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MISMATCH BETWEEN INDIGENOUS GHANAIAN AND HINDU-ARABIC SYSTEMS IN DIDACTISING COUNTING AND PLACE VALUE

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Abstract. Studies show that indigenous languages have exhibited enormous impact on the evolution and didactics of counting and place value. However, Ghana systems have different perspectives and pose varied successes on the didactics of counting and place value. In this study, we explored a mixed methods design to examine the mismatch between Ghanaian and Hindu-Arabic systems. With a sample of 178 participants, we further examined not only student-teachers' knowledge and transitioning but also their skills and conceptualisation in didactising nine Ghanaian languages with respective to the Hindu-Arabic system. Both quantitative and qualitative data were collected through test and interview instruments. They were analysed by utilising T-test, ANOVA and verbal narratives which complemented and corroborated each other. The one-sample t-test result indicates that there was no impact of Ghanaian languages on counting and place value systems. However, the ANOVA test result infers that there is an impact of indigenous Ghanaian language on counting and place value systems. The qualitative results confirmed that the student-teachers had average skills in didactising counting and place value systems in the Ghanaian indigenous languages. It was therefore recommended, among other things that, measures should be taken not only to synchronise the Ghanaian languages but also to finetune the languages in tandem with the Hindu.

Keywords: Ghanaian languages, Hindu-Arabic, counting and place value, mixed methods, triangulation design

1. Introduction

Place value and language systems are endorser of Lev Vygotsky sociocultural perspective, which elaborates the essential role of language in teaching and learning (Helou & Newsome, 2018; Ali & Acquah, 2022). Indigenous languages teaching are formal construction and assimilation of different languages to the applications in other disciplines of learning. Ali and Adu-Poku (2021) found that indigenous Ghanaian languages teaching can play a crucial role in the modern technical revolution of teaching and learning mathematics. Ali and Acquah (2022) also discovered that the knowledge of Ghanaian languages in the teaching and learning of counting and place value can propel performance in mathematics.

Elsewhere, counting and numeration using place value systems continue to improve day by day. The computer has made the revolution of place value and counting from binary and octal to hexadecimal (base 16) number system quite easy to learn and apply. Even though today's computers were extensively developed in the late 1950s for processing electronic signals, the medieval people of modern-day Ghana never considered the numeration systems as having the impacts on counting and place value (Ali & Acquah, 2022). Killian (2021) defines a number system as a way to represent numbers, and the commonest number systems in computers are binary, octal, decimal and hexadecimal. The impacts of the conversions among these numeration systems helped to improve upon the quality and representations of these numbers.

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However, studies (Acharya, Kshetree, Khanal, Panthi, & Belbase, 2021; Ali & Acquah, 2022; Ali & Adu-Poku, 2021; Negara, 2021) showed that early languages in Ghana were not linked to any of the number systems. The languages could have also used strokes such as |, ||, |||, and so on to epitomise counting and number system. It is believed that the horizontal strokes originated from either ancient Egypt such as —, =, ≡, or East Asia (Ali & Acquah, 2022). These mismatches hindered the effective didactics of mathematics in counting and place value.

2. Theoretical background

2.1. Cultures on Counting and Place Value Systems

Supiyati, Hanum and Jailani (2019), and Aydın-Güç and Hacısalihoğlu-Karadeniz (2020) opine that mathematics and cultural integration mean contextual and realistic mathematics and the various cultural products of our ancestors reveal artistic creativity that contains mathematics. Negara (2021) believes that cultural-mathematical integrated learning can be actualised by exploring the construction of the historical heritage sites or local cultures that are related to mathematical concepts. For instance, the mathematical activity related to Lampung traditional house involves the concepts of geometry such as one-dimension, two-dimension, three-dimension, transformation and numbers including odd, even, and rational numbers (Negara, 2021). Indeed, as Negara (2021, p.107) puts it, "the cultural elements have mathematical values to be taught to students contextually." It is necessary to bring in didactics of counting and place value as the bedrocks of counting during measurements and other mathematics activities to the limelight since culture and mathematics are inseparable.

Counting and place value systems have been used in different cultures, depending on how these cultures influence the concepts. Base 10 was the inventions of Romans, Egyptians, Greeks and Hindus, base 20 was the early discovery of the Mayans and base 60 was the brainchild of the Babylonians (ETC Montessori, 2022). Smith (2022) opines that base 10 numeration systems might have originated as results of using fingers or toes to perform counting activities and base 20 as a result of counting both fingers and toes. Base 60 arose as a result of measuring time and as a result of 60 having many divisors (Smith, 2022). The Hindu system, the widely circulated and used system, emanated from Chinese as a result of counting rods from the 3rd to 5th centuries. It reached India from the 5th to 9th, Arab empire in the 10th, and Europe in the 13th centuries. However, it reached Saharan Africa and Ghana in the 16th century (Houdement & Tempier, 2019). Except the Hindu system, the major hindrances to using all the other ancient number systems were the lack of well patterned symbols and place value system to determine the precise uncontentious values of a number at different places in different digits (Smith, 2022).

In modern times, international comparisons carried by PISA and TIMSS show vast differences in performances of pupils. Consistently, children in Asia tend to perform better than those in America, Europe and Africa. The reasons for the good performances of Asian children are attributed to the suitability of the tests to their cultures, cultural attitudes towards mathematics, mathematics experiences in out-of-school and appropriate counting language (Ann, 2022). Ann (2022) alludes to the fact that counting and place value are more transparent in the Asian countries than the rest. For instance, eleven, twelve and thirteen are read as ten-one, ten-two and ten-three respectively.

The culture of counting and place value systems in indigenous languages has made positive impact on the development of counting and place value. Studies has prevailed the superior performance of Asian children in arithmetic can be traced to the regular structure of their number systems (Browning & Beauford, 2012). However, the irregular system of English number word system is a disadvantage to children's learning of counting and place value. For instance, the Chinese meaning of "twenty-nine" can be described directly as "two-tens-nine". The phenomenon is also occurred in many indigenous languages of Ghana (Ali & Adu-Poku, 2021; Ali & Acquah, 2022).

An assumption of whole number universality has been predominant for both curriculum reformers and international evaluators (Sun & Bartolini Bussi, 2018). Even though the Hindu-Arabic number system is considered as the most effective counting and place value tools for computations and other number works, and has regularly been used by many countries, the concept of whole number and

place value is not culture-free. The Arabs, who marketed the Hindu number system, travelled a lot and dealt in business and commerce that required enormous amount of arithmetic. The concepts of profit and loss in their business explorations then required that they discovered not just the number zero but also its symbol to ease counting and numeration. That is, counting and place value systems are deeply rooted in a people's culture and indigenous language. The nine indigenous Ghanaian languages that were previously selected as mediums of classroom instruction follow the same cultural and linguistic orientations as in Asian, America and Europe (Ali& Adu-Poku, 2021; Ali & Acquah, 2022).

2.2. The Concept of Counting

There are different perspectives in interpreting counting. The first interpretation declares that counting is the process of assigning names to each object in a set and the last word represents the total number of objects. (Brown, Evans, Hunt, McIntosh, Pender, & Ramagge, 2011) In general, it illustrates the continuous and increasing mental or spoken number by a unit for every element of the set. By marking those elements, it intends to avoid revisiting the same elements. Another inference proposes that counting is identifying the elements of finite or infinite set by assigning a number name to each element until the enumeration of all the objects is complete (Brown, et. al., 2011). In both ways, counting must have names which originate from a people's language. Since language is an integral part of culture, it stands to reason that the language of the people must be well studied and understood before embarking on counting.

According to Gelman and Galistel (1978), there were originally five principles of counting. These were (1) one-to-one principle (only one word can be assigned to each object or set of objects), (2) stable-order principle (i.e. consistency with the order of counting words without skipping the names of the arrangement of the objects or sets of objects is paramount), (3) cardinal principle (i.e. last number counting word must be assigned to the last object or set of objects and that last number represent the total number), (4) order of an irrelevant principle (i.e. knowledge that the order of items counted is irrelevant), and (5) abstraction principle (i.e. how we count stays the same regardless of whether they are of the same colour, shape or size).

In recent times, Canada's Ministry of Education (2016) discovered another five principles which are worthy of inclusion. These were (1) conservation (i.e. count for a set of objects stays the same no matter whether they are spread out or close together), (2) subitising (i.e. ability to "see" or visualise a small amount of objects and know how many there are without counting), (3) hierarchical inclusion (i.e. all numbers preceding a number can be or are systematically included in the value of another selected number), (4) movement (i.e. when you move up the counting sequence, the quantity increases by one and as you move down, the quantity decreases by one), and (5) unitising (i.e. one can count a large group of items by decomposing the group into smaller, equal groups of items, and then count the smaller groups). Ali and Acquah (2022) opine that all these ten principles are expected to arm and equip student-teachers to handle conceptions and misconceptions in counting and place value.

2.3. The Concept of Place Value

The position of a digit in a number is described as place value as each digit has a value corresponding to the place it occupies. In order to obtain the position of the digit the number needs to be expanded in the base ten numeral. These positions start from the right and move to the left. In whole numbers, the right most position is called ones. The ones are followed by tens, hundreds, thousands, ten thousands, hundred thousands, and so on. In short, the farther the number from the ones, the bigger the value of the number. A number can contain two similar digits but dissimilar values. In this case, the magnitude of the digit is determined by the position it occupies. For example, 5 in 3,458 represent 5 tens, but 5 in 5,781 represent 5 thousands (Brown, et al., 2011; Ali & Acquah, 2022).

Furthermore, in the base ten numeration system, each place is ten times more than the value of the place to the right and vice versa. For instance, we will provide different numbers with the same digit placed differently. In 53, the 3 is in the ones position and the value is 3. In 138, the 3 is in the tens position and the value is 30. For 4,372, the 3 is in the hundreds position and the value is 300. In the number 23,629, the 3 is in the thousands position and the value is 3,000. In a bigger number line like

36,548, the 3 is in ten thousands place and its value is 30,000. It is therefore instructive to realise that the value of 3 increases ten times as one moves from the right to the left and the vice versa. In expanding the number 13,548, we would obtain $10{,}000 + 3{,}000 + 500 + 40 + 8$. It is therefore important to observe that counting and place value are two sides of the same coin (Ali & Adu-Poku, 2021).

2.4. Statement of the Problem

Teachers and student-teachers continue to handle counting and place value in a haphazard. The knowledge and skills in dealing with counting and place value have positive influence on teaching and learning of number sense, rational number, and proportion. As teachers and student-teachers will introduce the concept to students, it is necessary for them to possess comprehensive understanding on counting and place value. This will lead to significant correlation between students' ability in counting and place value and the corresponding principles such as relative position, unitising, and indigenous languages (Ali & Acquah, 2022). Many student-teachers are aware of the importance in comprehending counting and place value concepts. However, their awareness does not determine their breadth of understanding (Ali & Acquah, 2022). Consequently, knowledge and skills in unitising is a critical measure of children's conception of counting and place value. Yet, student-teachers cannot visualise the relationship between the relative sizes of numbers and units of places the numbers occupy. This compels them to operate within the realms of procedural understanding rather than conceptual understanding (Brendefur, Strother & Rich, 2018).

Furthermore, Brendefur et al. (2018) observed that English language is a barrier to conceptualising place value effectively. For instance, there are no observable patterns and structures in counting ones (1-9) and teen (11-19). It hinders children to realise that two means one-one, three means two-one and four means three-one. Again, in teens, it is extremely challenging for children to understand that eleven means one ten and one, twelve means one ten and two and thirteen means one ten and three ones. Ali and Acquah (2022) revealed that student-teachers have stronger knowledge initial place value in their indigenous languages for numbers between 1 and 10. Yet, higher numbers pose a lot of challenges in indigenous counting and place value.

The new Ghanaian curriculum espouses stakeholders to employ indigenous cultural artefacts, of which language is very vital. For the basic level of education, it calls for the use of indigenous Ghanaian languages as mediums of instruction for the first eleven years of schooling (Ministry of Education [MoE], 2019). To ensure this policy is achieved, it is vital to present counting and place value in a familiar and understandable indigenous language. Ali and Adu-Poku (2021) observed that it is rare to encounter people of Ghana grouping objects by tens. It happens because the languages used have different number bases, for instance the most common are twos, fours, and fives. In relation to that, every Ghanaian language begins counting by ones which influences student-teachers cannot arbitrarily group objects by tens up to hundred and more. Elsewhere, studies have provided some context that requires making sense of the numbers (Disney & Eisenreich, 2018; Ali & Acquah, 2022). It is expected that the Ghanaian languages can exemplify the context of 'a hundred' instead of saying 'one hundred.'

Ali and Adu-Poku (2021) observe that the number zero (0) could pose another critical challenge in counting and place value in the indigenous Ghanaian languages. Zero has evolved from just being an arbitrary symbol used to denote a blank space to a quantity of complex interpretations. The skills in navigating the concept of zero determine how student-teachers understand the counting and place value in the indigenous languages. Despite the discrepancies related to zero, it has become an important foundational, complex, and multi-functional problematic concept in place value (Russell & Chernoff, 2011). It is not uncommon to observe Ghanaian student-teachers struggle to make meaning and connect the concept to the English language. Ali and Adu-Poku (2021) observed that the concept of zero in the Ghanaian languages is not just 'empty' or 'nothing', but non-existent of a quantity. This

then becomes problematic if one wants to situate zero in the context of Hindu-Arabic number system. In order to address the problems outlined above, we set up the following two research questions:

1. How do the Ghanaian languages contextualise hundreds in Hindu-Arabic number system? (RQ1)

   Null hypothesis (H_0): There are no differences in conceptualisation between the indigenous Ghanaian and Hindu-Arabic systems.

2. How does hundred in Ghanaian language differ from the Hindu-Arabic number system? (RQ2)

3. Methods

3.1. The Research Design

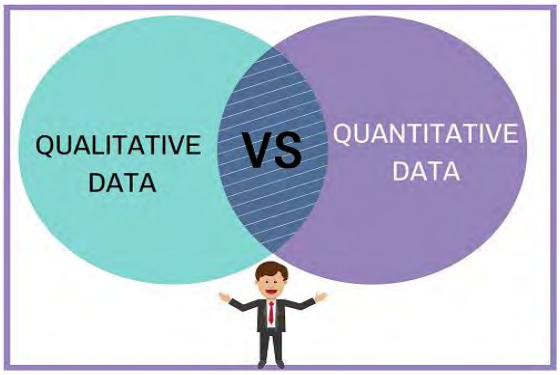

Figure 1. Mixed methods triangulation design (Creswell, 2013).

Figure 1 illustrates the framework that was used to address the aforementioned research problems in the concept of didactising counting and place value. In the triangulation mixed methods design, it included different but complementary data collected on nine Ghanaian languages that are examined externally by the West African Examinations Council (WAEC) in 2020. In this study, test items (quantitative instruments) were used to test the theory of counting and place value. In line with MoE (2019) approved course of study for student-teachers who pursues Bachelor of Education in Upper Primary degree to enable them to teach at the higher primary level, the test items included the following areas:

(1) counting numbers in both English and a Ghanaian languages;

(2) representing numbers in both English and a Ghanaian language;

(3) skills of transitioning in both English and a Ghanaian language;

(4) problem-solving and investigation.

In the interview guide, the items included the following:

(1) speaking and describing

(2) making judgments on the best solutions

(3) showing fluency and competency

(4) counting and writing the numbers

There are three parts of the design vis-à-vis qualitative only, quantitative only and both qualitative and quantitative. Particularly, the quantitative part of the items predict how the nine Ghanaian languages (independent variables) influenced (positively or negatively) the student-teachers knowledge (dependent variables or outcomes) in didactising counting and place value. The qualitative part takes live transcripts from the research participants to match with the quantitative part. Concurrent with this

data collection, qualitative interviews were performed on the central phenomenon for student-teachers. Both quantitative and qualitative parts sought to complement and corroborate each other.

3.2. Population and Sample

About 178 student-teachers of the academic year 2020/2021 took part in the study. These student-teachers study counting and place value as part of their initial teacher preparation in the university. Even though Ghana has more than 100 local languages, we selected nine indigenous Ghanaian languages. These languages have been participating in all external examinations conducted by WAEC for basic school level of education in Ghana. These languages also served as catalytic foundations for the inclusion of many other languages in future. Particularly, Twi and Ewe languages have developed appreciable levels of counting and place value systems beyond thousands (MoE, 2019).

3.3. Data Collection

The instruments sought to explain and describe the comprehensive Ghanaian languages on counting and place value systems. The necessary changes and adjustments on the concurrent multiple levels examined by the quantitative data and supported the findings with the qualitative interviews of fourteen groups (Creswell, 2014). These multiple sources of data were collected from counting and place values of ones, teens, tens, hundreds, and thousands. Since the interviews produced verbal reports and posed problems of poor or inaccurate articulations, the psychological tests consequently helped the researchers to complement the interview guide. Items in the test were closed ended containing these levels: excellent (1), very good (2), good (3), credit or average (4), and fair (5). This structure helped the researcher to take care of all ability groups (high, moderate, and low) (Cohen, Manion & Morrison, 2011).

The procedures for constructing the test instruments provided good timings as it improved reliability, motivation, and capabilities, and avoided pressures or unnecessary impediments. It was necessary for student-teachers to know both the overall time and time allowances for the different components relative to weightings and scores (Cohen et al., 2011). Immediately after the test, student-teachers were put in 14 groups of approximately 10 people for the group interview sessions. Laverty (2016) opines that interview allows for cordial relationship and mutual respect for both the interviewer and interviewee. The interactions provided timely feedbacks, probing, and prompting for further clarifications and making suggestions for future remedies. In addition, the student-teachers were more than willing to provide thorough and insightful responses on how they performed in counting and place value during the conversations.

The in-depth interviews were flexible and open-ended tools for the qualitative data collection. This enabled student-teachers to use verbal, spoken, and written Ghanaian languages in exploring the issues related to the counting and place value (Acharya et. al, 2021). This partly explains the reasons why the items on the interview guide were structured in tandem with the themes as the test items. The interviews compelled student-teachers to generate knowledge through debates, peer-teaching, and constructions of knowledge in counting and place value.

Lastly, the interview guides were standardised and focused on didactising counting and place value systems. This helped the student-teachers to discuss findings and interpretations of zero, ones, tens, teens, and hundreds. It equally helped them to transition from one level of place value to another. In the end, they applied counting and place value systems to real life situations (Creswell, 2012).

3.4. Data Analysis

We carried out the analyses of the tests data in three stages. In the first stage, we tested for the assumptions of the statistical tools. These assumptions are level of measurement, independence of observations of student-teacher, normal distributions, and homogeneity of variance. In the second stage, we tested for the conditions of validity and reliability. We used the Cronbach's alpha to measure reliability of the instruments and the design. The final stage was implemented to determine group differences with statistical significances (Creswell, 2014). Here, we used t-test statistics and analysis

of variance (ANOVA) to test student-teachers' skills and their ability to transition from ones into tens, hundreds, and thousands.

The tests were mainly differences in statistical significances (Ali & Acquah, 2022). Statistical differences do not necessarily mean it is appropriate in decision-making, but rather gives only confidence. In this study, confidence intervals, effect sizes, and power statistics were used to justify the statistical significances. Here, the confidence intervals were used to assess whether the sample selected truly represent the population. For confidence intervals including 0 showed no representativeness, while excluding 0 showed group representativeness. The effect size (Cohen d) allowed for not only significant statistically, but also indicates the importance or the effectiveness of the statistical significances (Brydges, 2019). Cohen (1988) proposed that 0.2 has small effect, 0.5 has medium effect, and 0.8 has large effect, which we adopted for this study.

On the other hand, the statistical powers measure how likely statistical tools identified statistical differences between groups (Keskin & Aktas, 2013; Polanin & Nuijten, 2018). The acceptable minimum power is purged at 0.80, which is normally based on the significance level of 0.05. Alternatively, this is interpreted as the ratio of a Type 2 error (1-power) to a Type 1 error as 0.20/.05 or 0.40 (Cohen, 1988). However, where no statistically significance differences were recorded, the researcher used ANOVA to control variables that might influence the relationships. This also helped to identify original speakers of the Ghanaian languages and remix them during the interviews (Creswell, 2014).

In the qualitative data analysis, we sought to segregate, code and schematise themes that emerged from the research questions. Even though qualitative data analysis revolves around personal experiences and interpretations of the researchers, the participants took active roles in identifying key themes. Since the qualitative analysis relied on the researchers' personal experiences, it was made systematically, sequentially, and transparently (Celano, 2015; Flick, 2015). Hence, the researcher coded the themes through the following procedures:

1. *Phase One*: The researcher transcribed each interview with initial potential themes, read through the interview texts, related the interview transcripts to the research questions, and identified common themes.
2. *Phase Two*: The researcher analysed each interview systematically by creating sets of codes through line-by-line, searching for themes, looking for actions, teasing out the differences, and discussing the recorded sessions.
3. *Phase Three*: The researcher reduced the codes into sub-categories of concepts: zero, ones, teens, tens and hundreds. This generated headings to compare and develop common/different themes across the Ghanaian languages' counting and place value.
4. *Phase Four*: The researcher compared the similarity and the difference among the themes across the Ghanaian languages in order to redefine patterns and move from general categories to more detailed specific subcategories (Creswell, 2014).

3.5. Addressing Threats to Internal Validity

Inherent in a mixed methods design is threats to internal validity. To tackle this issue, we addressed likely threats that may hamper the interpretations and applications of the results (Cohen et al., 2011; Creswell, 2014). Seltman (2015) argues that blinding in testing procedures has huge advantages. Apart from pretesting, the researcher blinded the student-teachers from knowing the treatment groups in order to avoid Hawthorne effects (Cohen et al., 2011).

At the data collection stage, the researcher minimised the Hawthorne effects, dropout rates, non-returns, time intervals between pre-test, and actual test. At the data analysis stage, the researcher validated student-teachers to avoid subjective interpretations, reduced halo effects and wrong reporting (Seltman, 2015). In the qualitative data, the researcher addressed the internal threats to validity by ensuring confidence, trust, authenticity, credibility, dependability, and confirmability. Particularly,

credibility was established through prolonged engagements, triangulations, debriefing, and checking members (Creswell, 2014).

3.6. Ethical Considerations

Generally, ethical issues arise prior to the research, introduction, methods, analysis, and reporting stages of the study (Cohen et al., 2011). Prior to the research, we needed to check the professional standards, approvals, permissions, vested interests, and publications. These issues were checked in order to avoid conflict of interest situations. Prior to the start of the study, we conversed informally with the participants by contacting personally, respecting opinions, debriefing participants on cultural, religious, gender and language differences, and obtaining appropriate consent. At the methods stage, the researcher has maintained trust and minimal disruptions to their learning, and pledged to avoid disclosing sensitive information but to stay within the interview protocols. Before the analysis, we used both quantitative and qualitative, reported contrary findings, and assigned alphabets to participants. Lastly, prior to reporting the findings, we openly reported the results by using unbiased language, disclosed finding sources, and gave credits to authors and participants (Creswell, 2013).

4. Results and Discussion

The results were analysed in stages according with two research questions which were analysed quantitatively for research question one and qualitatively for research question two.

4.1. Quantitative results

RQ1: How do Ghanaian languages contextualise hundred in Hindu-Arabic number system?

This research question will be answered in two parts. The first part will use the hypothesis and the second part will use the qualitative interview transcripts.

Hypothesis (H_0): There are no differences in conceptualisation between the indigenous Ghanaian and Hindu-Arabic systems".

Ali and Acquah (2022) performed an ANOVA technique to establish the statistical significances among the three place values in ones, teens and hundreds when counting numbers. The results showed significant differences. It was evident that the student-teachers had differences in counting and place values up to hundreds. The conclusion showed positive effects of the indigenous Ghanaian languages counting and place value in hundreds. To answer the research questions, we will use results from the previous study which presented significant differences among (the three place values) in counting (Ali & Acquah, 2022). It was evident that student-teachers had sufficient knowledge in counting and place values up to hundreds. The study concluded that there was a positive effect in using indigenous Ghanaian languages for the knowledge of counting and place value in hundreds. The skills of contextualising hundreds are displayed on Table 1.

Table 1. Conceptualising in indigenous Ghanaian languages

Language on Place Value	*t*	*df*	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Teens	26.376	177	.000	2.410	2.23	2.59
Tens	26.523	177	.000	2.331	2.16	2.50
Hundreds	24.470	177	.000	2.270	2.09	2.45

Table 1 addresses the question of the student-teachers' contextual knowledge in hundreds in Ghanaian languages. In our comparison of the indigenous Ghanaian languages, we found that student-teachers' conceptualisation in hundreds was significantly different ($t(177) = 24.470$, $p<0.01$). This means the student-teachers had different conceptualisation of not just hundreds but all other concepts in place value systems. Even though Ghanaian languages count differently, they can contextualise counting and place value systems in other cultures and languages (Disney & Eisenreich, 2018). In order to test the universality of the indigenous Ghanaian languages with other cultures and languages, we extended

the transitions from counting to place value, ones to tens, and hundreds to thousands. The results of these transitions have been displayed on Table 2.

Table 2. Conceptualising counting-place value, ones-tens and hundreds-thousands

Pairs	Paired Differences					*t*	*df*	Sig. (2-tailed)
	$\bar{x}$	*SD*	*SEM*	95% CI				
				Lower	Upper			
Counting –Place Value (Pair 1)	-.079	.757	.057	-.191	.033	-1.390	176	.166
Place Value-Tens (Pair 2)	-.657	1.626	.122	-.898	-.417	-5.393	177	.000
Hundreds – Thousands (Pair 3)	-.135	1.329	.100	-.331	.062	-1.353	177	.178

The results on Table 2 show that for Pair 1 and Pair 3, the p-values > 0.05 affirming that the student-teachers' skill was not statistically significant. Clearly, the insignificant mean difference shows that it was unlikely for student-teachers to contextualise beyond hundreds in Ghanaian languages. Therefore, there were more challenges in contextualising counting with larger numbers and its place values. Normally, as counting and place value has a higher progress, the complexity of the numbers being similar but the values being dissimilar pose more challenges (Brown, et al., 2011). Despite the successes, it was incumbent to extend the t-test statistics to ANOVA to enable us to describe the global universality of didactising counting and place value systems in the indigenous languages on Table 3. However, since majority of the indigenous Ghanaian languages' counting and place value systems does go beyond thousands, we restricted the extended transitions to hundreds (Ali & Acquah, 2022).

Table 3. One-way ANOVA results

Groups		Sum of Squares	*df*	Mean Square	*F*	Sig.
Teens	Between Groups	2.657	3	.886	.592	.621
	Within Groups	260.405	174	1.497		
	Total	263.062	177			
Tens	Between Groups	2.166	3	.722	.450	.717
	Within Groups	279.070	174	1.604		
	Total	281.236	177			
Hundreds	Between Groups	.974	3	.325	.209	.890
	Within Groups	270.082	174	1.552		
	Total	271.056	177			

As displayed on Table 3, we sought to compare the differences of the indigenous Ghanaian languages' conceptualisation of place value systems using three levels. We do not have enough evidence to reject null hypothesis (P>0.5) in tens, teens and hundreds. Upon subjecting the ANOVA test to further statistical analysis, the effect sizes of 10%, 0.7%, and 0.4% equally provided smaller explanations to the variances. This notwithstanding, the effect was bigger in teens rather than in tens and hundreds. . The question of how student-teachers contextualise hundred and how hundreds differ from the Hindu-Arabic popped up can be deduced from Table 2. Clearly, Ghanaian languages have no definite place values for higher numbers as compared to the English language (Brendefur et al., 2018). Ali and Adu-Poku (2021) observed that while there are special place values for thousands, millions, and so on, the Ghanaian languages lack structures for higher counting and place values. For instance, one thousand means *akpe* in Ewe language but one million could mean *akpe-kpe* because no single name exists for the name (Ali & Acquah, 2022).

4.2. Qualitative results

RQ1: How do Ghanaian languages contextualise hundreds in Hindu-Arabic number system?

Ali and Acquah (2022) found strong relationships between the indigenous Ghanaian languages and place values. The positive mean differences showed strong evidence that student-teachers had moderate knowledge in hundreds. Ali and Acquah also discovered the mean difference for place value was higher than the mean difference for counting. This is because student-teacher have more contextualise understanding of place value systems than the counting systems in the indigenous Ghanaian languages. In fact, in the indigenous Ghanaian languages, tens were found to be more patterned and structured like the Asian languages than ones, hundreds, and thousands.

Even though the quantitative results yielded statistical significances, it was still necessary for the participants to encounter live experiences in counting and place value. Again, we used the same nine indigenous Ghanaian languages undertake these live interactions. The interactions sought to compare similarities and differences in one, ten, and hundred and displayed on Table 4.

Table 4. Ghanaian languages keys of place values

Language	One	Zero	Ten	Hundred
Akan (Twi)	*Baako*	*Hwee*	*Adu*	*ɔha*
Dagbani	*Yini*	*Yoli*	*Pihi*	*kɔbiga*
Dagara	*Bonyeni*	*Kpale*	*Pie + Lizare*	*kɔɔ*
Ewe	*Deka*	*Nadekeo*	*Bla*	*Alofa*
Ga	*Ekome*	*Ekobe*	*nyɔŋmai*	*Oha*
Gonja	*Eko*	*Fuley*	*Ada*	*kalfa*
Fante	*Kor*	*Hwee*	*Eduo*	*ɔha*
Kasem	*Kalo*	*Konkolo*	*Fin*	*Bi*
Nzema	*Ko*	*Hwee*	*Abula*	*Yalɛ*

The live experiences with the student-teachers show that many of the indigenous Ghanaian languages lack consistent patterns and structures in moving from one to hundred. For instance, “baako” which means “one” in the Twi Akan speaking languages has no link with “adu” which means “ten” and “ɔha” which means “hundred”. It was realised that no any two or more had the same name for one. Not much was probed into this dissimilarity.

Apart from the Akan language groups (Twi, Fante, and Nzema) that use *hwee* as zero, the other six languages have unique names for zero. Zero is such a critical digit in counting and place value that it was particularly put on the radar for thorough examination. Zero has grown beyond being a mere space filler and value determine to highlighting the cultural significance of ‘nothingness’ (Ali & Adu-Poku, 2021). To have a better understanding on the student-teachers’ perspectives on zero in didactising the different indigenous Ghanaian languages, we provide Transcript 1 below.

Transcript 1

Interviewer : What is the meaning of zero in your dialect?

Student A : Zero (*hwee*) means ‘nothing’ in Fante. This could be interpreted as null or non-existent of an object.

Interviewer : Describe how your language can move in ones up to hundreds or even more numbers.

Student B : We the Akan number system places much emphasis on adding one in the ones. For example, 2 means 1 plus 1, 3 means 2 plus 1, 4 means 3 plus1, and so on. So, if we have a number like 15, we just say 10 plus 5. And because 10 are multiples of 2, we just say that 100 is two-fifties.

The responses of Transcript 1 perfectly aligned Akan Twi with the Hindu-Arabic numeration system. If we thoroughly examine the responses of Student B, we can come to a conclusion that numbers between 2 and 9 are counted and named according to the number of ones they contain. Also, tens are dissociated into 10 and ones as hundreds are partitioned according to multiples of 2. This transcript influences the patterns and structures of the Akan numeration system and encourages the smooth learning of mathematics. Thus, the Akan family of languages can count numbers even up to billion and beyond (Ali & Acquah, 2022).

Interestingly, the Akan number system places emphasis on adding one in the ones. For example, In Akan, two means 'baako' ne 'baako'1(literally interpreted as one and one), three means 'mmienu ne baako' (literally interpreted as two and one), and four means 'mmiensa ne baako' (literally interpreted as three and one). So, in teens, they add 'tens' and 'ones'. For instance, fifteen, we just say 'adu ne manu' or dumanu (literally meaning ten and five). In tens, they add 'ones' to the 'tens'. For instance, fifty means 'dunum' (ten and five). In hundreds, they count them in 'fifties'. For instance, one-hundred means 'dunum manu', which literally means two of the fifties or two-fifties. In modern times, one called 'oha' is used to represent hundreds (Ali & Adu-Poku, 2021).

Besides the Akan family of dialects, many of the indigenous Ghanaian languages have similar patterns and structures in counting and place value. The Ewe counting and place value system has unique tens (*ewo, wi, or wui*), hundreds (*alofa*), and thousands (*akpe*). With regards to the movement in ones and hundreds in Ewe, it is categorised as easy and simple. For instance, 100 means *alofadeka* which is literally interpreted as hundred ones, 200 means *alofaeve* which literally means hundred twos up to 900 means *alofashieke* which literally means hundred nines. One can observe that the ones are added to the hundreds to clarify the number of hundreds as contained in the Hindu-Arabic system. Similar observations can be made of the Dagbani language. In Dagbani, 100 means *kɔbiga*, 200 means *kɔbisi-ayi*, 300 means *kɔbisi-ata* up to 900 which means *kɔbisi-awei* (Ali & Acquah, 2022). This means the Ghanaian languages use not only multiples of two but also 10. This is apparent clear in the Dagara language as seen in Transcript 2.

There was a wide variant of the Dagara system of counting and place value. In the Transcript 2 below, the researchers sought to probe further into the unique patterns and structures of the Dagara.

Transcript 2

Interviewer : How does your language move in tens up to hundreds? What is the role of zero in counting and place value in your language?

Student C : In Dagara, *pie* stands for tens and *lizare* stands for twenty. So, thirty means *lizare-yini ne pie* (i.e., literally a twenty plus a ten). Zero has no place in Dagara language. It is not directly used to determine the place values as done in the Hindu-Arabic system.

According to the transcript, we noticed that student C has a unique Ghanaian interpretation of combining 20s (*lizare*) and 10s (*pie*). According to the translation of Dagara language, 40 means *lizare-ayi* which literally means two 20s, 50 means *lizare-ayi-ni pie* which literally means two 20 plus 10, 60 means lizare-ata literally means three 20s and so on. Therefore, one hundred means *lizare-anu*, which literally means five-20s. This clear case of departure of counting and place value in the indigenous Ghanaian languages is actually a setback to any unification and synchronisation.

Ali and Adu-Poku (2021), and Ali and Acquah (2022) discovered many similar discrepancies in the counting and place value systems of the indigenous Ghanaian languages. The languages abound with irregular counting patterns and differences in number bases. While the Akan Twi, Ewe, and Dagbani languages follow the base 10 numeration system, that of Dagara has both bases 10 and 20. It was therefore revealing to observe that zero plays no role in the transition of the counting and place value systems of the indigenous Ghanaian languages. Unlike the Ewe however, no mention of *one* was prefixed on the number *one-hundred (100)*. This is another complete departure of the indigenous Ghanaian languages from the Hindu-Arabic system (Ali & Acquah, 2022).

RQ2: How does hundred in Ghanaian language differ from the Hindu-Arabic number system?

We provide Table 5 on the name of one-hundred in each of the nine indigenous Ghanaian languages. This is being matched with the Hindu-Arabic system. Even though counting and place value systems in Base 10 was the inventions of Romans, Egyptians, Greeks and Hindus (ETC Montessori, 2022), the Hindu system was widely circulated and used by the Chinese, the Indians, the Arabs and Europeans (Houdement & Tempier, 2019). We believe that if student-teachers properly and effectively contextualise counting and place value systems in hundreds and beyond, the challenges that confront counting and place value systems could be reduced to the barest minimum (Smith, 2022). This might improve transparency in the indigenous Ghanaian languages' counting and place value systems. This would ultimately improve upon children's performance in mathematics at the early stages of education (Ann, 2022).

Table 5. Ghanaian languages keys of place values

Ghanaian Language	Hundred	Hindu-Arabic
Akan Twi	ɔha	One hundred
Dagbani	kɔbiga	One hundred
Dagara	kɔɔ	One hundred
Ewe	Alofa	One hundred
Ga	oha	One hundred
Gonja	kalfa	One hundred
Fante	ɔha	One hundred
Kasem	Bi	One hundred
Nzema	Yalɛ	One hundred

Conspicuously missing on Table 5 is the name 'one' as a prefix to the 'hundred'. For instance, the Akan Twi does count one-hundred as *ɔha baako*, the Nzema language does not call one-hundred as *yalɛ bulu* and the Gonja language does not call one-hundred as *eko-kalfa*. The interpretation of *ɔha baako* in Twi means something else. The number 'hundred' is accepted as 'one-hundred'. In the indigenous Ghanaian counting and place value, 'hundred' becomes a denomination rather than a quantity known as 'one hundred'. Ali and Acquah (2022) discovered that many of the languages perceived 'hundred' to be the highest number in counting and made no further efforts to discover more numbers for counting and place value to grow and fester.

That notwithstanding, the counting and place value system was tandem with the Ghanaian culture. Almost the cultures count using the denominations of ones, tens, and hundreds. The challenge now is to encourage the other indigenous Ghanaian languages to discover numbers up to thousands and beyond. Indigenous Ghanaian languages like Ga and Kasem are still too far from the other seven languages (Ali & Adu-Poku, 2021). Even though many more languages have been rolled out, the issue of counting and place value still lingers and poses a threat to the implementation of the new curriculum of Ghana (MoE. 2019).

5. Conclusion and Recommendations

5.1. Conclusion

The findings show that the results of the t-test were not statistically significant with respective to the student-teachers' contextual knowledge and skills in didactising counting and place value systems. We therefore inferred that student-teachers' skills the indigenous Ghanaian languages in didactising counting and place value. This not withstanding, the mean for place value was higher than the mean for counting. This means that there are proper and effective patterns and structures of place value than counting. And the relatively higher mean for tens equally shows that there are much more observed patterns and structures of tens than the other numbers.

We can also conclude that many indigenous Ghanaian languages have been perfectly aligned with the Hindu-Arabic numeration system. The 'ones' have unique names, 'tens' can be dissolved and

expanded up to 'thousands' and beyond. The Dagara language combines 20s (*lizare*) and 10s (*pie*). This clear case of departure could actually pose a setback to any unification and synchronisation in counting and place value.

Furthermore, it could be concluded that the tens and hundreds were irregular and could not be derived from the concept of zero. The number 'zero' was regarded not a real number in the sense of the word. So, it was perceived to only function as name for non-existent situations and not in counting and place value system.

Again, conspicuously missing in the transitioning of counting and place is the name 'one' as a prefix to the 'hundred'. This makes 'hundred' a denomination rather than a quantity. As some languages perceived 'hundred' to be too large to be counted beyond, many of the languages made no further efforts to discover counting and place value beyond hundreds.

These findings notwithstanding, we can conclude that indigenous Ghanaian languages counting and place value largely go in tandem with the Hindu-Arabic system. The challenge now is to encourage many other indigenous Ghanaian languages to discover numbers up to thousands and beyond. Therefore, assistance in the understanding of the two concepts is critically needed to propel performance and achievement in numeracy and mathematics.

5.2. Recommendations

The concepts of didactising counting and place value cannot be properly grasped through merely translating the indigenous Ghanaian languages counting systems into the Hindu-Arabic system. We therefore recommended that new temporary counting and place value systems be redesigned and reconceptualised to enable as many languages as possible grow and develop. We can achieve this by pooling diverse expertise from culture, science, technology, engineering and mathematics to education.

Secondly, indigenous Ghanaian languages that fail to meet the patterns and structures of the Hindu-Arabic system should reconsider revising and remodelling their counting and place value systems. This would not only meet the Hindu-Arabic system but also the tenets and structures of the other major indigenous Ghanaian languages. The teaching and learning of numeracy and mathematics cannot succeed without a common counting and place value system for the country.

On the whole, the indigenous Ghanaian languages must be synchronised with each other and with the Hindu system a common counting and place value. The old existing languages and the prospective new languages that clamour to officially join the new curriculum requirements should begin to reinvent and reinvigorate their languages, taking into consideration number, counting and place value. The initial conceptions of children in counting and place value have overriding consequences on the future performance and achievement of school children in numeracy and mathematics.

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