Agyindawuru	'Agyin's gong'	This symbol stands for faithfulness, alertness, and dutifulness. This was designed to commemorate the faithfulness of one Agyin who was a dutiful servant and gong-beater of the Asantehene.
	Akoma	'Heart'	This symbol stands for love, goodwill, patience, faithfulness, fondness, endurance, and consistency.

	Asase Ye Duru	'The earth hasweight'	This symbol stands for providence and the divinity of Mother Earth.
	Dame-Dame	'Chequered'	This symbol stands for craftiness, intelligence, and strategy.
	Nsoromma	'Star (child of theheavens)'	This symbol stands for faith and the belief in patronage and dependencyon a supreme being
	Nyame Dua	'God's tree (sacredstump)'	This symbol stands for God's presence and protection
	Owuo Atwedee	'Ladder of death'	This symbol stands for certainty and universality of death

Source: https://www.adinkrasymbols.org/pages/adinkra-sample-usage/

In Table 2, the value of 'equity' was represented by five Adinkra symbols. Though student-teachers did not get as many symbols as they got in Table 1, the meanings and interpretations of 'equity' were so powerful and intriguing. These ultimately would motivate and prompt them to learn mathematics. Equity has a direct bearing on strong support for all students, high expectations, collaborative learning, accommodating differences, and open-ended learning strategies (McDonald, 2021). Again, the interview with the participants shows that the benefits of equity have far-reaching and long-term positive learning outcomes. In this regard, student-teachers can exploit this value to extend inclusive-based mathematics learning, social equity, and equality of all manners of people. This value is cardinal in mathematics learning.

Table 2. Adinkra symbols and the mathematics value of equity

Symbol	**Name**	**Meaning**	**Interpretation**
	Bi Nka Bi	'No one should bite another'	This symbol stands for justice, fair play, freedom, peace, forgiveness, unity, harmony, and the avoidance of conflict or strife.
	Duafe	'Wooden comb'	This symbol stands for feminine consideration or good feminine qualities such as patience, prudence, fondness, love, and care.
	Kuronti ne Akwamu	'Kuronti and Akwamu'	This symbol stands for democracy, sharing ideas, taking council

	Mako	'Peppers'	This symbol stands for inequality and uneven development, from the proverb 'All peppers onthe same plant don't ripen at the same time'
	Sep	'Executioner's knife'	This symbol stands for justice

Source: https://www.adinkrasymbols.org/pages/adinkra-sample-usage/

In Table 3, the value of 'commitment to excellence' became the most popularly used and known symbol. Having as many as 14 symbols, it was discovered that this value stood for authenticity, genuineness, diligence, hard work, and self-sufficiency, among others. Mathematics excellence breeds high knowledge, communication, thinking, representations, and applications (Hamadallh & Jassim, 2021). Moreover, the interview shows that all these attributes contribute in no small way to enhancing student-teachers zeal and motivation to study mathematics and to teach mathematics. Commitment to excellence helps student-teachers to maintain a steady pace of learning and teaching. As a result, students easily get associated with the student-teacher emulate his/her examples, and become mentees.

Table 3. Adinkra Symbols and the mathematics value of commitment to excellence

Symbol	Name	Meaning	Interpretation
	Sankofa	'Go back and get it'	This symbol stands for the wisdom of learning from the past to build for the future. From the Akan proverb, 'Se wo be fi na woman kofa a yenkyiri,' meaning, 'It is not taboo to go back for what you forgot (or left behind).'
	Sankofa	Another Sankofa symbol	This symbol stands for the wisdom of learning from the past to build for the future. From the Akan proverb, 'Se wo be fi na woman kofa a yenkyiri,' meaning, 'It is not taboo to go back for what you forgot (or left behind).'
	Odo Nnyew FieKwan	'Love does not lose itsway home'	Those led by love always end up in the right place.
	Abe Dua	'Palm tree'	This symbol stands for wealth, resourcefulness, and self-sufficiency

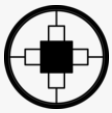
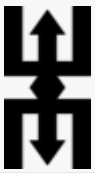
	Akoben	'War horn'	This symbol of a call to action, readiness to be called to action, readiness, andvoluntarism
	Aya	'Fern'	This symbol stands for endurance, independence, defiance against difficulties, hardiness, perseverance, and resourcefulness.
	Hwehwe mudua	'Measuring rod (rod of investigation) or rule'	This symbol stands for excellence, superior quality, perfection, knowledge, and critical examination.
	Menso Wo Kenten	'I am not carrying yourbasket'	This symbol stands for industry, self-reliance, and economic self-determination
	Mframadan	'Well-ventilated house'	This symbol stands for resilience and readiness to face the vicissitudes of life
	Mpuannum	'Five tufts (of hair)'	This symbol stands for loyalty and priestly office
	Nsaa	'A type of wovencloth'	This symbol stands for excellence, genuineness, and authenticity
	Okuafo Pa	'Good farmer'	This symbol stands for diligence, hard work, and entrepreneurship
	Osram ne Nsorom ma	'Moon and star'	This symbol stands for faithfulness, fondness, harmony, benevolence, love, loyalty, and femininity
	Wawa Aba	'Seed of the Wawa tree'.	This symbol stands for hardiness, toughness, and perseverance

Source: https://www.adinkrasymbols.org/pages/adinkra-sample-usage/

In Table 4, even though only five symbols were found suitable to represent the value of teamwork and collaboration, these symbols sufficiently describe and exemplify the tenets of teamwork in a mathematics class. Key elements of this value were sharing, reconciliation, forgiveness, intelligence, and support for others. Even though teamwork is relatively low value (Hill & Hunter, 2023), the elements are so central to the success of every mathematics lesson and must be encouraged (Hill, Hunter & Hunter, 2019). In addition, the interview shows that teamwork is now the centre of inquiry-based and child-centred pedagogies. This value invites active and deep learning of mathematics which helps students not to recall and

memorise facts and formulas but to understand and apply concepts beyond the classroom and examinations.

Table 4. Adinkra Symbols and the mathematics value of teamwork/collaboration

Symbol	Name	Meaning	Interpretation
	Dame-Dame	'Chequered'	This symbol stands for craftiness, intelligence, and strategy.
	Dono	'The double dono';	This symbol stands for united action,
	Ntoaso	joined tension talking drum.	alertness, goodwill, praise, rejoicing, andadroitness.
	Mpatapo	'Pacification knot'	This symbol stands for pacification, forgiveness, and reconciliation
	Nkonsonkonson	'Chain'	This symbol stands for unity and community
	Nteasee	'Understanding'	This symbol stands for understanding and cooperation
	Woforo Dua Pa A	'When you climb a good tree'	This symbol stands for support for goodcauses

Source: https://www.adinkrasymbols.org/pages/adinkra-sample-usage/

In Table 5, ten symbols were found to be most suitable to explain the value of 'trust and integrity'. It was discovered that 'trust and integrity' in mathematics bring peace, tranquility, self-discipline, self-control, and permanence of life. The value of mathematics truth relies heavily on consistency, inference, validity, proposition, agreement, and assumptions (Murawski, 2020). Coupled with truth is integrity, which gives student-teachers good moral standing, positive character building, and the ability to speak the truth at times.

This is not just a value that benefits the individual but the nation as a whole (Suyitno et al, 2019). Furthermore, the interview results show that these twin values give student-teachers the ability to work together, forge ahead in unity, and attain collective progress. Attaining collective goals is the main goal of mathematics. Goals must not be individualized but shared in this increasingly computerized and artificial intelligence world.

Table 5. Adinkra symbols and the mathematics value of truth and integrity

Symbol	Name	Meaning	Interpretation
	Nkyinkyim	'Twisting'	This symbol represents the tortuous nature of life's journey.
	Adwo	'Calmness'	This symbol stands for peace, tranquility, and quiet
	Akoko Nan	'The foot of a hen'	This symbol stands for discipline coupled with care and nurturing; from the Akan proverb, "Akoko nan tia ba na enkum ba,"
			literally, "The foot of a hen steps on the child(chick) but it doesn't kill the child (chick)."
	Ani Bere A Enso Gya	'No matter how red-eyed one becomes (i.e. how serious one becomes), his eyes do not spark flames'	This symbol stands for patience, self-containment, self-discipline, and self-control.
	Epa	'Handcuffs'	This symbol stands for law and justice.
	Kramo Bone Amma Yeanhu Kramo Pa	'The bad Muslim makes it difficult for a good one to be recognized'	This symbol stands for warning against deception and hypocrisy.
	More Dane	'Time changes (times change)'	This symbol stands for the temporariness of good times

	Nea Onnim	‘He who does not know’,	This comes from the proverb ‘‘When he whodoes not know learns, he gets to know.’’
	Nyame Nwu Na Mawu	‘God won’t die for me to die’.	This symbol expresses the immortality of thehuman soul
	Tamfo Bebre	‘The enemy will suffer; the enemy will stew in his juice’	This symbol stands for ill-will, jealousy, andenvy

Source: https://www.adinkrasymbols.org/pages/adinkra-sample-usage/

DISCUSSION

The five mathematics values are respect, equity, commitment to achieving excellence, teamwork/collaboration, and truth and integrity.

Mathematics Values in Adinkra Symbols

Adinkra are visual symbols with historical and philosophical significance originally printed on cloth which royals wore to important ceremonies. Originating from the Gyaman people of Ghana and la Côte d’Ivoire, the symbols have assumed global importance and are now found in logos, clothes, furniture, sculpture, earthenware pots, and many others. Saturated with meaning, these symbols have come to symbolize the richness of Akan culture and serve as shorthand for communicating deep truths in visual form. As an example, the fact that most universities in Ghana use at least one Adinkra symbol in their logo demonstrates the gravitastheir use has come to symbolize (Agbo, 2020).

Poirier, Eglash, and Babbitt (2023) show how students wear Adinkra cloth, asking them to pay particular attention to the geometry of the patterns. Each design represents a particular image, object, or idea to the Asante people who produce and wear the cloth. A proverbaccompanies each design and reminds those in the community of an important cultural concept. An artist covers or “tiles” an area with a specific design and must know where to place the designs and how many will be needed to cover the cloth as intended (Poirier, Eglash & Babbitt, 2023).

Also, Asante (Twi language group of Ghana) artists are experts at designing and placing patterns across the cloth they decorate so that entire areas become patterned. The estimates of how many squares will be needed to completely cover the paper’s surface, the placing, and gluing of the squares so that the entire surface of the colored paper is covered, and making sure to focus on the concept of area rather than on the formula for finding an area suggest a faster way of calculating area other than by counting. This could be premised on the length, width, area, and perimeter and the subsequent translation of word sentences into a formula can be applied when calculating the areas of differently shaped surfaces (Poirier, Eglash & Babbitt, 2023).

Another practical work on the values of Adinkra symbols is demonstrated by Spiesberger(2018) in an Adinkra graph. The Adinkra graph in mathematics is a graph that is a structure amounting to a set of objects in which some pairs of the objects are in some sense

”related. In this graph, nodes represent the points on the graph. There are two separate kinds of nodes, bosons, and fermions. The bosons and fermions are colored differently in the Adinkra Graph. Bosons are solid filled-in points, and Fermions are unfilled points on this graph. Having two different sets of nodes is what we call Bipartite, in graph theory. Edges represent the ‘Susy’ (short for supersymmetry) transformations between a boson and a fermion. There are many different coloured edges, but each edge of the same color represents the same transformation mathematically. Together the nodes and edges will create an Adinkra-which we use to represent the suppersymmetry. The Adinkra is a graph that has several properties. It gives the student-teachers a basic understanding of diving deeper into the physics and math behind this project (Spiesberger, 2018).

Further work on Adinkra and mathematics values can be demonstrated by Arthur (2017 and Okyere (2021). The Adinkra symbols are based on human body parts, geometric and abstractfigures, and fauna showing how animals play important roles as models of all that are instinctive. Arthur (2017) explained that the head is used in Adinkra to signify that one person cannot rule a state. The eye signifies love, sleepiness, the fragility of the physical body, agreement, vigilance, agitation, etc. The heart signifies love, patience, and devotion. Thus, Adinkra symbols are graphic designs of vines, birds, animals, human body parts, and geometric shapes, all of which represent more than their image and are understood within the context of Asante/Akan culture. Some of the geometric shapes used in Adinkra symbols include squares, rectangles, triangles, circles, and semi-circles. Each shape connotes an idea. For example, the circle symbolizes the presence and power of God and the sanctity of the male aspect of society.

Lastly, the square and the rectangle represent the sanctity of the male aspect of God and man, and it also symbolizes the territorial power and dominance of the male ruler (Arthur, 2017).Squares and rectangles are used to depict qualities such as perfection, wisdom, honesty, justice, courage, fairness, mercy, etc. Semi-circles or the crescent moon represent the female aspect of fertility, tender kindness, grace, and sereneness (Arthur, 2017). Similarly, Okyere (2021) revealedthat the crescent moon symbolizes the feminine aspect of society and its influence on life as a whole; it is seen as a symbol of maternal protection and feminine charm, and its meanings include beauty, female tenderness, and gracefulness. When combined with a star, the crescent represents female faithfulness in love.

Adinkra Symbols In Showcasing The Values of Affective Mathematics

The affective constructs in Table 1 to Table 5 refer to the values enshrined in the Adinkra symbols and personally demonstrated by the student-teachers espousing the values of the various symbols (Annenberg Learner, 2023). To show how the Adinkra symbols are relevant to mathematics, the student-teachers correctly demonstrated their interpretations of Adinkra symbols for the learning of effective mathematics. A careful analysis of their responses depicted an increased interest and love for the Adinkra symbols, mathematics learning, and largely getting educated on the values of indigenous Adinkra symbols in mathematics learning (Robas, Villamor & Orbea, 2018).

Also, the values socially mediated and culturally accentuated their positive attitudes towards mathematics. They were not only motivated to take up other cultural objects of mathematics richness but also to prioritize the selection and design of culturally responsive artifacts. Ultimately, the values in the Adinkra became essential and could strengthen allied

concepts of beliefs and attitudes. The values underlying the conjugate beliefs were both efficiency and process, thus forming strong driving forces toward their culture (Seah, 2019).

Again, the values of three rationalism-objectivism, control-progress, and openness-mystery broadened and helped them to explain the significance of the Adinkra symbols. Without understanding of symbols, the cultural elements and qualities of the symbols would have been valueless and of no use in mathematics. The connections among the various symbols essentially reduced the theoretical nature of explaining values in mathematics education. Possibly, it helped them to generalize the results of the symbols. In the spirit of *openness and mystery*, the student-teachers could examine and verify the truth about any mathematical essentialities both theoretically and practically. Rather than just knowing mathematics knowledge, they couldexplain how mathematics knowledge evolves and expands (Haciomeroglu, 2020).

In addition, this culturally sensitive pedagogy bridged the yawning gap between the school culture and the home and community cultures of student-teachers. The use of cultural knowledge, experiences, and performance styles was amply exhibited according to the student-teacher cultures. Even though the Adinkra symbols were not artifacts that were originally used to teach mathematics, they ended up excellently communicating the values of the families and communities of the student-teachers (Okyere, 2021). The cultural value of the Adinkra symbols could remain strong and progress steadily given similar mathematics contexts. However,the demonstration of mathematics as an object of cultural arts could grow faster than anticipated (Dushi, 2023). Certainly, the practical, cultural, and disciplinary values of mathematics would grow simultaneously and impact many educational values in schools and social life (Dushi,2023).

Furthermore, mathematics values are considered a cultural phenomenon. The student-teachers understood the relationship between culture and mathematics. The ideological, sociological, sentimental, and technological could determine the prospects of the student-teachers in their social, philosophical, and sentimental endeavors. The external environment would bring to bear the teaching and learning of mathematics as an interaction between people. The cultural phenomenon of mathematics education could inspire cultural phenomena, mathematical culture, the technology of mathematics, and the mathematical enculturation process generally (Zhang & Seah, 2021). Such a huge accomplishment uses values as the base factor to achieve the goals of the individual and the society. As a product, these values become the personal constructs and the sociocultural constructs. The social interactions of the individual's environment and other people around the individual could further generate new values and expand the value web necessary for mathematics learning (Zhang & Seah, 2021).

Lastly, although Adinkra symbols were initially the cultural emblems of the Akan ethnic groups of Ghana and Ivory Coast, they have largely been accepted and used for all social and cultural events. They form a cardinal part of symbols for all schools at all levels of education. They are exemplified in the rules and regulations of the schools. All students are extolled to the tenets of respect, commitment to excellence, truth/integrity, teamwork/collaboration, and equity (MoE, 2019). They are found in the national anthem, national pledges, patriotic songs, and religious workshops. However, their rare use and applications in mathematics teaching and learning remained a mirage. Possibly, much more of

this research can help stem the tide and reinvigorate the lost glory bestowed on them (Kuwornu-Adjaottor, Appiah & Nartey, 2015).

CONCLUSION

The results showed that many traditional universities in Ghana use the Adinkra symbols as their emblems. These emblems signify the mission and vision of the university and promote research, teaching, and learning to achieve the mission and vision. In Tables 1 to 5, the results showed that 'respect' ranked highest, and was closely followed by 'commitment to excellence', and 'truthand integrity'. The least values were 'teamwork' and 'equity'. So, in the learning of mathematics, these values have to be instilled into learners. Having given this culturally accentuated lesson, it was therefore recommended that culturally explosive pedagogies should beexploited to equip teachers and students to apply mathematics values for learning.

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