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EXPLORING TEACHER TRAINEES AND THEIR TUTORS' RECEPTIVENESS TO CULTURAL RELEVANCE OF MATHEMATICS IN THE COLLEGES OF EDUCATION

BY

JOSEPH KOFI ASIEDU

Thesis submitted to the Department of Mathematics and ICT Education, Faculty of Science and Technology Education, College of Education Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Doctor of Philosophy degree in Mathematics Education

SEPTEMBER 2024

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature ………………………… Date ………………………....

Name: Joseph Kofi Asiedu

Supervisor's Declaration

I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature …………………… Date ……………………………

Name: Prof. Ernest Kofi Davis

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ABSTRACT

This study explored the teacher trainees and their tutors' receptiveness to cultural relevance of mathematics in the Colleges of Education. A sequential explanatory mixed-methods design was used to explore the receptiveness of 1,160 teacher trainees and their 34 tutors to cultural relevance of mathematics teaching and learning. Participants were sampled from five Colleges of Education in one out of the five PRINCOF zones using convenient, purposive and stratified random sampling techniques. The data were collected through the use of questionnaires and semi-structured focus group interview guides. The quantitative data collected was analysed using descriptive statistics (percentages, means, and standard deviations) and inferential statistics (MANOVA). The qualitative data was analysed thematically and presented as narrative descriptions with illustrative examples. The findings showed that both teacher trainees and their tutors' perceptions about mathematical knowledge, mathematics pedagogy, and the links between culture and mathematical knowledge indicated trends toward cultural-related perceptions. In addition, their perceptions about links between culture and mathematics pedagogy, and the links between culture and mathematics curriculum were also cultural-related, an indication that their views were generally cultural-related. Again, sex had significant effect on teacher trainees' and a non-significant effect on their tutors' perceptions. Besides, the programmes of study and grade levels had significant effect on teacher trainees' perceptions. Again, it was found that there was significant difference in the perceptions of teacher trainees and their tutors. The study recommends among others that teacher education institutions should leverage on the receptiveness of teacher trainees and tutors to promote culturally responsive pedagogies in Colleges of Education.

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KEY WORDS

Colleges of Education

Receptiveness

Receptiveness to Cultural Relevance of Mathematics teaching and learning

Teacher Trainees

Mathematics Tutors

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DEDICATION

To my late mother Rosemary Akosua Benewaa

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CHAPTER ONE

INTRODUCTION

Improvement in mathematics education is based on sound knowledge of practical mathematics in almost every sphere of life. The meaningful development of human life attests to the information a person has gained through experience in mathematics. The major function of mathematics cannot be ignored in any society because of its significant role in social, cultural and economic development. Mathematics is an everyday activity seeing in the broad spheres of problem-solving, critical thinking, technology, career opportunities, time management and perseverance. Mathematics helps individuals to transmit, preserve, and enrich their culture (Acharya, et al, 2021).

Culture is a fundamental aspect of mathematics teaching and learning at all educational levels. As noted by Davis (2010, 2016); Bishop (1988); and resonated by Rosa and Orey (2020), teaching mathematics through cultural relevance and personal or local contexts helps students to know more about reality, culture, society, and environmental issues by providing them with mathematics content and approaches that enable them to successfully master academic mathematical contents. Besides, Davis (2013) in his study argued that exposing pre-service teachers to sociocultural issues in mathematics teaching and learning help them to conceptualise the relationship between everyday mathematical concepts and academic/school concepts. Learning becomes more meaningful when culture is linked to the teaching and learning process, especially in mathematics. Contextual learning is extremely relevant to the cultural community and makes learning thought-provoking and exciting for children (D'Ambrosio, 2007; Peni, 2019).

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Literature shows that modern mathematics educators in both developed and developing countries are finding new innovative ways of integrating cultural aspects in mathematics teaching and learning in schools. Mathematics education in Colleges of Education over the years had taken into consideration the aspects of culture in its teaching and learning process. One such innovative way of promoting interest in mathematics is through the integration of cultural aspects in mathematics teaching and learning. Failure to connect out–of–school mathematics with school mathematics has contributed to alarming abysmal performance in mathematics at the Colleges of Education in Ghana (Davis, 2010; Davis & Seah. 2016). The cultural aspects of mathematics teaching and learning approaches allow students to learn mathematics based on their previous knowledge and also appears to be responsible for the construction of their own current mathematical knowledge (Davis, 2016; Moll et al, 1992; David, 2016). This novel cultural aspects of mathematics approach has been endorsed by many countries across the globe like America, Australia, Japan, China, Malaysia, Estonia, Nepal, Brazil, and countries in sub-Sahara Africa including Ghana.

Therefore, there is the need for research in the area of cultural aspects of mathematics teaching and learning, more especially at the Colleges of Education level, since the problem of students' poor performance in mathematics is a grave concern to stakeholders in education. In addition, research indicates that the performance of students from two African countries who participated in recent 2019 TIMSS conducted for 4th and 8th grades students from 64 countries, appears to be the lowest among their elsewhere counterparts (Ina et al, 2019). Again, TIMSS (2003, 2007 &2011) also showed results of weak performance in mathematics among African countries who participated. It is important to note that

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these students with weak performance in mathematics were the same students who are enrolled in tertiary institutions especially Colleges of Education in Ghana, to be trained and come out as professional teachers to teach at the basic school level. Therefore, there is a pressing need for a pragmatic research study to explore perceptions of contemporary mathematics education and pedagogical practices for particular teacher trainees and their mathematics tutors in the Colleges of Education in sub-Sahara Africa, including Ghana. It is in this direction that the current study was carried out to explore the receptiveness of cultural relevance in mathematics teaching and learning at the Colleges of Education level in Ghana.

This introductory chapter sets the context of the whole study by providing the background to the study, the statement of the problem, the purpose of the study, research objectives, research questions and hypothesis, the significance of the study, delimitations and limitations, and the definition of key terms.

Background to the Study

Mathematics education has gained grounds recently in Ghanaian educational system. This is because it has several applications in human lives. Mathematics is often seen as the most essential tool for the development of any society. Regardless of this understanding of relevance of mathematics to the society, the general performance of students in mathematics at both tertiary and pre–tertiary levels has continued to remain low over the years in sub-Saharan African countries including Ghana. As a result, many mathematics educators and policy makers advocate for sustainable and inspiring mathematics curricula that can be used to improve the standards of mathematics education in Ghana.

Besides, teachers are the ones who have direct contact with the students in the school and classrooms, and their role is to implement the mathematics

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curriculum in every educational system to ensure quality mathematics education. The National Council of Teachers of Mathematics (NCTM, 2000) emphasises the need for effective mathematics teachers to have adequate knowledge and understanding of what they teach and be able to draw on this with flexibility in their teaching of mathematical tasks. For instance, Davis and Chaiklin (2015) emphasised that the radical-local approach to teaching and learning provides a perspective that can be used to develop mathematics teaching that will be appropriate for the majority of students, and practicable concerning historically existing conditions of mathematics education in Ghana. They believed school and out-of-school mathematics have been treated as in opposition or as mutually exclusive, and this conception blocks the realisation of particular goals formulated in the Ghanaian mathematics curriculum. For example, teachers do not attempt to draw on learners' experiential background to include students' out-of-school mathematical knowledge in teaching (Davis, 2010, 2016; Abreu & Duveen, 1995; Davis & Chaiklin, 2015).

Diverse cultures possibly might place varying beliefs on mathematics education, which can influence how male and female teacher trainees and their tutors recognise the mathematics as a subject taught in school. Literature points to the fact that individuals' mathematical conception is shaped by their social and social context, including sex, norms and expectations. A deeper thought of how sex influences individuals' views of mathematics and its cultural significance is an indications of development of inclusive and effective mathematics education programmes (Asante, 2010).

In order to address this prevailing mathematics educational issues in Ghana, a representative assembly led by Anamuah-Mensah and Benneh committee was

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formed to come up with a report that will address the difficulties we, as a nation were encountering in the educational system. Based on the Anamuah-Mensah and Benneh report (NTECF, 2017) formulated through a public consultative decision to improve the quality of teaching and learning at the basic school level, the new curriculum framework was designed to run a 4-year Bachelor of Education (B. Ed) degree programmes at forty–six (46) public Colleges of Education in Ghana. As a result, the first batch of students were admitted in the 2018/2019 academic year to pursue a B.Ed. programmes in Early Grade education, Primary education, and JHS education in all 46 public Colleges of Education. The intention was to phase out a 3-year diploma programme run by the Colleges of Education and to expand the curriculum to equip teacher trainees with the requisite knowledge, skills, and competencies needed to improve their teaching performance at the basic school level (NaCCA, 2018). The first batch of students across 46 public Colleges of Education are being mentored, examined, and certificated based on the University of Cape Coast (UCC) Bachelor of Education Curriculum.

However, in 2019, the Ministry of Education invited the other five public institutions to join the University of Cape Coast (UCC) to sign a memorandum of understanding (MOU) on the Colleges of Education affiliations to share the 46 public Colleges of Education. It is also important to note the subsequent batches (i.e., 2019/2020 academic year and onwards) of teacher trainees admitted were shared through college affiliations among six public institutions namely (University of Cape Coast (UCC), Cape Coast; University of Ghana (UG), Accra Legon; University of Education (UEW), Winneba; Kwame Nkrumah University of Science and Technology (KNUST), Kumasi; University for Development Studies (UDS), Tamale and AAMUSTED), Kumasi in Ghana. These six public universities are

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mandated to design curriculum, mentor, examine, and certify their colleges of affiliation. Teacher trainees who complete a four-year programme of study, certified by the six affiliated universities are awarded a Bachelor degrees in one of these: Early Grade education, Primary education, or Junior High education. The six public universities in partnership with T-Tel Ghana (2018) organise workshops and in–service training for tutors in their respective affiliate colleges to abreast them with new innovative approach to teaching and learning of mathematics. The four year groups including the first batch of teacher trainees and their tutors selected for this study from the five colleges were under three of the six public universities in Ghana.

The programmes for the new Bachelor of education degree were designed to train competent teachers who would teach at the basic school levels in Ghana. This new B.Ed. Programmes train Early Grade, Primary and Junior High School (JHS) teachers in public Colleges of Education in Ghana. In the case of the mathematics curriculum structure, teacher trainees offering these programmes are put under core mathematics and elective mathematics. The core mathematics teacher trainees are those studying the general programmes (non-mathematics elective). While the mathematics elective teacher trainees are those studying mathematics and ICT programmes. There are two mathematics curricula designed for the five selected Colleges of Education under three affiliate public universities namely UCC curriculum and national curriculum for KNUST and UDS affiliate colleges.

Some of the core mathematics courses designed for teacher trainees at UCC affiliated colleges include: Elementary Algebra; Geometry and Trigonometry; Methods of teaching primary school mathematics; Statistics & Probability I; Educational Statistics; and Mathematical Investigations (IoE, 2017). Again, some

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of the core mathematics course designed for teacher trainees at KNUST and UDS affiliated colleges include: Teaching, Learning, and Applying Number and Algebra; Theories in the Learning of Numeracy in the Early Grade and Upper Primary; Teaching and Assessing Numeracy II for Early Grade; Teaching and Assessing Mathematics for Upper Primary (Intermediate); Learning, Teaching and Applying Geometry and Handling Data; and Teaching and Assessing Mathematics for Upper Primary (Advanced)

The mathematics courses for the elective mathematics teacher trainees at UCC affiliate colleges include: Elementary Geometry; College Algebra; College Geometry; Trigonometry; Nature of Mathematics; Psychological Basis of Teaching-learning Mathematics ; Curriculum Studies in Mathematics; Algebraic Thinking; Methods of Teaching JHS Mathematics; Pedagogical Content Knowledge in Mathematics; Calculus; and Statistics & Probability II; and Vectors and Mechanics. While mathematics courses for elective mathematics teacher trainees at KNUST and UDS affiliate colleges include: Teaching and Assessing Junior High School Mathematics (Introductory); Learning, Teaching and Applying Euclidean Geometry and Trigonometry; Teaching and Assessing Junior High Mathematics (Advanced); Learning, Teaching and Applying Analytical Geometry; and Learning, Teaching and Applying Data Handling (NaCCA,2018).

Teacher trainees in their second semester, irrespective of their programmes of study and level might have taken at least one core or elective mathematics courses at the college. In addition, mathematics tutors in these five selected Colleges of Education who have been in a college for at least one semester might have taught at least one of these courses at any of the three B.Ed. programmes under study. Therefore, teacher trainees doing one of these programmes: Early Grade, Primary,

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and JHS education studying core and elective mathematics courses and their tutors might have acquire the needed knowledge, skills, and values required to teach mathematics at the foundation level. It is important to note that these teacher trainees studying core mathematics are expected to teach all subjects at the Primary School level including mathematics, while teacher trainees studying elective mathematics courses are also expected to teach mathematics at the Junior High School level. This means for a person to develop the right perception about mathematics, such an individual must be introduced to everyday mathematical concepts and activities at the foundation stage or primary school level (Davis, 2010). This makes the role of teachers at this level very important so far as the development of cultural aspects in mathematics teaching and learning is concerned.

The National Council for Curriculum and Assessment (NaCCA, 2018) emphasised the importance of incorporating the students' cultural experiences in mathematics instructions. The students and teachers' perceptions about the cultural relevance of mathematics depend largely on the activities in which they are directly involved within the community and their socio-cultural interactions. Students' acceptance of other cultural activities which are related to them enhance their understanding of the values and disciplines of mathematics as fundamental activities. The integration of learners' home experiences from their communities assists teachers in teaching mathematics meaningfully (Davis, 2016; Acharya et al, 2021).

However, the current state of mathematics teaching and learning in Ghana is relatively unchallenging, straightforward and focused on routine procedures during lessons. The teachers' inability to select culturally relevant tasks that will spark children's everyday mathematical concepts is obvious at the Colleges of Education

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in Ghana. The rationale for the implementation of the mathematics curriculum at the Colleges of Education is to expose teacher trainees and their mathematics tutors to approaches involved in drawing on learners' everyday practices to scaffold their understanding of school mathematics (NaCCA, 2018).

As noted in Anderson-Pence (2015), mathematics education has experienced a major conceptual change in the role of culture in learning and teaching for the past 30 years. This modification in thinking prompted many researchers and mathematics educators to re-examine the historical development and practices of mathematics education. Ghanaian school mathematics curricula emphasise the integration of cultural objects relevant to its instructions. Redesigning mathematics curricula to integrate cultural aspects to inform teachers to direct their teaching from a dialectic approach to a more harmonised and learner–centered approach in mathematics classrooms. For instance, an effort was put forward to reconstruct three essential parts of the curriculum into three levels based on the recognition of cultural engagements, as outlined in the intended curriculum, mathematical knowledge should be aware of three distinct educational structures: formal, non-formal, and informal mathematics education (Anderson-Pence, 2015). In terms of implementing mathematical knowledge in schools and classrooms, instructors should be aware of the culture-blind planned curriculum, multi-cultural classrooms, and teachers' roles as social anthropologists. Finally, the attained curriculum and mathematical knowledge should be cognisant with the learners' environment, which includes what they learn outside of school and their culture. Several key aspects for designing a curriculum include mathematics curriculum goals, subject standards, and the supplement teaching resources to support all of the standards (Bishop, 1994; Peni, 2019). The perceptions of teacher trainees and their tutors on the germaneness

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of cultural objects to mathematics learning are relative to their cultural background. The interactions with elders and peers in a society can be seen in the six fundamental activities which are common among all cultures (Bishop, 1988).

According to Rosa and Orey (2011. Pp. 33), “the kind of culturally relevant mathematics curriculum that examines the cultural congruence between students’ community and school indicates teachers’ respect for the cultural experiences of their students”. Several scholars have developed a theory of culturally relevant pedagogy that examines the teaching and learning process based on the explicit connection between the students’ cultural settings and the school curriculum (D’Ambrosio, 1990; Gay, 2000; Ladson – Billings, 1995; Rosa & Orey, 2003). Few studies have also reported on the cultural aspects of mathematics pedagogy.

Rosa et al (2016) asserted that ethnomathematics approaches are intended to make school mathematics more relevant and meaningful to students to increase the overall quality of education. Ladson-Billings (1995d) argued the culturally relevant teachers encouraged a community of learners rather than competitive, individual achievement. Again, the demand of a higher level of academic success for the entire class, individual success did not suffer.

Several studies done in cultural aspects of mathematical practices, ideas, and values of identifiable cultural groups (D’Amboise, 1990; Bishop, 1988, Davis, 2010, Rosa & Orey, 2011) in mathematics education at both tertiary and pre–tertiary levels which emphasise the importance of cultural aspects in teaching and learning of mathematics, only few were done in sub-Sahara Africa including Ghana. For example, Davis and Seah (2016) investigating socio culturally-related issues of teaching and learning activities carried out in Ghanaian primary school mathematics classrooms draws on the local aspects of mathematical knowledge and

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mathematics pedagogy, and how the teaching and learning activities carried out in mathematics classrooms in Ghana deal with these aspects. Known these studies, it is obvious to conclude that no known identifiable cultural objects have been designed for mathematics teaching and learning at the Colleges of Education in sub–Saharan Africa, including Ghana

Literature shows that few studies have been reported on the relationship between students' everyday mathematical concepts (out–of–school) and school mathematics. Davis, Bishop and Seah (2009) conducted research on Gaps between inside school and out-of-school mathematics in Ghana. In another study, Bandeira and Lucena (2004) investigated mathematical ideas and practices acquired by the members of a community of vegetable farmers in the Northeast region of Brazil which was based on the mathematical concepts that farmers used to harvest their produce, and commercialise vegetables, found out that the specific mathematical knowledge produced by farmers differed from the mathematical knowledge acquired in academic settings. Again, Nunes (1992) after exploring research on Brazilian vendors, concluded that mathematical ideas and practices that are used outside of the school may be considered as a process of modelling rather than a mere process of manipulation of numbers.

Then again, in the area of mathematics classroom interactions, Moll et al (1992) argued that students' funds–of–knowledge can be used within mathematics tasks to increase interest, engagement, and belongingness in the classroom. The perceptions of awareness of one's cultural worldview of mathematics, attitudes towards relevance of mathematics, and students and teachers' cultural competencies in mathematic constitute the receptiveness to cultural relevance of mathematics. The National Council for Curriculum and Assessment (NaCCA,

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2019) emphasises the importance of incorporating the students' cultural experiences in mathematics instructions. The students and teachers' perceptions about cultural relevance of mathematics depend largely on the activities that they directly involved within the community and their socio–cultural interactions which might reflect the in school mathematical concepts (Davis, 2010). Students' recognitions of cultural activities embedded in mathematics which are related to their own help them to understand the values and disciplines of mathematical concepts fundamental and universal activities.

Colleges of Education in this context is very important because these institutions train professional teachers to teach at the basic school levels in the country and therefore, the teacher trainees must possess the relevant mathematical beliefs and attitudes which would be communicated to their prospective pupils after their professional training. This study is specifically focused on teacher trainees studying mathematics as either core or elective course in their specialised programmes of study because they are being taken through professional training and are expected to teach mathematics at basic school levels in the country after completion. Again, the mathematics tutors' role is to help teacher trainees develop their cultural competencies in the field of mathematical knowledge so their perceptions about cultural aspects of mathematics teaching are needed in this context. The teacher trainees and tutors' receptiveness to the cultural relevance of mathematics teaching and learning will enable them to become agents of mathematics education at both pre-tertiary and tertiary levels. They will develop culturally responsive pedagogies that are essential for enhancing the learning experiences of students from diverse cultural backgrounds.

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Statement of the Problem

Despite the growing assertion that all students can do mathematics, the trends show those needs would be largely unattainable as a result of the failure rate of students in the subject (Davis & Abass, 2023). The search for new approaches to improving mathematics teaching and learning has not been successful (Davis et al, 2019, 2021). Although various attempts have been made to address students' issues with mathematics learning, there has been no change in students' performance (Davis, et al, 2021). In Ghana, mathematics learning is not only limited to the Colleges of Education but also in elementary schools and universities. Ghanaian students' achievement in mathematics as shown by reports from various national assessments such as the National Education Assessment (NEA) and Early Grade Mathematics Assessment (EGMA) conducted in 2016, national examinations which comprise BECE and WASSCE and international assessments such as Trends in International Mathematics and Science Study (TIMSS 2003, 2007& 2011), show that Ghanaian students achievement in numeracy over the years is quite low (Mereku, 2012). The recent poor performance of students in mathematics at the West African Secondary School Certificate Examination (WASSCE; WAEC, 2014, 2015, and 2016) Ghana, called for the need to investigate the system of education at the secondary education level (Abreh et al, 2018). Again, as noted in Davis and Abass (2023), there has been a consistent abysmal performance of students in mathematics in WASSCE recorded for five consecutive years (WASSCE; WAEC, 2018, 2019, 2020, 2021 and 2022).

Moreover, the poor performance of students in the Ghanaian Primary school, Junior High school, and Senior High school has been much worrying and concern to stakeholders in education. Over the years, numerous researchers and

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stakeholders have endeavoured to understand why a subject as vital and useful as mathematics consistently shows poor student performance nationwide.

In addition, teacher trainees admitted to Colleges of Education consistently face the same issue at the end of every semester examinations. Their performance in mathematics falls short of expectations raising concerns among all stakeholders. This is worrying because these teacher trainees are believed to have already covered most of the mathematics contents in Junior High and Senior High schools. The mathematics content taught in the first year at Colleges of Education is largely a review of what they learned in Senior High schools, yet they still struggle to perform or pass as expected. This nerve-wracking issue of poor performance in mathematics has persisted for a long time in Colleges of Education. The evidence supporting this claim is provided in the trend analysis below, which illustrates the situation among fourth-year teacher trainees in Ghana's Colleges of Education included in the study of their first-year mathematics examinations results for end–of–semester one examinations in both core and elective mathematics. The report from the chief examiners (now course coordinators) in April 2019 for the new Bachelor of Education Programmes in Mathematics (Algebra I), which is considered core mathematics course in Colleges of Education, revealed a concerned statistics. Out of 10,875 candidates who took the exams, only 3,359 (29.97%) scored 55% or higher. A big minority (4,597 out of 10, 875, representing 42.27%) candidates had scores from 50% to 54%, while a substantial number (3,019 representing 27.76%) of candidates scored below 50%. The report again, indicated that performance in both sections of Algebra (I) was average. However, the significant number of candidates scoring below 50%, highlighting the need for significant improvement in teacher trainees' performance in mathematics. The

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results for the first batch of teacher trainees (IoE, 2019) from the five selected colleges in Bono, Bono East, and Ahafo Regions of Ghana taking Mathematics as a core subject in Elementary Algebra (EBS 101) were as follows: College A (N = 215, M = 48.36, SD = 11.55); College B (N=396, M = 57.53, SD=10.65); College C (N =443, M=60.98, SD=8.23); College D (N = 229, M=54.99, SD=9.93); and College E (N = 187, M = 50. 88, SD = 11.45). The report further showed that Algebra II for elective students was also poor. There were high standard deviations associated with the mean scores of Algebra I and Algebra II (Asiedu, 2020).

Therefore, it is crucial to investigate why a subject as essential as mathematics yields such poor results among students in the Colleges of Education in Ghana. The report further recommended that tutors must expose teacher trainees to real-life application problems, encourage them to focus on identified weak content areas and teach them how to present solutions correctly, including the use of appropriate notations. According to chief examiners' report (IoE, 2019), mathematics tutors attributed the poor performance of teacher trainees to difficulties in determining the scope of topics and inadequate mathematics background of the students. This report clearly revealed the need to incorporate cultural aspects in mathematics teaching and learning at the Colleges of Education, especially in Ghana.

The concerns over students' performance in mathematics is widespread due to its crucial role mathematics play in all aspects of life and its application across various fields of education. Research from outside Africa, within Africa, sub–Saharan Africa, and in Ghana highlighted the global importance of students' mathematics performance. Despite numerous efforts, many students continue to struggle in this subject especially those in the Colleges of Education. While the current study reviews literature focusing on the relevance of cultural aspects in

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mathematics teaching and learning in school, most of these studies were done in basic schools, senior high schools, and universities, with limited research conducted in Colleges of Education.

Among the studies conducted outside Africa (Ladson-Billings, 1995; Gay, 2018; Bishop, 1988; Acharya et al, 2021; Diller & Moule, 2005; D'Ambrosio, 1990; Nabid, 2021; and Nunes, 1992) can be alluded to the fact that most researchers focused primarily on cultural aspects in mathematics teaching and learning as reported in the literature, and exploring ways to integrate in mathematics curriculum and pedagogies to address these prevailing issues.

Similarly, the studies conducted within Africa (Kang, 2004) also concentrated on identifying students' openness to cultural relevance in mathematics and exploring strategies for ethnomathematics perspectives of school curricula to integrate these issues in the teaching and learning of mathematics. In addition, studies conducted in Ghana (Davis, 2010, 2016; Davis, Bishop, & Seah, 2009; Davis & Chaiklin, 2015; Davis & Seah, 2016; Davis & Abbas, 2023) aimed at finding how effective the integration of aspects of culture helps to improve the students' performance in mathematics by designing an appropriate culturally responsive pedagogy for teaching and learning at both pre-tertiary and tertiary levels. However, these studies were operated under the assumption that the identified cultural objects were present at those educational levels without conducting substantial analyses to confirm their actual existence. Furthermore, they did not investigate the learners and teachers' receptiveness to cultural aspects of mathematics in their teaching and learning to identify which ones they most accurately perceived about mathematics as cultural–related or cultural–free.

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The literature revealed that many studies done on culturally relevant education at both pre-tertiary and tertiary levels emphasised culturally relevant pedagogy (CRP). These studies conducted on culturally relevant education concentrated on the role of the teacher in the implementation of the curriculum (Gay, 2000; Ladson-Billings, 1995). However, there is no known study conducted on the receptiveness (perceptions) to the cultural relevance of mathematics teaching and learning on the part of teacher trainees and tutors at the Colleges of Education, especially in Ghana. Again, no known studies had been done on the students' willingness to listen and accept the role of local aspects of culture in mathematics teaching and learning in Ghana. Teacher trainees' and their mathematics tutors' concepts of the cultural relevance of mathematics were under-emphasised. To fill these gaps that exist in the literature space, this study was intended to explore teacher trainees and their tutors' receptiveness to cultural relevance of mathematics and also to ascertain whether their views are cultural–related or cultural–free (Davis, 2016).

Purpose of the Study

The purpose of the study was to explore teacher trainees' and their mathematics tutors' receptiveness to cultural relevance of mathematics and also to ascertain whether their views of mathematics are cultural–free or cultural–related (Davis, 2010, 2016).

Objectives of the Study

The objectives of the study were to determine:

1. Whether the views held by teacher trainees and their mathematics tutors about mathematics are cultural-related or cultural-free.

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2. The effect of Sex on teacher trainees' and mathematics tutors' receptiveness to cultural relevance of mathematics.
3. The effect of Programmes of Study on teacher trainees' receptiveness to cultural relevance of mathematics.
4. The effect of Grade Levels (100, 200, 300 and 400) on teacher trainees' receptiveness to cultural relevance of mathematics.
5. Whether there is a significant difference between teacher trainees and their tutors' receptiveness to cultural relevance of mathematics.

Research Questions

The following research questions were formulated to guide the study:

1. How cultural related are the views held by teacher trainees and their Mathematics tutors about mathematics in the Colleges of Education?
2. What is the effect of Sex on teacher trainees and their mathematics tutors' receptiveness to cultural relevance of mathematics?
3. What is the effect of the Programme of Study on teacher trainees' receptiveness to the cultural relevance of mathematics?
4. What is the effect of Grade Level (100, 200, 300, and 400) on teacher trainees' receptiveness to the cultural relevance of mathematics?

Research Hypothesis

The hypothesis below was formulated to address the research objective (5)

Ho: There is no significant difference between the mean scores of teacher trainees and their mathematics tutors' receptiveness to the cultural relevance of mathematics.

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Significance of the Study

This study is significant because it will help the researcher to improve in the area of educational research and classroom practice so far as teaching and learning mathematics is concerned. Besides, the study will expose the researcher to understand the engagements in the mathematics classroom and to respond appropriately to such measures to improve learning.

The outcome of the study would help teacher trainees and mathematics tutors to be opened to cultural aspects of mathematics at various levels of mathematics education. The mathematical practices that are embedded in cultural activities will enable teacher trainees and their mathematics tutors to acknowledge the relevance of culture in mathematics teaching and learning. Again, mathematics tutors in Ghana will find the usefulness of this study because it will help them to make connections between students' culture and mathematics education.

The outcome of the study has the potential to benefit a wide spectrum of students (teacher trainees), practitioners (tutors), policy makers, the researcher, and future researchers. Thus, the values embedded in mathematics could be of great benefit to stakeholders in education and curriculum developers. Moreover, to the educational community, the findings of this study have the possibility to challenge the current paradigm of mathematics education in Ghana and inform policymakers on curriculum contents and pedagogical practices. The study would inform mathematics curriculum developers and implementers to incorporate cultural objects in mathematics instruction.

Furthermore, the outcome of the study could lead to an increase in mathematics tutors' socio-cultural awareness and a paradigm shift in mathematics education. Students who perceived mathematics as Eurocentric that can be acquired

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through acculturation would realise that mathematics is embedded in their culture and developing cultural competence would develop their mathematical competencies. Also, this research piece would inform members of particular cultural groups that their values, norms, activities, and beliefs form part of the mathematical culture so the enculturation process develops students' mathematics competencies.

Finally, the findings of the study will add to the literature on perceptions about the nature of mathematics education across the globe especially, at the tertiary level including Colleges of Education. Most ethnomathematics studies that have been conducted focused primarily on the elementary school level and therefore, the results of this study will serve as the source for literature on receptiveness to cultural relevance of mathematics at the tertiary level. The study adds to the knowledge base of ethnomathematics which is the cultural aspects of mathematics and its relevance to mathematics education.

Delimitations of the Study

This study was limited to the subject of mathematics and the concept of receptiveness to cultural aspects in mathematics education (Davis, 2016). The concept of receptiveness to the cultural relevance of mathematics was based on perceptions about the nature of mathematics conceptualised by Davis (2010); Rosa and Orey (2011; 2020); and Ladson–Billings (1995). The operational definition of receptiveness to the cultural relevance of mathematics was adapted to reflect the perspectives of Ghanaian Colleges of Education. In addition, five identical Colleges of Education in the Bono, Bono East, and Ahafo regions were used for the study. The stratified sampling of teacher trainees (studying mathematics as either core or elective) together with their mathematics tutors who were purposely selected in the

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five selected Colleges of Education were used in the study. The study is limited to teacher trainees offering Bachelor's degrees in Primary Education, Early Grade Education, and JHS Education programmes and mathematics tutors teaching at least one of these B.Ed. programmes. The findings from this research study are intended to be based only on the selected colleges but not generalised to include all the Colleges of Education in Ghana.

Limitations of the Study

The sample participants from five selected Colleges of Education used in this study were all from mixed institutions and therefore, did not include teacher trainees and mathematics tutors from single-sex colleges. However, the results of the study could have been different if the single-sex colleges had been included in the research study.

Definition of Key Terms

Mathematics Tutors: Refers to mathematics instructors or teachers teaching mathematics at the Colleges of Education in Ghana (author’s interpretation).

Teacher Trainees: Refers to student teachers who are currently pursuing a new B.Ed. programmes at the Colleges of Education in Ghana (author’s interpretation).

Receptiveness: Refers to willingness to listen, receive, and accept ideas (Cambridge English dictionary)

Receptiveness to Cultural Relevance of Mathematics: Refers to a willingness to listen, receive, and accept cultural ideas embedded in mathematics. It is the perception (beliefs and attitudes) towards cultural aspects of mathematics education (author’s interpretation for this study)

Culture-Related Perceptions: Refers to perceptions that take cognisance of mathematics in the out-of-school setting (Davis, 2010, 2016)

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Culture-Free Perceptions: Refers to perceptions that do not recognise mathematics as a cultural object (Davis, 2010, 2016).

Core Mathematics: Mathematics courses that may be studied by all teacher trainees who are not studying mathematics as a major or elective subject (Author's interpretation in this study)

Elective Mathematics: Mathematics courses that may be studied by all teacher trainees who are studying mathematics as a major or elective subject (Author's interpretation in this study)

Organisation of the Study

This thesis has been organised into five main chapters. Each chapter was organised into sections. Chapter One began with a brief introduction, the background to the study, a statement of the problem, the purpose of the study, and the objectives of the study are provided. In addition, the research questions, research hypothesis of the study, significance of the study, delimitations of the study, limitations of the study, the definition of terms, and the organisation of the study are also illustrated.

Chapter Two presented the related literature review of perceptions about mathematics teaching and learning for this study. The review began by providing a theoretical review of cultural aspects of mathematics, a conceptual review of receptiveness to the cultural relevance of mathematics, and a review of empirical studies. Other headings that were reviewed included beliefs and attitudes toward mathematics, teacher trainees and mathematics tutors' views about nature of mathematics, empirical review, and finally the summary of the chapter.

Chapter Three presented the processes involved in conducting the study. The chapter specifically talks about the research design, the study area, the population,

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participants, the sampling procedure, the data collection instrument, data collection procedures, and data processing and analysis. The chapter discusses the validity and reliability of the data collection instruments. Finally, this chapter presented ethical issues and ended with a summary of the chapter.

Chapter Four presented the results from the analysis and findings based on the study research questions and hypothesis. Discussions on the findings involved on the research questions and hypothesis. This chapter ends with a chapter summary.

Chapter Five was Summary, Conclusions, and Recommendations. It gives a summary of the key findings and conclusions. Finally, recommendations based on the results of the study and suggestions for future studies are provided.

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CHAPTER TWO

LITERATURE REVIEW

The purpose of this study was to explore teacher trainees and their tutors' receptiveness to the cultural relevance of mathematics and also to ascertain whether their views of mathematics are cultural-free or cultural-related (Davis, 2016). The literature review was organized under three main headings namely theoretical review, conceptual review, and a review of empirical studies. The first part of the review comprises a theoretical review on ethnomathematics perspectives (Bishop, 1988; Davis, 2010, 2015; D'Ambrosio, 1985; Rosa & Orey, 2011,), and the sociocultural theory of learning and its relation to Mathematics education (Vygotsky, 1934/87; 1978). The second part consisted of a review of key concepts/constructs used in this study. This includes a review of perceptions about the nature of mathematics (beliefs and attitudes), perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between culture and mathematical knowledge, perceptions about links between culture and mathematics pedagogy, and perceptions about links between culture and mathematics curriculum were also presented under conceptual review. The third part, the empirical studies of previous research was presented under an empirical review, and finally, the summary of the chapter.

Theoretical Review of Cultural Aspects of Mathematics.

The meaning of mathematics has recently drawn the global attention of many scholars and researchers in mathematics education. Researchers in mathematics education have categorised two types of mathematics: the mathematics students encounter in their local cultures/societies as "m" and Mathematics which they encounter in the school as "M' and position the recognition and respect for the

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former as being important (Davis, 2015). Scholars who relate mathematics to a subject being taught in schools see it as a universal subject and define it from a different perspective. For example, Azram (2014) described mathematics as a way of thinking and organising a logical proof. Other notable researchers also descry ibe mathematics as the language, science of patterns, problem-solving and modelling (Anderson-Pence, 2015; Steen, 1990; and Saccor, 2013). In this sense, there is an acceptance of the nature of mathematical knowledge as being absolute and unquestionable (Davis, 2015; Pinten & Francois, 2007). Besides, Knorr et al (2024) also describe mathematics as the subject of numbers, shapes, data, measurements, counting, and logical activities. These institutionalised views of mathematics are limited to cultures/societies in which the learners found themselves.

However logical and true mathematics is, one cannot prove the theorems, or solve problems of mathematics without using a language, signs, or symbols from the environment. The language which serves as a medium of instruction in schools, the symbols and signs used to express ideas, and the school community constitute culture (Vygotsky, 1934/1987; Yvette, 2015).

Culture is defined as the beliefs, values, attitudes, practices, social interactions, art, and literature that distinguish an ethnic group (Abidi, 1996; Banks, 2008, 2015). However, mathematics is not a culturally neutral discipline (Zaslavsky, 1996, 1998, Davis, 2010). It might be argued that all cultures have a wealth of artefacts demonstrating mathematical notions. Eglash (1999) explored the mathematics in the designs of traditional beadwork and basket weaving in indigenous cultures. According to the National Council of Teachers of Mathematics (NCTM, 1989), students should be exposed to a wide range of experiences

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connected to the cultural, historical, and scientific evolution of mathematics. Civil (2002) emphasised the need for the construction of mathematical experiences that are relevant to students' cultural backgrounds, as these experiences are frequently rich in mathematical notions

Davis (2010) remarks on the architectural design used in building the round houses in northern Ghana, for example, argued on a large number of geometrical shapes in the structure of the inhabitants. The roof has the shape of a cone while the house is cylindrical. This can be used in teaching geometry in the classroom. Hodge and Cobb (2019) emphasised that culture is a network of relatively stable practices that represent daily life within a group or community and are passed down from one generation to another. Language is a cultural component that is passed down from one generation to another. Many cultures have diverse dialects, yet their communications can be the same as they are all involve in one or more of six fundamental activities (Bishop, 1988).

Many theorists have broader views of mathematics than this unquestionable worldview. These broader views of legitimate mathematics take cognisance of local aspects of culture (Davis, 2015; Bishop, 1988; D' Ambrosio, 1985; Anderson-Pence, 2015). Bishop (1988) after postulating his six fundamental activities which appeared to be carried out by all cultural groups that have been studied and are also necessary and sufficient for the development of mathematics, argued that these practices define the development of mathematical knowledge in every cultural group (Davis, 2010, 2015; Anderson-Pence, 2015). Mathematical knowledge which is considered objective knowledge that can be subjected to proofs as well as criticisms has a strong social component embedded in (Presmeg, 2007, Davis 2015). Classroom mathematics teaching and learning is about social interactions

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among teachers and students from the same or diverse cultures. Culture has a strong influence on classroom mathematics discourse (Davis, 2018).

The out–of–school mathematical knowledge which positions culture as relevant to school mathematics at all levels of education has been endorsed by many mathematics education scholars in both developed and developing countries like America, China, Japan, Australia, Canada, Brazil, Nepal, and sub-Saharan Africa including Ghana. These local aspects of mathematical knowledge were conceived by proponents of socio-cultural and ethnomathematics perspectives in mathematics education.

The study was focused on ethnomathematics and sociocultural learning theories proposed as the underpinning theories that influenced teacher trainees and tutors' receptiveness to the cultural relevance of mathematics in the Colleges of Education.

Mathematics as a Cultural Object

Mathematics is a symbolic representation of physical reality, but it demands knowledge and learning skills. Because mathematics is so relevant to modern culture, the basic understanding of its nature is required for scientific knowledge. These Symbolic technologies and values are referred to as mathematical culture, and it is the product of a specific combination of cultural contacts and societal processes (Bishop, 1988). In recent times, researchers in mathematics education have pointed out that Mathematics, once regarded as culture and value-free, is no longer considered as such (Bishop, 1988; D"Ambrosio, 1999, 1985; Presmeg, 1998; Davis, 2010, 2016). Mathematical concepts based on cultural perspectives allow students to not only reflect and appreciate their own culture but also the culture and traditions of others. The involvement of members of the community is

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an essential part of the integration of cultural components into mathematical activities (Yvette, 2014).

Perceptions about the nature of mathematical facts being absolute, true, infallible, and unquestionable have changed recently (Pinxten & Francois, 2007; Davis, 2016; Ernest, 1989, 1996). Mathematical knowledge has a strong social component since it is considered objective knowledge that can be subjected to proofs as well as criticisms (Presmeg, 2007, Davis, 2016). According to Presmeg (1998), some scholars in the ethnomathematics perspectives have argued in recent decades that mathematics is a cultural product and must be identified as such in the classroom for students in developing nations to grasp the subject successfully. Presmeg proposed that the culture of both students and teachers could be an effective instrument in mathematics teaching and learning. Other scholars believe that good mathematics education must account for many home experiences that children bring to school (Davis, 2018, 2016).

Davis (2010) indicated that, for most colonised countries, some of the things accompanying colonisation, such as religion, have been contextualised, but in most cases, not mathematics education. He emphasised the nature of church services in Christian churches (especially in African Initiated Christian Churches) in most African countries in general, including Ghana today, demonstrating that the nature of service has been shaped by the local culture. Literature in this area, shows the Bible being read from an African cultural background rather than a Western cultural perspective (Davis, 2010). With the recent appearance of local drums, hearing local gospel music, in addition to the traditional songs sung at worship sessions. Christianity and Islam have seen rapid expansion in developing countries such as Africa as a result of their contextualisation. The same cannot be said about

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mathematics education after independence, even though the establishment of formal education during the colonial era brought Western mathematics and Christianity together (Davis, 2010). It is common knowledge to see and hear music and drumming in many churches and mosques in small towns and villages in developing countries in the world including Ghana. The songs, music, and drums are objects of some cultures and if they can be used in churches for worship, then the researcher suggested the same can be applied to mathematics teaching and learning in schools, especially Colleges of Education.

Bishop (1988) and Davis (2010) asserted that mathematics must be understood as a kind of cultural knowledge, which all cultures generate but which need not necessarily 'look' the same from one cultural group to another. The proposed six fundamental activities which appear to be carried out by all cultural groups that have been studied and are also necessary and sufficient for the development of mathematics(Bishop, 1988; Davis, 2010). The activities in the communities that they mentioned are:

Counting: The use of a systematic way to compare and order discrete phenomena. It may involve tallying or using objects or string to record, or special number words or names ....;

Locating: Exploring one's spatial environment and symbolising that environment, with models, diagrams, drawings, words or other means ....;

Measuring: Quantifying qualities for comparisons and ordering, using objects or tokens as measuring devices with associated units or 'measure-words'....;

Designing: Creating a shape or design for an object or any part of one's spatial environment. It may involve making the object as a 'mental template', or symbolizing it in some conventionalised way ....;

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Playing: Devising, and engaging in, games and pastimes, with more or less formalised rules that all players must abide by ....; and

Explaining: Finding ways to account for the existence of phenomena, be they religious, animistic or scientific... (Bishop, 1988; Davis, 2010, 2016)

A cultural object is a socially significant expression that is audible, visible, or physical and holds common significance. Cultural artefacts include ideas, music, beliefs, films, and styles. Mathematics as a cultural object, as well as the connection between mathematics and current society, must be reflected in the curriculum. According to Bishop (1988), mathematics is deeply rooted in the culture of students, therefore, it should be critical for their mathematics education to reflect that cultural foundation.

Literature shows that the mathematics curriculum at Colleges of Education in Ghana, over the years, failed to recognise the aspect of local culture in its teaching and learning. However, teacher trainees and mathematics tutors funds–of knowledge can be used within mathematics tasks to increase interest, engagement, and belonging in the classroom (Moll et al, 1992, 2006, 2013, 2019; Civil, 2016; David, 2016). The cultural experiences (Diller & Moule, 2005), and mathematics connections (Kusaeri et al, 2019) exposed teachers and learners to specific cultural knowledge, mastering a set of skills, building on a sound mastery of numeracy, developing and applying mathematical concepts to solve a range of problems in everyday situations.

Mathematics in Ghanaian Society

In Ghanaian society historically, mathematics was taught through informal means. Knowledge and mathematical concepts were transmitted orally and through apprenticeships. On the other hand, these informal mathematics education methods

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and procedures differ from one culture to another. Davis (2010, 2016) highlighted the variety of mathematical tasks that are found in a single activity by examining how the concept of mathematics is represented in Ghanaian society through counting, locating, measuring, designing, playing, and explaining.

According to Bishop (1988), these mathematical activities are fundamental activities that are carried out by people of all cultures. Counting, locating, measuring, designing, playing, and explaining are related to agriculture, construction, blacksmithing, craft and art, communication, games, gymnastics, and dance. Several researchers have looked at the interplay between cultural and mathematical values in various cultures (Bishop, 1988; Ernest, 1991; Davis, 2010).

In Ghana and Sub-Saharan Africa, informal mathematical knowledge is culturally and socially created. Examining the interrelationships between the various social and cultural groupings, Ernest (1991) provided valuable and timely accounts of the historical and cultural nature of mathematics, as well as the informal mathematical knowledge developed by diverse ethnic groups, especially in Ghana. Oral transmission and apprenticeship were used to acquire mathematical knowledge, skills, and abilities among these groups. Children from these diverse ethnic groups start formal education in school with already acquired mathematical knowledge such as measurement, sharing as a fraction, designing shapes, and patterns, and playing commonly done during the day and sometimes in the night. These activities help learners to understand school mathematics meaningfully.

Literature shows that a typical Ghanaian culture is well embedded in the informal educational system (Davis, 2010; Davis et al, 2009). The elderly make conscious efforts to bring up their children to be contributing members of society. Ghanaian society functions as a school, with elders serving as teachers. Traditional

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education encompasses all aspects of a person's development, such as social, moral, spiritual, intellectual, and psychomotor. Character building and instilling qualities such as honesty, courage, endurance, and hard work are stressed in Ghana's traditional educational system. These are society's deeply ingrained mathematical values and disciplines. Physical skill development is accomplished through games, gymnastics, and dances. Household activities, farming, and building houses and sheds, all of which required measurements and computations, were passed down to young people from Ghana's various ethnic groups informally. Agriculture, blacksmithing, and arts and crafts are among the children's survival skills. Traditional society's teaching methods include imitation, observation, and interaction. Using these procedures, learners learn mathematical knowledge and skills necessary to succeed in a certain community. Ghanaian culture includes artefacts such as sculpture, weaving, design, and carving. Ghanaian cultural activities include geometrical constructions, farming, music, dance, and games, all of which incorporate the six fundamental activities. As explained by (Davis, 2010, 2016), the mathematics in Ghanaian society includes counting, locating, measuring, designing, and playing games. All of the activities stated above, as well as other phenomena, have a kind of mathematical knowledge which are typically explained orally and using signs within a particular society in Ghana.

Some of these fundamental activities do occur in our daily lives, especially in the house. Some cultural activities like funeral rites, festivals, naming ceremonies, marriage ceremonies, games, music and dances, drumming, hunting, farming, and constructions among other things which form part of Ghanaian cultures may involve at least one of the six fundamental activities (Bishop, 1988; Davis, 2010, 2016). One fundamental activity can be seen in another. For instance, during the

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playing like, a game of 'Ampe', there is the counting of 'one, two, three' or in the local language (for example, in Twi: “me ne ohyia, me ne opare') signifying: 'I count one, I count two, I count three, and so on.

Davis (2016) noted that a considerable amount of arithmetic also goes on in Ghanaian society. Examples include the system of counting by some market women which is based on multiples of two, and the use of arithmetic by children who sell candies, newspapers, cold drinking water and oranges in both rural and urban areas. These children (both unschooled and schooled) engage in the process of doing and explaining the arithmetic they go through to arrive at the total cost of items a customer purchases.

Counting and measurement can be seen in Ghanaian farming and fishing communities, farmers and fishermen practice what they called “Nnoboa” (meaning “communal labour” involving two or more persons clearing individual’s land in turn) in support of each other. Measurement of farm lands measured in acres can be one, two, or more than two which cannot be clear by one person in one or two days, can be done by four or more people in a day. This practice helps farmers to clear large portions of lands during farming seasons. This can be used as an illustrative example in school to teacher ratio, proportion, and rates.

In a typical Ghanaian community, a funeral is another cultural practice that might involve more than one fundamental activity. During funeral ceremonies, individuals often have one week of observation to plan the real burial and final funeral rites. During this time, 'Abusuapanin' (the head of the extended family) and his elders plan the activities that will take place. These activities involve calculations, counting, and measurement in the form of estimation when considering the number of sympathisers who will attend the funeral rite, as well as

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budgeting for chairs, canopies, food and drinks, and ground for the celebration. People also exchange food and drink during funerals. In this situation, the guests are stationed at various locations where they can be served first before going to the funeral grounds.

Davis (2010, 2016) elaborated on designing as form of various rich mathematical principles that are embedded in the Akan kente (cloth made from coloured silk), basket and Northern Batari (Fugu) weaving designs. The architectural design for the circular houses in northern Ghana, for example, incorporates a vast number of geometric shapes. The home is cylindrical, but the roof is in the shape of a cone. The conical and cylindrical shapes of talking drums: "Fontomfrom which is used during festivals and durbars for the Akans and for coronation of chiefs and heads of state in Ghana; "Donno and Atumpan" drums used for Ghanaian music, dance, and communication all can be used for teaching geometry and algebra in school(see Appendix "H").

The local designs used in Ghanaian fabrics such as the "adinkra" (see figure 1), are very good examples of some of the regular and irregular shapes that students" experience in school. "Agyindawuru" for instance could be used in the introduction of the concept of geometrical constructions.

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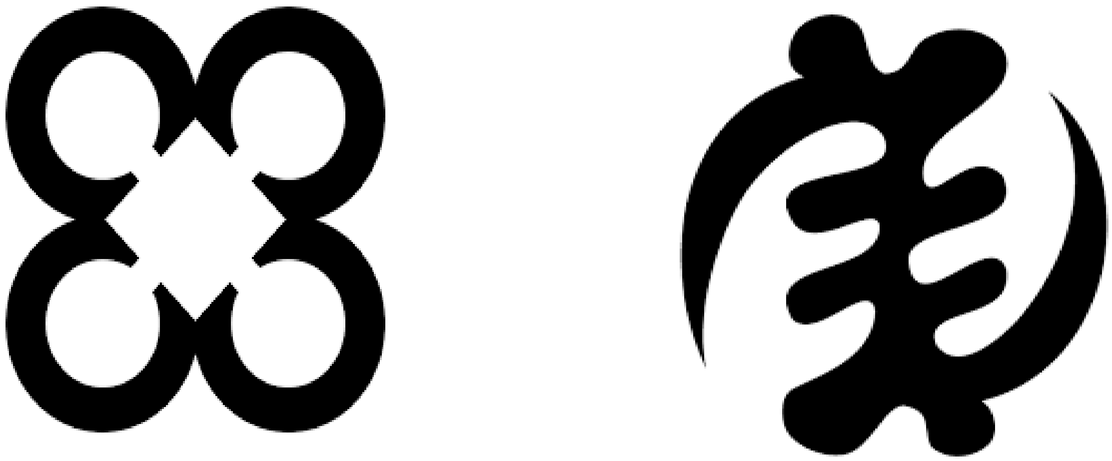

Name: Agyindawuru:

Interpretation: loyalty, vigilance and accountability

Meaning: Symbol of Trust and accountability to citizens.

Name: Gye Nyame

Interpretation: Except God

Meaning: Symbol of authority belongs to the Almighty God

Figure 1: Collection of some Adinkra symbols and meanings in Ghanaian society (source: Osei et al 2022).

Figure 2: Visual Expression-Bonwie Kente weaving (source: touringghana.com)

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Figure 3: Visual Expression - Ghanaian men and women turning Basket
(Source: africanexponent.com)

Figure 4: Visual Expression – Basket weaving (Source: africanexponent.com)

Another source of mathematics in Ghanaian society can be seen in games (Davis, 2010, Anamuah-Mensah et al, 2009). Games serve as a source of entertainment which brings together both young and adults in the Ghanaian communities. Davis (2010) highlighted some typical games in Ghanaian society such as “Oware”, “Draught” and “Tumatu” are good examples of games that may be useful in developing many mathematical concepts and also prepare children for problem-solving in mathematics. He mentioned “Tumatu” game, for example, could be used to develop the concept of addition (adding on). There are several

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Ghanaian games which can be used to teach mathematics in school. For instance, the 'Antoakyire' game normally played by Akan children in Ghana may be useful in developing their geometrical concepts and for problem solving.

Socio–Cultural Theory of Learning

Literature shows that parents, caregivers, peers, and the culture at large were responsible for developing the child's higher cognitive functions (Vygotsky, 1934/1987; Cherry, 2019). Learning can be done through social interactions and cultural resources like symbols, language, and communication (Vygotsky, 1934/1987, 1978). This mathematical approach enables students to develop their own meanings and knowledge by making sense of their own and others' experiences, thoughts, and understandings. Mathematics idea formation for teacher trainees entails active participation of learners in a task as well as interaction with peers and the environment.

Mathematics teachers who apply sociocultural approaches in their mathematics teaching assist students in growing their knowledge by scaffolding current concepts with prior knowledge and attempting to stay inside each student's zone of proximal development (Vygotsky, 1978). Socio-cultural theory of learning is very important because it emphasizes the role of culture in learning and also views knowledge construction as being socially constructed through the learners' participation in activities practiced in their cultures which therefore means that social interaction plays a very important role in a child's learning.

Mathematics education which is recognised as a social process, is based on ideas. Mathematics educators who consider these social components of mathematics education as important, debunk the notion that mathematics is an

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objective fact that cannot be formed by interaction with social groups (Rosa & Orey, 2011; Bishop, 1988; D'Ambrosio, 1985; Davis, 2010).

Vygotsky's theories of learning and its relation to mathematics education

Vygotsky (1934/1987) emphasised the role of language and culture in cognitive development and in how we perceive the world and claimed that they provide frameworks through which we experience, communicate, and understand reality. The language and the conceptual schemes that are transmitted through language are essentially social phenomena and that knowledge is co-constructed and assigns a leading role to individuals' activity in the learning process, different from previous educational theories that were mostly based on the passive and receptive role of the learner (Vygotsky, 1934/1987).

Moreover, mathematics educators must be familiar with the importance of symbol systems, such as language, logic, and mathematical systems, which are inherited by the learner as a member of a particular culture. Learning through social interactions between learners is intended as a modification of previous learning, or reorganisation of a basic structure. Social constructivists believe that a learner's ability to learn relies to a large extent on what they already know and understand, and the acquisition of knowledge should be an individually tailored process of construction. Social constructivism emphasizes the collaborative nature of learning and the role of language and culture in cognitive development.

Wells (1994) argued that Vygotsky's discussion of scientific concepts differs from everyday concepts in terms of defining characteristics and acquisition. Scientific concepts have four features: generality, systemic organization, conscious awareness, and voluntary control. These features distinguish scientific concepts

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from spontaneous ones, as they relate to experienced reality more abstractly and generally, primarily to other concepts within the relevant system.

Vygotsky (1934/1987) differentiates between everyday and scientific concepts. Everyday concepts are acquired through social activities within a child's culture, often spontaneously, while scientific concepts are systematic and formalised. Panofsky, John-Stener and Blackwell (1990) argue that everyday concepts form the basis for scientific concepts, providing "living knowledge." Their interaction with scientific concepts in school influences their perception and use of everyday concepts in the out-of-school context.

According to Ferreira (2014), everyday concepts emerge from dealings with concrete situations which are ontological, intuitive categories developed by each individual not counting on formal schooling while scientific concepts, which are formulated and transmitted culturally, emerge in the context of theories of objects and relational systems that establish associations among themselves and that, they constitute systems mediating human actions on phenomena.

Vygotsky (1934/1987) posited that children spontaneously engage with everyday concepts due to their focus on the object, while scientific concepts require a mediated attitude, forming an arbitrary conceptual system. Socio-cultural views of children's learning emphasise the importance of everyday concepts in meaningful learning. Davis (2010) emphasised that the use of such tools as language may act as mediating influences on children's learning. Language plays a crucial role in sociocultural development as it facilitates the transmission of past knowledge and practices to future generations (Wells, 1994). This learning theory promotes mathematical concepts and situates learning as social constructions that occur through building upon previous schema/experiences (Skemp, 1987).

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Growing up within a human group, the family or a professional community of practice such as professional decipherers, individuals acquire the cognitive tools and knowledge shared by the community. The cognitive tools individuals get from the community should allow them to construct new knowledge based on knowledge previously acquired. Vygotsky (1934/1987) stressed that the social environment plays a crucial role in children's development and acquisition of knowledge.

Conceptual Review of Receptiveness

The term receptiveness in the context of the study refers to an individual's willingness to listen, receive, or accept cultural ideas embedded in mathematics, which includes their beliefs and attitudes towards cultural aspects of mathematics teaching and learning. It is a person's beliefs and attitudes to cultural aspects of mathematics teaching and learning. The study situates the receptiveness to the cultural relevance of the mathematics framework as two dispositional factors: beliefs, and attitudes to cultural aspects of mathematics.

Teachers and students' beliefs and attitudes are very important in mathematics teaching and learning because of the distinctive roles they play in day-to-day classroom discourse. Receptiveness plays an important role in teaching and learning mathematics in a diverse cultural environment. A person's willingness to favourably accept an idea of the relevance of culture is often influenced by their beliefs and level of attitudes toward that idea. Kang (2004, P.17) stated that, a person's receptiveness to an idea can sometimes be gleaned from his or her response to the introduction of that idea. The receptiveness to the role of culture in teaching and learning mathematics includes being willing to: listen to others' cultures in views about teaching, learning, and doing mathematics; integrating culture in mathematics classroom discourse; and receiving, or accepting the use of

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culturally relevant pedagogies to teach and learn mathematics (Ladson–Billings 1995, 2014). Again, Kang (2004) also described receptiveness as the level of willingness or readiness to favourably consider a new suggestion or proposal. The views of the nature of mathematics and its relevance to a particular group of people in a specified locality can be seen through their beliefs and attitudes.

In the current study, these beliefs and attitudes were considered as perceptions about the nature of mathematics. The study positioned these perceptions as teacher trainees and their tutors' receptiveness to the cultural relevance of mathematics at the colleges of education in Ghana.

Conceptual Framework for the Study

The Contextualisation and operationalisation of the variables in the conceptual framework of the study reflected the states of Colleges of Education in the Ghanaian educational system. Figure 1 shows the conceptual framework that directed the focus of the study. The first part of the conceptual framework shows the relational path between the two variables (Beliefs and Attitudes) and their sub-constructs (*Problem–solving view, Static Platonist view, Instrumentalist view; and Self–confidence, Enjoyment, Motivation, and Value (usefulness)*) as conceptualised by Ernest (1989). The second part of the framework was adapted based on Davis (2010) conceptualisation of the perceptions about mathematics (*perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between culture and mathematical knowledge, perceptions about links between culture and mathematics pedagogy, and perceptions about links between culture and mathematics curriculum*). These concepts are entrenched in the values of mathematical culture which connect the pedagogical approaches that take place in the mathematics classroom discourse. Based on these five constructs, teacher

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trainees and their mathematics tutors' views were identified. The last part of the conceptual framework, in addition, evaluates the relations between views held by teacher trainees in their mathematics learning, as well as views held by mathematics tutors in their teaching as presented in Figure 5

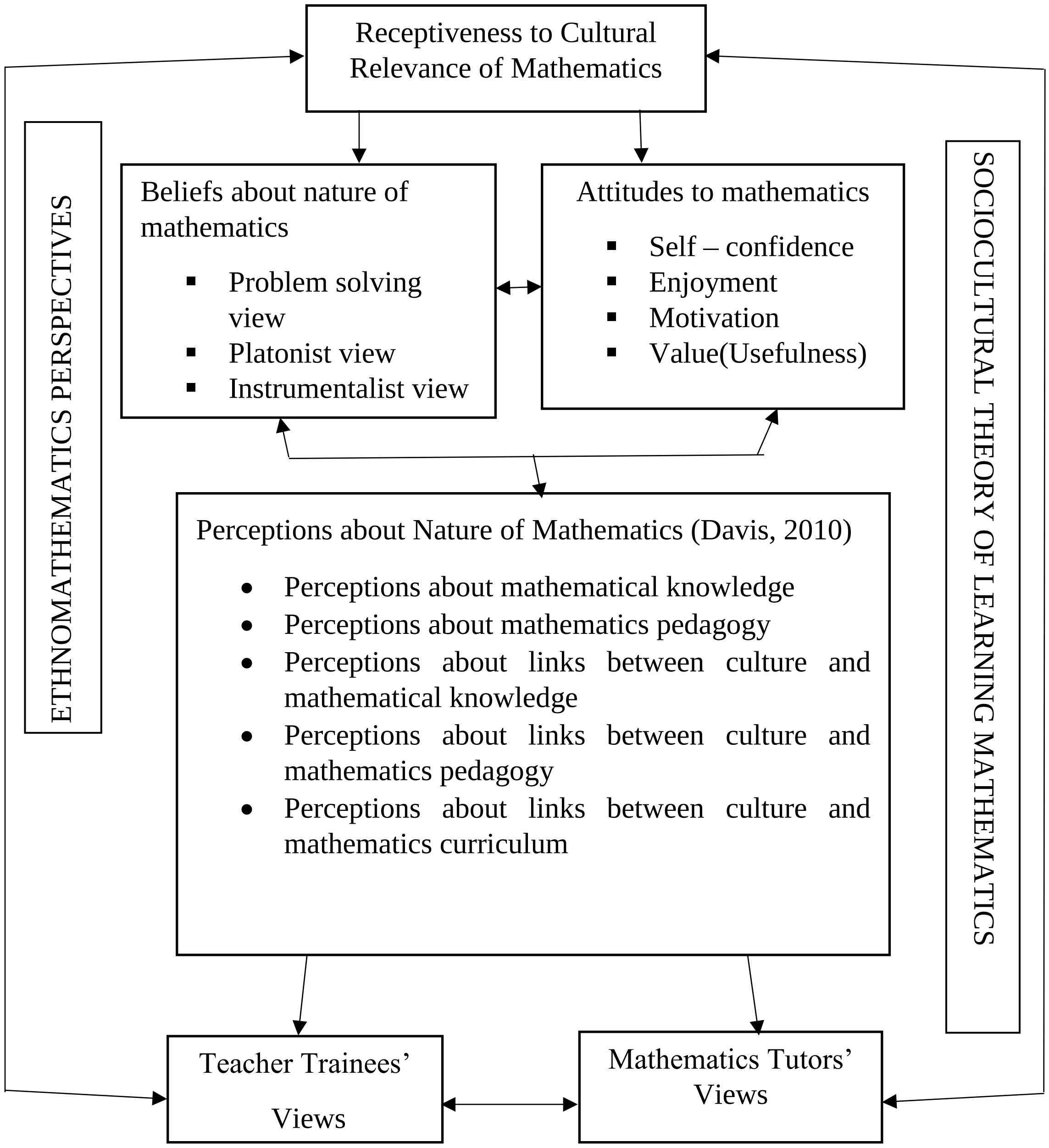

Figure 5: Conceptual Framework of the Study

Receptiveness to Cultural Relevance of Mathematics.

Receptiveness to the cultural relevance of mathematics refers to the willingness and ability of individuals to recognize and appreciate the cultural

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aspects and influences embedded in mathematics. It involves understanding that mathematics is not a purely abstract or universal field, but that it is shaped and influenced by cultural, historical, and social factors. Recognising that mathematics is culturally relevant involves accepting that mathematical knowledge and practices are not value or culture-free, but are frequently entwined with the societies in which they are developed and applied (Davis, 2016). This take in cognisance of mathematics not a culturally neutral or isolated subject but is influenced by and can have a significant impact on different cultural contexts (Davis, 2010).

In the current study, the receptiveness to the cultural relevance of mathematics has been operationalised as perceptions about mathematics. It is the perception associated with cultural aspects of mathematics education. Teacher trainees and mathematics tutors who have a willingness to listen, receive, and accept cultural ideas embedded in mathematics believe that mathematics is a cultural product. Regarding the cultural aspects of mathematics education, the attitudes and beliefs of teacher trainees and mathematics tutors are assessed. Although these attitudes and beliefs are psychological constructs that are similar, their nature and how they impact behaviour are different. While attitudes cover a wider variety of emotions and assessments, beliefs are mainly concerned with accepting or rejecting specific claims or statements. They have an emotive component, so they are not simply about what is true or false; they are also about what is preferred or despised. Constructs of beliefs and attitudes are important in influencing how people view mathematics. These psychological elements have a big impact on how people approach, interact with, and succeed in their mathematics learning. The researcher in this study used focus group interviews and survey

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questionnaires to examine beliefs and attitudes, even though they are subjective and challenging to measure accurately.

Literature on the receptiveness to cultural relevance in mathematics education revealed that college mathematics teachers can develop their cultural awareness and improve their dispositions for cultural responsiveness through targeted professional development (Parker et al, 2017; Gay, 2021). Beliefs and attitudes play key roles in mathematics learning and teaching. The learning outcomes of students are strongly related to their beliefs and attitudes about mathematics. Thus measuring teachers' and their students' mathematical knowledge must be made in awareness of their beliefs (Ernest, 1989).

The two psychological constructs of receptiveness to the cultural relevance of mathematics were defined and contextualised with their associated themes for measurement (as shown in the conceptual framework) to light the purpose of this study as explained below.

Beliefs about the Nature of Mathematics

Ernest (1989), proposed three sets of model factors to improve teachers' psychological foundations of the practice of teaching mathematics, including knowledge, beliefs, and attitudes. Beliefs are the subject of various important philosophical discussions. Beliefs can be held about oneself, beliefs about others, and beliefs about the world around us. Beliefs about mathematics is the cognitive construct which in each case shape our perceptions and perspectives in mathematics and ultimately shape our reality.

Many scholars have long argued that individuals' belief systems influence their behaviour and the decisions that they make throughout their lives. For instance, Teasley (2021) stated belief systems as principles that guide people

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through their everyday lives. A belief system is an ideology or set of principles that helps us to interpret our everyday reality. Knowledge, beliefs, and attitudes about mathematics constitute teachers' psychological foundations of teaching and learning. According to Ernest (1989), these psychological foundations of the practice of teaching and learning mathematics were under-emphasised by researchers on the teaching of mathematics in the teacher education system. Ernest (1989) affirmed the three fundamental beliefs about the nature of mathematics proposed by scholars in mathematics education:

First, the problem-solving view views mathematics as a dynamic, problem and continually expanding field of human inquiry. Mathematics is not a finished product, and its results remain open to revision.

Secondly, the Platonists view mathematics as a static but unified body of knowledge, consisting of interconnecting structures and truths. To them, mathematics is a monolith, a static absolute product, which is discovered, not created.

And lastly, the instrumentalists view mathematics as a useful but unrelated collection of facts, rules and skills.

Ernest (1989) further stated that beliefs consist of the teachers' system of beliefs, conceptions, values, and ideology. The conception of cultural relevance has a strong influence on teaching and learning mathematics in a classroom where learners come from diverse ethnic environments.

These three fundamental beliefs about the nature of mathematics proposed by scholars in mathematics education were defined and contextualised with their appropriate constructs for measurement (as shown in the conceptual framework) to explain the purpose of this study as represented below.

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Problem–solving View of Mathematics

Problem-solving is a fundamental aspect of mathematics, and various views and approaches exist regarding how it should be taught and understood. The perspectives of the problem-solving aspect of mathematics emphasize the mastery of standard algorithms and procedures. Students are expected to follow predefined steps to solve problems. Problem–solvers stress the importance of active engagement and building on prior knowledge. Students are encouraged to explore problems, make conjectures, and develop their strategies. To them, learning is centered on solving real-world problems. Students work on open-ended problems, promoting critical thinking and application of mathematical concepts (Ernest, 1989).

Therefore, the most effective approach to teaching and learning mathematics problem-solving involves a combination of these perspectives, tailored to the needs and abilities of the students. It is essential to draw a balance between providing guidance and allowing for creativity and critical thinking.

Platonist Views of Mathematics

Static Platonism is a philosophical perspective on mathematics that draws from Platonism, a broader philosophical tradition that traces its roots to the ancient Greek philosopher Plato. Static Platonism specifically relates to the nature and existence of mathematical objects and concepts. Platonists have views that mathematical objects, such as numbers, geometric shapes, and mathematical structures, exist independently of human thought or language. This view is often compared to Plato's Theory of Forms, where abstract, non-material entities exist in a realm of forms beyond the physical world.

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Mathematical truths are considered objective and independent of human beliefs or opinions (Ernest, 1989, 1991). Static Platonism suggests that mathematical truths hold universally and eternally, providing a stable and unchanging foundation for mathematical knowledge. Mathematical objects are not contingent on physical reality. They exist in their realm, distinct from the empirical world. Mathematical objects do not depend on physical objects or events; they have a non-causal influence on the world. Humans have a form of access to mathematical truths through intuition, reasoning, and intellectual insight

It is worth noting that, static Platonism is just one perspective within the broader philosophy of mathematics. While static Platonism provides a robust account of the existence and objectivity of mathematical entities, alternative views, such as nominalism and intuitionism, offer different ontological and epistemological positions on the nature of mathematical objects and the foundations of mathematics.

Instrumentalists' Views of Mathematics

Contrary to Platonism, which maintains the objective existence of mathematical entities, and formalism, which focuses on symbol manipulation, instrumentalism emphasises mathematics' utility and efficacy without assuming the existence of abstract mathematical objects. Instrumentalists regard mathematics primarily as a tool for problem-solving and describing empirical facts. The emphasis is on the practical application of mathematical procedures rather than the presence of abstract concepts

Instrumentalism avoids making ontological commitments to the existence of abstract mathematical objects or entities and the success of mathematical theories in predicting and explaining empirical observations is seen as sufficient

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justification for using mathematical tools. Mathematics is considered a formal language that provides a concise and effective way to express relationships and patterns. Mathematical statements are viewed as linguistic expressions with no independent reality beyond their utility in describing empirical phenomena. Instrumentalists stress the practical success of mathematics in the sciences and technology and the effectiveness of mathematical models in predicting and explaining natural phenomena. Instrumentalists are comfortable with the idea that different mathematical frameworks may be useful in different contexts, and the choice of mathematical tools is guided by pragmatic considerations and there is no insistence on a unique, "correct" mathematics; instead, different mathematical systems can be employed as long as they are useful. Their primary focus is on the application of mathematics to solve real-world problems and to achieve practical goals. Instrumentalists do not insist on the existence of absolute mathematical truths but rather on the usefulness of mathematical methods (Ernest, 1989).

Instrumentalism, in contrast to Platonism and Formalism, represents a more pragmatic and anti-realist approach to mathematical philosophy. While instrumentalists acknowledge the usefulness of mathematics, they do not necessarily support the existence of a separate realm of abstract mathematical concepts. Instead, the emphasis is on the practical utility of mathematical techniques in solving real-world issues

Ernest (1989) proposed an analytic model of different types of knowledge, beliefs, and attitudes of mathematics teacher, and their relation with practice. Davis (2010) stressed on nature of mathematics related to Ghanaian culture which debunk the assertion that mathematics is cultural–free. The current study adds to literature

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by exploring the views of teacher trainees and their tutors on cultural aspects of mathematics in the Colleges of Education in Ghana.

Teachers' mathematics beliefs constitute a key factor in research on teachers and their teaching practices. Thompson (1992) suggested further research into teachers' beliefs, knowledge, and instructional practices. Despite various studies on teachers' beliefs, Philipp (2007) maintained that a complex relationship among instructors' ideas, knowledge, and actions remains unclear.

This study operationalised beliefs to include teacher trainees and tutors' views of mathematics as cultural–free: perceptions that do not recognise mathematics as a cultural object, and cultural–related: perceptions that take cognisance of mathematics in the out–of–school setting (Davis, 2016). Teachers who perceive the cultural relevance of mathematical knowledge and mathematics pedagogy lay great emphasis on how to help their students develop knowledge of mathematical processes and concepts; employing students' funds–of knowledge to encourage them to explain and justify their answers; attach great importance to making connections between culture and mathematics with different ideas and solution strategies; and always select cognitively demanding tasks that help students to explore ideas and identify patterns (Jett, 2013). While teachers who held views about mathematics as being cultural–free are mainly concerned with making students become very efficient in learning and applying rules and procedures to get correct answers; rarely ask students to explain and justify their answers; and mostly assign less cognitively demanding tasks.

Improvements in teaching and learning cannot take place unless teachers and learners' deeply held beliefs about mathematics and its teaching and learning change. These changes in beliefs are associated with increased reflection and

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autonomy on the part of the mathematics teacher (Ernest, 1989, 1991). Thus the practice of teaching mathematics depends on several key elements, most notably the teacher's mental contents or schemas, particularly the system of beliefs concerning mathematics and its teaching and learning; the social context of the teaching situation, particularly the constraints and opportunities it provides; and the teacher's level of thought processes and reflection.

Attitude towards Mathematics

Attitude towards mathematics teaching and learning has a great impact on the performance of students in mathematics. The attitudinal variables including; self – confidence, enjoyment, motivation, and value have great influence on teacher trainees and tutors' knowledge and beliefs of mathematics. Ernest (1989) in his model suggested that a teacher's confidence on his or her mathematical ability, mathematical self–concept, and the valuing of mathematics influence a teacher's attitude towards mathematics teaching. Attitude towards mathematics teaching and learning is influenced by cultural competence on the part of both students and teachers.

Research studies done by many scholars on students and teachers' attitudes toward mathematics did not emphasise more on the perceptions about cultural aspects in mathematics teaching and learning at the tertiary level. The current study presents the attitudes of teacher trainees and their tutors to the cultural aspect of mathematics as perceptions about mathematics in the colleges of education in Ghana.

According to Ajzen (1993), the definition of attitude is a hypothetical construct that cannot be observed directly but can be inferred from measurable reactions to the attitude object. Attitudes take into account three components:

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affect, cognition, and behaviour (Mazana et al, 2019). The affective component of attitudes is composed of emotions, beliefs, and vision of the subject. Emotions are the feelings of enjoyment or pleasure in learning the subject or seeing it as boring, difficult, and dull. Beliefs are related to students' confidence in their abilities to learn the subject. Vision represents students' perceptions regarding mathematics. The cognition aspect of attitudes is the value, which represents the students' perceived usefulness of mathematics. Behaviour, on the other hand, is connected to students' motivation to learn that is reflected in student's actions, commitment, and performance in class.

Self–Confidence

According to Adelson and McCoach (2011), Self-confidence in mathematics refers to a student's perceptions of self as a mathematics learner that include beliefs about one's ability to learn and perform well in mathematics. Hannula et al (2004) stated that self-confidence is an important factor that influences students' learning and affects their mathematics performance. Van der Bergh (2013) argues that students with high self-confidence believe in their abilities and that they can be successful in learning mathematics, thus overcoming the fear of failing. These students are ready to take on mathematical challenges which increase their academic achievement, otherwise students with low self-confidence do not believe in themselves and thus tend to avoid taking mathematics challenges (Adelson & McCoach, 2011). Thus, this leads to minimising the chances of expanding their mathematical skills and success. Hence, it is desirable to study the students' attitudes toward their confidence and how it relates to performance (Stipek, 2001).

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Enjoyment

Enjoyment of mathematics is the extent to which the students enjoy doing and learning mathematics (Kupari & Nissinen, 2013). Students' enjoyment while learning can influence their behaviour or cognitive aspects of attitude (Syyeda, 2016). According to PISA (2012) results published by OECD (2013), students may learn mathematics because they find it enjoyable and interesting. They further posit that interest and enjoyment affect both the degree and continuity of engagement in learning and the depth of understanding. This means that the more students enjoy doing mathematics the more they are likely to engage in problem-solving thus enhancing their learning and performance. Since enjoyment, students' learning and performance are related, it is worth evaluating the students' status of mathematics enjoyment to keep track of students' learning and performance.

Motivation

Intrinsic motivation in this study is related to both interest and the desire to learn mathematics (Guy, Cornick & Beckford, 2015). Students are intrinsically motivated to learn mathematics if they have the desire to do so after finding learning mathematics interesting (OECD, 2013). It is believed that motivation is the driving force for learning (Yunus & Ali, 2009). Intrinsic motivation affects both the degree of student engagement, career choice, and performance. Therefore, studying motivational variables as related to attitude and achievement is crucial.

Mathematics education needs highly motivated (both intrinsic and extrinsic) students because it requires logical reasoning, problem-solving, and marking interpretations (Saritas & Akdemir, 2009). For a person to put in his or her maximum best in his or her job, then it requires that person should be motivated enough to increase productivity. Nowadays, teachers and their students go to school

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because teachers think they have to teach to earn a living and their students also feel it is a must for them to be in school. Teachers are of the view that their profession as teachers is looked down upon by other professions and as such, they are underpaid despite the duties that they perform as teachers. Teachers further express their dissatisfaction with their conditions of service as compared to other professions. This resentment from each of the teachers and the students indicates that both parties are not motivated enough to be content with what they have. Thus, if care is not taken might result in teachers being incompetent and inefficient in the discharge of their duties and this, in the long run, might lead to weak mathematics performance on the part of the students (Sule & Bintu, 2016). This, therefore, confirms the assertion that when a teacher is not motivated enough, he or she might not be committed to his or her duties, and if the student, on the other hand, is not motivated enough to study diligently then it can lead to the student performing poorly academically (Etsey, 2005). It is therefore essential that each of the mathematics teachers and their students is motivated enough to boost their performance.

A review of motivational research revealed that how students perceive their success in mathematics is associated with their motivational attitudes. The review further showed that the actions and attitudes of teachers in the mathematics classroom, the strategies employed in designing the teaching/learning instructions and the quality of the lesson delivered by the mathematics teacher contribute to motivating the students towards mathematics (Teoh et al, 2010).

Value (Perceived Usefulness)

Perceived usefulness refers to students' perception about the importance of mathematics in their everyday life and the future (Adelson & McCoach, 2011). The

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perceived usefulness of mathematics is believed to influence students' attitudes towards the subject. Perceived usefulness is the value students have for mathematics. If students recognise the importance of mathematics in their lives, they will become motivated to study, practice, and teach the subject (Syyeda, 2016). Students from diverse communities recognise the value of mathematics in their lives and future careers. The study conducted by Guy et al (2015) found that mathematics usefulness is a positive predictor of their academic success.

Perceptions about the Nature of Mathematics

Perception refers to the process by which individuals interpret and make sense of sensory information from the world around them. It involves the brain and sensory organs working together to recognise, organise, and understand sensory stimuli such as sight, sound, taste, smell, and touch. Perception plays a crucial role in how humans and other animals interact with their environment and make decisions. The cultural aspect of mathematics refers to the influence of culture on the development, practice, and interpretation of mathematical ideas and concepts. Mathematics is not a culturally neutral discipline; it is shaped by the societies and cultural contexts in which it is used and developed (Davis, 2010, 2016).

The perceptions about cultural aspects of mathematics can vary widely across different individuals, communities, and cultures (Bishop, 1991; Civil, 2002). Beliefs and attitudes play a crucial role in shaping individuals' perceptions of mathematics. These psychological factors can significantly influence how people approach, engage with, and succeed in learning mathematics. While beliefs and attitudes are subjective and difficult to quantify precisely, researchers often use various methods to measure them (Wilkins & Ma, 2003; Philipp, 2007). In the

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current study, the researcher employed survey questionnaires and structured interviews to explore the views of both teacher trainees and mathematics tutors.

Perceptions about Mathematical knowledge

The perception about mathematical knowledge refers to how individuals, including students, teachers, and the general public, view and understand mathematics, its value, and its relevance in various contexts. This perception can vary widely from person to person and may be influenced by various factors, including personal experiences, cultural background, educational background, and societal influences (Bishop, 1988; Artstein et al, 2014; Davis, 2016). Many individuals perceive mathematical knowledge as a practical tool for solving real-world problems. They view mathematics as a subject with direct applications in everyday life, such as budgeting, cooking, and problem-solving. In an educational context, mathematical knowledge is often seen as an academic subject that is taught in schools and universities. Some individuals may perceive mathematics as a subject they must learn to pass exams or fulfil academic requirements.

Mathematical knowledge is often associated with problem-solving and critical thinking skills (Ernest, 1989). Many people view mathematics as a way to develop logical and analytical reasoning abilities that can be applied in various areas. Cultural backgrounds can influence the perception about mathematical knowledge. In some cultures, mathematics may be highly valued and emphasised, while in others, it may be less prominent or even stigmatised (Davis, 2010; Atweh et al, 2001). Many people view mathematical knowledge as essential for pursuing careers in STEM (science, technology, engineering, and mathematics) fields (Gravemeijer et al, 2017; NaCCA, 2019). Students may perceive mathematics as a gateway to higher-paying job opportunities.

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Perceptions about Mathematics Pedagogy

The perception about mathematics pedagogy refers to how individuals, including students, educators, policymakers, and the general public, view and understand the methods, approaches, and practices involved in teaching and learning mathematics (Lerman, 2000; Booker et al, 2015). Students and teachers' perceptions about mathematics pedagogy encompass their beliefs and attitudes regarding how mathematics should be taught, the effectiveness of various pedagogical strategies, and the overall quality of mathematical instruction. The perception of mathematics pedagogy can vary widely and is influenced by a range of factors. Individuals may have different opinions about the teaching methods used in mathematics education. Some may favour traditional methods, while others may prefer more innovative and student-centered approaches, such as problem-based learning or inquiry-based teaching (Owens, 1988; Furner, 2000; Tarr et al, 2013). The perceived relevance of mathematics pedagogy is crucial. Teacher trainees and mathematics tutors possibly could evaluate whether the curriculum and teaching methods align with real-world applications and problem-solving skills.

The methods used for assessing student performance in mathematics can impact perception. Individuals may have views on the fairness and appropriateness of assessment methods, including exams, projects, and standardized tests. Students' perception of mathematics pedagogy can be influenced by how engaging and motivating the teaching methods are. An engaging and interactive approach is more likely to foster interest in mathematics. People may evaluate teachers based on their ability to communicate mathematical concepts effectively, provide individualised support, and create a positive and inclusive classroom environment (Naja, 2018). Cultural norms, societal values, and cultural attitudes towards education can

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influence perceptions of mathematics pedagogy. Different societies may have varying expectations and views of how mathematics should be taught.

Perceptions about Links between Culture and Mathematical Knowledge

The relationship between culture and mathematical knowledge is a complex and multifaceted one. Mathematical knowledge is not solely a universal and objective entity but is influenced by cultural factors in various ways. Perceptions about the links between culture and mathematical knowledge are multifarious.

First, different cultures have distinct problem-solving approaches and strategies. These cultural experiences and perspectives influence how individuals approach mathematical problems and the methods they employ to find solutions (Ascher, 2003, 2017).

Secondly, mathematical concepts can be understood and interpreted differently based on cultural backgrounds. For example, the cultural context may influence the way individuals conceptualise abstract mathematical ideas or perceive the relevance of certain mathematical principles. Also, the language used to express mathematical concepts is inherently tied to culture. Different languages may have unique ways of expressing mathematical ideas and cultural nuances can impact the interpretation of mathematical language. The way mathematics is taught and learned can reflect the cultural values and priorities of a society. This can impact accessibility and inclusivity in mathematics education. Moreover, different cultures have made significant historical contributions to mathematics. The mathematical knowledge inherited from diverse civilisations has shaped the discipline. For example, an ancient Greek, Indian, Chinese, and Islamic mathematical traditions have all played crucial roles in the development of mathematics (Gerdes, 2001). Furthermore, technological advancements and growing globalisation have made it

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easier for mathematical ideas to traverse cultural barriers. Mathematical information is now more accessible to a global audience resulting in increased diversity and collaboration in the discipline.

The desire to engage with the connection between classroom mathematics and everyday problems outside of school motivates research on mathematics learning, objectives of mathematics education, and general views about the needs of teacher education and teaching practice (Davis & Chaiklin, 2015). The conceptual scaffolding for mathematics education for a specific period and place does not have to be found in the annals of mathematical culture. What is required, is a system that links mathematics education to its societal context, and mathematics as a cultural phenomenon provides us with one such opportunity (Bishop, 1988). This cultural knowledge can be seen in both teacher trainees and mathematics tutors' mathematics classroom instructions. However, the views of teacher trainees and their tutors may differ because of differences in their cultural backgrounds.

Therefore, the relationship between culture and mathematics is complex and bidirectional. Cultural factors determine how people approach and interpret mathematics, but mathematics itself is a universal language that transcends cultural barriers, allowing for communication, and collaboration (Rosa & Orey, 2020; Bishop, 1988; Davis, 2010).

Perceptions about Links between Culture and Mathematics Pedagogy

The link between culture and mathematics pedagogy involves how cultural factors influence teaching and learning of mathematics. This relationship is crucial to creating effective and inclusive educational practices. Perceptions about the links between culture and mathematics pedagogy include: mathematics curriculum and teaching materials should be culturally relevant, diverse, integrating examples and

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problems that resonate with students' cultural backgrounds that enhance engagement and understanding; Problem-solving tasks should be presented in contexts that are familiar and relevant to students' daily lives; Connecting mathematical concepts to real-world scenarios within the cultural context of the students can enhance comprehension (Aguirre & del Rosario, 2023).

To recognise the impact of language on learning, teachers should be aware of linguistic and communication differences influenced by culture. Teachers adjusting their teaching styles to accommodate diverse language backgrounds can promote better understanding. Teachers should adopt a variety of teaching approaches that reflect the cultural diversity of their students. This includes incorporating different learning styles and strategies that may be more effective for students from various cultural backgrounds. Again, teachers should undergo cultural sensitivity training to better understand and connect with students from various cultural backgrounds. This training can enhance communication, foster positive relationships, and promote a more inclusive learning environment (Abdulrahim & Orosco, 2020; Aguirre & del Rosario, 2013).

A related study was conducted by Cruse (2019) to examine the impact of culturally relevant teaching on the self-efficacy and engagement of African American males in social studies. The three African American males were used as focal students in this seven – week study. A seven – week action research methods study including both qualitative and quantitative designs was used to collect data. Analysis of data revealed three trends that are consistent with culturally relevant pedagogy. Student engagement increased due to lessons that specifically dealt with culture, the communication of high expectations, and the establishment of positive relationships with students.

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Literature shows that it is the teaching and learning strategy that believes traditional schooling is uneven for students from specific groups, such as the underprivileged. This method of teaching and learning focuses on improving students' mathematical skills while maintaining or enhancing their cultural identities and boosting student empowerment by teaching them how to critically evaluate the world around them using mathematics (Gay, 2010; Ladson-Billings, 1995). Mathematics teachers of ethnically diverse students should use their cultural knowledge, prior experience, frames of reference, and performance styles to make learning interactions more meaningful and effective for them (Gay, 2000). Thus, acknowledging and incorporating cultural thoughts into mathematics pedagogy is essential for creating an inclusive and effective learning environment.

Perceptions about Links between Culture and Mathematics Curriculum

The links between culture and mathematics curriculum refer to how cultural factors influence the content, structure, and delivery of the mathematics curriculum. These links are crucial for developing inclusive and culturally responsive educational materials. Teacher education institutions' mathematics curriculum should incorporate the examples, problems, and applications that are culturally relevant and relate to students' home experiences (Rosa & Orey, 2020). However, not all mathematics textbooks have their examples situated in the context of that particular community. Integrating diverse cultural contexts helps students see the real-world applicability of mathematical concepts. The mathematics curriculum should acknowledge and highlight the historical contributions of different cultures to the development of mathematics. This recognition helps counteract the Eurocentric bias often present in traditional mathematical narratives. Incorporating examples and practices from various cultural traditions broadens students'

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perspectives and fosters an appreciation for diverse mathematical approaches (Bishop, 1988; Averill et al, 2009; Gates & Vistro-Yu, 2003).

Teachers presenting problems with diverse cultural contexts, allow students to apply mathematical skills to scenarios they can relate to, making the learning experience more meaningful. Students who are culturally knowledgeable are well grounded in community heritage, traditions, and can build on their local cultural knowledge and skills to achieve personal success and an awareness of their place in the world (Education, 1998). Language is a cultural object that influences mathematics teaching and learning. Curriculum designers should be conscious of language diversity and attempt to communicate mathematical topics in ways that are understandable to students from various language backgrounds. Textbooks and instructional materials should employ culturally relevant examples and visuals that avoid preconceptions (Davis, 2016; Education, 1998).

Representing other cultures accurately contributes to the creation of an inclusive learning environment. The curriculum should be prepared according to the cultural values and priorities of the community it serves. This guarantees that the mathematical content is perceived as relevant and important to students' daily lives (Davis, 2010, 2018; Education, 1998). A culturally responsive mathematics curriculum promotes inclusivity and understanding of mathematics as a universal language, incorporating ideas from worldwide traditions. This approach enhances the relevance of mathematical education for all students (Ladson-Billings, 1995; Gay, 2000). Mathematics instructors employing culturally relevant mathematics curricula investigate the cultural congruence between students' communities and schools, demonstrating teachers' respect for their students' cultural experiences (Rosa & Orey, 2011). Many researchers have established a theory of culturally

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relevant pedagogy (D'Ambrosio, 1990; Gay, 2000; Ladson-Billings, 1995; Rosa & Orey, 2003), which analysed the teaching and learning process based on the explicit relationship between the students' cultural contexts and the school curriculum.

However, these researchers' culturally relevant pedagogies do not place a high value on prospective teachers' openness to cultural relevance in mathematics Classroom mathematics learning and its impact on students' cognitive, affective, and psychomotor development are linked to students' cultural values and activities. These three learning domains make up students' attitudes toward mathematics. The goal of the Ghanaian National Teachers' Standards is to produce professional teachers in three areas: professional values and attitudes, professional knowledge, and professional practice (NTS, 2017). The ideals instilled in prospective teachers' knowledge from the communities in which they found themselves, as well as their attitudes toward a particular culture. These mathematical values are derived from societally determined cultural values and beliefs.

In today's diverse society, College of Education students need an effective, stimulating, and relevant mathematics curriculum. Educators have recognised the changing nature of society and incorporated technology into teaching. Establishing intellectual connections with students is crucial, but challenges like instructional styles, prescribed curriculum, and strict government policy hinder this development. Regardless of individual student's demographics and appearances, one of mathematics educators' goals for education is for all students to excel. However, of late, there has been a significant decline in mathematics performance among teacher trainees in Colleges of Education in Ghana. It would be reasonable for a researcher to explore and delve into the reasons for such a problem in

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mathematics teaching and learning from cultural perspectives among teacher trainees and tutors to make headway toward resolving the problem.

The dominant mathematics curriculum today is based on Eurocentric ideas and does not engage or promote the significance of other cultures in mathematical education. Because of this (D'Ambrosio, 1998; Ladson-Billings, 1995), offered ethnomathematics and culturally relevant pedagogy (CRP) as alternative approaches to mathematics education. Ethnomathematics and Culturally Relevant Pedagogy advocate for diversity ethics in educational approach. If education is to contribute to building a new social order, then, the only hope we have for achieving a just social equilibrium in mathematics is to anchor educational practices in the ethics of variety (D'Ambrosio & D'Ambrosio, 2013).

The National Council for Curriculum and Assessment (NaCCA, 2019) stressed the need to incorporate students' cultural experiences into mathematics lessons. When practical or culturally-based problems are evaluated in an appropriate social context, the practical mathematics of social groups is not trivial since it reflects themes that are vitally linked to students' daily lives (Rosa & Orey, 2011). Ghanaian students come from a wide range of genealogical, ethnic, cultural, and linguistic backgrounds: If the primary goal of education is to positively impact students' lives by providing them with vital information and skills through culturally appropriate, expert practice, then departures in mathematics curriculum and instruction necessitate a paradigm shift (Scott, 2018). Exploring mathematical ideas from different parts of the world contributes to a more inclusive curriculum.

Teacher Trainees' Views about Mathematics

Students' perceptions of the relevance of cultural aspects in mathematics teaching and learning have recently gained attention from teachers and stakeholders

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in mathematics education. It is being considered by scholars of mathematics education in developed and developing countries, especially sub-Saharan African countries including Ghana the need to integrate learners' everyday experiences into the school mathematics to build their mathematical knowledge. Teacher trainees need to acquire local aspects of mathematical knowledge for their future classroom interactions (Davis, 2018), and to effectively teach students whose cultural backgrounds and experiences are different from school demands (Gallivan, 2017). As affirmed in (Civil, 2007; Gallivan,2017; Davis, 2015, 2018), teachers making use of students' everyday experiences, home, and community can harness their mathematics learning in school. Though, researchers in ethnomathematics perspectives have suggested culturally relevant teaching as one method for enhancing students' mathematics learning, few research studies take into account students' views of culturally relevant pedagogy (Hubert, 2014)

To investigate how the views of primary school pupils towards the concepts of measuring and sharing in out-of-school settings reflect their conceptions and practices in school, Davis (2016) sampled 16 primary school pupils, eight each from primary 4 and primary 6 in two average achieving schools (one each from rural and urban schools) in Ghana. Two focus groups were formed for the study. Qualitative research design was employed and the data were collected through interviews from the participants. The data from the pupils' activities on measuring and division of mixed or decimal fractions were analysed qualitatively and reported as narrative with illustrated examples. The results showed that the culture of pupils has effects on their conceptions and practices in the measurement of capacity and division of a mixed or decimal fraction by a whole number in their real-life situations. His findings confirmed the local aspects of mathematical knowledge and

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suggested the need for mathematics teachers to assist learners in drawing and integrating out-of-school mathematics and school mathematics in teaching and learning.

Hubert (2014) after interviewing five students on their perspectives of Culturally Relevant Pedagogy and the effect that participating in culturally relevant mathematics instruction has on students' attitudes and interest toward mathematics found out that learners held positive views of Culturally Relevant Pedagogy and preferred the method over traditional mathematics instruction.

Mathematics Tutors' Views about Mathematics

Several scholars have positioned mathematics as a cultural product of society and suggested the need to integrate out-of-school mathematics into the school curriculum. In the area of teachers' views about mathematics, a lot has been done on local aspects of mathematical knowledge and mathematics pedagogy as far as research in the cultural aspect of mathematics is concerned. Teachers' views of the cultural relevance of mathematics have been noted to be very important as it adds to effective teaching and learning of the subject. As acknowledged by many scholars in mathematics education, the teacher's pedagogical approach has to be one of the major sources of conveying the relevance of learners' culture in teaching and learning mathematics at both tertiary and pre-tertiary levels either explicitly or implicitly.

Literature shows that the nature of classroom interaction can affect the way students learn mathematical concepts (Davis, 2018). Some teachers view classroom mathematics teaching and learning as specifying instructions for manipulating symbols. Thus, in a mathematics classroom environment, mathematical knowledge is presented as a pre-packaged system of knowledge in which rules and procedures

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must be remembered and followed to successfully position the view of mathematics as teacher-centered and culturally free. On the other hand, some teachers believe that mathematical knowledge should be presented as knowledge that can be discovered through social interaction in the classroom. Such views tend to allow learners to develop a conceptual understanding of mathematics since communication about mathematical reality provides them with the opportunity to make sense of mathematics (Davis, 2018; Cobb & Bauersfeld, 2012).

To explore the views of Ghanaian elementary school mathematics teachers on classroom teaching, Davis et al (2019) surveyed the views of Primary school and Junior High School (JHS) mathematics and science teachers on teaching to find out where their views would place the learners at the center of teaching and learning process. One hundred and fifty–seven (157) professionally trained Primary and Junior High school mathematics and science teachers in Cape Coast Metropolis of Ghana were selected using stratified random sampling. Data from participants was collected through a questionnaire and analysed qualitatively. The qualitative analysis was presented as a narrative description with illustrative examples and frequency counts (percentages). The results of the study showed that the teachers' views about teaching mathematics were mainly teacher–centered. The teachers' perceptions about mathematics teaching and learning see the learners as the audience. The student's role in the classroom is to listen, observe and practice procedures for solving mathematical tasks. Students' everyday experiences were not functional in a typical classroom mathematics discourse. The researchers however, recommended the need for the mathematics and science education community in Ghana to look at how best they can integrate sociocultural

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approaches in teaching to improve the performances of pupils in mathematics and science at the basic school level.

Regarding their recommendation above, expressed the relevance of incorporating sociocultural issues and students' everyday experiences in a mathematics classroom but their study failed to collect data on their perceptions about cultural aspects of mathematics teaching and learning at the basic school level. To determine the views of teachers on the cultural relevance of mathematics teaching and learning, Acharya et al (2021) conducted a qualitative study to explore mathematics educators' perceptions of the cultural relevance of basic school mathematics in Nepal. Five participants, two from elementary and senior high school, and three from university were purposely selected for the study. An in-depth interview was used to collect qualitative data from the five participants. The main themes that emerged after thematic analysis showed that mathematics educators held three perceptions about the cultural relevance of basic school mathematics namely, teaching in a native language, contextualising ethnomathematics, and local knowledge used in the curriculum as the teaching approach. Their study stressed the need to use native language in classroom mathematics instructions to help students develop their mathematical knowledge naturally and improve on performance in mathematics and other disciplines. Besides, their study revealed that teachers teaching in a cultural context of basic school motivate students to understand mathematics meaningfully. However, they argued that teachers engaging students in real-life situations in mathematics learning can create fun to arouse their interest in the subject. Looking at the above views, mathematics educators were open to the relevance of cultural aspects in mathematics teaching

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and learning. However, their study made no mention of basic school children's perception about mathematics.

To guarantee such dynamism, this current study collected data on the regular mathematics tutors teaching either core or elective mathematics in the selected Colleges of Education, together with first- through fourth-year teacher trainees taking mathematics as a core subject or an elective subject. The mathematics tutors' views were operationalised as perceptions about mathematics that tutors and teacher trainees consider cultural–related or cultural–free (Davis, 2010, 2016) in their teaching and learning experiences at the Colleges of Education level in Ghana. The teacher trainees' and their tutors' perceptions were identified under the five key constructs conceptualised in the framework to address the research questions and hypothesis formulated for the study.

Empirical Review

Literature shows several research works have been done to investigate the nature and theories underpinning the cultural aspects of mathematics teaching and learning in school. These studies have recently received recognition by mathematics educators in developed and developing countries. Most of these studies were done on cultural approaches to teaching and learning mathematics, while few studies looked at teachers' and students' perceptions of cultural aspects of mathematics. Notable among these studies included the following:

Davis (2015) explored the perceptions of primary pupils' on the relationship between out–of–school mathematics and school mathematics and how that relates to their teachers' and head teachers' perceptions about mathematics. Eight focus groups from 32 primary four and six pupils and their teachers and head teachers who were selected using stratified random sampling were interviewed. The results

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of the qualitative analysis showed that pupils' perceptions about the relationship between school mathematics and out-of-school mathematics were the same as the perceptions of their teachers and head teachers. However, the perception of pupils about school mathematics generally was different from out-of-school mathematics.

Davis and Seah (2016) investigated how the teaching and learning of mathematics take on board some of the social and cultural practices of students to help them understand school mathematics generally, and measurement in particular. Their research looked at how sociocultural issues connected to the teaching and learning activities in Ghanaian primary school mathematics classrooms are, with a particular focus on the teaching measurement of money. They argued that, due to the redenomination of the local currency in 2007, Ghanaian students found it difficult to measure money. The researchers chose 60 pupils at random from two average-achieving public primary schools, one from each of the rural and urban areas. The pupils chosen were from primary four and were each taught one lesson on money measurement. The lesson was mostly conducted in English, which is Ghana's official language of instruction in primary four. Teachers do not employ students' everyday social and cultural practices linked to money measurement, according to the study's findings. Teachers did not engage students in cultural dialogues to assist them in understanding the necessity of operating in the new currency. The study found that some people continue to communicate with old currency while utilising new currency notes (Davis & Seah, 2016).

Ladson-Billings (1995) studied eight secondary school teachers who were regarded as good and exceptional CRP instructors by their peers and school management. All eight teachers were female, with twelve to forty years of teaching

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experience and participated in a four-phase study. Five were African Americans and three were white. Each teacher participated in an ethnographic interview to describe her history, philosophy of teaching, thoughts about curriculum, classroom management, and parent and community involvement in the first phase of the project (Ladson-Billings, 1995d). Following daily classes, the second and third phases overlapped and consisted of classroom observations, audiotaping, videotaping, and reflective conversations with teachers (Ladson-Billings, 1995d). The fourth and final phase, as described by Ladson-Billings (1995d), required the instructors to work together as a research collective or collaborative to examine and understand their own and one another's practice. On standardized examinations, Ladson-Billings (1995d) discovered that kids who participated in CRP in the eight classrooms performed better than their district counterparts.

Ladson-Billings also discovered the empowerment that social relations and social engagement provided to the eight instructors who took part in the study in implementing CRP in the classroom. These culturally relevant teachers intentionally constructed social relationships to help them satisfy academic performance, cultural competency, and critical consciousness standards (Ladson-Billings, 1995d). According to Ladson-Billings (1995d), the teachers maintained fluid student-teacher ties, demonstrated a sense of belonging to all students, and encouraged students to collaborate and take responsibility for one another. Individual performance did not decrease as a result of the requirement for a higher level of academic achievement for the entire class.

Bandeira and Lucena (2004) looked at the mathematical beliefs and practices of members of a community of vegetable farmers in Brazil's northeast, which were based on the mathematical concepts that farmers used to collect their produce and

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commercialize vegetables. Farmers' mathematical understanding differs from that learned in academic settings, according to their research. The farmers' mathematical understanding was ingrained in their culture when it came to harvesting and sales.

Carraher (1991) did a follow-up inquiry into school failure by investigating young street vendors in Northeast Brazil to see how well they knew street mathematics, such as algorithms, compared to academic school computations. The findings revealed that the success rates in both environments differed. Vendors were better at addressing street context and linguistic difficulties, but not traditional or academic computation tasks.

Some important mathematical concepts are developed outside of school without specific instructions. These concepts and procedures would appear to arise through an individual's social interactions in everyday activities such as commerce and the production of goods (Carraher, Carraher & Schleiman, 1985; Davis, 2016).

As noticed in Nunes (1992) research on Brazilian vendors, mathematical ideas and practices utilised outside of school might be classified as a modelling process rather than a simple manipulation of numbers. Mathematical knowledge that is important to classroom learning comes naturally to students from a variety of cultural backgrounds. Even Indigenous people with little formal education or exposure to technology have the same geometrical and arithmetical intuitions as their Western contemporaries (Cimen, 2014). Throughout history, civilizations from around the world have shared the same concerns about how to deal with the same issues in their traditions. Their approaches or views of how to represent and practice these issues may differ. Their levels of presentation of these problems can be relative depending on how these problems appeared in the context or sociality in which they were located. This does not, however, imply that the problems or

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realities are unrelated. To put it another way, cultures developed similar answers to similar issues and difficulties, but in a variety of formats. As an example, we can use numbers and counting. Along with their traditions, different cultures used distinct symbolisations and ways of representing counting, numbers, and arithmetic. The Incas for example, utilised Quipus, the Chinese used knotted cords, and many other ancient societies, such as the Babylonians and the Indians, had their methods for expressing numbers and solving issues that required counting and arithmetic. This is another argument endorsed by CRT, but it assigns relativity to difficulties that are common to all cultures, rather than to the symbolisations, expressions, or techniques that different cultures use.

Davis et al (2009), conducted research on the gaps between inside school and out–of–school mathematics in Ghana. They looked at the mathematics curriculum in Ghanaian primary schools and the teaching of measurement and fractions in general. The authors discussed the lesson observation reported by Mereku (2004) on the teaching of the perimeter. Their study revealed that the use of the out–of–school knowledge acquired by children through their culture in sharing as a fraction was not mentioned at all in the curriculum. They identified the primary one as a curriculum where a lot of out–of–school contexts are mostly used in the development of the concept of measurement. In observing the teacher's lesson measurement, they observed that the formation of the concept of measurement pays very little attention to culture. They concluded that the neglect or probably ignorance of the role of the culture of pupils and teachers in pupils' mathematics learning may have contributed to gaps between out–of–school mathematics and inside school mathematics in Ghana.

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In addition, Davis (2018) conducted a study on the nature of mathematics classroom discourse and how that affects the way pupils learn mathematical concepts meaningfully. One hundred and one (101) primary six pupils and their teachers from three public primary schools were randomly selected and one mathematics lesson each was observed. The data collected were analysed qualitatively. The researcher analysed the rationale, general aims, and strategies for teaching and learning mathematics in the preamble of the primary school mathematics curriculum presented and discussed the relationship between the classroom microculture identified through lesson observation, and those espoused by the primary school mathematics curriculum. The results of the study showed that the classroom interactions were mainly in English language and teacher-centered. There was little or no social interaction in the classroom discourse. Though the study evaluated the rationale, general aims, and strategies for teaching and learning mathematics at the primary school that support public discourse in an inquiry mathematics classroom, it did not empower teachers to strictly use cultural objects to communicate and develop positive attitudes towards mathematics (Davis, 2010). The researcher observed that the actual mathematics classroom discourse that was recorded through observation differed from what appears to be the intention of the curriculum.

A similar study was conducted by Stipek et al (2001) to examine teacher beliefs and practices that are directly related to inquiry-oriented mathematics instruction. The goal is to better understand the nature of teachers' beliefs about mathematics teaching and learning and the links between their beliefs and practices. 21 fourth- through sixth-grade teachers from elementary schools throughout Los Angeles County (California) served as participants. Participants were asked to

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complete a 4-page survey questionnaire of their `Beliefs about mathematics and teaching. Findings showed substantial coherence among teachers' beliefs and consistent associations between their beliefs and their practices. Teachers' self-confidence as mathematics teachers was also significantly associated with their students' self-confidence as mathematical learners

Summary of Literature Review

This chapter focused on the review of the related literature that was aligned with the purpose and objectives designed for this study. The review began with a theoretical review, conceptual review, and a conceptual framework that presented all the variables, processes and relationships involved in the study. The conceptualised study constructs were reviewed and their operational definitions were provided for clear and concise measurement. These included the conceptual framework for the study, a review of perceptions about the nature of mathematics (beliefs and attitudes), perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between culture and mathematical knowledge, perceptions about links between culture and mathematics pedagogy and perceptions about links between culture and mathematics curriculum. Teacher trainees and mathematics tutors' views were also presented under conceptual review. The summary of the empirical review which highlights the main gaps identified in the literature which directed the focus of this study.

Based on the literature reviewed, it is clear how the cultural aspect is relevant in mathematics teaching and learning in mathematics education (Davis, 2010; Rosa & Orey, 2011; Bishop 1988; D'Ambrosio, 1985). More attention must be geared towards the development of ethnomathematics and socio-cultural perspectives in our educational system. It is also evident that generally, few studies had been done

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in the area of cultural aspects of mathematics research (Vygotsky, 1934/1987; Davis, 2010; Rosa & Orey, 2011), especially in sub-Saharan Africa and including Ghana. It is also worth mentioning that few studies were conducted to identify the perceptions about mathematics that are more receptive (more culturally-related) and the ones that are less receptive (least culturally-related). Most of such studies failed to find the reasons for such less cultural–related perceptions. Moreover, these studies did not explore further the views of teacher trainees and mathematics tutors about the cultural relevance of mathematics at the Colleges of Education.

The evidence from the literature shows that there is no known study that has been conducted in Ghana on students and teachers' receptiveness to the cultural relevance of mathematics at the tertiary level, more especially at the Colleges of Education level. Therefore, this study aims to fill the gaps that exist in the literature on perceptions of cultural aspects in mathematics teaching and learning at the Colleges of Education in Ghana.

The next Chapter Three presents the methods that were used to explore the formulated research questions and the hypothesis for the study.

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CHAPTER THREE

RESEARCH METHODS

The study aimed to explore teacher trainees and their mathematics tutors' receptiveness to the cultural relevance of mathematics and ascertain whether their views of mathematics are cultural–free or cultural–related (Davis, 2010, 2016). For this goal to be achieved, four research questions and one research hypothesis were formulated to guide the study. In the previous chapter, attention was devoted to a review of the literature relevant to the study. In this chapter, a discussion of the methodology employed in this study is considered. This chapter is subdivided into five sections. The first section deals with a research design that was used in carrying out this research and the research paradigm, while the second section talks about the study area, population and sample, and sampling procedure. The third section covers the data collection instruments, data collection procedure (including pre-testing of instruments), validity and reliability, while the fourth section deals with the data processing and analysis. The last section deals with ethical considerations. The chapter ends with a summary of all the issues discussed.

Research Design

The research approach involves not only the distinct method or procedure used but also the philosophical ideas (paradigm) that inform the nature of the research under study. It is therefore imperative to bring forth the paradigm that underpinned this research. The researchers refer to the research paradigm as a philosophical worldview (Aliyu et al, 2014; Cohen, Manion et al, 2018; Creswell & Creswell, 2017) of the existence of knowledge or truth from their perspectives. It includes a unified association of concepts, variables, and problems with their respective methodologies and appropriate tools. The procedures used to arrive at

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research findings and conclusions include making sure they can hold up in the face of competing hypotheses. This means the study was not restricted to a particular research paradigm but the combination of both positivist and interpretivist research paradigms to obtain more established findings that can be defended at the heart of a contending hypothesis.

Literature shows that there has been a growing interest in mathematics education fields for mixed methods research. Systematically this paradigm combines ideas from both quantitative and qualitative methods. Mixed methods researchers believe that by mixing knowledge claims, they can get richer data and stronger evidence rather than using a single method (Creswell, 2005; Gay, 2012). This idea is further strengthened by the belief that cultural and social phenomena are extremely complex and we need to employ multiple methods to better understand them (Christensen, 2022).

The pragmatic paradigm was used in conducting this study. The adoption of pragmatism responds to the current need to support Ghanaian teacher trainees and mathematics tutors to efficiently use cultural objects and functional-based approaches in developing mathematical conceptions in Colleges of Education in Ghana. The pragmatic paradigm is based on knowledge that works through careful observations, controlled experiments and interpretation. The pragmatist researcher’s role is to establish the precise nature of relationships between and among variables. Pragmatist research findings are mostly observable, quantifiable and predictable. The main objective of pragmatist research investigation is to explain relationships between theory and practice, eventually leading to the prediction and control of situations. Pragmatism's primary goal is to create practical

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knowledge that has utility for actions to make a purposeful difference in practice (Goldkuhl, 2012).

The pragmatic paradigm was deemed appropriate for this study as the research issues/questions will inform the methodology for this research study (Creswell, & Creswell 2005; Mertens, 2011). To develop a picture of the classroom situation, which made explicit the patterns, and events which comprise the learning environment, the researcher adopted a combination of both questionnaires and interviews to explore the views of teacher trainees and their mathematics tutors on the cultural relevance of mathematics. Cohen et al (2018) maintained that pragmatist studies mostly adopt both deductive and inductive approaches and the perspective that one needs to concentrate on both facts and meanings and therefore there is a need for human interest.

From the ontological perspective, concepts and variables (perceptions about the cultural relevance of mathematics) exist naturally in the social environment. The pragmatists assume that: there is no single tangible reality that can be understood, identified, and measured by all; and they view knowledge as a human and social construct. This allows the researcher in the current study to be able to interpret, explain and predict relationships in a causal framework that includes (1) relationships (i.e., teacher trainees and mathematics tutors' receptiveness to cultural relevance of mathematics are correlated), (2) prediction (i.e. mathematical knowledge; mathematics pedagogy; links between culture and mathematical knowledge; links between culture and mathematics pedagogy, and links between culture and mathematics curriculum,), and (3) mediation (i.e., beliefs and attitudes) could mediate the relationship between teacher trainees and their mathematics tutors' receptiveness to cultural relevance of mathematics. This study aligns with

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this assumption by investigating the differences between participants' views (teacher trainees and mathematics tutors) as identified by Davis (2010, 2016). It is also a known fact that beliefs and attitudes are psychologically and culturally constructed through formal or informal interactions and for that matter, can best be understood through the interpretation of the concepts or constructs in a defined social context. The classroom interactions between teachers, students and peers resulting in an effective classroom discourse serve as a means of transmitting mathematical knowledge, beliefs and attitudes that make sense in terms of a defined socio-cultural context (Ernest, 1989). To achieve beliefs of subjectivity in this study, the researcher stayed together with the participants during data collection.

Epistemology refers to the nature of knowledge, or in other words how we come to know about reality. The epistemological position of this study exists in one main direction. This perspective deals with the perceptions (Beliefs and Attitudes) of the cultural relevance of mathematics. Pragmatists assert that knowledge should be celebrated as profound, multiple realities, and the upright of individual interpretations and meanings rather than an appeal to singular or universal rationalism obtained in a very objective manner, without the values of the researchers or participants influencing its development. The knowledge that is subjectively obtained is certain; the truth is similar to reality; temporality and context in understanding phenomena; meanings are rooted in time, space, cultures, and societies and are not universally across. To appropriately develop truth, the researcher in this study personally established rapport with the research participants to allow methodological pluralism and subjectivity.

Moran-Ellis et al (2006) stated that methodological pluralism can be used to understand different aspects of social phenomena and to get a thick description of

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the social world. The flexible protocols were followed to administer questionnaires, and interviews, and analysis of the results to reduce bias in the study (Asif, 2013).

Methodological stance concerns how to conduct social and scientific research (Cohen et al, 2018). The Pragmatists emphasis research methods that allow for variables or concepts to be evaluated in terms of how they work and their consequences as the standard for action and thought. This allows for the social science researcher to craft fairly simulated environments to be able to minimise other extraneous factors, beyond the study variables; to be able to explain relationships between variables in the study. The pragmatic researchers request mixed (both quantitative and qualitative) methods to collect and analyse data by making statistical inferences. The pragmatist mixed methods research perspective requires a large sample size and statistical techniques to determine meaningful relationships (Cohen et al, 2018). This study used the sequential explanatory mixed methods research methodology by using a questionnaire and structured - interview to collect and analyse numerical and qualitative data about receptiveness to the cultural relevance of mathematics, using a large sample of 1,160 teacher trainees and 34 mathematics tutors selected randomly from five Colleges of Education.

The study aimed to explore the factors that influence teacher trainees and their mathematics tutors' receptiveness to the cultural relevance of mathematics in the Colleges of Education in Ghana. To achieve this goal, a sequential explanatory mixed method design (Creswell, 2013; Cohen et al, 2018) was used for this study. The sequential explanatory mixed methods design was employed to collect both quantitative and qualitative data from a cross-section of research participants to address the research questions and hypotheses that were posed in Chapter One. A cross-sectional survey of teacher trainees and their mathematics tutors' beliefs and

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attitudes to mathematics in the Ghanaian Colleges of Education in which inferences were made about their receptiveness to the cultural relevance of mathematics. This survey design was deemed appropriate since the study sought to explore teacher trainees and mathematics tutors in Colleges of Education receptiveness to the cultural relevance of mathematics without influencing the environment within which they found themselves.

Literature shows that a cross-sectional survey has the potential to provide a lot of useful information about the subjects of the study, for instance, teacher trainees and mathematics tutors in the Colleges of Education receptiveness to the cultural relevance of mathematics (Frankel & Wallen, 2000; Karaca, 2015). Mixed-methods design employs actions of inquiry that include data collection either roughly at the same period for the understanding of any problem that may arise in research. Both numeric and text information were employed for the data collection. This means the final results would be a representation of both quantitative and qualitative information. This design permits researchers to expound and translate the findings from a quantitative study by the use of qualitative results.

However, this design has also some strengths and weaknesses. The merits of the mixed-methods design are that it is straightforward to describe and present its report, it is beneficial when unconventional results arise from a previous study, it lends itself to the designing and validation of an instrument, and it helps to generalise to an extent, the qualitative data and can place research in a transformative framework (Creswell, 2013).

Mixed-methods design has flaws in terms of data collection and processing. Some of the weaknesses of mixed methods are that: more time is needed for the researcher to collect data. Sometimes, it is also difficult for the researcher to find

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solutions to inconsistencies that may happen between the different types of data that have been collected. Some of the mixed methods designs may generate uneven facts that become unpleasant to decide which result is the desired outcome (Creswell, 2013; Cohen et al, 2018). Despite these weaknesses, Creswell (2009) highlighted a comprehensive design for investigating all the facets of the research issue.

The purpose of a sequential explanatory mixed design is to use qualitative results to assist in explaining and interpreting the findings of a primarily quantitative design, the initial quantitative phase of the study may be used to characterise individuals along certain traits of interest related to the research questions (Cohen et al, 2018). The findings of the quantitative study determine the type of data to be collected in the qualitative phase (Gay, 2012). In this study, both teacher trainees and their mathematics tutors' questionnaires were collected and analysed first before determining the type of focus group to be selected for the interview. Thus, the researcher first collected quantitative, analysed, followed by qualitative data collection and analysis. Both data were analysed individually, and then triangulate both results. The results were compared, contrasted, and interpreted. The results obtained from the qualitative data were used to confirm that of the quantitative data. The operational structure and processes involved in the Sequential Explanatory Mixed–Methods Design is shown in Figure 6.

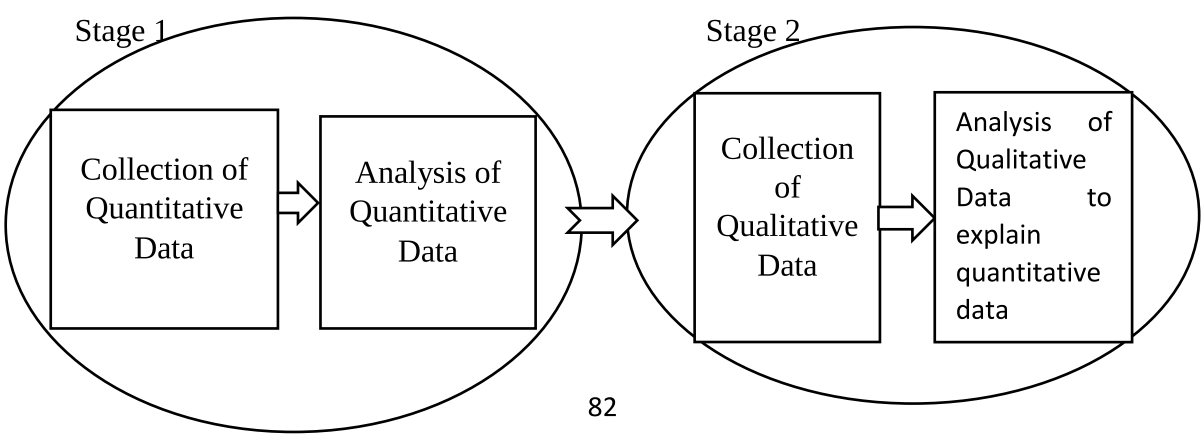

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Figure 6: Operational Structure of Sequential Explanatory Mixed-Methods Design (SEMMD)

SOURCE: (Adapted from Cohen et al, 2018)

Study Area

This study took place in the Bono, Bono East, and Ahafo (formerly Brong-Ahafo Region) Regions of Ghana. These three regions are located in the middle belt of Ghana. The three regions together constitute the second largest region in terms of their landmarks in square kilometres in Ghana. Their total land area is estimated to be 39,626 km^2 with 29 administrative districts/municipalities with the distribution of districts and municipalities as 6, 12 and 11 for Ahafo, Bono and Bono East Regions respectively. These three regions together cover 16.6 percent of the country's overall land area. Based on the population distribution on the 2000, 2010, and 2021 population and housing census, the three regions had an estimated population of 1,824,822; 2,282,128; and 2,976,807 (GSS, 2000; GSS, 2010; GSS, 2021) respectively with a growth rate of approximately 1.3% as against 2.1% national average. Ahafo, Bono and Bono East Regions (formerly Brong Ahafo Region**)** together share borders with the Black Volta River, Lake Volta, Ashanti, Eastern and Western regions, and Ivory Coast's southeastern border to the north, east, south and west respectively.

These three regions are similar in terms of socioeconomic status and educational attainment at all levels (pre- and tertiary). The main language spoken by these three regions is Akan. There are a lot of tourist attractions in these three regions some of which are the Kintampo waterfalls, Boabeng-Fiema Monkey Sanctuary, Bui Dam and Digya National Park. These regions have varied vegetative cover and a bi-modal rainfall. The major occupations of the people in these regions are agriculture and trading. These three regions are well known for the production

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of cocoa and timber in large quantities. The people from these communities rear livestock, poultry, and cultivate food crops like cocoyam, cassava, yam, maize, and plantain together with vegetables and fruits in large quantities. These three regions were known to be the food baskets of Ghana.

It is important to note that the male students' educational attainment is higher than that of their female counterparts at each grade level. These attainment levels for females imply that the majority of female students drop out of school due to the low economic status of the majority of the populace, early marriage, engagement in household activities, and other social vices such as teenage pregnancy.

The location of the three regions (Bono East, Bono, and Ahafo Regions of Ghana) involved in this study are shown on the map (see Figure 7).

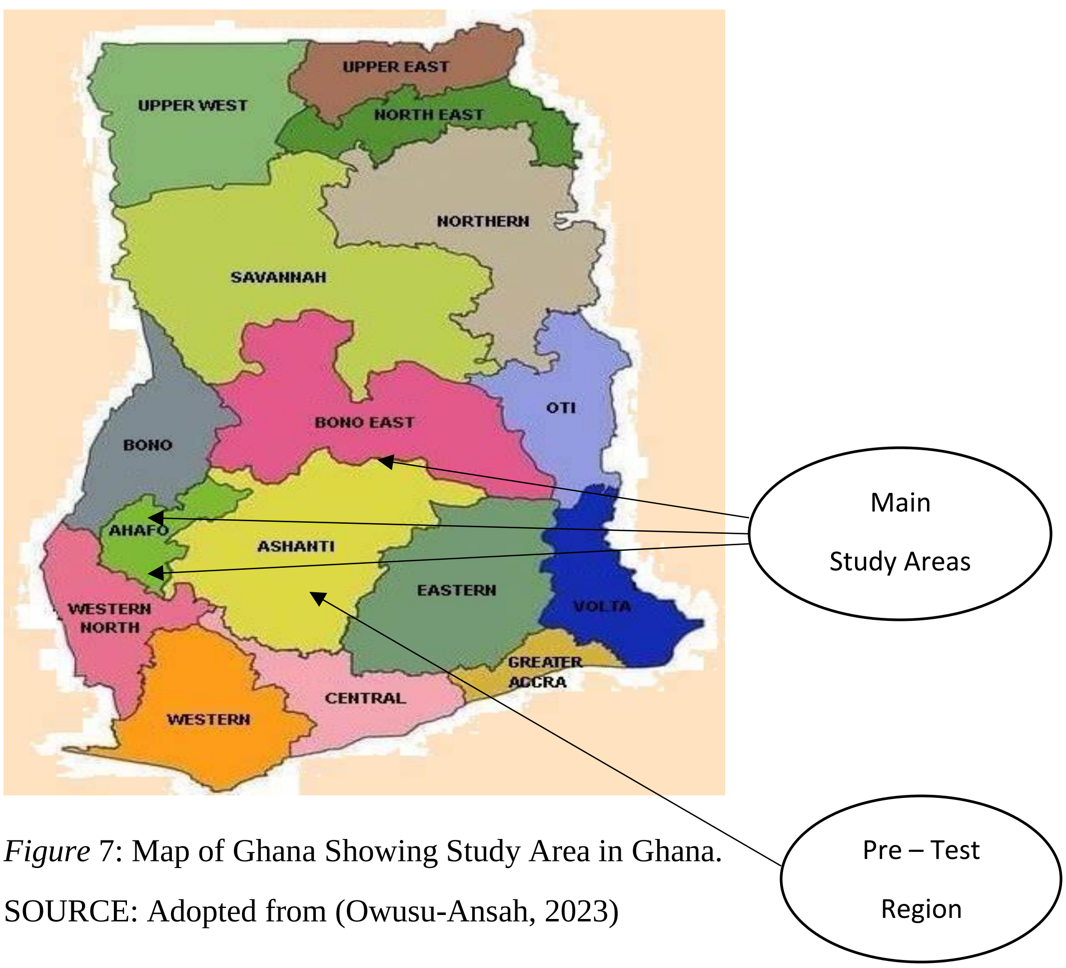

Figure 7: Map of Ghana Showing Study Area in Ghana.
SOURCE: Adopted from (Owusu-Ansah, 2023)

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The use of these three Regions in this study gives a fair representation of the Ghanaian situation. This is because demographic data in Ghana shows that more than half (55%) of the Ghanaian ethnic groups reside in these areas. There are several cultural practices and festivals within these regions. The inhabitants pride themselves on ancestral worship and spirituality (e.g., Islamic religion, traditional believes, and Christianity) are the dominant religions.

The industries within these three selected regions focus on the processing of wood and agricultural products. Mining of gold in both large and small scale is predominant among the indigenes. The number of Colleges of Education in this study area constitutes 10.9% of the number of public Colleges of Education in Ghana. All the five Colleges of Education in these three selected regions like all other Colleges of Education in Ghana are offering at least two Bachelor programmes in Basic Education (i.e. B.Ed. Early Grade Education, B.Ed. Primary Education, and B.Ed. Junior High School (JHS) Education). The five colleges of education in these three regions are all mixed schools.

Population

The total population of this study comprised all teacher trainees (7,350) and their mathematics tutors (34) in the five selected public Colleges of Education in the Bono, Bono East, and Ahafo Regions (formerly, Brong Ahafo Region) of Ghana. To safeguard the identity of the participants, pseudonyms have been used for the five Colleges of Education. In this study, the five selected Colleges of Education were identified as College A, College B, College C, College D, and College E respectively. The grade levels were named level 100, level 200, level 300, and level 400 respectively. Therefore, the general population distributions of all the teacher trainees from first-to fourth-year across the five selected Colleges of

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Education were 1110, 1750, 2260, 900, and 1330 for Colleges A, B, C, D, and E respectively. Table 1 shows the population distribution of first- to fourth-year teacher trainees in the five selected Colleges of Education in Bono, Bono East, and Ahafo Regions of Ghana.

Table 1 : Population Distributions of Five Selected Colleges of Education

COLLEGE	POPULATION				
	Level 100	Level 200	Level 300	Level 400	TOTAL
A	300	340	300	170	1110
B	450	450	450	400	1750
C	600	630	530	500	2260
D	250	250	250	150	900
E	350	350	350	280	1330
TOTAL	1950	2020	1880	1500	7350

Source: Field Data (2022)

The target population for this study was made up of (1310) teacher trainees offering B.Ed. Primary Education (BPME); B.Ed. Junior High Education (BJHSE); and B.Ed. Early Grade Education (BEGE) programmes and (34) mathematics tutors as at the 2021/2022 academic year in the five selected public Colleges of Education in Bono, Bono East, and Ahafo regions of Ghana. The distribution of the target population of teacher trainees from four grade levels was as follows: level 100(332); level 200(333); level 300 (330); and level 400(315). The target population for the four levels in the five respective selected Colleges of Education for this study were: College A (278), College B (280), College C (281), College D (235), and College E (236).

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The distributions of the target population for the three programmes were shown in Table 2

Table 2: Background Characteristics of Target Population (Teacher Trainees)

		PROGRAMMES		
COLLEGE	BEGE	BPME	BJHSE	TOTAL
A	44	103	131	278
B	44	105	131	280
C	45	105	131	281
D	-	104	131	235
E	-	105	131	236
TOTAL	133	522	655	1310

Source: Field Data (2022)

The sample participants were the first-year to fourth-year teacher trainees (1,160) taking mathematics as either a core or elective subject: (A (240); B (250); C (270); D (180) and E (220)) and their respective mathematics tutors (34) teaching either core or elective mathematics: (A(6); B(6); C(9); D(5); and E(8)) in the five selected Colleges of Education in three above mentioned regions of Ghana. All five selected colleges offer Bachelor of education programmes and the sampled level 400 teacher trainees for this current study were the first batch enrolled in the 2017/2018 academic year.

The programmes, curriculum and courses for all teacher trainees were designed, monitored, and supervised by the affiliate universities (University of Cape Coast (UCC), University for Development Studies (UDS), Kwame Nkrumah University of Science and Technology (KNUST), University of Ghana (UG), University of Education (UEW), AAMUSTED) in Ghana. T-Tel Ghana runs the

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same professional development programmes for tutors from the five selected colleges. These colleges have similar teaching and learning resources such as libraries, computer laboratories, and lecture rooms. The teacher trainees in these colleges are also taught by qualified tutors most of whom were trained by the same educational universities in Ghana.

Participants

Mathematics Tutors

A census of thirty-four (34) mathematics tutors who were purposively selected from the five (5) selected Colleges of Education used in this study comprised 3(8.82 %) females and 31(91.18 %) males. The distribution of mathematics tutors from colleges A, B, C, D and E were 6, 6, 9, 5 and 8 respectively.

Teacher Trainees

A total of one thousand, one hundred and sixty (1,160) first-through fourth–year teacher trainees who participated in this study were made up of 628 (54.10 %) males and 532 (45.90 %) females; 270(23.28%) level 100, 300(25.86%) level 200, 300(25.86%) level 300, and 290(25.00%) level 400. One hundred and thirty-three (133), representing 11.50% offer Early Grade education; four hundred and fifty-four (459) representing 39.50% offer Primary education; and five hundred and sixty-eight (568) representing 49.00% offer Junior High education. Out of 1,160 participants, 240 of them were from College A; 250 were from College B; 270 were from College C, 180 of them from College D and 220 were from College E respectively.

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Sampling Procedure

This study aimed to explore teacher trainees and their tutors' receptiveness to cultural relevance of mathematics, and also to ascertain whether their views of mathematics are cultural-related or cultural-free at the colleges of education in Bono, Bono East, and Ahafo Regions of Ghana. To achieve this goal, a multi-stage sampling technique was used. This allowed for different sample techniques to be employed at different stages of the data collection.

In the first stage, based on the National Conference of Principals of Colleges of Education (PRINCOF) five zones (5) of the 46 Colleges of Education namely, Ashanti-Brong Ahafo (ASHBA), Eastern-Greater Accra (EAGA), Central-Western (CENTWEST), Northern (NOR), and Volta and Oti (VOTI). One zone (Ashanti-Brong Ahafo, ASHBA) was conveniently selected. The ASHBA zone was then split into two, Ashanti and Brong Ahafo, from which the researcher conveniently selected Brong Ahafo (now Bono, Bono East and Ahafo Regions of Ghana). These three sampled regions have five colleges, of which three are located in the Bono Region and one each in Bono East and Ahafo Regions of Ghana. Stratified random sampling was employed because the five (5) Colleges of Education selected for this study were all not in the same region, and even if they were in the same region, they would not be in the same place. However, the mathematics curricula for these Colleges were also designed from the same framework for all Colleges of Education in Ghana. Again each college was divided into four strata namely level 100, level 200, level 300, and level 400 respectively. Besides, each level was divided into three programmes of study namely B.Ed. Early Grade Education, B.Ed. Primary Education, and B.Ed. JHS Education for all five colleges selected for the study.

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In the second stage, a census of (34) mathematics tutors was purposively selected from the five selected Colleges of Education because of the unique role they play in this study, and stratified random sampling was used to select one thousand, three hundred and ten (1310) teacher trainees from all three programmes of study, and who might have taken at least one mathematics course in their second semester at the college. The mathematics curricula for the five participating colleges were also designed from the same framework for all Colleges of Education in Ghana.

In the third stage, a stratified random sampling was used to select 1,160 teacher trainees in level 100(270); level 200(300); level 300(300); and level 400(290) of which 240 were from College A, 250 from College B, 270 from College C, 180 from College D, and 220 from College E. Once again, a stratified random sampling was employed to select participants from three programmes of study namely B.Ed. Early Grade (133), B.Ed. Primary (459), and B.Ed. Junior High (568). A total of (1160) teacher trainees made up of a proportionate number of males and females pursuing 4–year Bachelor of Education programmes in Primary, Early Grade, and JHS education studying mathematics as either core subject or elective subject were used because they are more likely to teach mathematics at the Basic School level (BSL).

Fraenkel, Wallen and Hyun (2015) described stratified random sampling (proportional or quota sampling) as a probability sampling technique that involves the division of the population into sub-groups called strata. The strata in the stratified random sampling for this study were formed because of the special characteristics posed by the participants within themselves. In this study, the researcher sampled (1,310) participants based on their gender, programme of study

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and grade levels. A simplified formula proposed in (Louangrath, 2017; Yamane, 1967; Singh & Masuku, 2014) for proportions was used to calculate the sample size for each grade level in the five colleges of education selected for this study. This formula was based on a 95% confidence level and the level of precision (P = 0.05) which was assumed to be $n = N / [1 + N (e)^2]$, where n is the sample size, N is the population size, and e is the level of precision. For this current study, a sample of the grade levels was obtained as, Level 100, $n = 1950/ [1 + 1950(0.05)^2] =$ 331.9(round up to 332), Level 200 (n = 333), Level 300 (n = 330), and Level 400 (n = 315). Cohen et al (2018) suggested that 10% of every population will be a good representation of the sample. In the current study, the sample size was more than 10% of the population size. Hence the sample size is appropriate for this study.

In the fourth stage, purposive sampling was used to select 50 teacher trainees (10 from each college) whose perceptions about mathematics after analysis of the questionnaire out of the main sample were highly culture-related and/or more culture-free for the interviews to take part in focus group interview sessions. The questionnaires for the main study were coded for teacher trainees (e.g. TTQ1, TTQ2, TTQ3…, TTQ10, and TQ 1,160), and all 34 mathematics tutors (e.g. MTQ1, MTQ2, MTQ 3…, and MTQ 34) respectively for the focus group interview session.

In addition, the participant teacher trainees and their tutors were also asked to keep the code numbers indicated in their questionnaires for one month. This enables the researcher to use the codes on their questionnaires to trace participants whose held views were highly cultural–free or showing trends to cultural–related perceptions for the interview sessions after the quantitative data analysis of their responses to research question one.

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Data Collection Instruments

Questionnaires and a structured interview guides were the two main data collection instruments used to collect data for this study. The researcher adapted the questionnaire and structured interview items from Davis (2010) based on readings in Chapter Two and in the area of perceptions about mathematics (Abreu & Cline, 1998, 2005; Abreu, Bishop & Geraldo, 2016; Bryant & Nunes, 2016; Ernest, 1989, 1996). Though the items were already tested, a few of them were modified by the researcher from already prepared instruments (Davis, 2004, 2010, 2016). To test for the validity of the research instruments, the researcher pilot-tested both questionnaires and interview guides by giving them to fellow graduate students, three mathematics education lecturers at the Department of Mathematics and ICT education, and a supervisor at the University of Cape Coast to complete the questionnaires and interview guides (Mertler & Charles, 2008; Oranga & Gisore, 2023). The researcher used the comments received from the professionals who responded to the questionnaire and interview guides to improve the instruments. The researcher pilot-tested the instruments in a pilot region in Ghana after going through ethical clearance at the University of Cape Coast. Through pilot testing of instruments in the Ashanti region of Ghana, the researcher got an opportunity to further address other problems such as clarity of questions, unclear choices, difficult questions and clarity of instruction to respondents amongst others. The duration of the administration of the instruments to each of the research participants in the pilot test was also noted. This enabled the researcher to modify the instrument in such a way that it could be administered without taking too much of the respondents' time. The researcher administered the questionnaires and the interview guides at a nearby college which was not part of the main study.

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This enabled the researcher to explain the purpose of the study to the respondents and also to answer any questions that respondents may have before they complete the questionnaires and interview guides.

Both the questionnaire and the interview guide were of two kinds with similar items. One for the mathematics tutors and the other for the teacher trainees. The questionnaires were used to explore teacher trainees' and their mathematics tutors' receptiveness to the cultural relevance of mathematics. The questionnaire method for data collection was deemed appropriate for this study because of the quantitative nature of data at the first stage of data collection.

Fifty (50) items questionnaire was used for collecting data from teacher trainees and their mathematics tutors on their views about the cultural relevance of mathematics learning and teaching. The items in the questionnaires were adapted from Davis (2010). The four-point Likert-scale questionnaire used Strongly Agree (SA = 4) as the highest scale and Strongly Disagree (SD = 1) as the lowest scale. The other items included: dichotomous questions with Yes = 1 and No =2; multiple choice check boxes; and open-ended questions (see Appendices A and B respectively). The questionnaires were contextualised to suit Ghanaian mathematics classrooms, more especially in the Colleges of Education.

The questionnaire instrument was used in two ways: one to measure teacher trainees' perceptions about mathematics and the other to measure mathematics tutors' perceptions about mathematics. The questionnaires for both teacher trainees and mathematics tutors were divided into two parts (quantitative data): the first part was to seek teacher trainees' demographic data (i.e., personal information) about the respondents and included college, age, gender, the programme of study, grade levels, and the specialty of the respondent, while mathematics tutors questionnaire

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also included college, age, gender, highest academic qualification, teaching experience, native language, place of residence, programme teaching, and specialty. The second part generally was made up of 50 items (perceptions about mathematics) that educed the views of teacher trainees and their mathematics tutors to the Cultural Relevance of Mathematics (CAM), whether cultural-free (i.e., perceptions that do not recognise mathematics as a cultural object) or cultural-related (i.e., perceptions that take cognisance of mathematics in the out-of-school setting). The medium of construction and dissemination of the questionnaire instrument items was the English language since that is Ghana's official medium of instruction at all stages of the country's educational systems.

The interview guides comprised open-ended semi-structured items that sought to explore teacher trainees and their mathematics tutors' views on the cultural relevance of mathematics. A semi-structured interview guide was used to help elicit teacher trainees and their mathematics tutors' perceptions about the nature of mathematics whether cultural–related or cultural–free (Davis, 2010, Davis, 2016). The interview was conducted through personal interaction between the participants and the researcher. The interview, as confirmed by Boyce and Neale (2006), is a qualitative way of collecting data from respondents through the conduct of an intensive conversation with some respondents to seek their views on a given subject, situation, problem or programme. In the current study, the researcher used focus group interviews guide to collect information about issues that are of great importance.

The items in the focused group interview guide comprised seven (7) sets of an opened–ended questions and their corresponding follow-up questions subject to the views expressed by the respondents. The interview guide items for both teacher

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trainees and their mathematics tutors were constructed to find out why the observed perceptions from the quantitative analysis for each of the two groups were relevant to teaching and learning mathematics at Colleges of Education. The interview questions were adapted from Davis (2010) by the researcher based on the themes observed from the quantitative data analysis. In this study, the information obtained from focus groups was audiotaped and/or recorded (see Appendices C and D respectively).

Data Collection Procedure

Pilot Testing of Instruments

Pilot testing of the research instruments began in September 2022, following the ethical approval. This was carried out in the Kumasi metropolitan assembly in the Ashanti Region of Ghana with 100 research participants (teacher trainees) comprising 25 teacher trainees from each level. The researcher randomly selected this college (using the table of random numbers) from the colleges in the Kumasi metropolis in the Ashanti Region of Ghana. The researcher personally wrote a letter to the Principal of the college through the head of the mathematics and ICT education department to introduce himself and the project to them and to request their students' participation as well.

The Principal of the college through the head of the department agreed and gave permission. The researcher had a short meeting with mathematics tutors during the first break time in the staff common room to introduce the project to them and requested assistance in the administration of the questionnaires after which he gave each of them the explanatory statement and consent form. The researcher waited during the second break time and held another short meeting with the students at the college’s assembly hall, introduced the project with explanatory

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statements and gave them the same consent form. Students who volunteered to participate generally declared their intention immediately after the introduction of the research project. One hundred (100) participants voluntarily agreed to participate in the pilot study. The two instruments were pre-tested on teacher trainees' views only, because the questionnaire items as well as the interview guides were the same as the items for the mathematics tutors so it was prudent to use them instead. The researcher, mathematics HOD, and tutors together with student participants agreed on the date for pilot testing of the instrument for data collection

Pilot Testing of Questionnaires

The instrument (questionnaire) was pilot-tested on 100 teacher trainees from all four levels (level 100, level 200, level 300, and level 400). The questionnaire instrument was administered to 100 teacher trainees, 25 from each level in September 2022 in a nearby college of education that was not included in the main study to ascertain the validity of the instrument. The researcher on the agreed date for data collection again had brief consultations with the mathematics Head of Department (HOD), three mathematics tutors and the 100 selected teacher trainees at their assembly hall and the aim of the data collection exercise was explained to them, after which the consent forms and volunteer's agreement forms were given to the participants. The researcher administered the questionnaire to the selected teacher trainees at the assembly hall. Three mathematics tutors and a HOD helped by administering the questionnaire to the participants. The respondents were to point out the degree to which they agreed or disagreed with the questionnaire items on a four-point Likert-type scale. The duration of the questionnaire was 50 minutes and was collected as soon as the time was due from teacher trainees.

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After collecting the completed pilot test questionnaire from the respondents, the researcher processed the data and analysed it after which he visited the college for the second time to interview respondents about their understanding of the items in the questionnaire. This was to ascertain whether the items in the questionnaire conveyed the meaning the item was supposed to have conveyed to the research participants. Through that process the items that were ambiguous as well as those that were misinterpreted were identified and improved. It took each of the research participants of the pilot study an average of 50 minutes to fill in the whole questionnaire.

The reason for this pilot testing was to make sure that the questionnaire was effectively suitable for what it was intended to measure. The pilot testing again was important because it enabled the weak items in the questionnaire to either be reconstructed or removed to ensure a highly reliable resultant questionnaire for the main study.

Pilot testing of Structured Interview Guide

Two weeks after the administration of the questionnaires, the researcher then went back to the college to interview a group of 10 students. The interview session took a maximum of 50 minutes. The interviews were audio-recorded using two tested and verified recorders. Multiple recorders were employed to prevent any unexpected events during the interview sessions. The interview was piloted to confirm that its items were capable of eliciting the required responses from participants by the study's objectives, as well as to ensure that the interview guide's items were corrected as needed. This was done to ensure that a better instrument was sent out to the field to collect data for the main study.

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Dealing with threats to the Validity of Instruments

Any worthy research study depends largely on how well the researcher positioned his or her results and findings amid any conflicting hypothesis. Cohen et al (2018) proposed that, though both validity and reliability can be applied to different types of research, how they are applied to different research approaches varies. For any survey research to yield beneficial results, the essential factors that researchers need to consider are the validity and reliability of the instruments (scales) used in research. Any study conducted using a measuring instrument that does not possess any one or both of these features will not yield beneficial results (Sürücü & Maslakçı, 2020). In this study, the researcher was concerned about the robust nature of questionnaires and structured interview guides to ascertain the validity and reliability of research instruments.

Using a sequential explanatory mixed methods (SEMMD) approach for this study requires a consideration of issues of validity from both quantitative and qualitative perspectives. Worthless research is when a piece of research work is not valid. Dealing with the validity of instruments concerns the nature of what is valid, what validity means, how to know if one has achieved an acceptable level of validity, how to address validity in research terms and how validity enters design, inferences and conclusions (Cohen et al, 2018).

Fraenkel et al (2012) refers to validity as the inferences that are made by a researcher due to the suitability, accuracy, significance and usefulness of the data that he or she has collected using a particular instrument. However, for this study, it was appropriate for the researcher to check and deal with threats to three different kinds of validity (Content-Related, Construct-Related, and Cultural-Related) and how their threats were defused in the study. These three different related validities

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were used to establish the basis and facts which were used to connect the conclusions drawn from the data collected from teacher trainees and their mathematics tutors (Cohen et al, 2018; Creswell, 2013). Hence, the researcher needed to show the broad links made between the collection of data, suggestions and outcomes that supported the sense of explanations given in the face of null or alternative hypotheses.

Content-Related Validity of Instruments

Content validity also assesses whether a questionnaire is representative of all aspects of the construct or concept. To demonstrate content validity, the instrument must show that it fairly and comprehensively covers the sphere or items that it intends to cover (Carmines & Zeller, 1979; Drost, 2011). As noted in Fraenkel et al (2012), content validity is the subject matter and layout of the instrument. Thus, for the definition of the constructs and the sub-constructs of the main themes to be determined, then the subject matter and design need to be in harmony. This means that the content of a data collection instrument must cover all the important aspects of the concept it is intended to measure. In this current study, the constructs influencing teacher trainees' and mathematics tutors' receptiveness to the cultural relevance of mathematics as identified in the literature were conspicuously reflected in the operationalisation of the conceptual framework and the structuring of the questionnaire and interview guide items.

The conceptual components influencing teacher trainees and their mathematics tutors' receptiveness to the cultural relevance of mathematics were operationally defined in terms of teacher trainees and tutors' perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perception about links between culture and mathematical knowledge, perception about links

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between culture and mathematics pedagogy, and perceptions about links between culture mathematics curriculum as whether cultural–free or cultural–related (Davis, 2016). These are no known and extensive conceptions for measuring an individual's mathematical and mathematics education views, including cultural objects which were reflected in the operationalisation and defined in the course of the study. Moreover, both questionnaire and interview guide items were carefully checked out to obtain a fair representation of all the variables involved in this research work.

The main concepts that supported the factors influencing receptiveness to the cultural relevance of mathematics were defined briefly in this study. This ensured a fair representation of all the constructs involved in this study. In a nutshell, the contents of perceptions were fully covered and fairly sampled for the construction of both questionnaire and interview guide items used for the data collection. Therefore, content-related validity was appropriately dealt with in this study.

Construct-Related Validity of Instruments

Construct–related validity was considered in this study through the use of correlation to find out whether the degree to which measures of the same constructs were well correlated and the degree to which measures of different constructs were nominally correlated. Construct validity shows the degree to which the data collection instruments measure the underlying characteristics they intend to measure (Vaske et al, 2017). A construct is defined as a characteristic of individuals (such as intelligence, belief, attitude, gender equity, and so on) or concepts that is not immediately noticed but may be studied by looking at other indicators that are related to it (Middleton, 2019). Construct validity assures that the techniques

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involved in measuring the concepts are consistent with the construct that is being measured.

According to Middleton (2019), construct validity also looks at whether a measurement tool accurately represents what one wants to measure. To achieve construct validity, the researcher must ensure that their indicators and measurements) are systematically designed based on the existence of important knowledge. Construct validity refers to the definition, operationalisation, and exhaustion of elements of the examined construct in a research study (Creswell & Creswell, 2018; Creswell, 2009; Cohen et al, 2018; Fraenkel et al, 2015).

The perception constructs for this study were defined following the definitions provided by different researchers (Davis, 2010, 2016; Ernest 1989) in the field of mathematics education. The components for each construct were demonstrated and represented in the research instruments (questionnaire and interview guide items) used in measuring the constructs. For instance, the sub-constructs (Perceptions about Mathematical Knowledge, Perceptions about Mathematics Pedagogy, Perceptions about links between Ghanaian Culture and Mathematical Knowledge, Perceptions about links between Ghanaian Culture and Mathematics Pedagogy, and Perceptions about Links between Ghanaian Culture and Mathematics Curriculum) of teacher trainees and their mathematics tutors which were examined, scrutinised, and corrected by experts and members of the mathematics education community of the University of Cape Coast before and after the pilot test were correctly defined and operationalised in this study.

The descriptive statistics findings and inferences made from this research study reflected the views held by teacher trainees and their tutors on the concept of receptiveness to the cultural relevance of mathematics teaching and learning. As a

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result, the specific concept acquired from this study was also defined in terms of cultural-related (perceptions that take cognisance of mathematics in the out-of-school setting), and cultural-free (perceptions that do not recognise mathematics as a cultural object) views as indicated in Davis (2010, 2016), depending on the level of presentation or display of each construct by teacher trainees and their mathematics tutors at the selected Colleges of Education (using mean ratings as the benchmark for measuring), in Bono, Bono East, and Ahafo Regions of Ghana. Hence, the above demonstrations indicate how threats to construct validity were neutralised in this study.

Cultural-Related Validity of Instruments

The concept of receptiveness (e.g., beliefs and attitudes) is known to be socio-culturally constructed (Burr, 2015; Seah & Bishop, 2000) through the interactions that take place in and out of school the mathematics classroom. For this reason, the instruments used in collecting data on the views of individuals about their perceptions about cultural aspects of mathematics teaching and learning necessarily should be able to provide culturally valid information (Cohen et al, 2018; Creswell & Creswell, 2018; Creswell, 2009) upon which relevant and meaningful inferences can be made from its findings. Thus, the questionnaire and structured interview guide instruments were constructed to reflect the College of Education mathematics classroom environment taking into consideration the cultural knowledge, attitudes, and belief systems of the people of these areas where the selected colleges are located including the college used for the pre-test of the instruments. This ensured good classroom discourse which made teacher trainees and their mathematics tutors comport themselves well to the exercise.

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Besides, the items in the instrument were constructed in the form of four-point Likert scale types from Strongly Agree (SA = 4) to Strongly Disagree (SDA = 1). The other items were three dichotomous questions in the form, Yes =1 and No = 2, the two check box questions and four open-ended short answer form questions making a total of fifty (50) items were used for this study. Some of the items were revised or replaced to get a fair representation of all the variables in the study. The questionnaire items were constructed to reflect the practices that take place in the Colleges of Education settings and the context of Bono, Bono East, and Ahafo Regions of Ghana.

The structured interview guide items were adapted by the researcher based on respondents' perceptions about the nature of mathematics teaching and learning at the College of Education situation and the culture within the communities where the study was conducted. English was used as an official language in the construction of the instruments which were employed for data collection. The English language has been the medium of instruction in Ghanaian schools including Colleges of Education in Ghana due to the colonisation by the British and hence, the reading and understanding of the items in both questionnaire and interview instruments was not a problem for both mathematics tutors and teacher trainees.

Dealing with threats to the Reliability of Instruments

Reliability is concerned with precision and accuracy in measuring a given variable. From the perspective of research, reliability is the ability to demonstrate that if the study is replicated on a similar group of respondents in a similar defined context it would yield similar results. This calls for internal consistency in the research instruments used for the data collection. To obtain high reliability in this study, the researcher verified the questionnaire instruments to ensure that they were

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appropriate for the College of Education mathematics classroom setting, as well as the Ghanaian mathematics classroom.

In this study, internal consistency reliabilities for perception constructs instruments were obtained through the use of Cronbach's alpha values that specifically, represented how well each of the items of an instrument relates to the rest of the instrument items (Cronbach, 1990). Therefore, to generate the reliability of the instrument for the pre-testing study, the items under the key constructs influencing the receptiveness of teacher trainees and their tutors to the cultural relevance of mathematics were set to reliability analysis. Based on the results obtained from the pre-test as the result of the Reliability Analysis, the scale constructions were made to determine the reliability coefficients of the constructs using Devillis (2012) reliability benchmarks.

Consequently, the items on perceived variables influencing teacher trainees' and their mathematics tutors' receptiveness to the cultural relevance of mathematics teaching and learning were put to Cronbach alpha analysis. Thus, The Cronbach's alpha for the perceived factors after the reliability analysis in the pilot- testing college were perceptions about mathematical knowledge (Cronbach's $\alpha = 0.824$), perceptions about mathematics pedagogy (Cronbach's $\alpha = 0.819$), perceptions about links between Ghanaian culture and mathematical knowledge (Cronbach's $\alpha = 0.820$), perceptions about links between Ghanaian culture and mathematics pedagogy (Cronbach's $\alpha = 0.771$), and perceptions about links between Ghanaian culture and mathematics curriculum (Cronbach's $\alpha = 0.798$) indicating the reliability of the instrument, with overall Cronbach's alpha = 0.824.

A Cronbach alpha reliability coefficient of 0.7 and above in social science research is a good measure (Pallant, 2005, 2011, 2020)). Therefore the reliability

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of the constructs obtained generally showed good internal consistency. In the process, the weaker and unclear questionnaire items were reconstructed to ensure a high reliability coefficient for each construct observed in the study.

Besides, data collected from the pre-test interview sessions were transcribed to see whether the responses obtained were in the position to provide answers and explanations to the research questions that guided the study.

The main study's results and findings were reported objectively, without the researchers' perspective or biases influencing the outcomes. The use of a sequential explanatory mixed-methods design approach enabled the qualitative data to provide a better understanding and explanation of the results and findings obtained from the quantitative approach.

Data Collection for the Main Study

After obtaining an institutional ethical clearance approval, a formal introduction letter from the Department of Mathematics and ICT education, the University of Cape Coast, and an official letter from the researcher (see Appendices I and J respectively) were sent to the respective selected Colleges of Education to seek out permission from the principals and decided on the planned date of collecting data for this current study. The researcher then had further discussions with the heads of mathematics departments who helped in the data collection process. On the day of the administration of questionnaires in each selected College of Education, a formal introduction was made to the principals, mathematics tutors, and their teacher trainees. The purpose of the study was then explained to them and the questionnaires were administered to teacher trainees by the researcher personally with the assistance of the five respective heads of the mathematics department (HODs, one from each college). One thousand, one hundred and sixty

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(1,160) teacher trainees in first-year to fourth–year offering B.Ed. Primary education, B.Ed. Early Grade education, and B.Ed. JHS education taking mathematics as either a core or an elective course was used for the administration of the questionnaire. They were made to sit in their lecture rooms and were given copies of the questionnaire to respond to. The items on the questionnaire were then explained to them. Having secured the necessary permission and statements of consent from all the participants, it was now time for data collection. The respondents were then given codes to indicate on their instruments. Further explanations were provided by the researcher on some items in the questionnaire which some respondents found difficult. Teacher trainees were given adequate time to read and respond to the items. Close supervision was made so that the participants did not have the chance to confer or discuss with each other. The allocated time for responding to the questionnaire items was 50 minutes.

The mathematics tutors' questionnaires were administered individually depending on their free periods on that particular day at the mathematics department offices and a staff common room. As with teacher trainees, the purpose of the study was explained to the mathematics tutors in their respective colleges. The administration of mathematics tutors' questionnaire followed immediately after their teacher trainees had finished. Also, the allocated time for responding to the questionnaire items was 50 minutes

Three weeks after the analysis of the questionnaire responses (quantitative data) to obtain the views held by the teacher trainees and their mathematics tutors (as whether cultural-related or cultural-free), the researcher went back to the respective colleges to conduct the focus group interview sessions for all 34 mathematics tutors and ten (10) teacher trainees whose perceptions on the

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questionnaire items were either highly cultural–related or cultural–free (i.e. 10 focus group from each college). A process that had already been followed for the pre-test of the instruments.

Again, permission and assistance from the principals and mathematics HODs in the respective colleges were sought for an interview session. The focus group interview sessions for both teacher trainees and mathematics tutors in each college were conducted at the assembly halls and mathematics department offices. The interview sessions were conducted by the researcher himself to ensure the confidentiality of the respondents' views. The sessions were conducted in turns during their break time on that day. Each interview session took a maximum of 50 minutes depending on the follow-up questions that arose during the interview. The responses resulting from the interviews were recorded using the coding book and, two tested and verified audio recorders to protect and ensure the maximum security of the qualitative data set.

Data Processing

Xia et al (2015) refers to the data processing as how the raw data collected are organised into computer-readable form by carefully examining, cleaning, transforming and modelling by the researcher to reveal important information, inform conclusions and uphold decision-making.

In this study, the quantitative data from the responded questionnaires were checked, examined, and cleaned for facial errors such as double ticking and unticked items. The questionnaire items were then keyed into the SPSS application software and the responses were coded using the four-point Likert type scale, dichotomous, open-ended questions, and check box type given on the questionnaires. The responded questionnaires were coded as follows: four-point

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Likert scale (Strongly Agree = 4, Agree = 3, Disagree = 2, and Strongly Disagree = 1; dichotomous response as Yes = 1 and No = 2. The four open-ended short form questionnaire items were coded as cultural–related = 1 and cultural–free = 2. The remaining check box items were keyed as (Measurement = 1, Lines and Space = 2, Fractions = 3, Data handling = 4, Game of chance = 5, Operations on numbers = 6, Word problem solving = 7, More than one choice = 8, and Other specification = 9; Counting = 1, Measuring = 2, Locating = 3, Playing = 4, Designing = 5, Explaining = 6, More than one choice = 7, and Other specification = 8). The data was then edited for observable entries and typographical errors in the SPSS application. The questionnaire items that showed negative correlations during the test run were recorded for them to correlate positively before the actual run of the analysis.

On the part of the qualitative analysis, the statements from the interview session recordings were thoroughly listened to repeatedly by three independent mathematics education experts (the researcher himself and two other mathematics tutors) and wrote exact reports played from the recorded audio tapes in a transcription book after listening to the same statements several times. The in–print statements were then rewritten to be read well and compared to the cultural-related mathematics perspectives that were under discussion during the interview session. This is then assigned to the appropriate cultural perspective viewed as a reason. On the other hand, if the statement is not explicit at the initial stage, then the statement is restructured to make sure that the keywords or the themes are retained in order not to change the focal idea of that statement or sentence. This process was repeated for all the five selected colleges under study and any other perceptions collected for each mathematical culture conception receptive by both teacher trainees and their mathematics tutors were generated. These included the cultural relevance of

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mathematics perceived by teacher trainees as one part and their tutors as another part and vice versa. The statements were transcribed using themes and sentence meanings developed from the concepts operationalised in the study. For the qualitative analysis, however, the data was analysed differently (transcription) since different qualitative and quantitative data were generated.

Data Analysis

Data analysis is significant in scientific research because it helps the researcher explain, answer, and test the linkages between research problems, questions, and hypotheses, allowing conclusions to be drawn (Eldridge, 2024). To answer the research questions raised and the hypothesis formulated for this study, both quantitative and qualitative data collected from teacher trainees and their mathematics tutors were analysed.

Quantitative Analysis

For the quantitative analysis, both descriptive (percentages, means and standard deviations) and inferential statistics (MANOVA) in the SPSS software application were used to analyse the data. The internal characteristics of the named perceptions were reported using the percentages, means, and the standard deviations. The cultural-free and cultural-related (Davis, 2010, 2016; Presmeg, 1998) perspectives were identified using the means of the named key construct variables (perceptions about mathematics). A one–way multivariate analysis of variance (MANOVA) was applied to determine the effects of gender on both teacher trainees and their mathematics tutors' receptiveness to cultural relevance of mathematics by comparing whether there are significant differences in the mean scores of dependent variables.

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Again, (MANOVA) was used to determine the effects of the programme of study (B.Ed. Early Grade, B.Ed. Primary, and B.Ed. JHS); and grade levels (100, 200, 300, and 400) on teacher trainees' receptiveness to the cultural relevance of mathematics by comparing the mean scores of the named variables to determine whether there were significant differences in the mean scores on the dependent variable (perception constructs) for the study.

Finally, MANOVA was applied to determine if significant differences existed between the views held by both teacher trainees and their mathematics tutors. In this study, the continuous variables (dependent variables) were the views held in mathematics teaching and learning obtained by descriptive analysis. These perceptions of mathematics held by both teacher trainees and their mathematics tutors were transformed into continuous (dependent) variables based on the items related to the questionnaires for the two respective groups(teacher trainees and tutors). This was done by the use of 'transform and compute variable' in the SPSS software. On the other hand, the teacher trainees and their mathematics tutors constitute the categorical (independent) variables

The assumptions of sample size, independence of observations, Normality, linearity and Homoscedasticity, and Homogeneity of variance-covariance matrices were tested before the analysis of the variables. To test linearity, a scatterplot was examined for each pairwise relationship to assess whether a linear relationship exists. Kolmogorov-Smirnov tests were conducted to assess whether each of the variables resembles a normal, bell-shaped distribution.

Qualitative Analysis

The data collected through the interview guide was carefully transcribed using codes, categories, and themes that were developed to generate frequency

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counts based on which the findings would be reported(Hill et al, 2019). To ensure the reliability of the qualitative data, a coding book was used to record the definitions and themes of concepts that were used in the study (Yin, 2009). The transcriptions were scrutinised to avoid easily discovered errors and obvious mistakes that would be made in the course of the transcription procedure during the transcription process (Gibbs, 2007). The transcription was done independently by the researcher and another independent expert in mathematics education after which the resulting results would be compared to raise the validity of the results. These results from the interviews were then used to explain the possible reasons for demonstrating the observed views after the quantitative analysis, to report a relatively impartial situation about the problem. Each interview was audio-recorded and after carefully listening, transcribed for coding and constructing themes. The major themes that evolved through thematic analysis of the interview data were: *mathematical/scientific concepts, Problem-Solving*; *Daily Life Application*s*; Discipline/Field of Study, Teaching and Learning Approaches, and Language use and Preference*. Each theme was described and interpreted to explain the data analysed in the quantitative stage.

Generally, the researcher obtained five focus groups from the five colleges of education for the teacher trainees which were represented as FGTTA, FGTTB, FGTTC, FGTTD, and FGTTE for teacher trainees from colleges A, B, C, D and E respectively. The focus groups for the 34 mathematics tutors with college names attached to individual college participants were also coded as FGMTA, FGMTB, FGMTC, FGMTD, and FGMTE for mathematics tutors from colleges A, B, C, D and E respectively. These codes were assigned to the responses for each response with a specific focus group. In a case where several focus groups gave the same or

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similar reason for the same statement, different codes may be assigned to one of those statements. Characteristics expressing common views held were grouped further and the relevant name was assigned to that set of elements that served a reason to that held view.

In analysing the qualitative data thematically, all the key characteristics relating to perception variables were identified in each statement by highlighting them. The numerous reasons given by both teacher trainees and their mathematics tutor in support of their relevant views were presented under research question one in chapter four. These results from the interviews were then used to explain the possible reasons for showing the perceived knowledge after the quantitative analysis, to report a comparatively fair position about the problem.

Ethical Issues

This research study involved human participants. Some ethical issues may be likely to arise during this study. Many researchers emphasised the need to take ethics into account while investigating social research and methodology. Ethics has been defined as a matter of principled sensitivity to the rights of others (Cohen et al, 2013, 2017; Cavan, 1977). Therefore it is imperative to demonstrate how these issues were addressed in this study. Some of the ethical issues ensured in this study were as discussed in the subsections that follow:

Ethical Issues in the Research Problem

To build trust, confidence, and respect with the respondents, the researcher made sure that the items in the questionnaires and the interview guide were well structured to meet the demands of the problem being studied. This research study does not tend to disregard any individual participant involved. This was properly checked during the pre-testing of the research instruments. Therefore, all

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participants were treated equally to avoid any biases as far as data collection is concerned.

Ethical Issues in the Purpose and Questions

The researcher, in this case, delivered and explained the purpose of the research to the participants so that both respondents and the researcher would have the same purpose in mind. This was achieved through the use of the English language which is the official language and medium of instruction in all levels of education in Ghana including Colleges of Education. Because all the participants were legible and fluent in the English language and for that matter, understanding and interpreting the instructions for the items in the questionnaire and interview guide did not pose any serious challenge to them.

Ethical Issues in Data Collection

To safeguard and value the rights of participants, the plan of this research study was sent to the Institutional Review Board (IRB) to be reviewed. Also, an Informed Consent Form was designed for respondents to sign before they take part in the research. This was to acknowledge the respondents' rights and protection during data collection and also to assure them that the information that may impinge on their rights will remain confidential. For that reason, the participants have the right to opt out of participating in this research study. The questionnaire for teacher trainees and their mathematics tutors as well as structured interview guides were administered in well-spaced and ventilated classrooms and offices to ensure stress-free conditions in the classrooms.

Ethical Issues in Data Analysis and Interpretation

This is to guarantee that the identities of the respondents are protected during and after the data collection process. Hence, pseudonyms were used in this study

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and the names and index numbers of the participants were detached from the responses at all stages of data processing and analysis, especially in both the questionnaire and the interview. The data as soon as collected and analysed could be kept by only the researcher and would not be accessible to anybody or association. In this study, the analysed data has still been kept under lock and key for one year after which it would be discarded by the researcher so that it does not fall into another hands.

Ethical Issues in Psychological Effects on Pedagogy

The study did not attribute any particular pedagogical approach and only explored the views held by teacher trainees and their mathematics tutors on the cultural relevance of mathematics, and also ascertain whether their views are cultural-related or cultural-free. In this case, both teacher trainees and mathematics tutors were made to respond to both questionnaires and interview guides for this study using the pedagogical approaches familiar to them. However, the researcher explained to the participants that there would be no psychological effects on pedagogical approaches that are expected since no additional or new pedagogical approach would be introduced. Although there are no known direct psychological effects from teaching and learning outcomes, the study allowed the teacher trainees and their mathematics tutors in the selected colleges to respond to appropriate pedagogical designed questions to strengthen their views that would be predictable as receptiveness to the cultural relevance of mathematics.

Ethical Issues in Writing and Disseminating the Research

Unfair Language or words that are against individuals just because of, racism or ethnicity, issues of gender or sexual orientation, disability, or age were not entertained in this research. Besides, this study did not indulge in any falsification

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whatsoever or scheme of findings resulting from the results of the study. In another vein, the researcher did report objectively on the findings generated to reflect the views of teacher trainees and their mathematics tutors perceptions on the cultural relevance of mathematics teaching and learning in Bono, Bono East, and Ahafo Regions of Ghana.

Chapter Summary

The primary purpose of this chapter was to explain and present the main research methods and tools employed in conducting this research study. First, the chapter discussed the type of research design that underpins this research and its appropriate paradigm. The design was identified to be the sequential explanatory mixed-methods design. The description of the study area for the research was to give a fair knowledge about the characteristic nature of the people in this area.

The chapter again presented the population, the sample, the sampling procedure, the research instruments, the data collection procedure, as well as data processing and analysis. In addition, this chapter discussed how the pilot pre-test was conducted by the researcher to validate the research instruments used for the data collection. Besides, the researcher illustrated how the validity and reliability of the research instruments were ensured in the main study. The chapter discussed how ethical issues were addressed in the study.

The next chapter, Chapter Four presents the results obtained from the data analysis and discussion based on the research questions and hypothesis that guided the study.

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CHAPTER FOUR

RESULTS AND DISCUSSION

The purpose of the study was to explore teacher trainees and their tutors' receptiveness to the cultural relevance of mathematics and also to ascertain whether their views are cultural-related or cultural-free (Davis, 2010, 2016). In the previous Chapter Three, the methods employed to achieve the stated purpose were presented. In this chapter, the results obtained from the study were presented based on the research questions and the hypothesis formulated to guide the study in Chapter One. The presentation of the results began with the biographical data of the respondents, the test of assumptions for the statistical tools that were used for the study, followed by the findings and discussion of the results, and ends with a summary of the chapter.

Results

The next section that follows illustrates the data analysis results as well as how the study's research questions and hypothesis were addressed.

Biographical Data of Participants

The result of teacher trainees' biographical data was presented first followed by their tutors'

Teacher Trainees

A total of one thousand, one hundred and sixty (1,160) teacher trainees taking mathematics as either a core or an elective subject from the five selected Colleges of Education took part in this study. The biographical distributions of the teacher trainees from the five selected Colleges of Education in Ghana are shown in Table 3.

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Table 3 : Biographical Characteristics of Teacher Trainee (N = 1,160)

Biodata	Category	N	Percentage (%)
Sex	Female	564	48.6
	Male	596	51.4
	Total	1,160	100.0
Age(in years)	Less than 23yrs	238	20.5
	23-28yrs	823	71.0
	29-34yrs	78	6.7
	35yrs and above	21	1.8
	Total	1,160	100.0
Programme of Study	B.Ed. Early Grade Education	133	11.4
	B.Ed. Primary Education	459	39.6
	B.Ed. JHS Education	568	49.0
	Total	1,160	100.0
Level	Level 100	270	23.2
	Level 200	300	25.9
	Level 300	300	25.9
	Level 400	290	25.0
	Total	1,160	100.0

SOURCE: FIELD DATA (2022)

The results from Table 3 showed that out of a total number of one thousand, one hundred and sixty (1,160) participants, 238(20.5%) were less than 23 years old, large majority 873 (70.9%) were within the range of 23 – 28 years, while 78 (6.7%) were within the age range of 29 – 34 years. The remaining 21 (1.8%) were 35 years and above. One hundred and thirty–three (133) comprising 11.46% were pursuing Early Grade programmes, while 459 (39.57%) were offering Primary education. The majority 568 (48.97%) were studying JHS education and taking mathematics

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as an elective or core subject. This clearly showed that almost half of the teacher trainees who participated in this study are taking mathematics as an elective subject. The distribution of teacher trainees in the four (4) levels were: 270 (23.2%) in level 100, 300 (25.9%) in level 200, 300 (25.9%) in level 300, and 290 (25.0%) in level 400. Approximately the same number of participants were drawn from each level. This ensures a fair representation of the results.

Mathematics Tutors

A total number of thirty-four (34) mathematics tutors were purposively selected from the five (5) selected Colleges of Education that were used in this study. The biographical distributions of the tutors were presented in Table 4

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Table 4 : Biographical Characteristics of Mathematics Tutors (N = 34)

Biodata	Category	N	Percentage (%)
	Female	3	8.8
Sex	Male	31	91.2
	Total	34	100.0
Age(in years)	Less than 29 years	0	0.0
	30 – 39 years	4	11.8
	40 – 49 years	24	70.6
	50 years and above	6	17.6
	Total	34	100.0
Highest Academic qualification	BSc/B.Ed.	0	0.0
	MPhil/MSc/M.Ed.	30	88.2
	PhD	4	11.8
	Total	34	100.0
Working Experience at the College level	Below 5 years	6	17.6
	5 – 10 years	14	41.2
	11 years and above	14	41.2
	Total	34	100.0
A native of community teaching	Yes	9	26.5
	No	25	73.5
	Total	34	100.0
Communicating with students in their dialects	Never	1	2.9
	Once or two times	16	47.1
	Three or four times	2	5.9
	More than four times	15	44.1
	Total	34	100.0

SOURCE: FIELD DATA (2022)

The results from Table 4 showed that, out of thirty-four (34) mathematics tutors who were purposively sampled from the five selected Colleges of Education

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in Ghana to take part in this study, 3 (8.8%) were females and 31 (91.2 %) were males. The sample distribution of mathematics tutors from colleges A, B, C, D and E were 6, 6, 9, 5 and 8 respectively. 4 (11.8 %) of the mathematics tutors have ages within the age bracket of 30 – 39 years, 24 (70.6 %) of them were within the age group of 40 – 49 years, 6 (17.6 %) of them were within the range of 50 years and above. Mathematics tutors who have taught below 5 years in their respective Colleges of education were 6 (17.6 %), from 5 – 10 years were 14 (41.2 %), while those who have teaching experience of 11 years and above at the colleges were 14 (41.2%). The majority of mathematics tutors, 30 (88.2%) have their highest academic qualification of MSc/Med/MPhil, whereas 4 (11.8%) have PhD as their highest academic qualification. All the mathematics tutors sampled from the five selected Colleges have taught at least one of the three B.Ed. programmes in their respective colleges.

Again, a substantial majority, 33 (97.1%) have a specialty in mathematics major and 1(2.9%) teaches mathematics as a minor. A total of thirty–four (34) mathematics tutors, 9 (26.5%) of them were natives from the community in which they teach, while 25 (73.5%) come from communities different from the study area. Of a total number of thirty–four (34) mathematics tutors, 1 (2.9%) has never spoken the dialects of the students in class before, 16 (47.1%) communicate once or two times with students' dialects while only 2 (5.9%) communicate three or four times with dialects of students during mathematics teaching. The remaining 15 (44.1%) do communicate more than 4 times with students' dialects in the classroom.

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Test of Assumptions on Statistical Tools used in this study

Assumptions for conducting MANOVA

For a Multivariate Analysis of Variance (MANOVA) to be conducted for the effect of gender on both teacher trainees and their mathematics tutors, the effect of teacher trainees' programme of study, the effect of teacher trainees' grade levels, and differences between the views held by teacher trainees and their mathematics tutors on the cultural relevance of mathematics, five key assumptions should be considered namely, Sample size, independence of observations, Normality, linearity and Homoscedasticity, and Homogeneity of variance-covariance matrices. These key assumptions were checked before the actual analysis.

Assumption of Sample Size

To satisfy this assumption, the sample size should be adequate. In this study the sample sizes for the two groups were considered to be generally large enough to produce valid results as they were more than 30 (1,160 and 34) in each case

Assumption of Independence of Observation

This is the assumption that observations should be independent of one another. Independence of observations was not violated since the two sets of respondents (teacher trainees and mathematics tutors) used in this study were independent groups. The administration of the questionnaires and data analysis were done independently.

Assumption of Normality

This assumption expects that, the dependent variables should be approximately follow multivariate normal distribution with each group formed by levels of the independent variables. The normal curve imposed on the histogram for the teacher trainees' data set seems normally (bell-like shape) distributed. For the

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mathematics tutors' data set, the distribution seems slightly skewed to the right (positively skewed), but the bell-like shape can be observed. The normality graphs for both teacher trainees and their mathematics tutors were presented in Figures 8 and 9 respectively.

Teacher Trainees

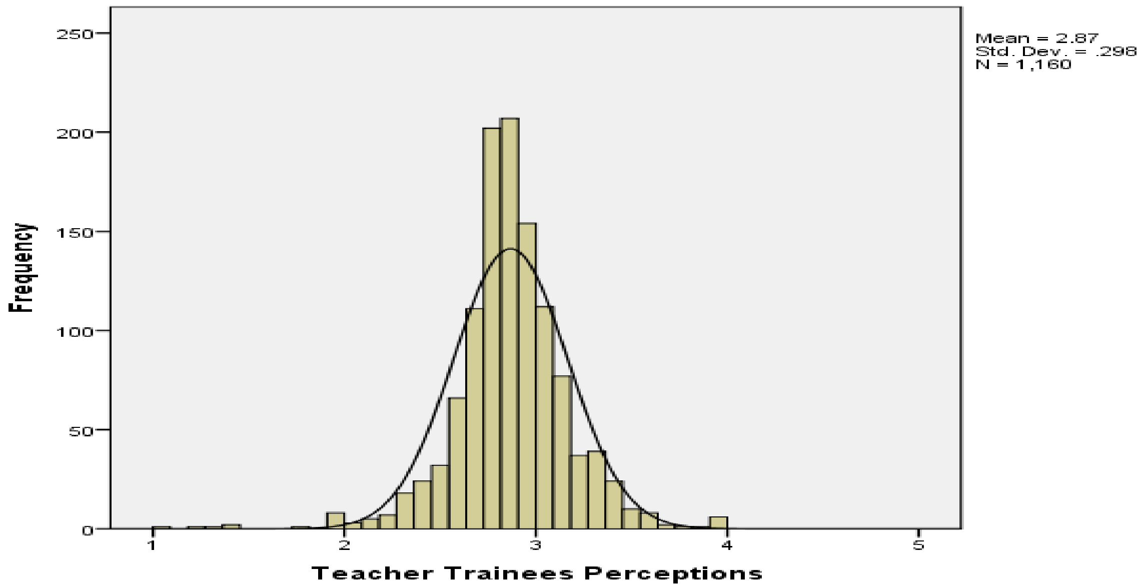

Figure 8: Normality of Teacher Trainees' Data Set
SOURCE: Field Data (2022)

Mathematics Tutors

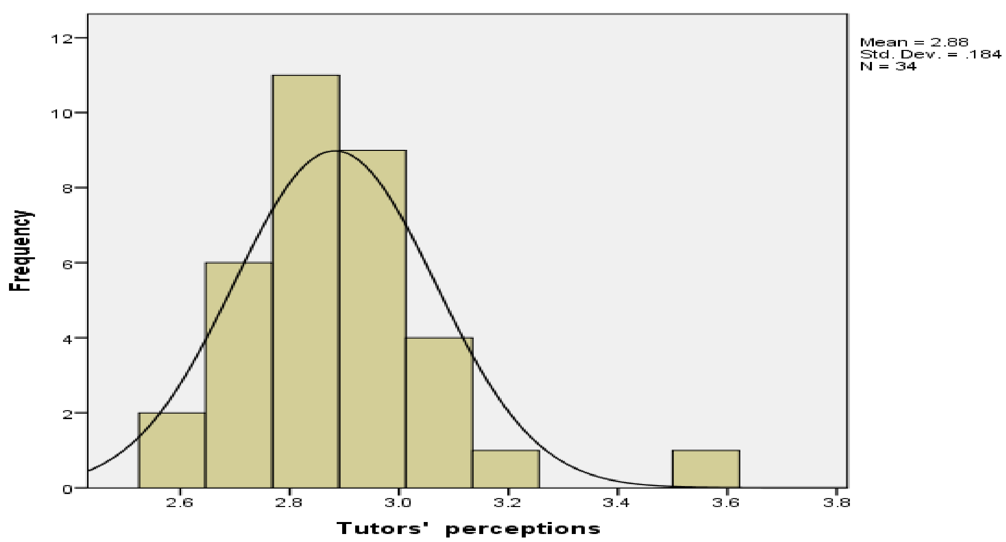

Figure 9: Normality of Mathematics Tutors' Data Set

SOURCE: Field Data (2022).

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Results of Kolmogorov-Smirnov[a] normality tests for mathematics tutors and teacher trainees' views revealed that tutors' overall perception group variables Sig. value of 0.158 greater than α value of 0.05 indicating normality. While teacher trainees' perception group variables Sig. value (0.000) less than α value of 0.05, suggesting the violation of the assumption of normality (see Appendix E). However, the actual shape of the distribution for each group can be seen in the histograms (see Figures 8 & 9). The scores appear to be reasonably normally distributed and this is supported by closed inspection of normal probability plots (i.e. Normal Q–Q Plot, see Appendix G) with reasonably straight lines.

Assumption of Linearity and Homoscedasticity

This assumption expects a linear relationship among all pairs of dependent variables with each group of independent variables. In this study, the linearity between the two data sets was observed to be around a positive straight line, indicating there exists a sort of moderate positive relationship between them. Therefore, the linearity assumption was not violated in this study (see Figure 10).

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SCATTER PLOT FOR TEACHER TRAINEES AND TUTORS

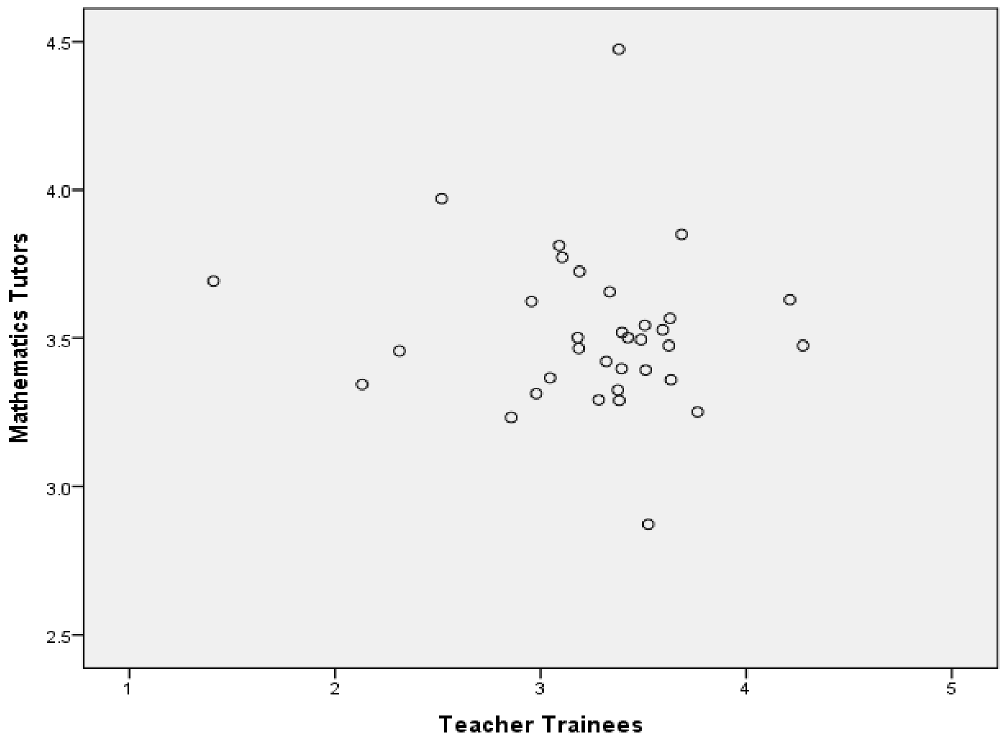

Figure 10: Scatter Plot Showing the Relationship between Teacher trainees' and their Mathematics Tutors' Data Sets.

SOURCE: Field Data (2022)

The homoscedasticity was also checked as the nature of the resultant scatter plot for the two data sets. It was observed that there appeared to be a cigar shape in a slight diagonal direction (see Figure 10). Again, linearity was also checked using a matrix of scatterplots between each pair of variables separately for teacher trainees and tutors. These matrix plots showed evidence of linearity, therefore the assumption of linearity was satisfied (see Appendix F)

Assumption of Homogeneity of Variance–Covariance Matrices

This assumption expects that the covariance matrices of dependent variables are equal across the groups. This means that the variability of scores for each of the groups should be similar. The result of Levene's tests for equality of variances indicated significant alpha values greater than 0.05, which suggests that variances

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for the two groups can be assumed to be equal and therefore the assumption of homogeneity of variance was met (see Appendix E). Again the homogeneity of group sizes was checked by inspection of the sample sizes for each group variable. For this study, the group sizes were approximately equal which indicated that the validity of the results was not affected. Finally, the homogeneity of covariance matrices was also examined, and the Box's M Test of Equality of Covariance Matrices showed a Sig. value (0.173) greater than 0.05 which suggests that the assumption has not been violated (see Appendix. E)

Cultural-Related Views Held by Teacher Trainees and their Mathematics Tutors about Mathematics

Research question one sought to explore the views of teacher trainees and their mathematics tutors about mathematics and to ascertain whether their views are cultural–related or cultural–free. Results from the questionnaire survey were presented under these five areas of perceptions namely perceptions about mathematical knowledge (PMK), perceptions about mathematics pedagogy (PMP), perceptions about links between Ghanaian culture and mathematical knowledge (PGCMK), perceptions about links between Ghanaian culture and mathematics pedagogy (PGCMP), and perceptions about links between Ghanaian culture and mathematics curriculum (PGCMC)). The results from the questionnaire items were presented as planned in the previous chapter (three).

The results of teacher trainees' responses to the questionnaire survey and focus group interview were presented first followed by the results of their mathematics tutors. Teacher trainees' perceptions were presented separately from their tutors' perceptions due to their separate roles in the Colleges of Education system. Presenting teacher trainees and mathematics perceptions separately will

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therefore help the researcher to ascertain how similar or different their perceptions are. Though the mean scores and standard deviations are appropriate for the Likert-type items, the mean scores were mostly used and treated as indicative of possible information in the study. The mean scores were used to report trends of cultural-related perceptions about mathematics as well as the percentages.

Teacher Trainees' Perceptions about Mathematics

In this section, the results of the teacher trainees' perceptions about mathematics were presented. The items were rated to analyse the teacher trainees' responses to the questionnaire's Likert-type items. All culture-free items, for instance, "Mathematics should only be studied by bright people in the society" and "Mathematics should be made an optional subject at all levels including Colleges of Education level" were rated as follows: Strongly Disagree - 4, Disagree-3, Agree-2 and Strongly Agree– 1. All the culture-related items were rated as follows: Strongly Agree - 4, Agree - 3, Disagree - 2 and Strongly Disagree – 1. Thus, this item "mathematics should only be studied by bright people in the society" and all culture-free (CF) items were reversal items when the means were calculated. Therefore, a mean scores of 2.5 to 2.9 show the trends to cultural-related perceptions while mean scores of 3.0 to 4.0 shows cultural-related (CR) perceptions.

However, a mean score of 2.4 and below indicates culture-free (CF) perceptions for each item in the Likert-type items. The results from the Likert-type items were summarised in Tables 6, 7, 8, 10 and 12.

The presentation of the result analysis of research question one was preceded by the presentation of the means, standard deviations, and reliability (Cronbach's alpha) values of perception constructs held by teacher trainees (see Table 5).

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Table 5 : Means, Standard Deviations, Cronbach's Alpha Values of Teacher Trainees' Perceptions about Mathematics (N = 1,160)

Teacher trainees' views about mathematics	Number of items	Mean	Standard Deviation	Cronbach's Alpha
Perceptions about mathematical knowledge	10	2.89	0.374	0.794
Perceptions about Mathematics Pedagogy	9	2.62	0.465	0.804
Perceptions about links between Ghanaian culture and mathematical knowledge	6	2.61	0.457	0.822
Perceptions about Links between Ghanaian Culture and Mathematics Pedagogy	12	3.03	0.384	0.781
Perceptions about links between Ghanaian culture and Mathematics Curriculum	4	3.18	0.459	0.812
OVERALL	**41**	**2.87**	**0.298**	**0.843**

SOURCE: Field Data (2022)

As indicated in Table 5, the means and standard deviations of five (5), perceptions about mathematics held by teacher trainees as a result of "transform and compute" variable in SPSS included: Perceptions about mathematical knowledge (M = 2.89, SD = 0.374), Perceptions about mathematics pedagogy (M = 2.62, SD = 0.465), Perceptions about links between Ghanaian culture and mathematical knowledge (M = 2.61, SD = 0.457), Perceptions about links between Ghanaian culture and mathematics pedagogy (M = 3.03, SD = 0.384), and Perceptions about links between Ghanaian culture and mathematics curriculum (M = 3.18, SD = 0.459) respectively. In addition, three held views indicated the trend to cultural-related perceptions while the remaining two were cultural–related.

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The Cronbach alpha value for each construct shows a strong level of internal consistency within the perception items forming those constructs. Table 5 shows the range of the Cronbach alpha reliability coefficients were 0.781 – 0.822 for teacher trainees. The alpha coefficients were within the acceptable value of 0.60 for purposes of research (Nunnally, 1978; Henderson et al, 1998).

The results of descriptive statistics of the views held by teacher trainees in Table 5 were addressed separately on the number of items under each construct.

Teacher Trainees' Perceptions about Mathematical Knowledge

Table 6 presents the results of teacher trainees' perceptions about mathematical knowledge from the Likert-type items. Results from Table 6 show that only (4 out of 10, representing 40%) of the items had mean scores of three or higher (culture-related perceptions). Three of the items had mean scores ranging from 2.6 to 2.9 (trends towards culture-related perceptions), while the remaining three items had mean scores ranging from 2.0 to 2.2(culture-free perceptions). The results revealed that the majority (70%) of teacher trainees' held views about mathematical knowledge show either the trends of cultural–related perceptions or cultural-related perceptions.

The majority of them either strongly agreed or agreed that "mathematical knowledge is useful" (1,105 out of 1,160, representing 95.3%), "mathematical knowledge has many applications in life" (1,076 out of 1,160, representing 92.8%), and "mathematics is interesting" (1,071, out of 1,160, representing 92.3%). More than half did not agree that "mathematics is a difficult subject" (687 out of 1,160, representing 59.2%), and "Mathematics is boring" (802 out of 1,160, representing 69.1%). Majority of teacher trainees see the universal notion of mathematics, as a

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substantial number (913 out of 1,160, representing 78.7%) of them either strongly agreed or agreed that "Mathematical truth is certain and infallible", "Mathematical knowledge is an objective knowledge" (839 out of 1,160, representing 72.4%), and "Mathematical knowledge is the same everywhere" (894 out of 1,160, representing 77.4%)

Table 6: Teacher Trainees' perceptions about mathematical knowledge (N = 1,160)

Item	Statement		SA	A	DA	SDA	M	SD
1	Mathematical truth is certain and infallible(CF)	N	275	638	132	115	2.1	0.86
		%	23.7	55.0	11.4	9.9	-	-
2	Mathematical knowledge is an objective knowledge(CF)	N	250	589	214	107	2.2	0.86
		%	21.6	50.8	18.4	9.2	-	-
4	Mathematical knowledge is the same everywhere(CF)	N	433	461	144	122	2.0	0.96
		%	37.7	39.7	12.4	10.5	-	-
5	Mathematical knowledge is useful(CR)	N	720	385	23	32	3.6	0.67
		%	62.1	33.2	2.0	2.8	-	-
6	Mathematical knowledge has many applications in life(CR)	N	660	416	36	48	3.5	0.75
		%	56.9	35.9	3.1	4.1	-	-
7	Mathematical truth can be rejected based on sound logical argument(CR)	N	311	517	219	113	2.9	0.91
		%	26.8	44.6	18.9	9.7	-	-
8	Mathematics is an easy subject(CR)	N	237	462	266	195	2.6	0.99
		%	20.4	39.8	22.9	16.8	-	-
13	Mathematics is interesting(CR)	N	475	596	44	45	3.3	0.72
		%	40.9	51.4	3.8	3.9	-	-
29	Mathematics is boring (CF)	N	90	268	301	501	3.1	0.97
		%	7.8	23.1	25.9	43.2	-	-
30	Mathematics is a difficult subject (CF)	N	256	217	331	356	2.7	1.23
		%	22.1	18.7	28.5	30.7	-	-

Note: SA-Strongly Agree, A-Agree, DA - Disagree, SDA -Strongly Disagree, M- Means, SD- Standard Deviation

SOURCE: Field Data (2022)

It is evident from Table 6, the results indicated teacher trainees' perceptions about mathematical knowledge showed trends toward cultural-related perceptions.

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To explore further teacher trainees' views about mathematical knowledge, they were requested to indicate "what comes to their mind when someone mentions mathematics to them", and also asked to give a brief account of "what mathematics meant to them" (see items 47 and 48, Appendix A). Responses on what comes to teacher trainees' minds when someone mentions mathematics to them were grouped into two categories, namely culture–related responses and culture–free responses.

A Few (108 out of 1,160, representing 9.31%) of them did not respond to question 47. A substantial minority (301, representing 25.95%) gave cultural–free responses. Cultural-free responses given by teacher trainees were related to calculations. Some of the typical culture-free responses they gave included the following:

"Calculation with formulas" (TT13, TT56, TT109, TT257, TT346, TT354, TT890, TT 709, TT 1002, TT1152).

"Study of science, quantity, structure, space and change" (TT199,).

"Abstract representation of shapes and numbers" (TT73). "Study of numbers and symbols" (TT1, TT504, TT1124).

The majority (751 out of 1,160, representing 64.74%) of teacher trainees gave cultural-related responses. More than half (401, representing 53.4%) of teacher trainees who gave culture-related responses gave reasons relating to everyday activities. Some typical cultural-related responses they gave included the following:

"Critical thinking, logical reasoning and day-to-day Problem-solving" (TT37, TT65, TT68, TT110, TT185, TT225, TT232, TT248, TT270, TT282, TT286, TT288 TT289, TT295, TT303, TT309, TT999,TT1052).

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"Everyday activities" (TT2, TT15, TT35, TT100, TT609, TT867, TT1000).

"Everything involves the use of operations in our daily lives" (TT315).

"Mathematics deals with principles to solve problems in our daily lives" (TT364).

The Results of teacher trainees' responses to item 48, "Briefly explain what mathematics means to you?" Only few (149 out of 1,160, representing 12.8%)) did not respond to it. The vast majority (1011 out of 1160, representing 87.2%) of them responded to this item 48. Their responses to this item were also categorised into two groups, namely culture-related responses and culture-free responses. More than half (627 out of 1,160, representing 54.1%) of them gave culture-related responses. The remaining three hundred and eighty–four (384 out of 1160, representing 33.1%) gave cultural–free responses. Some of the typical culture-free responses they gave included the following: "Mathematics is about calculation, it deals with thinking and understanding. Just understand the formula and rules about mathematics" (TT244, TT907). "Mathematics is a discipline that involves the use of numbers, symbols, formulas and operations to make meaning and to represent the world we live in" (TT232, TT297, TT494). "Mathematics is a subject of numbers, shapes, data, measurement and logical activities" (TT29, TT1158). "Mathematics means to add, subtract, multiply, and divide numbers" (TT248, TT600, TT859, TT350). "Mathematics is the science and study of quality, structure, space, and change" (TT58, TT500, TT1124) "Mathematics is an abstract science of numbers, quantity and space" (TT66, TT236, TT233). "Mathematics is a creative activity that comes out as a result of complex theory or thought" (TT81). "Mathematics is the logical study of shapes, arrangement, quantity, and many related concepts" (TT36, TT51, TT62, TT68, TT105).

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Some of the typical culture-related responses given by teacher trainee' participants included the following: "Mathematics is basically about critical thinking and problem-solving" (TT36, TT290, and TT305). "Mathematics simply means finding solutions to problems concerning numbers" (TT77). "Mathematics is a way of solving mathematical problems through critical thinking" (TT290). "Mathematics is a day-to-day activity" (TT67, TT97, TT101, TT350, TT534, TT555, and TT559). "Mathematics is part of life" (TT553). "Mathematics is my source of fun, at my leisure time I solve mathematics to free myself" (TT234). "Everything around us is all about mathematics" (TT9, TT103). "Mathematics is a fundamental part of human thought and logic, and integral to attempts of understanding the world and ourselves" (TT82). "What I know about mathematics is our everyday lifetimes such as counting, multiplication and the rest" (TT283, TT333). "Mathematics is used in our daily life activities such as buying and selling" (TT343, TT562). "Everyday experience in life" (TT314, TT348). "The means of using numbers in the daily life activities" (TT221, TT227, TT274, TT277, TT284). "Mathematics is a subject that has given humans the chance to understand the world better and has also helped to enhance the life of mankind in all aspects of our lives" (TT311). "Mathematics is the managing of life and making good use of our things through the use of symbols and numbers in its operations" (TT295). "Mathematics is the way we think and forms part of our every life including cooking, measuring, comparing, eating etc. in solving problems in society" (TT293). "Mathematics is the basic arithmetic and logical operations in our daily lives" (TT286). "It is a logical discipline that involves the use of signs, symbols and other tactile representations to enhance human beings in their lively activities" (TT298). "Mathematics is the application of operations in our daily lives" (TT315).

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"Mathematics involves the use of theories, principles, and methods to solve mathematical tasks and problems we encounter daily" (TT364).

The results analysis showed the views expressed by teacher trainees about mathematical knowledge on open-ended questions (items 47 and 48, Appendix A) indicated more culture-related perceptions. However, the closed-ended questions presented in Table 6 confirmed the trend towards culture-related perceptions as more than two-thirds (70%) of respondents held views that showed the trends of cultural-related perceptions.

The evidence from the results of Likert-type and open-ended questions (see items 47 and 48, Appendix A) indicated that teacher trainees' perceptions about mathematical knowledge showed trends to culture-related perceptions. The overall mean score for ten Likert–type items for perceptions about mathematical knowledge in Table 5 was 2.9 indicating a trend to cultural-related perceptions. The results analysis indicated that teacher trainees generally seemed to appreciate cultural aspects of mathematical knowledge rather than universal knowledge which is the same everywhere in the world.

Results of Teacher Trainees' Perceptions about Mathematics Pedagogy

Table 7 presents teacher trainees' perceptions about mathematics pedagogy. Results from Table 7 showed that (4 out of 9, representing 44.4%) of items had mean scores of three or higher (culture-related perceptions), more than one-quarter (3 out of 9, representing 33.3%) had mean scores ranged from 2.5 to 2.6 (trend towards culture-related perceptions), and the remaining two had mean scores of 2.2 (culture-free perceptions). The results revealed further that they appreciated students' involvement in mathematics lessons, as all of them either strongly agreed or agreed to the statement that, "teaching and learning mathematics involves active

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participation of learners throughout the lesson" (1072 out of 1,160, representing 92.4%). A substantial number of the teacher trainees however, appeared to link success in mathematics learning to the innate ability of the learner, as more than half of them either strongly agreed or agreed that "Learners' success in mathematics depends on their intellectual abilities" (791 out of 1,160, representing 78.2%). The results revealed further that teacher trainees cherished the role of language in teaching and learning mathematics, as more than half strongly disagreed or disagreed that, "Language has nothing to do with mathematical thinking" (791 out of 1,169, representing 68.4%). However, they strongly agreed or agreed that, "Children are very likely to understand mathematics better when they are taught in the language they understand best" (1,069 out of 1,160, representing 92.2%). A little above half of teacher trainees either strongly disagreed or disagreed that, "Mathematics should be made an optional subject at all levels including colleges of education level" (618 out of 1,160, representing 53.2%). "Mathematics should only be studied by bright people in society" (893 out of 1,160, representing 77%).

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Table 7 : Teacher Trainees' Perceptions about Mathematics Pedagogy (N = 1,160)

Item	Statement		SA	A	DA	SDA	M	SD
9	Learners success in mathematics depends on their intellectual abilities(CF)	N %	289 24.9	502 43.3	214 18.4	155 13.4	2.2 -	0.96 -
15	Mathematics should be made an optional subject at all levels including colleges of education level(CF)	N %	270 23.3	272 23.4	258 22.2	360 31.0	2.6 -	1.15 -
16	Learning mathematics basically requires memorizing facts(CF)	N %	228 19.7	382 32.9	236 20.3	314 27.1	2.6 -	1.09 -
18	Teaching and learning mathematics involves active participation of learners throughout the lesson (CR)	N %	676 58.3	396 34.1	53 4.6	35 3.0	3.5 -	0.72 -
19	Learning mathematics is all about ensuring accuracy in the application of algorithms in class exercise(CF)	N %	214 18.4	432 37.2	219 18.9	295 25.4	2.5 -	1.06 -
26	Mathematics should only be studied by bright people in the society(CF)	N %	101 8.7	166 14.3	220 19.0	673 58.0	3.3 -	1.00 -
28	Mathematics learning is all about practicing a given task over and over again(CF)	N %	324 27.9	429 37.0	270 23.3	137 11.8	2.2 -	0.97 -
33	Language has nothing to do with mathematical thinking(CF)	N %	104 9.0	262 22.6	339 29.2	455 39.2	3.0 -	0.99 -
34	Children are very likely to understand mathematics better when they are taught in the language they understand best(CR)	N %	619 53.4	450 38.8	53 4.6	38 3.3	3.4 -	0.73 -

Note: SA-Strongly Agree, A-Agree, DA - Disagree, SDA -Strongly Disagree, M-Means, SD - Standard Deviation

SOURCE: Field Data (2022)

It is evident from the results in Table 7 that teacher trainees' perceptions about mathematics pedagogy attest a trend towards culture-related perceptions, as a substantial minority (4 out of 9, representing 44.4%) of the items had mean scores ranging from 3.0 to 3.5(cultural-related perception). More than a quarter (3 out of

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9, representing 33.3%) of items had mean scores of 2.5 and 2.6 (a trend towards cultural-related perception), and the remaining two (2 out of 9, representing 22.2%) received culture-free responses. The overall mean score for perceptions about mathematics pedagogy as presented in Table 5 was 2.6 indicating trend to cultural-related perceptions. Therefore the results on the views held by teacher trainees about mathematics pedagogy generally, showed trends to cultural-related perceptions.

Results of Teacher Trainees' Perceptions about Links between Ghanaian Culture and Mathematical Knowledge

Table 8 shows teacher trainees' perceptions about the links between culture and mathematical knowledge. Results from Table 8 revealed that only one (1 out of 6, representing 16.67%) of items had a mean score of 3.0 (culture-related perceptions), five had mean scores ranging from 2.7 to 2.9 (trends toward culture-related perceptions), with no culture-free perceptions. The results showed that more than half (707 out of 1,160, representing 60.9%) of the teacher trainees confirmed their universal view of mathematical knowledge, as they either strongly agreed or agreed that, "mathematical practices differ from culture to culture." Also a substantial number of them (844 out of 1,160, representing 72.8%) also either strongly agreed or agreed that "Every culture makes its own mathematics". The majority of them, however, appeared to appreciate links between culture and mathematical knowledge, as they either strongly disagreed or disagreed that, "mathematics has very little relevance to indigenous communities" (781 out of 1,160, representing 67.3%), and "indigenous culture practices has no place in mathematics" (755 out of 1,160, representing 65.1%).

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Table 8: Teacher Trainees' Perceptions about Links between Ghanaian Culture and Mathematical Knowledge (N = 1,160)

Item	Statement		SA	A	DA	SDA	M	SD
10	Mathematical practices differ from culture to culture(CR)	N	249	458	253	200	2.7	1.00
		%	21.5	39.5	21.8	17.2	-	-
23	Indigenous culture practices have no place in mathematics teaching and learning(CF)	N	78	327	413	342	2.9	0.91
		%	6.7	28.2	35.6	29.5	-	-
24	Mathematics is not free from (moral, ethical, religious etc.) values (CR)	N	227	676	164	93	2.9	0.80
		%	19.6	58.3	14.1	8.0	-	-
25	Every culture has its own way of doing mathematics(CR)	N	314	530	205	111	2.9	0.91
		%	27.1	45.7	17.7	9.6	-	-
31	Values such as moral, ethical or religious are present in mathematics teaching and learning(CR)	N	331	555	171	103	3.0	0.89
		%	28.5	47.8	14.7	8.9	-	-
32	Mathematics has very little relevance to Indigenous communities(CF)	N	85	294	484	297	2.9	0.89
		%	7.3	25.3	41.7	25.6	-	-

Note: SA-Strongly Agree, A-Agree, DA - Disagree, SDA -Strongly Disagree, M-Means, SD- Standard Deviation

SOURCE: Field Data (2022)

For each result in Table 8, it is evident that teacher trainees' perceptions about links between culture and mathematical knowledge were said to be on a trend towards culture-related perceptions as the majority (5 out of 6, representing 83.3%) of items had mean scores ranged from 2.7 to 2.9 (trends towards cultural-related perceptions), and the remaining one cultural-related perception had mean score of 3.0. Teacher Trainees were further asked to indicate whether they believed the activities carried out in various societies generate mathematics, which may not be the same as school mathematics (see Appendix A, item 44). Analysis of teacher

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trainees" responses to this item showed that the majority (1065 out of 1160, representing 91.8%) of them answered, "Yes" to this item. Only few (95 out of 1160 representing 8.2%) of teacher trainees answered "No" to this item. This shows that vast majority of them believed that activities teachers and students carry out in their societies could generate some form of mathematics. The analysis of the result of item 44 confirmed the previous observation from the Likert type items in Table 8 that, a substantial number of teacher trainees appeared to appreciate some links between culture and mathematical knowledge.

Table 9 presents activities that teacher trainees believed generate mathematics (item 45, see Appendix A). The result in Table 9 showed that the minority of teacher trainees (77 out of 1160, representing 6.6%) did not respond to item 45. A meaningful majority (660 out of 1160, representing 56.9%) of teacher trainees who answered this item 45 indicated two or more activities they thought could either generate mathematics or not. Only few (14 out of 1160, representing 1.2%) of them had the views that other activities such as cooking, dancing, drumming, singing, gardening, weighing items, checking inventories and writing bills, as activities that generate mathematics. The remaining four hundred and nine (409 out of 1160, represent 35.3%) of them indicator either one of the following six fundamental activities: counting, measuring, locating, playing, designing, and playing could generate mathematics. A meaningful number perceived Counting (179, 15. 4%), Measuring (92, 7.9%), Locating (24, 2.1%), and Playing (64, 5.5%) as activities that could generate mathematics. Besides, a few of them perceived Designing (13, 1.1%) as an activity that generates mathematics. The remaining (37 out of 1,160, representing 3.2%) did indicate that "Explaining" is the only activity in their communities that could generate mathematics. This is of course, in the

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Ghanaian context explaining is embedded in all our activities. The other activities (1.2%), apart from those presented in Table 9, such as cooking, gardening, weighing items, taking stocks of items, writing bills, and banking, as activities that generate mathematics.

Table 9: Teacher Trainees' Perceptions about Activities that generate Mathematics (N = 1,160)

Topic	Frequency	Percentages (%)
NR	77	6.6
Counting	179	15.4
Measuring	92	7.9
Locating	24	2.1
Playing	64	5.5
Designing	13	1.1
Explaining	37	3.2
More than one	660	56.9
Others(specify)	14	1.2
Total	1160	100.00

Note: NR - Non - Response
SOURCE: Field Data (2022)

The evidence from the results in Table 8, Table 9 and item 44 reveals that teacher trainees' perception about links between culture and mathematical knowledge indicated the trends toward culture-related perceptions. The overall mean score for Likert–type items for teacher trainees' perceptions about links between culture and mathematical knowledge in Table 5 was 2.6 indicating (a trend to cultural related perception). Teacher trainees seem to appreciate the connection between culture and mathematical knowledge

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Results of Teacher Trainees' Perceptions about Links between the Ghanaian Culture and Mathematics Pedagogy

Table 10 presented teacher trainees' perceptions about links between culture and mathematics pedagogy from four - point Likert scale type items. Results from Table 10 showed that the majority (9 out of 12, representing 75%) of the items had mean scores ranged from 3.1 to 3.4 (culture-related perceptions), and the remaining three had mean scores of 2.5 and 2.7 (trends toward cultural-related perceptions). The results revealed that, large majority of teacher trainees either strongly agreed or agreed with items with mean scores greater than three. They generally appreciated the support that "use of out – of – school mathematics practices in school mathematics will facilitate learners' understanding of school mathematics" (968 out of 1,160, representing 83.4%). More than half of teacher trainees had a sense of cultural practices by indigenes, as majority of them either strongly agreed or agreed that, "mathematical practices in our indigenous culture can support children's learning in school mathematics" (1,039 out of 1,160, representing 89.5%). Every student knows their cultural activities which they shared with other students in school, as a substantial number of them either strongly agreed or agreed that, "Culture plays an important role in mathematics learning" (778 out of 1,160, representing 67.1%). Integrating students' funds–of knowledge in classroom mathematics discourse could offer more opportunities for students to negotiate their conception in mathematics, as the majority of them either strongly agreed or agreed that, "incorporating cultural experiences into school mathematics will help students learn mathematics meaningfully" (986 out of 1,160, representing 85%). The out-of-school culture notions could offer to mathematics pedagogy, as vast majority of them either strongly agreed or agreed that, "teaching mathematics

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requires application of what children already know, including mathematical practices in their homes to help them to understand the lesson” (1,098 out of 1,160, representing 94.7%), “Learners perform better when mathematics activities are related to their socio cultural background” (1026 out of 1,160, representing 88.4%), “Teaching mathematics requires using children’s mathematical practices in their culture to help them understand the lesson” (1,073 out of 1,160, representing 92.5%), “Teachers’ use of out–of–school mathematics practices in school mathematics will better equip children to use out–of–school mathematics more effectively” (1,033 out of 1,160, representing 89.1%), “mathematics lessons and activities should relate and reflect the socio cultural practices of the learner” (1,022 out of 1,160, representing 88.1%), “teachers’ knowledge of mathematical practices in learners’ culture may help in mathematics teaching and learning” (1,052 out of 1,160, representing 90.7%). However, more than half (618 out of 1,160, representing 53.2%) either strongly disagreed or disagreed that “doing mathematics requires rules which has little to do with Indigenous culture”, and “nature of school mathematics makes the introduction of out-of-school mathematics practices in-school mathematics impossible” (630 out of 1,160, representing 54.3%).

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Table 10 : Teacher Trainees 'Perceptions about Links between Ghanaian Culture and Mathematics Pedagogy (N = 1,160)

Item	Statement		SA	A	DA	SDA	M	SD
3	Doing mathematics requires rules which has little to do with indigenous culture(CF)	N %	185 15.9	357 30.8	352 30.3	266 22.9	2.6 -	1.01 -
11	Use of out–of–school mathematics practices in school mathematics will facilitate learners' understanding of school mathematics(CR)	N %	418 36.0	550 47.4	91 7.8	101 8.7	3.1 -	0.88 -
12	Mathematical practices in our indigenous culture can support children's learning in school mathematics(CR)	N %	419 36.1	620 53.4	85 7.3	36 3.1	3.2 -	0.71 -
14	Culture plays an important role in mathematics learning(CR)	N %	248 21.4	530 45.7	133 11.5	249 21.5	2.7 -	1.04 -
17	Incorporating cultural experiences into school mathematics will help students learn mathematics meaningfully(CR)	N %	426 36.7	560 48.3	117 10.1	57 4.9	3.2 -	0.80 -
20	Mathematics lessons and activities should relate and reflect the socio cultural practices of the learner(CR)	N %	415 35.8	607 52.3	93 8.0	45 3.9	3.2 -	0.74 -
21	Teachers' use of out–of–school mathematics practices in school mathematics will better equip children to use out–of–school mathematics more effectively(CR)	N %	257 22.2	776 66.9	71 6.1	56 4.8	3.1 -	0.69 -
22	Learners perform better when mathematics activities are related to their socio cultural background(CR)	N %	475 40.9	551 47.5	84 7.2	50 4.3	3.3 -	0.77 -
27	Nature of school mathematics makes the introduction of out-of-school mathematics practices in school mathematics impossible(CF)	N %	220 19.0	310 26.7	429 37.0	201 17.3	2.5 -	0.99 -
35	Teachers' knowledge of mathematical practices in learners' culture may help in mathematics teaching and learning(CR)	N %	438 37.8	614 52.9	66 5.7	42 3.6	3.3 -	0.72 -
36	Teaching mathematics requires using children's mathematical practices in their culture to help them understand the lesson(CR)	N %	377 32.5	696 60.0	46 4.0	41 3.5	3.2 -	0.68 -
37	Teaching mathematics requires application of what children already know, including mathematical practices in their homes to help them understand the lesson(CR)	N %	517 44.6	581 50.1	36 3.1	26 2.2	3.4 -	0.66 -

Note: SA-Strongly Agree, A-Agree, DA - Disagree, SDA -Strongly Disagree, M- Means, SD- Standard Deviation (SOURCE: Field Data, 2022)

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For each result in Table 10, it is perceived that teacher trainees' perceptions about links between Ghanaian culture and mathematics pedagogy were said to be culture-related, as more than half (9 out of 12, representing 75%) of the items received culture-related responses. The remaining three (3 out of 12, representing 25%) had mean scores ranging from 2.5 to 2.7 (trends toward cultural-related perceptions)

In furtherance with an exploration of teacher trainees' perceptions about links between Ghanaian culture and mathematics pedagogy, they were asked to indicate by ticking "Yes" or "No", whether they believed that one's cultural practices have a place in mathematics teaching and learning in the college. They were also requested to indicate which topics allowed for the inclusion of out-of-school mathematics (see items 42 and 43, Appendix A). The results revealed that (985 out of 1160, representing 84.9%) of them answered "yes", and a few (175 out of 1160, representing 15.1%) of teacher trainees answered "no" to question 42 "Do you believe that one's cultural practices have a place in mathematics teaching and learning in a college?"

Table 11 presents the topics that teacher trainees thought allow for the inclusion of out-of-school mathematical practices (item 43, see Appendix A). Analysis of results presented in Table 11 indicated that teacher trainees who responded 'yes' to item 42, few (152 out of 1160, representing 13.1 %) of them did not answer item 43. The majority (833 out of 1,160, representing 71.8%) answered item 43. The first topic was measurement with (123 out of 1,160, representing 10.6%) teacher trainees indicated that, it allowed for the inclusion of out-of-school mathematical practices. This was followed by lines and space, with the least

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number (18 out of 1160, representing 1.6%) of respondents. The other topics included the following: fractions with (22 out of 1160, 1.9%), followed by data handling with 56 responses (4.8%), and game of chance with 36 responses (3.1%). The remaining two topics were operations on numbers with 34 (2.9%) of them and word problem solving with a total of 81 (7.0%) responses. More than half (635 out of 1160, representing 54.7%) indicated at least two of these topics allowed for the inclusion of out-of-school mathematical practices. Only (3 out of 1160, representing 0.3%) perceived other topics such as "ratio and proportion" (TT52), "profit and loss" (TT295), and "set problems and mensuration" (TT293) as other topics allowed for the inclusion of out–of–school mathematical practices.

Table 11: Teacher Trainees' Perceptions about topics that allows for inclusion of out of-school mathematical practices (N = 1,160)

Topic	Frequency	Percentages (%)
NR	152	13.1
Measurement	123	10.6
Lines and Space	18	1.6
Fractions	22	1.9
Data handling	56	4.8
Game of chance	36	3.1
Operations on numbers	34	2.9
Word problem solving	81	7.0
More than one	635	54.7
Other (specify):	3	0.3
Total	1,160	100.0

Note: NR – Non - Response
SOURCE: Field Data (2022)

Festivals, naming ceremonies, marriage rites, and funerals have been the traditional mode for the preservation of the rich Ghanaian culture. In this study, teacher trainees were asked to indicate whether they believed mathematics

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education could also be used to preserve the Ghanaian culture (see Appendix A, item 49). Analysis of the results showed that the majority (973 out of 1160, representing 83.9%) of the teacher trainees answered ‘Yes’ to this item while the few minority (187 out of 1160, representing 16.1%) of them responded ‘No’. To gather more information about the perceptions of teacher trainees on the relevance of culture in mathematics, they were asked to give reasons for their choice in item 49 (see Appendix A, item 50). Less than a quarter (289 out of 1160; representing 24.9%) of teacher trainees did not respond to item 50 (TT108, TT189, TT203, TT218, TT314,). Of those who responded to item 50, a substantial number (768 out of 1160; representing 66.2%) of them gave cultural–related views, and a few number (103 out of 1160, 8.9%) of them gave cultural–free responses as well.

A few minority (84 out of 1160, representing 7.2%) of teacher trainees who responded ‘No’ to item 49 did not give any reason for their answers (TT51, TT343, and TT357). Typical examples of cultural–frees views included the following: “though they might need some calculation and measurement, yet that has no way to preserve it” (TT1111), “because not all Ghanaian culture can be used to teach mathematics” (TT290), “mathematics cannot be applied in all our cultural norms and therefore should not be preserved” (TT289), “It has fewer link to the activity like festivals and funerals” (TT282), “because mathematics has nothing to do with preservation of culture” (TT197), “mathematics does not relate to culture in any way” (TT291), “the little I know about Ghanaian culture practices has nothing to do with mathematics” (TT33), “mathematics ideas have no place in preserving our culture” (TT277), “Our culture does not necessary need mathematical ideas, beliefs or knowledge to preserve it” (TT274), “it would be nice if we can do it but it is not necessary as people will not be interested” (TT490), “it is not related to our cultural

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heritage" (TT502), "I don't know how mathematics will preserve our culture" (TT503), and "Culture preservation has nothing to do with mathematics" (TT985). A small (205 out of 1,160, representing 17.7%) who answered 'Yes' also did not give reasons for their answers (TT61, TT82, TT137, TT200, TT201, TT217, TT232, TT237, TT249, TT328, TT333, TT346, TT348, TT365, TT372).

The reasons given by those who believed mathematics education could be a vehicle for the preservation of the Ghanaian culture were in the following categories: preservation of indigenous mathematical concepts in the Ghanaian culture; creating awareness about the existence of aspects of the Ghanaian culture; learning mathematics through the use of traditional games and dances; improving beliefs/attitudes about mathematics and Ghanaian culture; (i.e. links between mathematics and the Ghanaian culture); and usefulness of mathematics and those unclear responses.

Some of the typical examples included the following: "Because the mathematics can be directly linked with our culture" (TT358), "Because mathematics has great relevance in part of our Indigenous culture" (TT699), "It improves the learners' knowledge and understanding of their culture" (TT1137), "teaching mathematics from known to unknown by using our language as a medium of instruction will help to preserve the culture and aid understanding of mathematics" (TT74), "it improves the learners' understanding of their culture" (TT40), "because a lot of mathematical concepts are reflected in our everyday lives" (TT13), "For data and historical preservations" (TT242), "Because during this festivals, mathematics is being showcased especially time" (TT204), "time conscious in the sense that, we can make comparison or the time intervals as whether it is late or not. Again, it enables us to do basic calculations by subtraction

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of time, the addition of time" (TT60), "mathematics brings balance in terms of ideas of things in Ghanaian culture" (TT306), "mathematics brings balance, so in Ghanaian culture, materials from particular community can be used in teaching mathematics" (TT311), "mathematics portrays the culture and civilization of the society and also helps in preservation and transmission of culture"(TT78, TT307), "this is because the aspect of man's life and understanding deals with numbers and calculations" (TT309), "mathematics plays an integral role in every aspect of life including our culture" (TT199, TT278), "like a game in 'Oware' deals with counting, addition and subtraction" (TT296), "everything we do is mathematics, farming, cooking, sharing of plots, selling and buying etc. they help in our culture preservation" (TT320), "because it helps to remember the date to be celebrated" (TT283, TT284), "because it deals with the day, month, and the year it needs to be calculated" (TT72), "because mathematics helps to keep data on a historical cultural heritage, keeping date, time and years help future generation to benefit from it" (TT52), "this is because mathematics is seen in all aspect of daily activities through which data and history is recorded. mathematics also helps us to find solutions to problems" (TT53), "because time is an essence and counting is used to identify the day, month, and year the activity is to be held" (TT1025), "Knowledge of events can be written down through the knowledge of mathematics"(TT345), "Mathematical concepts based on cultural perspectives allow students to not only reflect and appreciate their own culture but also the culture and traditions of others" (TT36, TT73, TT100), "since our everyday activities involve mathematics, we have to prioritise it and make it aspect of our culture" (TT9, TT233, TT286), "Culture is our way of life and mathematics is an everyday activity" (TT111), "because, after everything is done, calculation will be apply in every field of culture" (TT295),

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"historical reasoning of culture are being documented pertaining to the time they happened, and people do calculate to know using mathematics" (TT298), "culture plays an important role in mathematics, celebrating festivals of Art and Culture incorporates measuring, counting, playing, designing, and locating. Because all these are infused in our culture, it is good to preserve it" (TT34), "based on certain mathematical knowledge, I think certain methods can be used to preserve Ghanaian culture" (TT364), "mathematics has a great impact on our culture since today history was made, our daily life activities involve the use of mathematics consciously or not" (TT297), "data could be represented in charts to make analysis on finance, population, and other matters relating to Ghanaian cultures" (TT512), "Because mathematics is part of our daily activities"(TT520), "when mathematics is made to reflect or relate with people's culture, they are able to learn and understand the concept that is taught the better. In so doing, the culture of such people to which the concept that is taught reflect or relate, is preserved" (TT526), "mathematics goes across everything that happens in this world" (TT543).

It is evident from their reasons presented above that more than one-half (768 out of 1160, representing 66.2%) of teacher trainees who gave reasons why mathematics education could be used as a vehicle for the preservation of the rich Ghanaian culture, attributed it to links between mathematics and culture and others attributed its usefulness to the society. Only a few (103 out of 1160 representing 8.9%) of teacher trainees perceived the irrelevance of mathematics in the preservation of Ghanaian rich culture.

Therefore it can be concluded from the analysis of the results presented in Tables 10 and 11, and the open-ended questions responses (see Appendix A, items 49 and 50) on teacher trainees' perceptions about links between culture and

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mathematics pedagogy generally showed more cultural-related perceptions. The overall mean score of teacher trainees' perception about the links between culture and mathematics pedagogy in Table 5 was 3.03 indicated cultural-related perceptions. This is an indication that they perceived culture to play some important role in mathematics teaching and learning.

Results of Teacher Trainees' Perceptions about the Links between Ghanaian Culture and Mathematics Curriculum

Table 12 presents the results of teacher trainees' perceptions about links between the Ghanaian culture and mathematics curriculum from Likert-type items. Results from Table 12 showed that all four items had mean scores ranging from 3.0 to 3.3 (culture-related perceptions). Incorporating cultural objects into college mathematics curriculum could help in the smooth enactment of classroom mathematics to harness students' understanding of concepts, as a vast majority of them either strongly agreed or agreed that, "mathematics curriculum should be incorporated with elements of cultural events of people in a community" (1,078 out of 1,160, representing 92.9%).

Mathematics curriculum designed using students' cultural referents could call for their active participation in the classroom discourse, as a large majority of them either strongly agreed or agreed that "mathematics curriculum should be seen by students as relevant to their future lives" (1,004 out of 1,160, 86.6%), "mathematics curriculum should resonate, as far as possible, with diverse home cultures" (1,025 out of 1,160, representing 88.4%). The results further revealed that the majority of teacher trainees either strongly agreed or agreed that, "mathematics curriculum should be experienced as 'real' by all students" (1,094 out of 1,160, representing 94.3%).

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Table 12: Teacher Trainees' Perceptions about the Links between Ghanaian Culture and Mathematics Curriculum (N = 1,160)

Item	Statement		SA	A	DA	SDA	M	SD
38	Mathematics Curriculum should be seen by students as relevant to their future lives(CR)	N %	420 36.2	658 56.7	49 4.2	33 2.8	3.3 -	0.67 -
39	Mathematics curriculum should be incorporated with elements of cultural events people in a community(CR)	N %	401 34.6	603 52.0	89 7.7	67 5.8	3.2 -	0.79 -
40	Mathematics curriculum should be experienced as "real" by all students(CR)	N %	413 35.6	681 58.7	38 3.3	28 2.4	3.3 -	0.64 -
41	Mathematics curriculum should resonate, as far as possible, with diverse home cultures (CR)	N %	224 19.3	801 69.1	98 8.4	37 3.2	3.0 -	0.64 -

Note: SA-Strongly Agree, A-Agree, DA - Disagree, SDA -Strongly Disagree, M-Means, SD- Standard Deviation

SOURCE: Field Data (2022)

For each result in Table 12, it is evident that teacher trainees' perceptions about links between Ghanaian culture and mathematics curriculum were said to be culture-related, as all (4 out of 4, representing 100%) of the items received culture-related responses. The results from Table 12 revealed mean scores ranging from 3.0 to 3.3 (cultural-related responses), and overall mean score in Table 5 was 3.2 (cultural-related perception).

The results analysis of quantitative part of research question one showed that teacher trainees held views on five areas of perceptions about(mathematical knowledge, mathematics pedagogy, links between culture and mathematical knowledge, links between culture and mathematics pedagogy, and links between culture and mathematics curriculum). Besides all the five held views were ranked

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from trends to cultural–related and cultural–related by teacher trainees in their mathematics teaching and learning. However, the best-ranked perception by teacher trainees was the links between culture and mathematics curriculum, followed by links between culture and mathematics pedagogy, mathematical knowledge, mathematics pedagogy, and lastly, the links between culture and mathematical knowledge. Moreover, the best spread was also observed within the perceptions about mathematical knowledge, followed by links between culture and mathematics pedagogy, links between culture and mathematical knowledge, links between culture and mathematics curriculum, and the poorest spread was seen within the perceptions about mathematics pedagogy (see Table 5). A few number of items in the Likert-type questionnaire had mean scores below 2.5 (cultural-free responses). An open-ended items also had few responses related to cultural-free perceptions. The main themes observed in quantitative part of research question one were: mathematical/scientific concepts, discipline/field of study, problem-solving, daily life applications, teaching and learning approaches, and language use and preference.

The results analysis shows that, teacher trainees seemed to appreciate relevance of cultural aspects in mathematics teaching and learning. However, to provide reasons for the held views by the teacher trainees, the observed views on the nature of mathematics held by teacher trainees in their mathematics learning were shared with them. This was to enable them to assign reasons why they held those perceptions in their mathematics teaching and learning. The open-ended semi-structured interview guide was made up of two parts for the teacher trainees to respond to with some follow-up questions depending on the need. The first part was to find out the meaning of mathematics and its importance in their mathematics

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learning (perceptions about nature of mathematics). The second part was on contextual understanding which emphasises the importance of teaching mathematics in a way that connects with students' real-life experiences, cultural backgrounds, and preferred language for teaching and learning mathematics, and curriculum design that caters for the needs of diverse students (see Appendix C).

The most predominant responses for each perception were summarised after the thematic transcription of the data (views) collected from the teacher trainees through focused group interviews across all the five colleges involved in this study.

Teacher Trainees' Responses to Interview Guide

Teacher Trainees' Perceptions about Mathematics

The two main held views of teacher trainees observed in the five focus group interviews after qualitative analysis indicated cultural-free (perceptions that do not recognise mathematics as a cultural object) and cultural-related (perceptions that take cognizance of mathematics in the out-of-school setting) as indicated in Davis (2010, 2016). The main themes observed in cultural-free responses included the following: Mathematical/Scientific concepts and Discipline/Field of study. Moreover, the main themes observed for cultural-related responses in the questionnaire items included the following: problem-solving, daily life application, teaching and learning approach, and language of preference respectively.

Five Focus groups of teacher trainees responded to the questions about the nature and the role of mathematics in educational development, and language, culture, and real-life applications in mathematics education in a number of ways. Only few group of participants were unable to give any response at all. Those who did respond appeared to interpret the questions in a variety of different ways. Some teacher trainees seemed to interpret the questions in terms of their immediate

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mathematics learning in the classroom. The groups again, interpreted the questions in terms of the purpose of mathematics for them in the "real-life applications and daily problem solving". Furthermore, the groups also interpreted the questions with respect to the preference for teaching, learning, and designing of mathematics curriculum in school. The responses of those who did answer the questions have been organised according to a number of major themes, and these are explored below. (Note: Acronyms in brackets refer to the identity of individual focus groups. Identifying acronyms beginning with FGTT are for Teacher trainees in Colleges, A, B, C, D, and E are FGTTA, FGTTB, FGTTC, FGTTD, and FGTTE). Where two or more focus groups give the same responses, their pseudonyms were put together against that response.

Mathematical/Scientific Concepts

Some teacher trainees in all five focus groups views of mathematical/scientific concepts showed that their reasons can be said to show cultural-free perceptions. Some teacher trainees in the five groups referred to particular aspects of mathematical content in their explanations of what mathematics is about. Many spoke about aspects of scientific approaches, calculations and proofs, and numbers and symbols. A few mentioned discipline or field of study.

Quite a number of the teacher trainees gave reasons relating to scientific approaches. Typical examples of the reasons relating to scientific approach were: *"Mathematics as a science, is the use of scientific methods to identify problems, analyse the problems, and evaluate the problems* (FGTTA); and "*Mathematics is a branch of science that deals with numbers and their operations, symbols and notations" (FGTTB, FGTTC).*

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Majority of teacher trainees gave reasons relating to calculations trying to justify that all proofs are part of mathematical concepts.

*"Mathematics is about calculations and proofs" (FGTTA, FGTTB, FGTTC, FGTTD)."*Some trainees express their views of mathematics as simply the use of numbers and symbols in the classroom.

"Mathematics is a way of life that deals with numbers and symbols (FGTTC); Mathematics is a branch of science that deals with numbers and its operations, symbols and notations" (FGTTB, FGTTC).

Discipline/Field of Study

The analysis of the responses for perceptions related to disciplines/field of study showed that, the reasons provided by the teacher trainees mostly on field of study. Only few teacher trainees in two focus groups gave reasons to meaning of mathematics as a discipline and field of study. One group stated that

"Mathematics is a field of study that deals with properties and relationships with numbers, axioms, and shapes" (FGTTD).

One respondent mentioned patterns, shapes, and explained how various operations and domains are interconnected.

"Mathematics is a field of study that deals with… operations, patterns, and shapes" (FGTTD).

However, majority of responses showed a divergent views about nature of mathematics which involve element from culture of people. Some cultural-related views expressed by the teacher trainees were presented as:

Problem–Solving

The reasons provided by the teacher trainees for problem-solving were grouped under four sub-themes namely critical thinking, problem-solving,

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communication, and conceptual understanding. The majority of the reasons by teacher trainees were related to problem-solving.

"*Mathematics is the use of numerical values to solve daily problems in our locality" (FGTTA, FGTTB).* Teacher trainees in one group described the processes involved in problem-solving: *"Mathematics is a process of solving our daily life problems" (FGTTA);* and "*Mathematics is a process of solving our daily life problems" (FGTTA).*

Some trainees stated that the nature of mathematics is about critical thinking and logical reasons for analysing and solving real life problems. *"Mathematics enables students to develop critical thinking and problem solving" (FGTTD);* and *"Mathematics helps students to analyse situations and find solutions to them"* (*FGTTC).*

Daily Life Applications

The analysis of teacher trainees responses on perceptions about mathematics related to daily life applications were grouped into five sub-themes including: practical and real-life application, problem-solving, communication, engagement, and cultural relevance and connections. Most of the responses were related to practical and real-life applications. Some trainees focused on the usefulness of mathematics for their everyday lives and many of these referred to needing mathematics so as to be able to work with in their homes, communities, and farms.

Some teacher trainees gave typical reasons relating to practical and real-life applications. *"Mathematics is a way of life that deals with numbers and symbols" (FGTTC); "Mathematics is about daily life activities so it helps learners to acquire basic computational skills to solve daily problems" (FGTTB, FGTTD).*

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Many respondents in one group expressed their views on the applications of mathematics in their communities and other fields:

"Because mathematics is used in our daily lives, it helps us in solving problems in our homes and communities" (FGTTC); and "Mathematics helps in agricultural sector. For instance, planting of tubers of yams, the farmers calculate the number of yam pieces that can be sewn in a day, two days……, etc. In this case the farmers can estimate and know the total pieces of yam tubers and total number of 'mounds' for one week planting……… so they have basic calculations in their daily lives" (FGTTC).

Quite a large number of teacher trainees talked about the usefulness of mathematics. Some teacher trainees focused on the usefulness of mathematics for their everyday lives and many of these referred to needing mathematics so as to be able to work at the market, health sector, hotels, and restaurants, and the use of money in various sectors: *"We teach or learn mathematics because it is used in our daily lives especially at the market and in our homes" (FGTTA); "Mathematics is about daily life activities so it helps learners to acquire basic computational skills to solve daily problems" (FGTTB, FGTTD); "Mathematics is applied at the health sector, hotels, and restaurants. For instance, if a doctor diagnose and prescribes the medicine for the patience….and calculate the right prescription and dosage for recovery period" (FGTTE); "In traditional medicine, herbalists calculate, count number of days, and do measure the required medicine for patience in our communities" (FGTTC); and "In a market sector, the traders transacting their goods become mathematical finance literate…….because they apply addition, subtraction, multiplication, and division of goods and services. They use money in*

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their daily transactions so they understand profit and loss, simple interest, commission and discounts on goods and services" (FGTTD).

Teaching and Learning Approaches

By integrating mathematics teaching and learning with relevant contexts, students can better understand and apply mathematical concepts. This approach makes learning more meaningful and accessible by showing how mathematics is used in everyday life and across different cultures, often communicated through language. This contextual learning emphasises the importance of teaching mathematics in a way that connects with students' real-life experiences, cultural backgrounds, and language practices. Cultural backgrounds influence how students relate to mathematical concepts, making it important to connect mathematics to cultural contexts to enhance learning. Applying mathematics to real-world situations allows students to see its relevance and usefulness, making the subject more meaningful and easier to grasp. Together, these elements emphasise the importance of teaching mathematics in a way that is relevant, understandable, and connected to students' lives and experiences.

Teacher trainees from five focus groups reasons for teaching and learning approaches views were put under six sub-themes namely, engagement and participation, engagement and interest, communication, conceptual understanding, abstract concept understanding, and cultural relevance and connection.

Some of the reasons given by teacher trainees were related to the use of cultural objects such as songs, games, artefacts as relevant materials for appropriate teaching and learning mathematics:

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"*The use of songs in teaching number sense arouses the interest of learners and enhances their understanding of mathematical concepts……….so song serves as a sparkling ingredient to the learning of mathematics" (FGTTA, FGTTD); "Using songs like 'Little Finger Dance Number One,' 'Little Finger Dance Number Two,'……meaning: one, two, three, etc., helps children to understand counting numbers" (FGTTB).*

A substantial number of teacher trainees elaborated on the mathematical concepts embedded in their rich cultures. Some mentioned the use of artefacts such as drums during festivals, funerals, churches, and other ceremonies which are in the form of cylindrical shapes that can be used to communicate mathematical ideas:

"Drums are used on occasions such as funerals, festivals, and naming ceremonies…….it is used to recite words, timing, and making sounds to notify the audience. It serves as a channel of communication of ideas (i.e., it is used to convey number sense, time, or clock representation) to people in a particular community" (FGTTB); and "Artifacts like cylindrical drums can be used to teach geometry in the classroom. The volume and total surface area of cylindrical solid shapes can be taught using drums" (FGTTC).

Some teacher trainees thought that games, puzzles, riddles, and local stories contain mathematical concepts which involve problem–solving, critical thinking and sound logical reasoning, engagement and interest that can help in teaching and learning mathematics. Some teacher trainees stated that:

"Games like 'Tumatu', 'Oware', and 'Ampe' help learners to engage in arithmetic computations and logical reasoning through play………'Ampe' involve counting and calculation during play, making the learning process engaging and interactive" (FGTTA, FGTTB, FGTTC, and FGTTC); "The local idea through

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stories and riddles helps learners to grasp abstract concepts in mathematical knowledge better" (FGTTE); and "Drumming during occasions involves a drama aspect where the number of characters and their roles follow a certain mathematical pattern" (FGTTB).

Language Use and Preference

The way mathematics is communicated and understood depends on the language used, which shapes how students interpret and solve problems. The reasons for language use and preference given by teacher trainees were put under two sub-themes namely, preference for local language and preference for blended (local and English languages).

Some typical reasons provided by the teacher trainees for Language of preference for teaching and learning of mathematics were mostly related to the use of local language for both teaching and learning mathematics, and designing of mathematics curriculum:

"I prefer using local language because if we express ideas in local dialects, the learners are able to understand it better than using it in foreign language (i.e. English language)………learners will be able to acquire the knowledge faster than using foreign language" (FGTTA, FGTTB); and "I prefer the use of our local language in teaching because children understand the concepts more when using their own dialects than using English language" (FGTTC, FGTTE).

Some teacher trainees have a notion that blending the two languages in teaching, learning and designing the curriculum will be effective for mathematics learning. Some stated that:

"The level learners determine the type of language to use. It is advisable to use local language at lower primary so that they can understand the concepts better at

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their level.....but when it comes to upper primary and the higher level both local language and English language should be blended" (FGTTA); "Curriculum should be flexible and be blended with both local language and English language when it comes to its development and implementation. The curriculum as a document should be written in English language, but during interpretation, the teachers should be able to interpret it in learners' own language. In this case, mathematics teachers should be posted to the community where understanding of local language will not be a problem to them. If teachers can speak the language of learners, they will be able to explain the mathematical concepts better to them" (FGTTA, FGTTC, FGTTD); "Ghana is a multilingual state with different dialects such as Akan, Ga, Ewe, Dagomba, Gonja, Dagbani, etc. The English language is our medium of instruction and because it has been accepted as an official language, the mathematics curriculum should be designed in English but when it comes to its implementation, the teachers should explain the concepts to learners in their local language" (FGTTB, FGTTC); and "The teachers should be assigned to communities where they understand the language and other cultural activities of learners so that teaching and learning of mathematics can be done in both local language and English language" (FGTTB).

The above reasons provided by the teacher trainees revealed why the views about cultural relevance of mathematics held by them were vital in their learning. In some cases, they even provided how these views are linked with each other. Their perspectives highlight the multifaceted nature of mathematics, portraying it not only as a practical tool for solving problems but also as a structured and systematic discipline with connections to science, daily life, and various fields of study.

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In the next section, the result of the analysis of mathematics tutors' responses to research question one: was presented.

Mathematics Tutors' Perceptions about Mathematics

As with teacher trainees, the results of the analysis of 41 questionnaire items from the Likert type, closed, and multiple–choice items under this section, based on the five areas of perceptions namely perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between Ghanaian culture and mathematical knowledge, perceptions about links between Ghanaian culture and mathematics pedagogy, perceptions about links between culture and mathematics curriculum. The results were summarised in Tables 14, 15, 16, 18, and 20 respectively. As with teacher trainees, mathematics tutors' held views mean scores range of 2.5 to 2.9 indicating trends toward culture-related perceptions, and mean scores ranging from 3.0 to 4.0 indicate cultural-related perceptions. A mean score of 2.4 and below indicates cultural-free perceptions for each of the individual items in the four-point Likert-type items respectively (see previous sections in this Chapter).

Similar to teacher trainees, the presentation of mathematics tutors' results of the questionnaire analysis were presented first followed by the themes observed from the focused group interview responses. The presentation of results analysis of research question one was preceded by the presentation of descriptive statistics (means and standard deviations) and reliability (Cronbach's alpha) values of mathematics tutors' views held about mathematics (see Table 13).

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Table 13: Means, Standard Deviations, and Cronbach's Alpha Values of Mathematics Tutors' *Perceptions about Mathematics* (N = 34)

Mathematics tutors' views about mathematics	Number of items	Mean	Standard Deviation	Cronbach's Alpha
Perceptions about Mathematical Knowledge	10	2.91	0.276	0.664
Perceptions about Mathematics Pedagogy	9	2.59	0.370	0.710
Perceptions about links between Ghanaian culture and mathematical knowledge	6	2.67	0.307	0.726
Perceptions about Links between Ghanaian Culture and Mathematics Pedagogy	12	3.21	0.261	0.754
Perceptions about Links between Ghanaian Culture and Mathematics Curriculum	4	3.26	0.305	0.677
OVERALL	**41**	**2.88**	**0.184**	**0.770**

SOURCE: Field Data (2022)

As indicated in Table 13, the means and standard deviations of five (5), perceptions about mathematics held by mathematics tutors as a result of "transform and compute" variable in SPSS include; Perceptions about mathematical knowledge (M = 2.91, SD = 0.276, Cronbach's alpha = 0.664), Perceptions about mathematics pedagogy (M = 2.59, SD = 0.370, Cronbach's alpha = 0.710), Perceptions about links between Ghanaian culture and mathematical knowledge (M = 2.67, SD = 0.307, Cronbach's alpha =0.726), Perceptions about links between Ghanaian culture and mathematics pedagogy (M = 3.21, SD = 0.261, Cronbach's alpha =0.754), and Perceptions about links between Ghanaian culture and mathematics curriculum (M = 3.26, SD = 0.305, Cronbach's alpha =0.677) respectively. The overall perception had (M = 2.88, SD = 0.184, Cronbach's alpha = 0.770). Results from Table 13 showed that (3 out of 5, representing 60%) of

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mathematics tutors' held views showed the trends to cultural-related perceptions while the remaining (2 out of 5, representing 40%) were cultural–related.

The Cronbach alpha value for each construct shows moderate to high levels of internal consistency within the perception items forming those constructs. Table 8 shows the range of the Cronbach alpha reliability coefficients was 0.66 to 0.77 for mathematics tutors' perceptions about mathematics. The alpha coefficients were within the acceptable value of 0.60 for purposes of research (Nunnally, 1967, 1978; Henderson et al, 1998).

Results of Mathematics Tutors' Perceptions about Mathematical Knowledge

Table 14 presents the mathematics tutors' perceptions about mathematical knowledge, from the Likert-type items. Results from the analysis of tutors' perceptions about mathematical knowledge showed that (6 out of 10, representing 60%) of the items had mean scores of three or higher (culture-related perceptions), only one (1 out of 10, representing 10%) had a mean score of 2.7(trend towards cultural-related perceptions). The remaining three (3 out of 10, representing 30%) had mean scores ranges of 1.8 and 1.9 (culture-free perceptions).

Results from Table 14 showed that more than half (22 out of 34, representing 64.7%) of tutors either strongly agreed or agreed that, "mathematical truth can be rejected based on sound logical argument", and "mathematics is an easy subject" (27 out of 34, representing 79.4%). A substantial number of tutors acknowledged the importance of mathematics in their everyday lives as the majority of them either strongly agreed or agreed that, "mathematical knowledge is useful" (34 out of 34, representing 100%), and "mathematical knowledge has many applications in life"(34 out of 34, representing 100%). Mathematical games and puzzles make mathematics interesting in the classroom. The fun of mathematics arouses the

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interests of learners as the majority of mathematics tutors either strongly agreed or agreed that, “mathematics is interesting” (34 out of 34, representing 100%). Every culture has its way of doing mathematics, as a substantial minority (6 out of 34, representing 17.6%) either strongly disagreed or disagreed that, “mathematical knowledge is the same everywhere”, “mathematical truth is certain and infallible” (6 out of 34, representing 17.6%), and “mathematical knowledge is an objective knowledge” (6 out of 34, representing 17.6%). As with teacher trainees, however, the results of mathematics tutors further showed a substantial number of them either strongly disagreed or disagreed that “mathematics is boring” (33 out of 34, representing 97.1%), and “mathematics is a difficult subject” (32 out of 34, representing 94.1%).

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Table 14 : Mathematics Tutors' Perceptions about Mathematical Knowledge (N = 34)

Item	Statement		SA	A	DA	SDA	M	SD
1	Mathematical truth is certain	N	13	15	4	2	1.9	0.86
	and infallible(CF)	%	38.2	44.1	11.8	5.9	-	-
2	Mathematical knowledge is	N	15	13	5	1	1.8	0.82
	an objective knowledge(CF)	%	44.1	38.2	14.7	2.9	-	-
4	Mathematical knowledge is	N	13	15	5	1	1.8	0.80
	the same everywhere(CF)	%	38.2	44.1	14.7	2.9	-	-
5	Mathematical knowledge is	N	23	11	-	-	3.7	0.48
	useful(CR)	%	67.6	32.4	-	-	-	-
6	Mathematical knowledge	N	23	11	-	-	3.7	0.48
	has many applications in	%	67.6	32.4	-	-	-	-
	life(CR)							
7	Mathematical truth can be	N	5	17	8	4	2.7	0.88
	rejected based on sound	%	14.7	50.0	23.5	11.8	-	-
	logical argument(CR)							
8	Mathematics is an easy	N	14	13	5	2	3.2	0.89
	subject(CR)	%	41.2	38.2	14.7	5.9	-	-
13	Mathematics is	N	17	17	-	-	3.5	0.51
	interesting(CR)	%	50.0	50.0	-	-	-	-
29	Mathematics is boring(CF)	N	-	1	11	22	3.6	0.55
		%	-	2.9	32.4	64.7	-	-
30	Mathematics is a difficult	N	1	1	13	19	3.5	0.71
	subject(CF)	%	2.9	2.9	38.2	55.9	-	-

Note: SA-Strongly Agree, A-Agree, UD – Undecided, DA - Disagree, SDA - Strongly Disagree, M- Means, SD- Standard Deviation

SOURCE: Field Data (2022).

Results from Table 14 revealed that mathematics tutors' perceptions about mathematical knowledge showed more than half (6 out of 10, representing 60%) of the items received culture-related responses, while one showed the trend towards cultural-related perceptions.

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As with the teacher trainees, mathematics tutors were also requested to indicate what comes to their mind when someone mentions mathematics to them and what mathematics meant to them (see items 47 and 48, Appendix B). Analysis of the results revealed that (29 out of 34, representing 85.3%) of them responded to item 47, “What comes into your mind when someone mentions mathematics to you?” Only five (5 out of 34, representing 14.7%) of them did not respond to item 47 (MT15, MT22, MT25, MT27, and MT28).

Similar to teacher trainees, tutors’ responses to this item were put into two groups namely, culture-related response and culture-free response. Less than half (13 out of 34, representing 38.2%) of them gave responses relating to calculations. Typical examples of culture-free responses included the following: “Calculations, remembering of facts and formula” (MT5, MT18, MT26, MT27, and MT34). “Scientific knowledge in solving problems” (MT8, MT16, MT21). “Ways of counting, measuring and handling of data” (MT23). “Something that has a relationship with numbers and unknown variables” (MT14). “Study of patterns, and numbers to generate rules” (MT26). “Quantity, shape and space” (MT33). “Basic arithmetic operations: plus, minus, multiplication and division” (MT20). “Computation of numbers” (MT34). One tutor had a view that “Mathematics is simplification” (MT17).

A substantial minority (16 out of 34, representing 47.1%) of them gave culture–related responses. Typical examples of culture-related responses they gave included the following: “It is a day-to-day activity” (MT2, MT7, MT10, MT12, MT13, and MT32). “It is a way of life” (MT9). “Everything I do from wake up to going to sleep” (MT4, MT24). “Reality” (MT29). “A subject worth study by all students” (MT30). “A kind of knowledge that is very useful in everyday life” (MT3,

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MT11, MT31). “Expressing ideas and processes in numbers and symbols” (MT19). One gave the reason as, “Critical thinking, logical reasoning, and problem-solving” (MT1).

Analysis of tutors’ responses to item 48, “Briefly explain what mathematics means to you?” revealed that (4 out of 34, representing 11.8%) of them did not respond to this item (MT 24, MT 27, MT 28, and MT 34). Mathematics tutors’ responses to what mathematics meant to them were also grouped into two groups, namely culture-related responses and culture-free responses. The minority (12 out of 34, representing 35.3%) of them gave culture–free responses. Some glaring examples of cultural-free responses given by mathematics tutors included the following: “Logical and analytical” (MT8, MT31). “Mathematics is the study of structure and shape of an object” (MT12, MT13). “It is the logical study of quantity, shape and space” (MT33).

“Is several quantities and shapes” (MT29). “The use of numbers in a logical manner” (MT14). “Mathematics is the study of number and space” (MT15). “Expressing ideas and processes in numbers and symbols” (MT19). “The use of arithmetic operations in computing numbers” (MT21).

The majority (18 out of 34, representing 52.9%) of mathematics tutors gave cultural–related responses. Some of the distinctive examples of cultural–related responses included the following: “It is the presentation of facts, calculations and solving of real-life issues by the use of mathematical models” (MT5). “Mathematics means data to me on critical thinking, logical reasoning, and problem-solving” (MT1, MT22). “It is a way of life because mathematics is learnt in our daily life activities” (MT 9). “Learning to solve daily problems using mathematics” (MT 6). “It is what helps us to solve daily activities in daily lives as

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well as the basis to all subjects in school" (MT7). "It is a scientific knowledge which involves the use of numbers, values and shapes in solving everyday problems" (MT16). "It means everything I do and things around me" (MT17). "Making use of figures, designs and patterns to solve problems in the immediate environment" (MT26). "I apply mathematics in everything I do in my life" (MT25). "Mathematics equips us with the knowledge needed to live a meaningful life" (MT31). "Mathematics is the application of cognitive knowledge in solving real-life problems" (MT32). "Doing, finding a solution to problems" (MT20).

The results analysis showed that the views expressed by mathematics tutors about mathematical knowledge on two items with open-ended questions, the responses from item 47 showed trends toward cultural-related perceptions, while item 48 had more culture-related views. The results presented generally confirmed trends toward culture–related perceptions from the Likert-type items and open-ended questions responses. It is evident from the results presented on mathematics tutors' views about mathematical knowledge that their views showed trends to culture-related regardless of some culture–free response in some few items. Contrary to teacher trainees' views, a small majority of them did not support the perception of mathematical knowledge as being universal knowledge that is certain, infallible, and the same everywhere in the world.

Results of Mathematics Tutors' Perceptions about Mathematics Pedagogy

Table 15 presents mathematics tutors' perceptions about mathematics pedagogy. Six (6 out of 9, representing 66.7%) had mean scores greater than three (cultural–related perceptions). Only one (1 out of 9, representing 11.1%) had a mean score of 2.6 (trend towards cultural-related perceptions). The remaining two had mean scores ranging from 2.0 to 2.4 (culture-free perceptions). The result from

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Table 15 in the same way as teacher trainees, the majority of mathematics tutors appeared to also appreciate the role of the learner in mathematics pedagogy, as all of them either strongly agreed or agreed that “teaching and learning mathematics involves active participation of learners throughout the lesson” (34 out of 34, representing 100%), “children are very likely to understand mathematics better when they are taught in the language they understand best”(33 out of 34, 97.1%). However, they appeared to perceive achievement in mathematics learning not solely dependent on the inherent knack of the learner, as the majority of them either strongly disagreed or disagreed to the statements, “learning mathematics basically requires memorizing facts” (29 out of 34, 85.3%), “learning mathematics is all about ensuring accuracy in the application of algorithms in class exercise” (21 out of 34, representing 61.8%), and “mathematics should only be studied by bright people in the society” (22 out of 34, representing 64.7%). The result further revealed the overwhelming majority of mathematics tutors either strongly disagreed or disagreed to two items that, “mathematics should be made an optional subject at all levels including Colleges of Education level” (31 out of 34, representing 94.1%), and “language has nothing to do with mathematical thinking” (31 out of 34, representing 91.2%).

The results further revealed that a little more than half of mathematics tutors either strongly disagreed or disagreed that, “learners' success in mathematics depends on their intellectual abilities”(19 out of 34, representing 57.9%), and “mathematics learning is all about practicing a given task over and over again”(21 out of 34, representing 61.8%).

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Table 15 : Mathematics Tutors' Perceptions about Mathematics Pedagogy (N= 34)

Item	Statement		SA	A	DA	SDA	M	SD
9	Learners success in mathematics depends on their intellectual abilities(CF)	N %	- -	15 44.1	10 29.4	9 28.5	2.0 -	0.76 -
15	Mathematics should be made an optional subject at all levels including Colleges of Education level(CF)	N %	3 8.8	- -	12 35.3	19 55.9	3.4 -	0.89 -
16	Learning mathematics basically requires memorizing facts(CF)	N %	2 5.9	3 8.8	20 58.8	9 26.5	3.1 -	0.78 -
18	Teaching and learning mathematics involves the active participation of learners throughout the lesson(CR)	N %	19 55.9	15 44,1	- -	- -	3.6 -	0.50 -
19	Learning mathematics is all about ensuring accuracy in the application of algorithms in class exercise(CF)	N %	5 14.7	8 23.5	16 47.1	5 14.7	2.6 -	0.92 -
26	Mathematics should only be studied by bright people in the society(CF)	N %	1 2.9	11 32.4	- -	22 64.7	3.6 -	0.66 -
28	Mathematics learning is all about practicing a given task over and over again(CF)	N %	6 17.6	7 20.6	14 41.2	7 20.6	2.4 -	1.01 -
33	Language has nothing to do with mathematical thinking(CF)	N %	2 5.9	1 2.9	14 41.2	17 50.0	3.4 -	0.81 -
34	Children are very likely to understand mathematics better when they are taught in the language they understand best(CR)	N %	12 35.3	21 61.8	- -	1 2.9	3.3 -	0.63 -

Note: SA-Strongly Agree, A-Agree, DA - Disagree, SDA -Strongly Disagree, M-Means, SD- Standard Deviation

SOURCE: Field Data (2022)'

It is evident from the results presented on mathematics tutors' perceptions about mathematics pedagogy in Table 15 that, a substantial majority (6 out of 9, representing 66.7%) of the held views had mean scores ranging from 3.1 to 3.6 (culture-related perceptions). A majority of them recognised the significance of culturally responsive teaching in mathematics classrooms.

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Results of Mathematics Tutors' Perceptions about Links between the Ghanaian Culture and Mathematical Knowledge

Table 16 presents mathematics tutors' perceptions about links between culture and mathematical knowledge from the four-point Likert-type items. The result indicated that the majority (5 out of 6, representing 83.3%) of the items had means scores ranging from 3.1 to 3.4 (cultural–related perceptions). The remaining one item had mean scores of 2.8 (trend towards cultural-related perceptions). The results showed that more than half of tutors confirmed their worldwide views about mathematical knowledge, as they either strongly agreed or agreed with the statements that, "every culture has its own way of doing mathematics" (25 out of 34, representing 73.2%), and "mathematical practices differ from culture to culture" (26 out of 34, representing 76.4%). However, the majority of them rather seemed to appreciate links between culture and mathematical knowledge, as they either strongly disagreed or disagreed that, "Indigenous culture practices has no place in mathematics teaching and learning" (30 out of 34, representing 88.4%), "mathematics has very little relevance to Indigenous culture" (30 out of 34, representing 88.4%). Every culture has its values and disciplines which are embedded in mathematics, as a substantial number of mathematics tutors either strongly agreed or agreed that, "mathematics is not free from (moral, ethical, religious etc.) values" (30 out of 34, representing 88.4%), and "values such as moral, ethical or religious are present in mathematics teaching and learning" (34 out of 34, representing 100%).

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Table 16: Mathematics Tutors' Perceptions about Links between Ghanaian Culture and Mathematical Knowledge (N = 34)

Item	Statement		SA	A	DA	SDA	M	SD
10	Mathematical practices differ from culture to culture(CR)	N	13	13	7	1	3.1	0.84
		%	38.2	38.2	20.6	2.9	-	-
23	Indigenous culture practices has no place in mathematics teaching and learning(CF)	N	3	1	15	15	3.2	0.89
		%	8.8	2.9	44.1	44.1	-	-
24	Mathematics is not free from (moral, ethical, religious etc.) values(CR)	N	9	21	2	2	3.1	0.75
		%	26.5	61.8	5.9	5.9	-	-
25	Every culture has its own way of doing mathematics (CR)	N	5	20	6	3	2.8	0.81
		%	14.7	58.5	17.6	8.8	-	-
31	Values such as moral, ethical or religious are present in mathematics teaching and learning (CR)	N	14	20	-	-	3.4	0.50
		%	41.2	58.5	-	-	-	-
32	Mathematics has very little relevance to Indigenous culture(CF)	N	2	2	18	12	3.2	0.80
		%	5.9	5.9	52.9	35.3	-	-

Note: SA-Strongly Agree, A-Agree, DA - Disagree, SDA -Strongly Disagree, M-Means, SD- Standard Deviation

SOURCE: Field Data (2022)

For each result in Table 16, it is evident that mathematics tutors' perceptions about links between Ghanaian culture and mathematical knowledge were said to be culture-related, the majority (5 out of 6, representing 83.3%) of the items received culture-related responses, and the remaining one item showing a trend of cultural-related perception.

Similar to teacher trainees, mathematics tutors were also requested to indicate whether they believed the activities carried out in various societies generate mathematics, which may not be the same as school mathematics (see Appendix B, item 44). The results from the analysis of their responses showed that all (34 out of

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34, representing 100%) of them answered "yes" to this item. This shows that all of them believed that activities teachers and students carry out in their societies could generate some form of mathematics. This confirmed the finding from the Likert-type items in Table 16 above that the mathematics tutors appeared to appreciate some links between culture and mathematical knowledge.

Results analysis of tutors' responses to item 45 (see Appendix B) on their choice of activities that they thought could generate mathematics were presented in Table 17. The results in Table 17 showed that, the majority of mathematics tutors perceived more than one activity (31 out of 34, representing 91.2%) that generates mathematics. One mathematics tutor gave counting (2.9%) as the only activity that generates mathematics. the remaining two tutors stated other activities such as games and chance, drumming and dancing classified as activities that generate some form of mathematics. The majority of tutors who perceived the activities that generate mathematics indicated at least two of the following six fundamental activities (Bishop, 1988): counting, measuring, locating, playing, designing, and playing.

Table 17 : Mathematics Tutors' Perceptions about activities that may generate Mathematics (N = 34)

Topic	Frequency	Percentage (%)
Counting	1	2.9
More than one activity	31	91.2
Other activity	2	5.9
Total	34	100.0

SOURCE: Field Data (2022)

For all (34 out of 34, representing 100%) mathematics tutors who believed that activities carried out in various societies generate mathematics, which may not

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be the same as school mathematics did not respond to item 46. It is evident from the results presented on mathematics tutors' perceptions about links between culture and mathematical knowledge that, such links are more appreciated by the tutor participants. Thus the results generally showed tendencies toward culture-related views about the links between culture and mathematical knowledge.

Results of Mathematics Tutors' Perceptions about Links between Ghanaian Culture and Mathematics Pedagogy

Table 18 presents mathematics tutors' perceptions about links between culture and mathematics pedagogy. Results from Table 18 showed that the majority (10 out of 12) of the items had mean scores greater than three (culture-related perceptions). The remaining two had mean scores of 2.5 and 2.7 respectively (culture-free perceptions). As compared with the teacher trainees, none of the mathematics tutors' responses to questionnaire items on the links between culture and mathematics pedagogy had a mean score below 2.5 (culture-free perceptions). The result further revealed the same way as teacher trainees, mathematics tutors held a value of integration of culture to support mathematics teaching and learning, as all of them either strongly agreed or agreed that, "mathematical practices in our Indigenous culture can support children's learning in school mathematics" (34 out of 34, representing 100%), "mathematics lessons and activities should relate and reflect the socio-cultural practices of the learner" (34 out 34, representing 100%), "teaching mathematics requires using children's mathematical practices in their culture to help them understand the lesson" (34 out of 34, representing 100%), "teaching mathematics requires application of what children already know, including mathematical practices in their homes to help them to understand the lesson" (34 out of 34, representing 100%). The results

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further showed the majority of mathematics tutors either strongly agreed or agreed that, “the use of out–of–school mathematics practices in school mathematics will facilitate learners’ understanding of school mathematics” (34 out of 34, representing 100%), and “incorporating cultural experiences into school mathematics will help students learn mathematics meaningfully” (34 out of 34, representing 100%). Mathematics tutors’ concepts on the influence of culture in teaching and learning mathematics could help learners understand mathematical concepts better as the majority of them either strongly agreed or agreed that, “culture plays an important role in mathematics learning” (33 out of 34, representing 97.1%), “teachers’ use of out–of–school mathematics practices in school mathematics will better equip children to use out–of–school mathematics more effectively”(34 out of 34, representing 100%), “learners perform better when mathematics activities are related to their socio cultural background”(33 out of 34, representing 97.1%), and “teachers’ knowledge of mathematical practices in learners’ culture may help in mathematics teaching and learning”(33 out of 34, representing 97.1%). The rules and procedures are found in mathematics just as in games and other cultural-related activities, as more than half (22 out of 34, representing 54.7%) of mathematics tutors either strongly disagreed or disagreed that, “doing mathematics requires rules which have little to do with Indigenous culture.” Students' funds-of-knowledge help them to acquire new concepts easily in mathematics learning, as more than half (20 out of 34, representing 57.0%) either strongly disagreed or disagreed that, “the nature of school mathematics makes the introduction of out-of-school mathematics practices in-school mathematics impossible.”

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Table 18: Mathematics Tutors' Perceptions about Links between Ghanaian Culture and Mathematics Pedagogy (N = 34)

Item	Statement		SA	A	DA	SDA	M	SD
3	Doing mathematics requires rules which have little to do with Indigenous culture(CF)	N	4	8	16	6	2.7	0.91
		%	11.8	23.5	47.1	17.6	-	-
11	The use of out–of–school mathematics practices in school mathematics will facilitate learners' understanding of school mathematics(CR)	N	9	25	-	-	3.3	0.45
		%	26.5	73.5	-	-	-	-
12	Mathematical practices in our Indigenous culture can support children's learning in school mathematics(CR)	N	14	20	-	-	3.4	0.50
		%	41.2	58.8	-	-		
14	Culture plays an important role in mathematics learning(CR)	N	16	17	-	1	3.4	0.66
		%	47.1	50.0	-	2.9		
17	Incorporating cultural experiences into school mathematics will help students learn mathematics meaningfully(CR)	N	14	20	-	-	3.4	0.50
		%	41.2	58.8	-	-	-	-
20	Mathematics lessons and activities should relate to and reflect the sociocultural practices of the learner(CR)	N	17	17	-	-	3.5	0.51
		%	50.0	50.0	-	-	-	
21	Teachers' use of out–of–school mathematics practices in school mathematics will better equip children to use out–of–school mathematics more effectively(CR)	N	14	20	-	-	3.4	0.50
		%	41.2	58.8	-	-	-	-
22	Learners perform better when mathematics activities are related to their socio-cultural background(CR)	N	15	18	-	1	3.4	0.65
		%	44.1	52.9	-	2.9	-	-
27	The nature of school mathematics makes the introduction of out-of-school mathematics practices in-school mathematics impossible(CF)	N	7	7	12	8	2.5	1.08
		%	20.6	20.6	33.5	23.5	-	-
35	Teachers' knowledge of mathematical practices in learners' culture may help in mathematics teaching and learning(CR)	N	8	25	1	-	3.2	0.48
		%	23.5	73.5	2.9		-	-
36	Teaching mathematics requires using children's mathematical practices in their culture to help them understand the lesson(CR)	N	11	23	-	-	3.3	0.48
		%	32.4	67.6	-	-	-	-
37	Teaching mathematics requires the application of what children already know, including mathematical practices in their homes to help them to understand the lesson(CR)	N	15	19	-	-	3.4	0.50
		%	44.1	55.9	-	-		

Note: SA-Strongly Agree, A-Agree, DA - Disagree, SDA -Strongly Disagree, M-Means, SD- Standard Deviation

SOURCE: Field Data (2022

For each result in Table 18, it is evident that mathematics tutors' perceptions about links between culture and mathematics pedagogy were said to be culture-

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related, as the vast majority (10 out of 12, representing 83.3%) had mean scores ranging from 3.2 to 3.4 (culture-related perceptions), and the remaining one with mean score of 2.5 and 2.7 (trends toward cultural-related perceptions)

To further explore mathematics tutors' views about links between culture and mathematics pedagogy, they were asked to indicate whether they believe that one's cultural practices have a place in mathematics teaching and learning in a college (see Appendix B, item 42). From the analysis, the results of mathematics tutors' responses showed that all (34 out of 34, representing 100%) mathematics tutors answered "yes" to this question. This is an indication that the majority of mathematics tutors also generally perceived that one's cultural practices have a place in mathematics pedagogy. This confirmed the results in Table 18, which revealed culture-related perceptions about links between culture and mathematics pedagogy.

Similar to teacher trainees, mathematics tutors were asked to indicate the choice of topics in their views allowing for the inclusion of out–of–school mathematics practices (see Appendix B, item 43). Table 19 presents the topics that tutors perceived as allowing for the inclusion of out-of-school mathematical practices. The results showed that all the respondents indicated one or two of the topics that allow for the inclusion of out–of–school mathematics (34 out of 34, 100%). Only one (1 out of 34, representing 2.90 %) of them perceived measurement as the only topic that allows for the inclusion of out–of–school mathematics. The majority (32 out of 34, representing 94.1%) of the respondents chose at least two topics such as measurements, lines and space, fractions, data handling, game and chance, operation on numbers, and word problem-solving as topics that allow for the inclusion of out – of – school mathematics. The remaining

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one (1 out of 34, representing 2.9%) of tutors perceived other topics such as probability, ratio and rates, and geometry that allow for integration of out–of–school mathematics.

Table 19: Mathematics Tutors' Perceptions about topics that allow for the inclusion of out – of – school Mathematical practices

Topic	Frequency	Percentages (%)
Measurements	1	2.94
More than one	32	94.12
Others	1	2.94
Total	34	100.0

Note: NR - Non - Response
SOURCE: Field Data (2022)

In the same way as teacher trainees, mathematics tutors were also asked to indicate whether they believed mathematics education could also be used as a vehicle for the preservation of the Ghanaian culture (see Appendix B, item 49). The results of mathematics tutors' responses showed that the majority (33 out of 34; representing 97.1%) of them answered "yes" to this item. Only one (1 out of 34, representing 2.9 %;) of tutors responded "no" to the item 49. Again, less than a quarter (8 out of 34, representing 23.5%) of mathematics tutors who answered "yes" and one tutor who answered "no" to the item 49 did not give reasons for their choice of answers to the item 50 (MT2, MT3, MT8, MT12, MT13, MT15, MT22, MT26, and MT27). This indicates that (25 out of 34, representing 73.5%) of them gave reasons why they believe or did not believe that mathematics could also be a vehicle for the preservation of the Ghanaian culture. One mathematics tutor (MT33) gave reason to the item 50 that, "mathematics education has no relevance to our rich culture" (cultural-free perception). The majority (24 out of 34, representing 70.6%) of mathematics tutors gave reasons relating to cultural-related perceptions.

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Some of the reasons given by tutors who believed mathematics education could also be a vehicle for the preservation of the rich Ghanaian culture were grouped into several categories including the following: the role of mathematics in everyday activities, preserving indigenous mathematical ideas in the Ghanaian culture, creating awareness about the existence of aspects of Ghanaian culture, learning mathematics through the use of traditional games, connection between mathematics and the Ghanaian culture, function of mathematics, and other idiosyncratic responses. Some of the typical responses they gave included the following: "By relating to our indigenous artefacts with mathematical thinking and ideas" (MT1, MT7)." Topics such as measurements, game and chance, and word problem solving can be related to the cultural norms and students be made to use them in their daily examples" (MT4, MT5). "It will help because people will appreciate the role of mathematics in our day to day activities" (MT9, MT21). "The aesthetic beauty of cultural display show patterns and designs that depict the aspect of mathematics such as counting, designing, explanation, etc. which are embedded in mathematics "(MT34). "The aesthetic beauty and designs display by people during the occasion show patterns, values, rules, and disciplines which are embedded in mathematics" (MT14). "Mathematics and culture are inseparable because people construct mathematical knowledge from experience around their environment" (MT16). "Collecting and handling of data, analyzing and interpreting data, making inference and taking decisions in our day-to-day problem-solving" (MT17). "Some of our games have a mathematical background. Example is playing of Oware game" (MT18). "Historical dates and records of events are mathematically explained" (MT19). "In the teaching of topics such as mensuration, space and shapes, mathematics teachers can use students' cultural settings in their presentations. For

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example, huts could be used in presenting conical shapes and other related topics" (MT20). "Mathematics is applied in real life" (MT21).

"Awareness of time and creativity" (MT10, MT32). "The symbols of our culture and drawn base in mathematics. The food they prepare for the festival is based on mathematics" (MT23). "Mathematics affords us to learn how to calculate interest and compound interest" (MT28). "By way of leveraging indigenous cultural practices in teaching and learning of school mathematics" (MT30).

It is evident from the responses given above that reasons relating to the functional value of mathematics and perceived links between mathematics and culture were the major reasons why the majority (24 out of 34, representing 70.6%) of mathematics tutors believed mathematics education could also be a vehicle for the preservation of Ghanaian culture. Only one (1out of 34, representing 2.9%) of them gave the cultural-free perception that "mathematics education has no relevance to our rich culture".

Therefore, the results presented in Table 19 and items 42, 43, 49, and 50 generally showed that the mathematics tutors generally had culture-related perceptions about links between culture and mathematics pedagogy. This is an indication that tutors appeared to acknowledge that culture could support mathematics teaching and learning.

Results of Mathematics Tutors' Perceptions about the Links between Ghanaian Culture and Mathematics Curriculum

Table 20 presents mathematics tutors' perceptions about links between the Ghanaian culture and mathematics curriculum from four-point Likert-type items. Results from Table 20 show that all four items had mean scores ranging from 3.1 to 3.4 (culture-related perceptions). As with teacher trainees, incorporating cultural

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objects into college mathematics curriculum could help in the smooth representation of classroom mathematics to harness students' understanding of concepts, as the majority of mathematics tutors either strongly agreed or agreed that, "mathematics curriculum should be incorporated with elements of cultural events of people in a community" (31 out of 34, representing 91.2%). Mathematics curriculum designed using students' cultural referents could call for their active participation in the classroom discourse, as the vast majority of them either strongly agreed or agreed that "mathematics curriculum should be seen by students as relevant to their future lives" (34 out of 34, representing 100%), "mathematics curriculum should be resonated, as far as possible, with diverse home cultures" (32 out of 34, representing 94.1%). The results further show that, the majority of teacher trainees either strongly agreed or agreed that, "mathematics curriculum should be experienced as "real" by all students" (32 out of 34, representing 94.1%).

Table 20: Mathematics Tutors' Perceptions about the Links between Ghanaian Culture and Mathematics Curriculum

Item	Statement		SA	A	DA	SDA	M	SD
38	Mathematics curriculum should be seen by students as relevant to their future lives (CR)	N %	14 41.2	20 58.8	- -	- -	3.4 -	0.50 -
39	Mathematics curriculum should be incorporated with elements of cultural events of people in a community (CR)	N %	10 29.4	21 61.8	2 5.9	1 2.9	3.2 -	0.67 -
40	Mathematics curriculum should be experienced as "real" by all students CR)	N %	11 32.3	21 61.8	2 5.9	- -	3.3 -	0.54 -
41	Mathematics curriculum should be resonated, as far as possible, with diverse home cultures (CR)	N %	7 20.6	25 73.5	1 2.9	1 2.9	3.1 -	0.59 -

Note: SA-Strongly Agree, A-Agree, UD – Undecided, DA - Disagree, SDA - Strongly Disagree, M- Means, SD- Standard Deviation

SOURCE: Field Data (2022)

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The evidence from Table 20 showed that all (34 out of 34, representing 100%) mathematics tutors had cultural–related perceptions of the links between Ghanaian culture and the mathematics curriculum. As with teacher trainees, mathematics tutors perceived that mathematics curricula in Ghanaian schools should be incorporated with culture of learners.

Having followed mathematics tutors' views of mathematics, which resulted from quantitative analysis, it was revealed that the views held by mathematics tutors generally showed the trend of cultural – related perceptions about mathematics.

The views held by the mathematics tutors in their mathematics teaching showed an overall mean of 2.9 and a standard deviation of 0.184 based on the 41 questionnaire items analyses. In response to research question one, the mathematics tutors appear to show trends toward cultural–related perceptions about mathematical knowledge, mathematics pedagogy, and the links between culture and mathematical knowledge (see Tables 14 and 15). However, as with teacher trainees, mathematics tutors had cultural-related perceptions about links between culture and mathematics pedagogy, and links between Ghanaian culture and mathematics curriculum (see mean scores of items in Tables 16, 18 & 20) respectively.

As with teacher trainees, to understand the views held by mathematics tutors on cultural relevance of mathematics, an open-ended semi-structured interview guide were shared with them to provide reasons for their held views of quantitative part of research question one. However, none of the focus group interview responses from mathematics tutors showed cultural-free perceptions after thematic analysis.

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Mathematics Tutors' Responses to Interview Guide

Mathematics Tutors' Perceptions about Mathematics

As with teacher trainees, the main themes observed in mathematics tutors responses to focus group interviews were summarised to provide reasons for their held views indicating cultural-related or cultural-free perceptions. The main themes observed in mathematics tutors' cultural-related responses from focus group interviews were: problem-solving, daily life application, teaching and learning approaches, and language use and preference. There was no observable cultural-free responses from interviews guides. The most prevailing responses for the perceptions about mathematics after the thematic transcription of the data (views) collected from the 34 mathematics tutors through focused group interviews across all the five colleges involved in this study were summarised in the next section.

As with teacher trainees, the responses of mathematics tutors who did answer the questions have been organised according to number of major themes, and these are explored below. (Note: Acronyms in brackets refer to the identity of individual focus groups. Identifying acronyms beginning with FGMT are for Mathematics tutors in Colleges, A, B, C, D, and E, were FGMTA, FGMTB, FGMTC, FGMTD, and FGMTE). Where two or more focus groups give the same responses, their pseudonyms were put together against that response

Problem–Solving

The reasons provided by the mathematics tutors for problem-solving were grouped under four sub-themes namely critical thinking, problem-solving, communication, and conceptual understanding. The majority of mathematics tutors see mathematics as an essential in problem space. Their reasons were related to problem-solving. Some teacher trainees from the two groups stated that:

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"The principles involved in mathematics require some formulas and rules to solve problems in our daily lives" (FGMTA); "I will say mathematics is a process of identifying the everyday life problems, defining the problems and solving them" (FGMTB).

Daily Life Applications

The analysis of mathematics tutors' responses on perceptions about mathematics related to daily life applications were grouped into five sub-themes including: practical and real-life application, problem-solving, communication, engagement, and cultural relevance and connections. Most of the responses were related to practical and real-life applications. Some typical reasons given by tutors relating to practical and real-life applications were: "*I think mathematics is the use of principles, procedures, and methods to look at real life issues that will help us to come out with solutions to a problem in our daily life" (FGMTB, FGMTC & FGMTE).*

Some mathematics tutors focused on the usefulness of mathematics for their everyday lives and many of these referred to needing mathematics so as to be able to work with in various sectors. *"The principles involved require some formulas and rules just like what we do every day in our homes" (FGMTA); "Mathematics is the study of lines, equations, and principles for solving real life issues" (FGMTC); "For me I think mathematics is a way of life. For instance buying and selling, we have to know counting, addition, subtraction, and number sense" (FGMTD, FGMTE); "Mathematics helps us in the areas such as statistics. For instance, in a statistical service where it helps government to know the population of people in a particular community so that their budget can be drawn" (FGMTB).*

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Teaching and Learning Approaches

The reasons for teaching and learning approaches views as with teacher trainees, were put under six sub-themes namely, engagement and participation, engagement and interest, communication, conceptual understanding, abstract concept understanding, and cultural relevance and connection. Some of the reasons given by mathematics tutors related to their immediate utility of cultural objects in mathematics instructions. Some gave reasons relating to usefulness of drums and other artefacts to enhance understanding of mathematical concepts. Some tutors stated that

"The use of drumming and role play for example, can be used to capture the attention of learners in classroom mathematics learning" (FGMTA).

One group mentioned game as very powerful cultural tool for an effective teaching and learning of mathematics. Some tutors stated

"The game of 'Oware' for instance, which is normally play by two people in which each player has six holes. Each hole is filled with 4 stones…..the stones which the players use were arranged in 4s. In this case we can use Oware to teach counting and multiples of numbers. The players guess and think critically to solve problems when they are playing Oware" (FGMTE).

Majority of mathematics tutors considered the cultural practices to be the driving wheel for out-of-school mathematical notions which have a place in school mathematics teaching and learning. Some tutors stated that

"The typical examples like hunting and fishing can be used in teaching probability. Hunting is a cultural practice of people living a forest areas while fishing is done by those around a coastal belt of the country. During hunting, the hunters do calculate distances, measure their steps, guess, and aim at the prey before shooting.

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With this practice, there is chance of hitting or missing their target. In the case of fishing, the fishermen cast the fishing nets with the aim of catching more fish. In this case there is always probability of catching fish or not catching" (FGMTD); "Setting of traps is also another form of hunting in the rural communities. Traps hunting is based on chance, and deals with creativity and innovation" (FGMTA); "In naming ceremonies and funerals for example, the application of numbers take place because you measure the materials needed for the occasion through estimation of numbers during naming ceremonies as well as funeral rites" (FGMTD); and "Sharing of items in our house can be used in schools to teach fractions. For instance, the sharing of food and meat is what children do every day in their homes and communities. In this case, we can relate their home knowledge of fractions with an illustrative examples to teach fractions in school. With this previous knowledge, fractions can be taught of as sharing that will help the learners to understand it better" (FGMTA).

Mathematics tutors considered the children's everyday activities such as going on errands in the house can be used as an illustrative example in the classroom teaching and learning of mathematics. Some tutors mentioned

"Children going on errands to market to buy items that involve two or more quantities. For instance, Kofi was sent to market to buy five tubers of cassava and two bunches of plantain for the family. His mother gave him Gh₵50.00 to purchase the above items and bring back the change. The cost of one tuber of cassava was Gh₵2.00 and one bunch of plantain was Gh₵10.00, what will be the total cost of five tubers of cassava and two bunches of plantain?" (FGMTE).

Majority of tutors considered some cultural practices can be used as illustrative examples in teaching probability. Some tutors stated

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"Yes, the typical example is hunting and fishing. Hunting is a cultural practice of people living a forest areas while fishing is done by those around a coastal belt of the country. During hunting, the hunters do calculate distances, measure their steps, guess, and aim at the prey before shooting. With this practice, there is chance of hitting or missing their target. In the case of fishing, the fishermen cast the fishing nets with the aim of catching more fish. In this case there is always probability of catching fish or not catching" (FGMTD); and

"Setting of traps is also another form of hunting in the rural communities. Traps hunting is based on chance, and deals with creativity and innovation" (FGMTA).

Some considered mathematical concepts embedded in their cultural festivities, funerals, and other ceremonies. Majority of tutors mentioned: *"In naming ceremonies and funerals for example, the application of numbers take place because you measure the materials needed for the occasion through estimation of numbers during naming ceremonies as well as funeral rites" (FGMTD).*

Mathematics tutors gave reasons for their views of activities in the home that generate mathematics which may not be the same as the school mathematics but can be used to enhance conceptual understanding. Some tutors mentioned

"Counting is done in our homes during the cooking of meals" (FGMTA, FGMTB); "Rearing of animals in the house involves counting. For example shepherds, every morning go to the pen and count the number of farm animals before they send them out for grazing and in the evening too they do counting to check their numbers again" (FGMTC, FGMTE); "Measurement takes place in a house as a result of the addition of salt to the stew or soup, however, this kind of measurement is done through estimation which is not the same as classroom measurement" (FGMTD);

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"Measurement is done at the market, shops and restaurants. We estimate the size of human feet or body before purchasing footwear and clothes that will fit the child who is not present physically" (FGMTB); "Counting is done in our homes during the cooking of meals (FGMTA, FGMTB); "Playing games like 'ampe' the players do add and subtract numbers. For instance, 'one', 'two', when you missed out and the winner counts and adds to her score. In this case, the players apply the rules of the game here" (FGMTE); "Designing of our houses was in the form of geometric shapes with architectural paintings. The other artefacts like drums, basketry, weaving, knitting, pottery, and sculpture were done with patterns and colour harmony. For instance, the 'Ata Kwame' building (mud house) were designed buildings in the form of geometrical shapes" (FGMTA); and "Explaining in our communities were in the form of storytelling, proverbs, and idiomatic expressions. For instance the story of old legendary 'Kwaku Ananse' can be used to represent anybody in a community who thinks to possess all wisdom. This helps us to teach morality to people in our community. 'Kwaku Ananse' can be represented by 'x' and 'y' (FGMTB).

Language Use and Preference

The way mathematics communicated and understood depends on the language used, which shapes how mathematics teachers and students interpret and solve problems in mathematics classroom. The reasons for language use and preference given by teacher trainees were put under two sub-themes namely, preference for local language and preference for blended (local and English languages). Some typical reasons provided by the teacher trainees for Language of preference for teaching and learning of mathematics were:

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"I prefer the use of both local and English languages because not all the concepts you can use English language to explain while the use of local language too will help the learners to understand the concepts better" (FGMTC, FGMTD); "To me, I prefer the use of local language in teaching mathematics. Because teachers and learners can express themselves better in their local language than English language" (FGMTA, FGMTB); "To me, I think we should still stick to the use of the English language to develop the curriculum but when it comes to its implementation, the teachers should be allowed to use the local language to explain the concepts to the learners" (FGMTD); and *"I prefer the use local language to develop the curriculum and English language to be used sometimes by teachers to explain some terms and symbols which are not found in our local languages. Thus the curriculum should be community based" (FGMTC).*

The above reasons provided by the mathematics tutors revealed why the views of the cultural relevance of mathematics held by them were vital in their teaching. In some cases, they even provided how these views are linked with each other. Indeed, the above reasons presented by the mathematics tutors explain the relevance of incorporating cultural aspects in mathematics teaching and learning at the five colleges used for this study. Tutors' responses provide diverse perspectives on the definition of mathematics, highlighting its practical applications and its role in addressing real-life issues.

The next section presents results of research question two.

Effect of Sex on Teacher Trainees' and their Mathematics Tutors' Receptiveness to the Cultural Relevance of Mathematics

To address Research Question Two, a one-way multivariate analysis of variance (MANOVA) was conducted to explore the differences in receptiveness to

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the cultural relevance of mathematics by sex of both teacher trainees and their mathematics tutors (Female, Male). A MANOVA is an appropriate statistical analysis when assessing differences in multiple continuous dependent variables between three or more groups (Pagano, 2009; Mertler et al, 2021). Before analysis, the assumptions of normality and homogeneity of variance were tested by examination of the Kolmogorov-Smirnov test and Levene's test, respectively. Statistical significance for either test at $\alpha = .05$ suggests that the assumption was met.

The results of research question two was addressed separately regarding the responses obtained from the two groups (teacher trainees, N = 1,160, and their mathematics tutors, N = 34). To explore the effect of sex on teacher trainees' and their mathematics tutors' receptiveness to the cultural relevance of mathematics in teaching and learning, a one-way MANOVA analysis was conducted with an independent variable (sex) having two groups (1) Female, (2) Male. Five dependent variables were used: *Perceptions about Mathematical Knowledge (PMK), Perceptions about mathematics pedagogy (PMP), Perceptions about links between culture and mathematical knowledge (PGCMK), Perceptions about links between culture and mathematics pedagogy (PGCMP), and Perceptions about links between culture and mathematics curriculum (PGCMC)).* Teacher trainees' results were presented first followed by their mathematics tutors.

The next section presents the results of effect of sex on teacher trainees' receptiveness to the cultural relevance of mathematics teaching and learning.

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Results of Effects of Sex on Teacher Trainees' Receptiveness to Cultural Relevance of Mathematics

To determine if there is a statistically significant difference in the mean scores of the views held by female and male teacher trainees on the cultural relevance of mathematics, a one-way between–groups multivariate analysis of variance (MANOVA) was performed to explore differences in the mean scores of views held by female and male teacher trainees. Five dependent variables were used: Perceptions about Mathematical Knowledge, Perceptions about Mathematics Pedagogy, Perceptions about links between Ghanaian Culture and Mathematical Knowledge, Perceptions about links between Ghanaian Culture and Mathematics Pedagogy, and Perceptions about links between Ghanaian Culture and Mathematics Curriculum. The independent variable was sex (female, male).

Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity, with no serious violations noted. There were four sets of statistics to select from, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root. Because the independent variable has only two groups, the F–tests for Wilks' Lambda, Hotelling's Trace and Roy's Largest Root are identical. Tabachnick et al (2013) recommend Wilks' Lambda for general use.

The result revealed the statistically significant difference between female and male teacher trainees on the combined dependent variables, F (5, 1154) = 4.12, Significance level (ρ) = .001; Wilks' Lambda = .98; partial eta squared ($\eta^{2)}$ = .02). The result of the F-test with a significance level (ρ) = .001 indicated that there was a statistically significant difference between female and male teacher trainees on

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the combined dependent variables. Therefore, in general, sex has a significant effect on teacher trainees' receptiveness to the cultural relevance of mathematics whether cultural-related or cultural-free (see Table 21).

Table 21: Summary of Multivariate Analysis of Variance (MANOVA) for Sex Groups Variable–Teacher Trainees

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared($ŋ^2$)
Trainees' Sex	Wilks' Lambda	.982	4.115[b]	5.000	1154.000	.001	.018

a. Design: Intercept + Sex
b. Exact statistic
SOURCE: Field Data (2022)

To explore further what dependent variables resulted in this significant difference in the mean scores, a test of between-subject effects analysis in MANOVA was conducted. Table 22 showed the results of tests of between-subjects effects of female and male teacher trainees on five dependent variables. When the results were considered separately, the only three differences to reach statistical significance using an alpha level of .05 were Perceptions about mathematical knowledge, F (1, 1158) = 4.58, ρ = .033, partial eta squared ($ŋ^2$) = .004. The F-value of 4.58 indicated that there was a statistically significant difference between the mean scores of female and male teacher trainees' perceptions about mathematical knowledge. The p-value of .033 confirmed that this difference in the mean scores is statistically significant at the alpha level of .05. Again, the partial eta squared ($ŋ^2$) value of .004 suggests the effect size is very small. This means that gender accounts for only 0.4% of the variance in perceptions about mathematical knowledge. However, this statistical difference cannot be ignored.

Perceptions about links between Ghanaian Culture and Mathematics Pedagogy, F (1, 1158) = 6.901, ρ = .009, partial eta squared ($ŋ^2$) = .006. The F-value of 6.90

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indicated a statistically significant difference between the mean scores for female and male teacher trainees' perceptions about the links between Ghanaian culture and mathematics pedagogy. The small p-value of .009 indicated that this difference is statistically significant. Also, the partial eta squared (η^2) value of .006 also indicated a very small effect size, with gender explaining only 0.6% of the variance. Again, while the difference is statistically significant, the practical effect of sex on this perception is negligible.

Perceptions about links between Ghanaian Culture and Mathematics Curriculum, F (1, 1158) = 19.25, ρ = .000, partial eta squared (η^2) =, 016. The F-value of 19.25 showed a statistically significant difference between male and female teacher trainees in perceptions about the links between Ghanaian culture and the mathematics curriculum. The p-value of .000 indicated this difference is highly statistically significant. The partial eta squared (η^2) value of .016 represents a small effect size, with sex accounting for 1.6% of the variance in perceptions. While this effect size is larger than the previous two, it still represents a small statistical effect. The results of the remaining two dependent variables (Perception about Mathematics Pedagogy and Perceptions about Links between Culture and Mathematical Knowledge) revealed no statistically significant differences between the mean scores of female and male teacher trainees (see Table 22).

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Table 22: Tests of Between-Subjects Effects of (MANOVA) for the Independent Variable and the Dependent Variables – Teacher Trainees

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared (η^2)
Sex	Perceptions about Mathematical Knowledge	.639	1	.639	4.581	.033	.004
	Perception about Mathematics Pedagogy	.103	1	.103	.475	.491	.000
	Perceptions about Links Between Culture and Mathematical Knowledge	.017	1	.017	.080	.777	.000
	Perceptions about Links between Culture and Mathematics Pedagogy	1.015	1	1.015	6.901	.009	.006
	Perceptions about Links between Culture and Mathematics Curriculum	4.002	1	4.002	19.254	.000	.016

a. R Squared = .004 (Adjusted R Squared = .003) e. R Squared = .016 (Adjusted R Squared = .016)
b. R Squared = .000 (Adjusted R Squared = .000)
c. R Squared = .000 (Adjusted R Squared = -.001)
d. R Squared = .006 (Adjusted R Squared = .005)
SOURCE: Field Data (2022)

To determine where the significant differences were among the three dependent variables, the Estimated Marginal Means for males and females were checked to find the magnitude of the differences in the mean scores (see Table 23)

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Table 23: Estimated Marginal Means for Male and Female Teacher Trainees' Receptiveness to Cultural Relevance of Mathematics

Dependent Variable	Trainees' Sex	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Perceptions about mathematical knowledge	Female	2.866	.016	2.835	2.897
	Male	2.913	.015	2.883	2.943
Perceptions about Mathematics Pedagogy	Female	2.611	.020	2.572	2.649
	Male	2.630	.019	2.592	2.667
Perceptions about Links between Culture and Mathematical Knowledge	Female	2.608	.019	2.571	2.646
	Male	2.616	.019	2.579	2.653
Perceptions about links between Culture and Mathematics Pedagogy	Female	3.002	.016	2.970	3.034
	Male	3.061	.016	3.030	3.092
Perceptions about Links between Culture and Mathematics Curriculum	Female	3.124	.019	3.086	3.161
	Male	3.241	.019	3.205	3.278

SOURCE: Field Data (2022)

An inspection of the mean scores of views held by female and male teacher trainees indicated that males reported slightly higher levels of held perceptions about mathematical knowledge (M = 2.91 SD = 0. 382) than females (M = 2.87, SD = 0. 364). The result revealed that male teacher trainees' perceptions about mathematical knowledge showed more trends toward cultural-related perceptions than their female counterparts. The results revealed a statistically significant effect of sex on teacher trainees' perceptions about mathematical knowledge as males' views indicated more trends to cultural-related perceptions than females.

Again, males reported slightly higher levels of perception about the links between culture and mathematics pedagogy (M = 3.06, SD = 0. 381) than females (M = 3. 00, SD = 0. 386). The male teacher trainees' perceptions about the links

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between culture and mathematics pedagogy were more culturally related than female teacher trainees. The statistically significant difference in the mean scores between male and female teacher trainees' held views showed that gender has a significant effect on teacher trainees' perceptions about links between culture and mathematics pedagogy.

The last significant difference was seen in the perception about the links between Ghanaian culture and mathematics curriculum. The results showed that the views of the male teacher trainees were a little higher (M = 3.24, SD = 0.443) than females (M= 3.12, SD= 0.469). The results indicated that male teacher trainees' perceptions were more culturally related than females' in terms of links between culture and mathematics curriculum. The results findings of a statistically significant difference in the mean scores between male and female teacher trainees' held views showed that sex has a significant effect on teacher trainees' perceptions about links between culture and mathematics curriculum.

Furthermore, the results indicated generally, significant differences between male and female teacher trainees for the three dependent variables mentioned. Hence, there is evidence to show that, sex has a statistically significant effect on teacher trainees' perceptions. The remaining two dependent variables, perceptions about mathematics pedagogy and perceptions about links between culture and mathematical knowledge were similar in the mean scores as a result of the views held by both male and female teacher trainees. However, male teacher trainees' views indicated more trends to cultural-related perceptions than females.

Therefore, the results generally showed that sex has statistically significant effects on teacher trainees' receptiveness to the cultural relevance of mathematics teaching and learning.

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The next section presents the results of the effects of sex on mathematics tutors' receptiveness to the cultural relevance of their mathematics teaching.

Results of Effects of Sex on Mathematics Tutors' Receptiveness to Cultural Relevance of Mathematics

As with teacher trainees, a one-way between-groups multivariate analysis of variance (MANOVA) was performed to explore differences in the mean scores of views held by female and male mathematics tutors. Five dependent variables were used: *Perceptions about Mathematical Knowledge, Perceptions about Mathematics Pedagogy, Perceptions about links between Ghanaian Culture and Mathematical Knowledge, Perceptions about links between Ghanaian Culture and Mathematics Pedagogy, and Perceptions about links between Ghanaian Culture and Mathematics Curriculum*. The independent variable was sex (male, female).

Similar to teacher trainees, the F–tests for Wilks' Lambda was used to determine the statistical significance. Table 24 shows the summary results of multivariate analysis of variance (MANOVA) of the effect of sex on the views held by mathematics tutors on the cultural relevance of mathematics. The result revealed there was no statistically significant difference between female and male mathematics tutors' held views on the combined dependent variables, F (5, 28) = 0.60, Sig. level (ρ) = .0.697; Wilks' Lambda = .90; partial eta squared ($\eta^{2)}$ = .097. The F-value of 0.60 suggests that the variance between male and female tutors is not significantly greater than the variance within each group. The p-value (ρ) of 0.697, greater than 0.05 typically indicated that the result is not statistically significant. In this case, a large p-value of 0.697 strongly suggests that any observed differences are likely due to chance rather than a true difference between males and females. The result analysis showed that male and female mathematics tutors do

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not differ significantly on the combined dependent variables. The similarity among the groups is supported by a high p-value (0.697) and small F-test (0.604). Therefore, the views of male and female tutors on these variables are essentially the same (see Table 24)

Table 24: Summary of Multivariate Analysis of Variance (MANOVA) for Sex Groups Variable –Mathematics Tutors (N = 34)

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared(η^2)
Tutors' Sex	Wilks' Lambda	.903	.604[b]	5.000	28.000	.697	.097

a. Design: Intercept + Sex
b. Exact statistic
SOURCE: Field Data (2022)

The results from Table 25 showed the significance test of between-subjects effects of sex for all the five dependent variables. When the results for the dependent variables were considered separately, there were no mean score differences to reach statistical significance using alpha level of .05. The results of univariate analysis of variance in Table 25 showed that there was no statistical significance difference between female and male mathematics tutors held views on any of dependent variables: Perceptions about mathematical knowledge, F(1, 32) = .014, ρ = .905, partial eta squared (η^2) = .000. This indicated that female and male mathematics tutors have similar perceptions about mathematical knowledge; perceptions about mathematics pedagogy, F (1, 32) = .081, ρ = .778, partial eta squared (η^2) = .003. Again significance level of 0.778 indicated that female and male tutors' perceptions about mathematics pedagogy were the same; Perceptions about links between Ghanaian Culture and Mathematical knowledge F (1, 32) = .969, ρ = .332, partial eta squared (η^2) = .029, also showed that there was no significant difference in the mean scores of the views held by both female and male

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mathematics tutors regarding perceptions between Ghanaian culture and mathematical knowledge. The results further, showed that were similar views held by female and male mathematics tutors on Perceptions about links between Ghanaian Culture and Mathematics Pedagogy, F (1, 32) = 1.092, ρ = .304, partial eta squared (η^2) = .033; and Perceptions about links between Ghanaian Culture and Mathematics Curriculum, F (1, 32) = .200, ρ = .658, partial eta squared (η^2) = 006(see Table 25).

The results analysis showed no significant difference between male and female mathematics tutors in terms of the combined dependent variables. The small effect size indicated that gender does not statistically influence on the combined dependent variables. Therefore, the views of male and female mathematics tutors on the five combined dependent variables are statistically similar (see Table 25).

Table 25: Tests of Between-Subjects Effects of (MANOVA) for the Independent Variable and the Dependent Variables – Mathematics Tutors

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Sex	Perceptions about Mathematical Knowledge	.001	1	.001	.014	.905	.000
	Perceptions about Mathematics Pedagogy	.011	1	.011	.081	.778	.003
	Perceptions about Links between Culture and Mathematical Knowledge	.091	1	.091	.969	.332	.029
	Perceptions About Links between Culture and Mathematics Pedagogy	.074	1	.074	1.092	.304	.033
	Perceptions about Links between Culture and Mathematics Curriculum	.019	1	.019	.200	.658	.006

a. R Squared = .000 (Adjusted R Squared = -.031)
b. R Squared = .003 (Adjusted R Squared = -.029)
c. R Squared = .029 (Adjusted R Squared = -.001)
d. R Squared = .033 (Adjusted R Squared = .003)
e. R Squared = .006 (Adjusted R Squared = -.025)
SOURCE: Field Data (2022)

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To determine the held views that resulted in non-significant differences in the mean scores of five dependent variables between male and female mathematics tutors, an estimated marginal means generated from MANOVA were used to explore whether their similar views are cultural-free, showing trends toward cultural-related perceptions, or cultural-related. Results from Table 26 showed that female mathematics tutors shared similar views with male mathematics tutors on the five dependent variables. The results showed that female and mathematics tutors had similar cultural-free perceptions about mathematics pedagogy (Male, M=2.38, SD= 0.385; female, M =2.44, SD = .192). Besides, the female and male tutors shared similar trends toward cultural-related perceptions on two dependent variables, perceptions about mathematical knowledge (male, M = 2.91, SD = 0.283; female, M = 2.93, SD =.252), and perceptions about links between culture and mathematical knowledge (male, M = 2.68, SD = 0.314; female, M = 2.50, SD =.167). Again, the two gender groups of mathematics tutors had a similar cultural-related view on the remaining two dependent variables, perceptions, about links between culture and mathematics pedagogy (male, M = 3.20, SD = 0.264; female, M = 3.36, SD = .210), and perceptions about links between culture and mathematics curriculum (male, M = 3.25, SD = 0.281; female, M = 3.33, SD = .577). Therefore, the results revealed one similar dissenting (cultural-free) view, two similar trends toward cultural-related perceptions, and two similar cultural-related perceptions (see Table 26).

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Table 26: Estimated Marginal Means for Male and Female Mathematics Tutors' Receptiveness to Cultural Relevance of Mathematics (N=34)

Dependent Variable	Mathematics Tutors' Sex	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Perceptions about mathematical knowledge	Female	2.933	.162	2.603	3.263
	Male	2.913	.050	2.810	3.016
Perceptions about Mathematics Pedagogy	Female	2.444	.217	2.003	2.886
	Male	2.380	.067	2.243	2.517
Perceptions about links between culture and mathematical knowledge	Female	2.500	.177	2.139	2.861
	Male	2.683	.055	2.570	2.795
Perceptions about links between culture and mathematics pedagogy	Female	3.361	.151	3.054	3.668
	Male	3.196	.047	3.101	3.292
Perceptions about links between culture and mathematics curriculum	Female	3.333	.178	2.971	3.696
	Male	3.250	.055	3.137	3.363

SOURCE: FIELD DATA 2022

It is evident from the results analysis that the male and female mathematics tutors share similar views on all five dependent variables. There were no statistically significant differences in the mean scores of five dependent variables perceived by the two groups. Therefore, the results in general showed that gender does not have any statistically significant effect on mathematics tutors' receptiveness to the cultural relevance of mathematics teaching and learning.

The next section presents the results of the effects of a programme of study on teacher trainees' receptiveness to the cultural relevance of mathematics.

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Effect of the Programme of Study on Teacher Trainees' Receptiveness to the Cultural Relevance of Mathematics

To address Research Question 3: *"What is the Effect of Programme of Study on Teacher Trainees' Receptiveness to Cultural Relevance of Mathematics?",* a one-way multivariate analysis of variance (MANOVA) was conducted to assess for differences in receptiveness to cultural relevance of mathematics by programme of study (B.Ed. Early Grade Education, B.Ed. Primary Education, and B.Ed. JHS Education). A total number of one thousand, one hundred and sixty (1,160) teacher trainee participants from five selected Colleges of Education in Ghana, (133 out of 1,160, representing 11.47%) of them were offering B.Ed. Early Grade Education; (459 out of 1,160, representing 39.57%) were offering B.Ed. Primary Education, whilst (568 out of 1, 160, representing 48.96%) were also offering B.Ed. JHS Education. The next section presents the result of the effect of the programme of study on teacher trainees' receptiveness to the cultural relevance of mathematics teaching and learning.

Results of the Effect of Programme of Study on Teacher Trainees' Receptiveness to Cultural Relevance of Mathematics

To explore the effect of the programme of study on teacher trainees' held views on the cultural relevance of mathematics, a one-way MANOVA was conducted to examine differences in the mean scores of the three programmes of study by teacher trainees. Five dependent variables were used: Perceptions about Mathematical Knowledge, Perceptions about mathematics pedagogy, Perceptions about links between culture and mathematical knowledge, Perceptions about links between culture and mathematics pedagogy, and Perceptions about links between culture and mathematics curriculum.

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Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity, with no serious violations noted. Table 27 showed that there was a statistically significant difference amongst programmes of study on combined dependent variables F (10, 2306) = 6.297, ρ = .000; Wilks' Lambda = .95; partial eta squared = .03. The p-value (ρ = .000) is less than the alpha value of 0.05 confirmed that the differences among the programmes were statistically significant.

Therefore, there is a statistically significant difference among the programmes of study on the combined dependent variables. Hence programme of study has a significant effect on teacher trainees' receptiveness to the cultural relevance of mathematics.

Table 27: Summary of Multivariate Analysis of Variance (MANOVA) for Programme of Study Groups Variable –Teacher Trainees (N = 1,160)

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared (η^2)
Programme of Study	Wilks' Lambda	.948	6.297[b]	10.000	2306.000	.000	.027

a. Design: Intercept + Programme of Study
b. Exact statistic
SOURCE: Field Data (2022)

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When the results of the dependent variables were considered separately (see Table 28), the three differences to reach statistical significance at an alpha level of .05 were Perceptions about Mathematics Pedagogy, *F* (2, 1157) = 8.70, *ρ* = .000, partial eta squared = .002; Perceptions about links between Ghanaian Culture and Mathematics pedagogy, *F* (2, 1157) =7.99, *ρ* = .000, partial eta squared = .014; and Perceptions about links between Ghanaian Culture and Mathematics Curriculum, *F* (2, 1157) = 4.316, *ρ* = .014, partial eta squared = .007. The results showed that there were statistically significant differences in the mean scores of views amongst teacher trainees pursuing the three programmes of study. Though the views of the other two dependent variables by programmes of study were not significant, there were slight differences in the mean scores for the three groups in terms of trends toward cultural-related perceptions.

Table 28: Tests of Between-Subjects Effects of MANOVA for the Independent Variable and the Dependent Variables – Teacher Trainees (N = 1,160)

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
	Perceptions about Mathematical Knowledge	.347	2	.174	1.242	.289	.002
	Perceptions about Mathematics Pedagogy	3.712	2	1.856	8.697	.000	.015
Programme of study	Perceptions about Links between Culture and Mathematical Knowledge	1.171	2	.585	2.808	.061	.005
	Perceptions about Links between Culture and Mathematics Pedagogy	2.334	2	1.167	7.991	.000	.014
	Perceptions about links between Culture and Mathematics Curriculum	1.812	2	.906	4.316	.014	.007

a. R Squared = .002 (Adjusted R Squared = .000)
b. R Squared = .015 (Adjusted R Squared = .013)
c. R Squared = .005 (Adjusted R Squared = .003)
d. R Squared = .014 (Adjusted R Squared = .012)
e. R Squared = .007 (Adjusted R Squared = .006)
SOURCE: Field Data (2022)

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To determine where the significant differences exist amongst the three dependent variables (*Perceptions about Mathematics Pedagogy, Perceptions about links between Culture and Mathematics Pedagogy, and Perceptions about links between Culture and Mathematics Curriculum*) across the three programmes of study by teacher trainees (B.Ed. Early Grade Education, B.Ed. Primary Education, and B.Ed. JHS Education), Tukey's Honestly Significant Difference (HSD) Post Hoc multiple comparison test was carried out (see Table 29). This test was performed to find out what difference resulted in the significant F- ratio obtained from the overall MANOVA. The use of Tukey's Honestly Significant Difference (HSD) Post Hoc test was explained by the fact that the number of teacher trainees selected across the different programmes of study were not equal (Pallant, 2011). This is because the test makes use of the harmonic mean sample size for unequal group sizes.

The results further indicated that statistically significant pairwise differences were obtained in the three significant dependent variables (*Perceptions about Mathematics Pedagogy, Perceptions about links between Culture and Mathematics Pedagogy, and Perceptions about links between Culture and Mathematics Curriculum*) as against programmes of study by the teacher trainees. The results from Table 29 revealed there was no statistically significant difference amongst the independent groups Early Grade, Primary, and JHS in the dependent variable Perceptions about Mathematical Knowledge. The result also showed a statistically significant difference among the groups in perceptions about mathematics pedagogy: Early grade differed from Primary and JHS groups, while the Primary group did not differ from the JHS group. The B.Ed. primary group showed more trend towards cultural-related perceptions about mathematics pedagogy than JHS

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and Early grade programmes. The Early Grade programme showed the lowest trend towards cultural-related perceptions about mathematics pedagogy.

Again, the results of the differences in the mean scores among the three programmes indicated that teacher trainees offering JHS education programme's perceptions about links between culture and mathematics pedagogy were more cultural-related than the primary education programme of study. Only Early Grade education programme teacher trainees' views showed trends toward cultural-related perceptions.

The result further showed a significant difference among B.Ed. Early Grade and B.Ed. JHS groups in Perceptions about links between Ghanaian Culture and Mathematics Curriculum.

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Table 29 : Post Hoc Tests (Tukey HSD) – Teacher Trainees (N = 1,160)

Dependent Variable	(I) Teacher Trainees' Programme of Study	(J) Teacher Trainees' Programme of Study	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Perceptions about Mathematical Knowledge	B.Ed. Early Grade	B.Ed. Primary	.04	.037	.575	-.05	.12
		B.Ed. JHS	.00	.036	.998	-.08	.09
	B.Ed. Primary	B.Ed. Early Grade	-.04	.037	.575	-.12	.05
		B.Ed. JHS	-.03	.023	.296	-.09	.02
	B.Ed. JHS	B.Ed. Early Grade	.00	.036	.998	-.09	.08
		B.Ed. Primary	.03	.023	.296	-.02	.09
Perceptions about Mathematics Pedagogy	B.Ed. Early Grade	B.Ed. Primary	-.19*	.045	.000	-.29	-.08
		B.Ed. JHS	-.17*	.045	.001	-.27	-.06
	B.Ed. Primary	B.Ed. Early Grade	.19*	.045	.000	.08	.29
		B.Ed. JHS	.02	.029	.791	-.05	.09
	B.Ed. JHS	B.Ed. Early Grade	.17*	.045	.001	.06	.27
		B.Ed. Primary	-.02	.029	.791	-.09	.05
Perceptions about links between Culture and Mathematical knowledge	B.Ed. Early Grade	B.Ed. Primary	.11*	.045	.047	.00	.21
		B.Ed. JHS	.08	.044	.138	-.02	.19
	B.Ed. Primary	B.Ed. Early Grade	-.11*	.045	.047	-.21	.00
		B.Ed. JHS	-.02	.029	.705	-.09	.04
	B.Ed. JHS	B.Ed. Early Grade	-.08	.044	.138	-.19	.02
		B.Ed. Primary	.02	.029	.705	-.04	.09
Perceptions about Links between Culture and Mathematics Pedagogy	B.Ed. Early Grade	B.Ed. Primary	-.07	.038	.127	-.16	.02
		B.Ed. JHS	-.14*	.037	.001	-.22	-.05
	B.Ed. Primary	B.Ed. Early Grade	.07	.038	.127	-.02	.16
		B.Ed. JHS	-.06*	.024	.027	-.12	-.01
	B.Ed. JHS	B.Ed. Early Grade	.14*	.037	.001	.05	.22
		B.Ed. Primary	.06*	.024	.027	.01	.12
Perceptions about Links between Culture and Mathematics Curriculum	B.Ed. Early Grade	B.Ed. Primary	-.11	.045	.052	-.21	.00
		B.Ed. JHS	-.13*	.044	.009	-.23	-.03
	B.Ed. Primary	B.Ed. Early Grade	.11	.045	.052	.00	.21
		B.Ed. JHS	-.02	.029	.670	-.09	.04
	B.Ed. JHS	B.Ed. Early Grade	.13*	.044	.009	.03	.23
		B.Ed. Primary	.02	.029	.670	-.04	.09

Based on observed means.
The error term is Mean Square (Error) = .210.
*. The mean difference is significant at the .05 level.
SOURCE: Field Data (2022).

The differences and the magnitude of the mean scores can be seen in the results in Table 30 showing the estimated marginal means for the three statistically significant dependent variables across the three programmes of study by teacher trainees.

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Table 30: Estimated Marginal Means for Teacher Trainees' Programme of Study

				95% Confidence Interval	
Dependent Variable	Trainees' Programme of Study	Mean	Std. Error	Lower Bound	Upper Bound
Perceptions about Mathematical Knowledge	B.Ed. Early Grade	2.906	.032	2.842	2.970
	B.Ed. Primary	2.869	.017	2.835	2.903
	B.Ed. JHS	2.904	.016	2.873	2.935
Perceptions about Mathematics Pedagogy	B.Ed. Early Grade	2.465	.040	2.387	2.544
	B.Ed. Primary	2.651	.022	2.609	2.693
	B.Ed. JHS	2.632	.019	2.594	2.670
Perceptions about Links between Culture and Mathematical Knowledge	B.Ed. Early Grade	2.695	.040	2.618	2.773
	B.Ed. Primary	2.589	.021	2.547	2.631
	B.Ed. JHS	2.612	.019	2.574	2.649
Perceptions about Links between Culture and Mathematics Pedagogy	B.Ed. Early Grade	2.937	.033	2.872	3.002
	B.Ed. Primary	3.011	.018	2.976	3.046
	B.Ed. JHS	3.072	.016	3.041	3.104
Perceptions about Links between Culture and Mathematics Curriculum	B.Ed. Early Grade	3.079	.040	3.001	3.157
	B.Ed. Primary	3.184	.021	3.142	3.226
	B.Ed. JHS	3.209	.019	3.171	3.246

SOURCE: Field Data (2022)

The results from Table 30 showed the marginal means estimated from the highest to the lowest for the three statistically significant perception variables across the three programmes of study were as follows:

First, regarding Perceptions about Mathematics Pedagogy, an inspection of the mean scores indicated that, the B.Ed. Primary education group reported slightly higher levels of perceived mathematics pedagogy (M = 2.7, SD = 0.43) than the other two groups, B.Ed. Early Grade Education (M = 2.5, SD = 0.58) and B.Ed. JHS Education (M = 2.6, SD = 0.46). B.Ed. JHS education programme teacher trainees on the other hand showed more trend to cultural-related perceptions than those offering the B.Ed. Early Grade Primary education programme. Thus the programme of study has a statistically significant effect on teacher trainees'

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perceptions about mathematics pedagogy. Teacher trainees offering B.Ed. Early Grade education had more trends toward cultural-related perceptions about mathematical knowledge than any of the other two groups.

Secondly, the result revealed another significant difference in the mean scores of the three groups in the dependent variable (Perceptions about links between Ghanaian Culture and Mathematics Pedagogy). An inspection of the mean scores indicated that B.Ed. JHS Education group reported slightly higher levels of held views on the links between culture and mathematics pedagogy (M = 3.1, SD = 0.38) than either of the remaining two groups, B.Ed. Primary Education (M = 3.0, SD = 0.38) and B.Ed. Early Grade Education (M = 2.9, SD = 0.39). The results revealed that, only early grade teacher trainees, whose perceptions about links between culture and mathematics pedagogy showed trends toward cultural-related perceptions. The findings further revealed that, B.Ed. JHS education teacher trainees' perceptions about links between culture and mathematics pedagogy were more culturally related than B.Ed. primary education teacher trainees. Despite being statistically significant, the actual difference in any two mean scores was negligible, less than 1 scale point. However, the differences in the mean scores cannot be ignored. Therefore, the programme of study has a significant effect on teacher trainees' perceptions about perceptions about links between culture and mathematics pedagogy.

Furthermore, there was a statistically significant difference in perceptions about the links between Ghanaian culture and mathematics curriculum. An inspection of the mean scores indicated that the B.Ed. JHS education programme reported slightly higher perceptions about links between culture and mathematics curriculum (M = 3.21, SD = 0.48) than either of the remaining two groups, B.Ed.

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Primary Education programme (M = 3.18, SD = 0.46) and B.Ed. Early Grade Education programme (M = 3.08, SD = 0.35). The results revealed that B.Ed. JHS education teacher trainees' views held about links between culture and mathematics curriculum were more culturally related than the other two programmes of study. Again B.Ed. Early Grade education teacher trainees had the least cultural-related views. Therefore programme of study has a significant effect on teacher trainees' views of links between culture and mathematics curriculum.

In addition, the results showed there were no statistically significant differences between the mean scores of the views held by teacher trainees offering the three programmes on the two other dependent variables (perceptions about mathematical knowledge and perceptions about links between culture and mathematical knowledge). The results indicated that the views of teacher trainees doing all three programmes had their mean scores ranging from 2.6 to 2.9 (trends toward cultural-related perceptions). The results generally show that there were no statistically significant differences in the means scores for the two dependent variables by the three groups, however B.Ed. Early slightly higher on the trends toward cultural-related perceptions about mathematical knowledge (M = 2.91, SD = 0.40) than either of the other two groups, B.Ed. JHS (2.90, SD = 0.37) and B.Ed. Primary (M = 2.87, SD = 0.38); and also slightly ahead in terms of trends to cultural-related perceptions about links between culture and mathematical knowledge (M = 2.69, SD = 0.45) than either of the other two groups, B.Ed. JHS (M = 2.61, SD = 0.43) and B.Ed. Primary (M = 2.59, SD = 0.49).

The overall mean scores of the views held by teacher trainees doing the three B.Ed. programmes of study on five combined perceptions about mathematics show that of trends toward cultural-related perceptions. There were significant

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differences in the mean scores by programmes of study: B.Ed. JHS education had more trends toward culturally related perceptions about mathematics (M=2.89, SD = 0.288) than either of the other two groups, B.Ed. Primary (M= 2.86, SD = 0.307) and B.Ed. Early Grade (M = 2.82, SD =0.301).

It is evident from the analysis of the results that, the difference in the mean scores was statistically significant for each dependent variable by the programme of study despite small effect sizes. The results showed that the views held about mathematics by teacher trainees offering B.Ed. Early Grade Education, B.Ed. Primary education, and B.Ed. JHS education programmes had variant trends toward cultural-related perceptions. Therefore, the programme of study generally, has a significant effect on teacher trainees' receptiveness to the cultural relevance of mathematics.

The next section presents the effects of grade level on teacher trainees' perceptions about mathematics.

Effect of Grade Level on Teacher Trainees' Receptiveness to the Cultural Relevance of Mathematics

In addressing research question four, a one–way MANOVA was conducted to find differences in the mean scores of the four grade levels (100, 200, 300 and 400) by teacher trainees. The result analysis revealed that a total of one thousand, one hundred and sixty (1,160) teacher trainees participated in this study (270 out of 1,160, representing 23.28%) of them were in level 100; (300 out of 1,160 representing 25.86%) of teacher trainees were in level 200; (300 out of 1,160, representing 25.86%) of them were in level 300; while the remaining 290 out of 1,160, representing 25.00%) were in level 400. The results of the views held by

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teacher trainees' in these four grade levels about the cultural relevance of mathematics were presented in the next section

Results of the Effect of Grade Levels (100, 200, 300, and 400) on Teacher Trainees' Receptiveness to Cultural Relevance of Mathematics?"

To explore the effect of grade levels on the perception of mathematics by teacher trainees, one–way between–groups multivariate analysis of variance was conducted with an independent variable having four levels: level 100, level 200, level 300, and level 400. The five dependent variables were used: *perceptions about mathematical knowledge*, *perceptions about mathematics pedagogy, perceptions about links between Ghanaian culture and mathematical knowledge, perceptions about links between Ghanaian culture and mathematics pedagogy, and perceptions about links between Ghanaian culture and mathematics curriculum*.

The preliminary assumption was tested to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity, indicating no serious violations noted. Results in Table 31 revealed there was a statistically significant difference amongst grade levels on the combined dependent variables, F (15, 3180) = 3.73, ρ= .000; Wilks' Lambda = .95; partial eta squared = 0. 02 (see Table 31).

Table 31: Summary of Multivariate Analysis of Variance (MANOVA) for Levels (100, 200, 300, & 400) Groups Variable –Teacher Trainees

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared(ŋ)
Level	Wilks' Lambda	.953	3.725	15.000	3180.00	.000	.016

a. Design: Intercept +Level

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

SOURCE: Field Data (2022)

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To determine what perception reaches a significant difference, the results for the dependent variables were considered separately. The results indicated that only two of the dependent variables (perceptions about mathematics pedagogy and perceptions about links between culture and mathematical knowledge) had differences in mean scores that reached statistical significance at an alpha level of .05(see Table 32). The results from Table 32 revealed the significant tests of between-subjects effects for all the five views held about mathematics. There were statistically significant differences for Perceptions about Mathematics Pedagogy, F (3, 1156) = 9.59, ρ = .000, partial eta squared = .02; and Perceptions about links between culture and Mathematical knowledge, F (3, 1156) = 6.01, ρ = .000, and partial eta squared = .02. The results indicated that the significant differences in the mean of views held by teacher trainees in the four levels showed varying trends toward cultural-related perceptions. Hence the views of teacher trainees in the four grade levels were different in terms of trend towards cultural-related perceptions about mathematics pedagogy and links between culture and mathematical knowledge.

The results in Table 32 revealed no statistically significant difference in the mean scores of views held by teacher trainees in four levels on perceptions about mathematical knowledge, F(3, 1156) = 1.88, ρ = .132, and partial eta squared = .02, with the mean scores showing trends toward cultural-related perceptions; perceptions about links between culture and mathematics pedagogy F (3, 1156) = 0.49, ρ = .690, and partial eta squared = .000, with mean scores indicating cultural-related perceptions; and perceptions about links between culture and mathematics curriculum F (3, 1156) = 2.44, ρ = .063, partial eta squared = .02, with mean scores indicating cultural-related perceptions (see Table 32)

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Table 32: Tests of Between-Subjects Effects of (MANOVA) for the Independent Variable and the Dependent Variables – Teacher Trainees (N=1,160)

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Level	Perceptions about Mathematical Knowledge	.785	3	.262	1.877	.132	.005
	Perceptions about Mathematics Pedagogy	6.089	3	2.030	9.594	.000	.024
	Perceptions about Links between Culture and Mathematical Knowledge	3.721	3	1.240	6.009	.000	.015
	Perceptions about Links between Culture and Mathematics Pedagogy	.217	3	.072	.489	.690	.001
	Perceptions about links between Culture and Mathematics Curriculum	1.541	3	.514	2.442	.063	.006

a. R Squared = .005 (Adjusted R Squared = .002)
b. R Squared = .024 (Adjusted R Squared = .022)
c. R Squared = .015 (Adjusted R Squared = .013)
d. R Squared = .001 (Adjusted R Squared = -.001)
e. R Squared = .006 (Adjusted R Squared = .004)
SOURCE: Field Data (2022)

To determine where the significant differences exist amongst the two significant dependent variables (*Perceptions about Mathematics Pedagogy*, and *Perceptions about links between Culture and Mathematical Knowledge*) across the three Grade Levels by teacher trainees (Level 100, Level 200, Level 300, and Level 400), Tukey's Honestly Significant Difference (HSD) Post Hoc multiple comparison test was carried out (see Table 33). This test was performed to find out which difference resulted in the significant F- ratio obtained from the overall MANOVA. Statistically significant pairwise differences were observed in the two significant dependent variables (*Perceptions about Mathematics Pedagogy* and *Perceptions about links between Ghanaian Culture and Mathematical Knowledge*)

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as against grade levels by the teacher trainees: level 100, level 200, level 300, and level 400. The results from Table 33 revealed there was a statistically significant difference between the independent groups' levels (100 & 200; 200 & 300; and 300 &400) on dependent variable Perceptions about Mathematics Pedagogy.

The results in Table 33 showed the mean score of the views held by Level 100 differed slightly from the mean scores of Level 200; the mean of Level 200 was a little lower than the mean score of 300; and Level 300 had a mean score slightly greater than level 400 for perceptions about mathematics pedagogy.

The second statistically significant difference among the four groups on perceptions about links between culture and mathematical knowledge was (100 & 300; 200 & 300; and 300 & 400). The results in Table 33 showed the mean score of the views held by Level 300 differed slightly higher than the mean scores of either of the three other groups for perceptions about mathematics pedagogy (see Table 33).

Table 33 : Post Hoc Tests (Tukey HSD) – Teacher Trainee

Dependent Variable	(I) Teacher Trainees' Grade Level	(J) Teacher Trainees' Grade Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Perceptions about Mathematical Knowledge	Level 100	Level 200	.02	.031	.929	-.06	.10
		Level 300	-.05	.031	.371	-.13	.03
		Level 400	-.02	.032	.940	-.10	.06
	Level 200	Level 100	-.02	.031	.929	-.10	.06
		Level 300	-.07	.030	.102	-.15	.01
		Level 400	-.04	.031	.621	-.12	.04
	Level 300	Level 100	.05	.031	.371	-.03	.13
		Level 200	.07	.030	.102	-.01	.15
		Level 400	.03	.031	.717	-.05	.11
	Level 400	Level 100	.02	.032	.940	-.06	.10
		Level 200	.04	.031	.621	-.04	.12
		Level 300	-.03	.031	.717	-.11	.05
Perceptions about Mathematics Pedagogy	Level 100	Level 200	-.15*	.039	.001	.05	-.25
		Level 300	-.04	.039	.676	-.14	.06
		Level 400	.06	.039	.352	-.04	.16
	Level 200	Level 100	.15*	.039	.001	-.25	.05

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		Level 300	-.19*	.038	.000	-.29	-.09
		Level 400	-.08	.038	.129	-.18	.01
	Level 300	Level 100	.04	.039	.676	-.06	.14
		Level 200	.19*	.038	.000	.09	.29
		Level 400	-.11*	.038	.024	.01	-.20
	Level 400	Level 100	-.06	.039	.352	-.16	.04
		Level 200	.08	.038	.129	-.01	.18
		Level 300	.11*	.038	.024	-.20	.01
Perceptions about Links between Culture and Mathematical Knowledge	Level 100	Level 200	-.02	.038	.959	-.12	.08
		Level 300	-.12*	.038	.007	-.22	-.02
		Level 400	.03	.038	.913	-.07	.12
	Level 200	Level 100	.02	.038	.959	-.08	.12
		Level 300	-.10*	.037	.028	-.20	-.01
		Level 400	.04	.037	.639	-.05	.14
	Level 300	Level 100	.12*	.038	.007	.02	.22
		Level 200	.10*	.037	.028	.01	.20
		Level 400	-.15*	.037	.000	.05	-.24
	Level 400	Level 100	-.03	.038	.913	-.12	.07
		Level 200	-.04	.037	.639	-.14	.05
		Level 300	.15*	.037	.000	-.24	.05
Perceptions about links between Culture and Mathematics Pedagogy	Level 100	Level 200	.01	.032	.995	-.08	.09
		Level 300	-.02	.032	.912	-.10	.06
		Level 400	-.02	.033	.878	-.11	.06
	Level 200	Level 100	-.01	.032	.995	-.09	.08
		Level 300	-.03	.031	.794	-.11	.05
		Level 400	-.03	.032	.746	-.11	.05
	Level 300	Level 100	.02	.032	.912	-.06	.10
		Level 200	.03	.031	.794	-.05	.11
		Level 400	.00	.032	1.000	-.08	.08
	Level 400	Level 100	.02	.033	.878	-.06	.11
		Level 200	.03	.032	.746	-.05	.11
		Level 300	.00	.032	1.000	-.08	.08
Perceptions about links between Culture and Mathematics Curriculum	Level 100	Level 200	.00	.038	1.000	-.09	.10
		Level 300	-.02	.038	.973	-.12	.08
		Level 400	-.09	.039	.116	-.19	.01
	Level 200	Level 100	.00	.038	1.000	-.10	.09
		Level 300	-.02	.037	.945	-.12	.08
		Level 400	-.09	.038	.077	-.19	.01
	Level 300	Level 100	.02	.038	.973	-.08	.12
		Level 200	.02	.037	.945	-.08	.12
		Level 400	-.07	.038	.251	-.17	.03
	Level 400	Level 100	.09	.039	.116	-.01	.19
		Level 200	.09	.038	.077	-.01	.19
		Level 300	.07	.038	.251	-.03	.17

Based on observed means.
The error term is Mean Square (Error) = .210.
*. The mean difference is significant at the .05 level.
SOURCE: Field Data (2022)

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To determine the differences and the magnitude of the mean scores for statistically significant dependent variables, an estimated marginal means from (MANOVA) for the five dependent variables across the four grade levels by teacher trainees was used (see Table 34).

Table 34: Estimated Marginal Means for Levels (100, 200, 300, & 400) of Teacher Trainees (N = 1,160)

Dependent Variable	Teacher Trainees' Grade Level	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Perceptions about Mathematical Knowledge	Level 100	2.859	.022	2.816	2.901
	Level 200	2.878	.023	2.833	2.922
	Level 300	2.896	.022	2.853	2.939
	Level 400	2.928	.022	2.886	2.971
Perceptions about Mathematics Pedagogy	Level 100	2.517	.027	2.465	2.569
	Level 200	2.599	.027	2.546	2.625
	Level 300	2.663	.028	2.608	2.718
	Level 400	2.707	.028	2.655	2.759
Perceptions about Links between Culture and Mathematical Knowledge	Level 100	2.557	.027	2.505	2.609
	Level 200	2.582	.027	2.528	2.636
	Level 300	2.601	.026	2.550	2.653
	Level 400	2.704	.026	2.653	2.756
Perceptions about links between Culture and Mathematics Pedagogy	Level 100	3.015	.022	2.972	3.059
	Level 200	3.023	.023	2.977	3.069
	Level 300	3.044	.022	3.001	3.088
	Level 400	3.047	.023	3.003	3.091
Perceptions about Links between Culture and Mathematics Curriculum	Level 100	3.155	.026	3.103	3.207
	Level 200	3.159	.028	3.104	3.214
	Level 300	3.176	.026	3.124	3.228
	Level 400	3.246	.027	3.193	3.299

SOURCE: Field Data (2022)

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The results from Table 34 showed the marginal means estimated from the highest to the lowest for the five statistically significant perception variables across the four grade levels. The results of estimated marginal means for the statistically significant dependent variables showed that the mean score of the level 400s' perceptions about mathematics pedagogy was slightly higher (M = 2.71, SD = 0.478) than either of the other three levels, level 300 (M= 2.66, SD =0.453); level 200 (M = 2.60, SD = 0.440); and level 300 (M = 2.52, SD = 0.467). The results indicated that the views held by level 400 about mathematics pedagogy showed more trends toward cultural-related perceptions than either of the other three levels. The second highest trend towards cultural-related perceptions about mathematics pedagogy was level 300, followed by level 200, and the least was level 100 (see Table 34). An inspection of the estimated marginal means of perceptions about mathematics pedagogy by four levels showed a statistically significant difference despite the small effect size. Therefore the grade level of teacher trainees has a statistically significant effect on their held views.

In addition, an inspection of the mean scores of perceptions about links between culture and mathematical knowledge held by teacher trainees in four grade levels revealed that teacher trainees in level 400 had more trends toward cultural-related perceptions (M = 2.7, SD =0.512) than either of the other three groups, level 300 (M = 2.60, SD = 0.363); level 200 (M = 2.58, SD = 0.459); and level 100 (M = 2.56, SD = 0.472). The results indicated level 100 had the least trend towards cultural-related perceptions about the links between culture and mathematical knowledge. Though the actual difference in any two mean scores was negligible,

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less than 1 scale point, the statistical significance of the mean difference cannot be ignored.

The results further showed that there was no statistically significant difference amongst the mean scores of the perceptions about mathematical knowledge held by teacher trainees in four grade levels. All four levels had similar views showing trends to cultural-related perceptions. However, their mean scores differed slightly. Hence grade level has significant effect on teacher trainees' perception about mathematical knowledge. Moreover, the results indicated that teacher trainees in all four grade levels had similar cultural-related perceptions about links between culture and mathematics pedagogy, and perceptions about links between culture and mathematics curriculum. However, the level 400's views were more culturally related than either of the other three grade levels (see Table 34).

Therefore, the results in general, showed that grade level has significant effect on teacher trainees' receptiveness to cultural relevance of mathematics teaching and learning.

Difference between the Mean scores of Teacher Trainees' and their Mathematics Tutors' Receptiveness to the Cultural Relevance of Mathematics

To address the Research Hypothesis, **"***Ho:* There is no significant difference between the mean scores of teacher trainees' and their mathematics tutors' receptiveness to the cultural relevance of mathematics", a qualitative comparison was made on the five perception areas (Perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between culture and mathematical knowledge, perceptions about links between culture and mathematics pedagogy, and perceptions about links between culture and

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mathematics curriculum) held by both teacher trainees and their mathematics tutors in their mathematics teaching and learning.

To further explore the differences in mean scores that exist statistically between teacher trainees (1,160) and their mathematics tutors (34), a one-way between-group multivariate analysis of variance (MANOVA) was conducted on the combined perceived variables of interest to assess for differences in receptiveness to the cultural relevance of mathematics by teacher trainees and their mathematics tutors (Trainees, Tutors). The independent variable in the analysis corresponded to groups (Group 1: Teacher Trainees, Group 2: Mathematics Tutors). The continuous dependent variables corresponded to perceptions about mathematics held by the two groups (*Perceptions about Mathematical Knowledge (PMK), Perceptions about mathematics pedagogy (PMP), Culture and mathematical knowledge (GCMK), Culture and mathematics pedagogy (GCMP), and Culture and mathematics curriculum (GCMC*). Prior to conducting the analysis, the assumptions of normality and homogeneity of variance were tested by examination of the KS test, Levene's test and the Box's Test of Equality of Covariance Matrices, respectively.

As evidenced by the KS tests in the previous section, the normality assumption was met for mathematics tutors but violated by teacher trainees. However, the F test is robust to violations of normality, especially when the sample size is greater than 30 (Howell & Howell 2013). The assumption for homogeneity of variance was met as the findings for Levene's tests were all but one not significant ($p > .05$). The results of the multivariate F test (see Table 35) were presented in the next section.

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Results of The Research Hypothesis "*Ho:* There is no significant difference between the mean scores of teacher trainees' and their mathematics tutors' receptiveness to the cultural relevance of mathematics".

This section presented the result analysis on the research hypothesis of significant difference between the mean scores of both teacher trainees' and their mathematics tutors' receptiveness to the cultural relevance of mathematics. Results of the multivariate F-test indicated a statistically significant difference between teacher trainees and mathematics tutors on combined dependent variables, F(5, 1154) = 3.59, ρ= .003; Wilks' Lambda =. 99, partial eta squared (η^2) = .015. Table 35 shows the multivariate analysis of variance (MANOVA) for the perceptions of the cultural relevance of mathematics held by both teacher trainees and their mathematics tutors.

Table 35: Summary of Multivariate Analysis of Variance (MANOVA) for Perceptions of Mathematics Variable – Teacher Trainees and their Mathematics Tutors

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared(η^2)
Groups	Wilks' Lambda	.985	3.593[b]	5.000	1154.000	.003	.015

a. Design: Intercept + hypo
b. Exact statistic
SOURCE: Field Data (2022)

To determine the significant dependent variables, further analysis of the univariate ANOVAs was conducted (see Table 36). The results revealed that four out of five dependent variables of the tests of between-subjects effects were statistically significant while the remaining one was not significant ($\rho > 0.05$).

When the results for the five dependent variables were considered separately, the four difference to reach statistical significance, using an alpha level of 0.05,

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were: Perceptions about mathematics pedagogy, *F* (1, 1158) = 4.135, ρ = .042, partial eta squared = .004; Perceptions about links between culture and mathematical Knowledge, *F* (1, 1158) = 11.34, ρ =.001, partial eta squared =.010; Perception about links between culture and mathematics Pedagogy,

F (1, 1158) =6.57, ρ =.011, partial eta squared = .006; and Perception about links between culture and mathematics Curriculum, *F* (1, 1158) = 10.24, ρ = .001, and partial eta squared = .006 (see Table 36)

Table 36: Tests of Between-Subjects Effects of (MANOVA) for the Independent Variable and the Dependent Variables – Teacher Trainees and Their Mathematics Tutors

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
	Perceptions about mathematical knowledge	.444	1	.444	3.478	.062	.003
	Perceptions about Mathematics Pedagogy	.895	1	.895	4.135	.042	.004
Differences	Perceptions about links between culture and mathematical knowledge	2.179	1	2.179	11.339	.001	.010
	Perceptions about links between culture and mathematics pedagogy	.947	1	.947	6.565	.011	.006
	Perceptions about links between culture and mathematics curriculum	2.203	1	2.203	10.236	.001	.009

a. R Squared = .003 (Adjusted R Squared = .002)
b. R Squared = .004 (Adjusted R Squared = .003)
c. R Squared = .010 (Adjusted R Squared = .009)
d. R Squared = .006 (Adjusted R Squared = .005)
e. R Squared = .009 (Adjusted R Squared = .008)
SOURCE: Field Data (2022)

To determine where the significant differences were among the four dependent variables, the Estimated Marginal Means for teacher trainees and mathematics tutors' perceptions about mathematics were checked to find the

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magnitude of the differences in the mean scores (see Table 37). An inspection of the mean scores indicated that mathematics tutors reported slightly higher levels of perceived mathematics pedagogy (M=2.70, SD = .464) than teacher trainees (M = 2.54, SD = .507). Though significant, the actual mean difference was very small.

The result again indicated that tutors reported higher mean scores in their held views about links between Ghanaian culture and mathematical knowledge (M = 2.59, SD =.437) than teacher trainees (M = 2.33, SD = .487). Despite being statistically significant, the actual difference in the two mean scores was very small, less than 1 scale point. The result from an estimated marginal means further showed that tutors reported slightly higher mean scores of perceived links between culture and mathematics Pedagogy (M = 3.00, SD = .375) than teacher trainees (M = 2.83, SD = .503). Although significant differences existed between the two groups, the actual difference in the two mean scores was very small, less than 1 scale point. Again, an inspection of the mean scores indicated that tutors reported slightly higher levels of perception about links between culture and mathematics Curriculum (M = 3.15, SD = .458) than teacher trainees (M = 2.89, SD = .634).

Though statistically significant, the actual difference in the two mean scores was very small, less than 1 scale point (see Table 37).

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Table 37: Estimated Marginal Means for the Differences in the Mean Scores of Teacher Trainees (N =1,160) and Mathematics tutors' (N=34) Receptiveness

				95%Confidence Interval	
Dependent Variable	Differences	Mean	Std. Error	Lower Bound	Upper Bound
Perceptions about mathematical knowledge	Mathematics tutors	2.872	.011	2.851	2.893
	Teacher trainees	2.756	.061	2.636	2.876
Perceptions about Mathematics Pedagogy	Mathematics tutors	2.701	.014	2.673	2.728
	Teacher trainees	2.536	.080	2.379	2.692
Perceptions about links between culture and mathematical knowledge	Mathematics tutors	2.590	.013	2.565	2.616
	Teacher trainees	2.333	.075	2.186	2.481
Perceptions about links between culture and mathematics pedagogy	Mathematics tutors	2.995	.011	2.973	3.018
	Teacher trainees	2.826	.065	2.698	2.954
Perceptions about links between culture and mathematics curriculum	Mathematics tutors	3.148	.014	3.121	3.175
	Teacher trainees	2.890	.080	2.734	3.046

SOURCE: FIELD DATA (2022)

It is evident from the results analysis that teacher trainees reported higher levels in their mean scores of the four significant dependent variables than their mathematics tutors. Teacher trainees and their tutors had variant perceptions about mathematics. The views of teacher trainees were more inclined towards cultural-related perceptions than their mathematics tutors. Therefore, the views of teacher trainees were significantly different from their tutors.

The next section presents a discussion of the findings from the results illustrated in the previous presentations in the order of how the research questions and the hypothesis were answered with their suitable headings.

Discussion of Results

The study aimed to explore teacher trainees and their mathematics tutors' receptiveness to the cultural relevance of mathematics and ascertain whether their

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views of mathematics are cultural-free or cultural-related (Davis, 2016). This section offers a discussion of the results and findings of the study. The study's findings were discussed under the four research questions, and one hypothesis was formulated to guide the study. The results and findings were discussed independently regarding the two groups of respondents (teacher trainees and their mathematics tutors). This enabled the researcher to explore the similarities and differences in the research participants' responses between the two groups. Constructs and major themes were developed from the study's questions and hypothesis to allow the researcher to discuss the above presentations. The following discussions were conducted under the developed constructs and derived themes from both the questionnaires and structured interview guides.

Perception about Mathematics

Many researchers in mathematics education have a notion that sociocultural classroom interactions pave the way for students to develop mathematical concepts that can be used to solve problems (Vygotsky, 1934/1987, Davis, 2013). Cultural products can be used as mathematical objects in teaching and learning in school (Bishop, 1988; Davis, 2010; Kusaeri et al, 2019). As already stated in Chapter Two, culture-related perceptions in this study refer to perceptions that take cognisance of mathematics in the out-of-school setting, whilst culture-free perceptions are perceptions that do not recognise mathematics as a cultural object (Davis, 2010, 2016). Also, a receptiveness to the cultural relevance of mathematics refers to the willingness and ability of an individual to recognise and appreciate the cultural aspects and influences embedded in mathematics (Kang, 2004; Ladson-Billings, 1995).

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Even though this study was conducted at the college level, some of its perceived constructs reflected the findings of some existing studies conducted at the other tertiary and pre-tertiary levels around the world (Davis, 2010, 2016; Acharya et al, 2021). This section was divided into two parts to make it easier to compare teacher trainees' perceptions about mathematics with those of mathematics tutors. The perceptions of mathematics by teacher trainees were presented first, followed by those of mathematics tutors.

Teacher Trainees' Perceptions about Mathematics

Teacher trainees' perceptions about mathematics comprise five areas of perceptions, namely perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between Ghanaian culture and mathematical knowledge, perceptions about the link between Ghanaian culture and mathematics pedagogy, and perceptions between Ghanaian culture and mathematics curriculum.

The results revealed that a substantial portion of the teacher trainees perceive mathematical knowledge as culturally related as more than a quarter (4 out of 10) of items had mean scores of three or greater than three, and the other (3 out of 10) of the items showed trends to cultural-related perceptions with mean scores ranging from 2.6 to 2.9 (see Table 9). The results of the study also support the finding of Davis (2010) that indicated the students' perceptions about mathematics reflected those of head teachers, and teachers. The results indicated that 70% of the teacher trainees' views were either inclined towards culture-related perceptions or showed cultural-related perceptions. These more cultural-related responses suggest a growing recognition among teacher trainees of the importance of cultural context in understanding and teaching mathematics. The findings confirmed ((Davis, 2010;

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Atweh et al, 2001) assertion that cultural backgrounds of students and teachers can influence their perceptions of mathematical knowledge. The results indicated teacher trainees' recognition of mathematics being both valuable and applicable to real-world scenarios, which could positively influence how they approach teaching and learning of the subject as the overwhelming majority acknowledged 'mathematical knowledge is useful', indicating a strong recognition of its value, and 'Mathematics has many applications in life' reflecting an understanding of its practical relevance. The majority of teacher trainees found mathematics interesting, showing a positive attitude toward engaging with the subject as they did not agreed that "mathematics is a difficult subject", which might reflect their confidence in their mathematical abilities or the effectiveness of their training, and 'mathematics is boring", reinforcing the overall positive perception of the subject. However, while a substantial portion of the teacher trainees perceive mathematical knowledge as culturally relevant, there was small portion of teacher trainees who still view mathematics as neutral or detached from cultural influences. This is sits well with Davis (2016) finding of children's out-of-school mathematics concepts influence on their school mathematical concepts.

The findings from the open-ended questions revealed that a substantial portion of teacher trainees perceived mathematics not just as an abstract subject, but as something closely connected to their daily life, practical activities, and problem-solving in various contexts. The findings indicated that these teacher trainees recognised the role of mathematics in routine tasks and see it as a tool for directing daily life which confirms Young-Loveridge et al (2006) finding on students conceptions of mathematical content as a problem-solving in particular, the usefulness of mathematics for everyday life, and importance of mathematics

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for the future. For instance, TT999 perception of mathematics as "Critical thinking, logical reasoning and day-to-day problem-solving" and TT364 held view of "Mathematics deals with principles to solve problems in our daily lives" show a practical alignment toward mathematics, viewing it as essential for addressing real-world challenges. The findings from interview with *(FGTTA, FGTTB)* confirmed Tan (2023) assertion that, students give value to mathematics because of its application in real life. For instance, *"Mathematics is the use of numerical values to solve daily problems in our locality; Mathematics is a process of solving our daily life problems (FGTTA); Mathematics is a process of solving our daily life problems (FGTTA); Mathematics enables students to develop critical thinking and problem solving (FGTTD); Mathematics helps students to analyse situations and find solutions to them* (*FGTTC)"*. The results of focus group interviews supported the idea that mathematics is primarily about using numerical values to solve everyday problems in local contexts. This perspective emphasises the practical and applied nature of mathematics, which is tailored to the unique needs and situations of different communities. Mathematics helps students to analyze situations, identify patterns, and derive solutions, fostering critical thinking and problem-solving skills. It is not just about learning specific formulas or techniques but also fostering a mindset that values inquiry, analysis, and logical reasoning. This approach cultivates critical thinking and problem-solving skills both within and beyond the classroom (Ernest, 1989).

The results further revealed that an insignificant portion of the teacher trainees however, tend to focus on the abstract and technical aspects of mathematics, such as calculations, formulas, and the study of numbers and shapes (cultural-free) responses. For example, statements like, *"Mathematics is about calculation, it deals*

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with thinking and understanding (TT244, TT907), and *Mathematics is an abstract science of numbers, quantity, and space* (TT66, TT236, TT233) reflected a more traditional, perhaps academic, view of mathematics, detached from cultural or everyday contexts. The findings from interview with (*FGTTA, FGTTB, FGTTC, FGTTD, and FGTTE)* confirmed Gokalp (2020) assertion that students view mathematics as something that deals only with numbers and calculations. For example, *"Mathematics is about calculations and proofs", Mathematics is a branch of science that deals with numbers and its operations, symbols and notations (FGTTB, FGTTC) and Mathematics is a field of study that deals with properties and relationships with numbers, axioms, and shapes (FGTTD).* The findings from interviews with FGTTA, FGTTB, FGTTC, FGTTD, and FGTTE revealed that mathematics is primarily concerned with calculations and proofs, with participants FGTTB and FGTTC highlighting its foundational elements. FGTTD expanded this definition to include the properties and relationships of numbers, axioms, and shapes, encompassing geometric and algebraic aspects. This broader view appreciates the diverse branches of mathematics, including geometry, algebra, and number theory.

The teacher trainees' perceptions about mathematics pedagogy were also showed culture-related perceptions, as a substantial majority (7 out of 9, representing 77.8%) of the items in the teacher trainees' questionnaires had either culture-related or showing trends toward cultural-related responses. Out of nine items, four had mean scores of three or higher, indicating a strong alignment with culture-related perceptions. This suggests that these teacher trainees see mathematics as inherently connected to cultural contexts and everyday experiences. Students involvement in mathematics lessons supports Schliemann and Carraher

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(2002) exploratory study on how students' mathematical thinking evolves from their previous understandings and experiences out-of-school and their participation in school activities as they become acquainted with formal mathematical principles and conventional mathematical notation. Their finding shows that children develop logical and mathematical thinking through actions, reflections, social interactions, games, and discussions, encountering conventional representations and reasoning practices that influence their course and mathematical thought which agrees with this study as an overwhelming majority (92.4%) of the teacher trainees indicated that "teaching and learning mathematics involves active participation of children develop logical and mathematical thinking (through actions, reflections, social interactions, games, and discussions, encountering conventional representations and reasoning practices that influence their course and mathematical thought learners) throughout the lesson". This consensus underscores the importance these teacher trainees place on engaging students actively in the learning process, reflecting modern educational practices that emphasise student-centered learning. Three items had mean scores between 2.5 and 2.6, reflecting a trend towards culture-related perceptions. While these scores are lower, they still indicate a recognition of cultural relevance, albeit not as strongly as the items with higher scores.

The study again, revealed that language and mathematical thinking which is in line with Davis's (2010, 2016) findings of head teachers' language preference for teaching and learning mathematics, as more than half (68.4%) of the trainees strongly disagreed or disagreed with the statement that "language has nothing to do with mathematical thinking", indicating an appreciation for the role of language in shaping mathematical understanding that "children are very likely to understand

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mathematics better when they are taught in the language they understand best". The finding highlighted the importance that the teacher trainees place on language as a critical factor in effective mathematics instruction. They recognised that teaching in a language familiar to students can significantly enhance comprehension and engagement which supports Davis (2010) findings of students' perceptions toward the accessibility of mathematics being mandatory status of mathematics and mathematics for "Bright" Students as just over half (53.2%) of the trainees did not agree with the statement that "mathematics should be made an optional subject at all levels including colleges of education", and "mathematics should only be studied by bright people in society". This suggests that while there is an insignificant minority that supported the mandatory status of mathematics, a significant majority might be open to the idea of making mathematics optional, potentially reflecting concerns about its accessibility or relevance for all students. Teacher trainees' perceptions reflect a potentially elitist view of mathematics, where the subject is seen as the domain of those with exceptional intellectual abilities (Ernest, 1989). Such a perception could influence how these future teachers approach the subject in their classrooms, potentially leading to practices that might exclude or discourage students who are perceived as less "bright."

The results indicated less than a quarter (22.2%) of items had mean scores of 2.2, an indication culture-free perceptions. This implies that some teacher trainees still perceive mathematics more abstractly or neutrally, disconnected from cultural influences. Linking success to intellectual ability, a significant proportion (78.2%) of the teacher trainees either strongly agreed or agreed that "learners' success in mathematics depends on their intellectual abilities." This suggests that many of the trainees attribute success in mathematics primarily to innate cognitive abilities,

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potentially overlooking other factors such as effort, mindset, or the quality of instruction. This view could have implications for how they approach teaching, possibly leading to a focus on ability-based differentiation or scaffolding in their future classrooms.

The study further revealed that teacher trainees are increasingly acknowledging the influence of culture on mathematical knowledge reflecting Davis (2016) findings relating cultural influences on Ghanaian primary school pupils' conceptions in measurement and division of fractions. For instance, the majority of teacher trainees believed that activities in various societies can generate distinct forms of mathematics. This suggests that mathematical concepts are embedded in everyday cultural practices, which may not always align with formal school mathematics. A diverse range of respondents identified activities that could generate mathematics, with 56.9% of them identified two or more activities. A significant number (35.3%) identified one of Bishop (1988) six fundamental activities as sources of mathematics, with counting and measuring reflecting a more traditional view. The recognition of "explaining" as an activity that generates mathematics is particularly interesting in the Ghanaian context.

The study showed that a majority of teacher trainees recognised the link between Ghanaian culture and mathematics pedagogy, as 75% of items in the study received culture-related responses, suggesting that trainees are increasingly recognising the influence of Ghanaian cultural practices on mathematics teaching and learning. The remaining 25% had mean scores ranging from 2.5 to 2.7, indicating an inclination towards integrating cultural practices into mathematics pedagogy. A large majority (84.9%) believed that cultural practices have a place in college level mathematics teaching and learning. This aligns with the growing

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emphasis on culturally responsive pedagogy, which seeks to make learning more relevant and effective by connecting it to students' cultural backgrounds. A smaller portion (15.1%) did not believe that cultural practices have a place in mathematics education. This finding also sits well with Davis (2010, 2016) study of cultural influences on primary school students' mathematical conceptions in Ghana which found an extensive use of informal units of measure, drawing on the need to integrate everyday and school mathematical knowledge in the teaching and learning situation

The study revealed that the majority of teacher trainees (83.9%) believe that mathematics education can help preserve Ghanaian culture, indicating a strong recognition of its connection to cultural practices and heritage. However, a minority (16.1%) expressed skepticism, believing that mathematics is unrelated to cultural practices or limited in application. A large portion (66.2%) of teacher trainees who supported this idea, cited culturally related reasons for their perceptions. They suggested that linking mathematics with indigenous cultural practices could help preserve traditional knowledge and skills, such as games, crafts, and agricultural practices. Some trainees also highlighted the importance of mathematics in documenting historical events and timekeeping.

The study also indicated that teacher trainees' views on cultural integration into the mathematics curriculum, arguing it enhances students' understanding and retention of abstract concepts. They believed this approach should be relevant to students' future lives, resonate with diverse home cultures, and be experienced as 'real' by all students.

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Mathematics Tutors' Perceptions about Mathematics

The study showed that as with teacher trainees, mathematics tutors also held areas of perceptions about mathematics (mathematical knowledge, mathematics pedagogy, links between culture and mathematical knowledge, links between culture and mathematics pedagogy, and links between culture and mathematics curriculum). The study showed that most mathematics tutors (64.7%) believed mathematical truth can be challenged through logical reasoning, and 79.4% found it to be easy subject. They believe mathematical knowledge is useful and interesting, especially when taught using games and puzzles. A smaller number (17.6%) disagreed with the statements like "mathematical knowledge is the same everywhere." The majority of respondents disagree with the negative perceptions of "mathematics being boring" (97.1%) and "mathematics being a difficult subject" (94.1%), indicating a strong positive attitude towards mathematics. The study showed that over 60% of mathematics tutors' perceptions are influenced by cultural context (i.e., everyday activities), a little above one-third (38.2%) identifying it with calculations indicating a split between traditional and practical perspectives which aligns with Davis (2010) study on cultural influences on Ghanaian primary school pupils' conceptions in measurement and division of fractions.

A few (35.3%) of tutors' views focused on logical and analytical aspects of mathematics, while 52.9% believed it is deeply connected to real-life problem-solving and everyday activities. This suggests a growing recognition of cultural dimensions in mathematical knowledge, influenced by tutors' deeper understanding.

The study further showed that, the majority of mathematics tutors (66.7%) were culturally sensitive, recognising the importance of cultural contexts in

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students' understanding. However, some tutors may focus on universal principles, overlooking diverse backgrounds. Active participation and native language use are also crucial. Tutors rejected the idea of memorising facts and emphasise the importance of critical thinking and problem-solving. They advocated for culturally responsive teaching practices, making mathematics more relevant and accessible to diverse students. Most of mathematics tutors (83.3%) emphasised the importance of cultural awareness in understanding the discipline, challenging the traditional view of it as a culture-free subject. They acknowledged the role of Indigenous cultural practices in teaching the moral, ethical, and religious values in mathematics, urging education to be deeply rooted in these contexts.

The study again, indicated mathematics tutors established the truth that, everyday activities in various societies generate mathematical knowledge, despite differing from formal school mathematics. The majority of tutors (91.2%) indicated that multiple activities generate mathematics, emphasising the importance of incorporating culturally relevant examples into mathematics education to enhance students' understanding and appreciation of mathematics. Activities like counting, measuring, locating, playing, designing, and playing reflect fundamental mathematical concepts deeply embedded in everyday cultural practices. Integrating culturally relevant examples into mathematics education enhances learning, making it more meaningful and effective. Teachers should adopt a culturally responsive approach, incorporating examples from diverse backgrounds.

The study showed that mathematics tutors strongly believed in incorporating indigenous cultural practices into school mathematics to enhance learning experiences. They believed in culturally responsive teaching, which contextualizes

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concepts and validates students' cultural backgrounds, promoting an inclusive and engaging learning environment. The majority of tutors were in support of the practical application of mathematics, highlighting the need for educators to adopt culturally responsive teaching methods.

The findings from the interviews revealed that all five focus (mathematics tutors) groups' views about the nature of mathematics indicated the trends to cultural-related perceptions as the majority of them perceived mathematics as "*problem-solving, critical* thinking*, and daily life activities,* which aligns with Ernest (1989) problem-solving views of mathematical knowledge.

The study once again, showed that all (34 out of 34, representing 100%) of tutors believed that cultural practices are essential in college mathematics teaching. They believe that connecting students' cultural backgrounds to mathematical concepts makes the subject more relevant and accessible. The majority of tutors identified multiple topics where out-of-school mathematical practices could be integrated into the curriculum. This holistic approach fosters a deeper understanding of mathematical concepts by connecting them to students' lived experiences. However, the study also highlighted the need for ongoing professional development for tutors to effectively integrate cultural practices into their teaching.

A study further revealed that mathematics tutors found the incorporating cultural elements into college mathematics curricula improves student engagement and understanding. The majority (91.2%) agreed that this approach makes abstract concepts relatable, fosters a more inclusive learning environment, and encourages active participation in classroom discussions, enhancing deep learning and critical thinking skills.

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Effects of Sex on Receptiveness to Cultural Relevance of Mathematics Teaching and Learning

The study revealed that sex significantly influences teacher trainees' perceptions of the cultural relevance of mathematics (see Table 24, Table 25, and Table 26). Male teacher trainees showed a stronger inclination towards recognising and valuing cultural elements in mathematics, with slightly higher mean scores in these areas. This indicates that sex influences how teacher trainees perceive the integration of cultural elements into mathematics teaching methods, with male trainees being more likely to recognise and value Ghanaian culture within the curriculum. The tendency for male trainees to show more culturally related views in specific areas could be influenced by various factors, such as differences in socialisation, educational experiences, or exposure to culturally relevant teaching practices.

The study revealed that both male and female teacher trainees reported similar mean scores on perceptions of mathematics pedagogy and links between culture and mathematical knowledge. However, males were slightly more inclined towards cultural-related perceptions than their female counterparts. The results generally revealed that sex has a significant effect on teacher trainees' receptiveness to the cultural relevance of mathematics teaching and learning at the Colleges of Education.

Findings from the study also revealed there was no statistically significant difference between the views of female and male mathematics tutors on the combined dependent variables. The lack of a statistically significant difference between male and female mathematics tutors indicates that their views on the combined dependent variables are essentially the same (see Table 27, Table 28, and

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Table 29). The study found that sex does not have any significant influence on mathematics tutors' perceptions about mathematics pedagogy. Both male and female tutors shared a cultural-free perceptions about mathematics pedagogy, believing teaching methods are universally applicable regardless of cultural context. This suggests that while culture is important, teaching strategies are not strongly associated with it.

The study indicated that both male and female mathematics tutors showed similar trends in understanding the influence of culture on mathematical knowledge and the relationship between culture and mathematical knowledge. The study found that both male and female tutors recognise the strong connection between cultural context and mathematics teaching, implying that pedagogy is influenced by cultural factors and the mathematics curriculum should incorporate cultural elements. The study therefore found that, sex has no significant effect on mathematics tutors' receptiveness to cultural relevance of mathematics teaching and learning.

Effects of Programmes of Study on Teacher Trainees' Perceptions about Mathematics

Findings from the study indicated that there was a statistically significant difference among the programmes of study concerning the combined dependent variables (see Table 30, Table 31, Table 32, and Table 33). The study indicated that the specific programme of study significantly influences a teacher trainee's receptiveness to the cultural relevance of mathematics. The study revealed significant differences in perceptions of mathematics pedagogy among different programmes, with Primary education having the highest cultural-related view, while Early Grades showed the lowest trend. Teacher trainees in the JHS Education programme had more culturally-related perceptions about links between culture

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and mathematics pedagogy, while the B.Ed. Early Grade Group showed less noticeable trends.

The study found significant differences in perceptions between B.Ed. Early Grade and B.Ed. JHS groups regarding the links between Ghanaian culture and mathematics curriculum. Teacher trainees in the Primary Education and JHS Education programmes showed a strong trend towards cultural-related perceptions about mathematics pedagogy, suggesting that the curriculum might emphasize cultural relevance more effectively. The Early Grade Education group had the least cultural-related views, suggesting a potential gap in the curriculum's emphasis on cultural integration in mathematics. These differences highlight the importance of the specific training programme in shaping teacher trainees' perceptions of cultural integration in mathematics.

The study therefore found that, programme of study has a significant effect on teacher trainees' receptiveness to cultural relevance of mathematics teaching and learning at the colleges of education.

Effects of Grade level (100, 200, 300, & 400) on Teacher Trainees' Perceptions about Mathematics

The study revealed significant differences in the combined dependent variables among different grade levels, indicating that grade level plays a crucial role in influencing these variables (see Table 34, Table 35, Table 36, and Table 37). The study found significant differences in teacher trainees' perceptions about mathematics pedagogy and links between culture and mathematical knowledge across grade levels, suggesting a need for consistent cultural perspectives in teaching. Teacher trainees' perceptions about mathematics pedagogy and the links

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between culture and mathematical knowledge vary across grade levels, indicating training and experiences may influence their understanding.

The study found that teacher trainees at Level 400 showed higher mean scores in understanding the links between culture and mathematical knowledge. This suggests a deeper understanding of the relationship between culture and mathematical knowledge. The rise in the mean scores from Level 100 to Level 400 suggests a mature understanding of mathematics pedagogy developed during the final year of training.

The study indicated that cultural awareness in mathematics education progresses gradually throughout teacher training programs, with Level 400 being the peak stage, suggesting targeted interventions or curricular enhancements could enhance this. Teacher trainees' perceptions about mathematical knowledge increase across grade levels, highlighting the importance of cultural relevance in mathematics education, with grade level significantly affecting trainees' receptiveness. Therefore, the grade level has a significant effect on teacher trainees' receptiveness to the cultural relevance of mathematics teaching and learning at the colleges of education.

The Significant Difference between the Mean scores of Teacher Trainees and their Mathematics Tutors' Receptiveness to Cultural Relevance of Mathematics

The findings from the study showed the comparative views of how teacher trainees and their mathematics tutors differ in their perceptions about the cultural relevance of mathematics (see Table 35, Table 36, and Table 37). The study revealed a significant difference in the mean scores of perceptions about cultural relevance of mathematics between teacher trainees and mathematics tutors. The

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differences in perceptions between teacher trainees and their tutors could inform the development of curricula and training programmes. For instance, understanding how tutors and trainees differ in their views on cultural relevance can help tailor professional development and training initiatives to bridge any gaps in understanding.

Significant differences in mean scores between teacher trainees and mathematics tutors were found across all dependent variables, indicating the two groups of participants' held views on nature of mathematics differ. Teacher trainees consistently showed higher mean scores, indicating a subtle divergence in their perception about cultural integration into the mathematics curriculum. These findings might indicate that teacher trainees are slightly more attuned to the interplay between culture and mathematics, possibly due to recent exposure to contemporary educational theories or newer training programmes that emphasise cultural relevance. On the other hand, mathematics tutors, who may have more teaching experience, might view these connections with a slightly different perspective, perhaps rooted in more traditional approaches.

Therefore, the study in general, found a significant difference between the mean scores of all the five perceptions about mathematics held by both teacher trainees and their tutors. Thus, the study does not support the null hypothesis, "there is no significant difference between the mean scores of teacher trainees and their mathematics tutors' receptiveness to the cultural relevance of mathematics.

Chapter Summary

This chapter aimed at presenting the results and discussions on views held by teacher trainees and their mathematics tutors on mathematics teaching and learning, effects of gender on teacher trainees' and mathematics tutors' perceptions about

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mathematics, effects of a programme of study and grade levels on teacher trainees' views of the cultural relevance of mathematics, and the significant differences between the mean scores of teacher trainees and their mathematics tutors' receptiveness to the cultural relevance of mathematics.

From research question one, five perceptions areas (perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between Ghanaian culture and mathematical knowledge, perceptions about links between Ghanaian culture and mathematics pedagogy, and perceptions about links between culture and mathematics curriculum) held by both teacher trainees and their mathematics tutors indicated trends to cultural-related perceptions. The major themes obtained from open-ended questionnaires and interview responses for both teacher trainees and their tutors were mathematical/scientific concepts, discipline/field of study, problem-solving, daily life applications, teaching and learning approaches, and language use and preference.

Based on the one-way multivariate analysis of variance (MANOVA) conducted, it was revealed that sex has statistically significant effects on teacher trainees' receptiveness to the cultural relevance of mathematics teaching and learning. However, the views of male and female mathematics tutors were similar. Hence gender does not have any significant effect on mathematics tutors' receptiveness to cultural relevance of mathematics.

Again, the study revealed the variation in the mean scores by a programme of study on teacher trainees' views about the nature of mathematics was statistically significant. In addition, the study revealed significant differences across grade levels in various aspects related to the cultural relevance of mathematics.

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Finally, it was revealed that the difference in mean scores of teacher trainees' and their mathematics tutors' receptiveness to the cultural relevance of mathematics was statistically significant. The results indicated that overall, there is a relatively variant level of receptiveness between teacher trainees and their mathematics tutors regarding the cultural relevance of mathematics teaching and learning at the selected colleges of education. Therefore the views of teacher trainees and their mathematics tutors were different.

The next section which is chapter five presents a summary, conclusions and recommendations for this study.

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CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary of the study, conclusions drawn from its findings and recommendations based on the findings generated from this study.

Summary

The purpose of this study was to explore teacher trainees and their mathematics tutors' receptiveness to cultural relevance of mathematics and also to ascertain whether their views held were cultural–free or cultural-related at the colleges of education. A sequential explanatory mixed-methods design was used. Stratified random sampling technique was used to select the regions, colleges of education, first-year to fourth-year B.Ed. (Early Grade, Primary, and JHS) teacher trainees whiles purposive sampling procedure was used to select their mathematics tutors.

A sample of 1,160 first-through fourth-year teacher trainees studying either core or elective mathematics courses from the five colleges of education, and all their mathematics tutors (34) were selected for this study. Besides, fifty (50) of these teacher trainees (10 from each college), and all thirty-four (34) mathematics tutors as well were selected purposely for the focused group interview sessions in each college of education. Four research questions and one research hypothesis were formulated to guide the conduct of the study. These research questions were: "How cultural related are the views held by teacher trainees and their mathematics tutors about mathematics in the Colleges of Education?; What is the effect of sex on teacher trainees and their mathematics tutors' receptiveness to cultural relevance of mathematics?;

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What is the effect of programme of study on teacher trainees' receptiveness to cultural relevance of mathematics?; What is the effect of grade level on teacher trainees' receptiveness to cultural relevance of mathematics?; and the Hypothesis however, was "there is no significant difference between the mean scores of teacher trainees' and their mathematics tutors' receptiveness to cultural relevance of mathematics"

The quantitative data collected was analysed using descriptive statistics (percentages, means and standard deviations) and inferential statistics (MANOVA), while the qualitative data collected was analysed qualitatively. The summary of the key findings obtained is presented in the next section.

Summary of Key Findings

How cultural related are the views held by teacher trainees and their Mathematics tutors about mathematics in the Colleges of Education? The following findings were obtained:

1. The finding of the study revealed that both teacher trainees and their mathematics tutors' perceptions about mathematical knowledge, mathematics pedagogy, and links between Ghanaian culture and mathematical knowledge indicated trends toward cultural-related perceptions. Besides, the results indicated that, both had cultural-related perceptions about links between Ghanaian culture and mathematics pedagogy, and links between Ghanaian culture and mathematics curriculum.
2. The best strongly ranked trend towards cultural–related views held by teacher trainees was Mathematical knowledge, followed by Mathematics pedagogy, and last was the links between Ghanaian culture and Mathematical knowledge respectively. The results revealed that teacher trainees' perceptions about links

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between culture and mathematics curriculum was more culturally related than their perceptions about links between culture and mathematics pedagogy.

3. As with teacher trainees, the best strongly ranked trends toward cultural–related views held by mathematics tutors was Mathematical knowledge, followed by links between culture and Mathematical knowledge, and the last was Mathematics pedagogy. Again, the more cultural-related perceptions held by mathematics tutors was links between culture and Mathematics curriculum followed by links between culture and Mathematics pedagogy.

4. Finally, the findings from the open-ended and interview questions revealed that a substantial portion of the teacher trainees and their tutors perceived mathematics not just as an abstract subject, but as something closely connected to daily life, practical activities, and problem-solving in various contexts. The results revealed that teacher trainees and their mathematics tutors provided various reasons why their cultural–related views held by them were important in their mathematics teaching and learning. For instance, mathematical knowledge and mathematics pedagogy were perceived because they have links with the six fundamental activities (counting, locating, measuring, playing, designing, and explaining). The out–of–school mathematics practices such as measurement (e.g., capacity), and addition (counting) were the most highly dominant reasons among these cited reasons. Again, the reasons given in support of views of mathematics curriculum and pedagogy were related to the use of cultural objects such as artefacts (drums), songs, and games in teaching and learning of mathematics, and language use and preference. The results showed that the majority of them gave reasons relating to preference for local language in mathematics curriculum design and delivery. These vast cultural-related

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responses suggest a growing recognition among teacher trainees and their tutors of the importance of cultural context in understanding and teaching mathematics.

The results indicated teacher trainees and their tutors' recognition of mathematics being both valuable and applicable to real-world scenarios, which could positively influence how they approach teaching and learning the subject.

What is the effect of sex on teacher trainees' and their mathematics tutors' receptiveness to cultural relevance of mathematics? The following findings were obtained:

1. Findings from the study showed that sex has a statistically significant effect on teacher trainees' receptiveness to cultural relevance of mathematics, particularly in the areas of mathematical knowledge, links between culture and mathematics pedagogy, and the links between culture and mathematics curriculum. Male teacher trainees consistently reported slightly higher mean scores in these areas, indicating a stronger inclination towards recognising and valuing cultural elements in mathematics.
2. The findings indicated that males tend to hold more trends toward cultural-related views about mathematical knowledge, and little higher culturally related than females. The statistically significant difference in their perceptions indicated that gender does play a role in influencing how trainees view the cultural relevance of mathematical knowledge. The results showed that male teacher trainees are more inclined to see connections between culture and mathematics pedagogy, with their views being more culturally related than those of females. The statistically significant difference suggests that sex influences how trainees perceive the integration of cultural elements into mathematics teaching methods.

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3. The tendency for male teacher trainees to show more culturally related views in specific areas could be influenced by various factors, such as differences in socialisation, educational experiences, or exposure to culturally relevant teaching practices.
4. The results further revealed that two dependent variables, perceptions about mathematics pedagogy and perceptions about links between culture and mathematical knowledge, both male and female teacher trainees reported slight differences in their mean scores.
5. The results of the study therefore indicated that sex has statistically significant effect on teacher trainees' receptiveness to cultural relevance of mathematics teaching and learning.
6. Findings from the study also revealed there was no statistically significant difference between the views of female and male mathematics tutors on the combined dependent variables (Perceptions about Mathematical knowledge, Perceptions about Mathematics pedagogy, Perceptions about links between culture and Mathematical knowledge, Perceptions about links between culture and Mathematics pedagogy, and Perceptions about links between culture and Mathematics curriculum). The lack of a statistically significant difference between male and female mathematics tutors indicates that their views on the combined dependent variables are essentially the same.
7. The results showed that mathematics tutors exhibited similar trends toward cultural-related perceptions on three dependent variables (Perceptions about: Mathematical knowledge, Mathematics pedagogy, and links between culture and mathematical knowledge). Both male and female tutors showed a trend toward recognising the influence of culture on mathematical knowledge,

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mathematics pedagogy, and links between culture and mathematical knowledge. The findings further indicated similar cultural-related perceptions about links between culture and mathematics pedagogy and links between culture and mathematics curriculum, as both male and female tutors recognised a strong connection between cultural context and the way mathematics is taught, suggesting that they believe pedagogy is influenced by cultural factors, strongly associated the mathematics curriculum with cultural influences, reflecting a shared understanding that the curriculum should or does integrate cultural elements.

8. Finally, the findings indicated that sex has no significant effect on mathematics tutors' receptiveness to cultural relevance of mathematics.

What is the effect of programme of study on teacher trainees' receptiveness to cultural relevance of mathematics? The following findings were obtained:

1. Findings from the study indicated that there was a statistically significant difference amongst the programmes of study (B.Ed. Early Grade Education, B.Ed. Primary Education, and B.Ed. JHS Education) for the combined dependent variables.
2. The study found significant differences in perceptions about mathematics pedagogy amongst different programmes, with the B.Ed. Primary education programme indicated the strongest trend towards cultural-related perceptions. The B.Ed. Primary group viewed mathematics pedagogy through a culturally relevant lens, while the B.Ed. Early Grade group showed the lowest trend, indicating a potential gap. Teacher trainees in the JHS Education programme had more culturally-related perceptions about links between culture and

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mathematics pedagogy, while the B.Ed. Early Grade Group showed less noticeable cultural-related perceptions.

3. The study found significant difference in perceptions between B.Ed. Early Grade and B.Ed. JHS groups regarding the links between Ghanaian culture and mathematics curriculum. Teacher trainees in the Primary Education and JHS Education programmes showed a strong trend towards cultural-related perceptions about mathematics pedagogy, suggesting that the curriculum might emphasise cultural relevance more effectively. The Early Grade Education group had the least cultural-related views, suggesting a potential gap in the curriculum's emphasis on cultural integration in mathematics. These differences highlight the importance of the specific training programmes in shaping trainees' perceptions about cultural integration in mathematics teaching and learning.
4. The JHS Education programme teacher trainees' perceptions were more culturally related than those of the Primary Education trainees. This suggests that teacher trainees in the JHS programme may be more attuned to the cultural aspects of teaching mathematics. The Early Grade Education group, while showing trends toward cultural-related perceptions, reported the lowest mean score, indicating a weaker emphasis on the cultural links in mathematics pedagogy.
5. The results further revealed that teacher trainees offering B.Ed. JHS education programme’s views were slightly higher than those doing B.Ed. Primary education, while teacher trainees doing B.Ed. Early Grade education programme’s views were the least cultural–related. The overall mean scores for the combined perceptions about mathematics indicated that the JHS Education

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group had the highest trend toward culturally related perceptions (M = 2.89, SD = 0.288), followed closely by the Primary Education group (M = 2.86, SD = 0.307), and then the Early Grade Education group (M = 2.82, SD = 0.301). Hence, the programme of study has a significant effect on teacher trainees' receptiveness to cultural relevance of mathematics.

What is the effect of grade level on teacher trainees' receptiveness to cultural relevance of mathematics? The following findings were obtained:

1. Findings from the study showed that there were statistically significant differences amongst the grade levels (100, 200, 300, and 400) for the combined dependent variables. The statistically significant differences amongst grade levels suggest that grade level is an important factor influencing the combined dependent variables(Perceptions about Mathematical knowledge, Perceptions about Mathematics pedagogy, Perceptions about links between culture and Mathematical knowledge, Perceptions about links between culture and Mathematics pedagogy, and Perceptions about links between culture and Mathematics curriculum).
2. The results further indicated significant differences in teacher trainees' perceptions about mathematics pedagogy and links between culture and mathematical knowledge across grade levels. There were also slight differences in the mean scores of perceptions about (Mathematical knowledge, links between culture and Mathematics pedagogy, and the links between culture and Mathematics curriculum), suggesting a need for a consistent approach to integrating cultural perspectives in mathematics teaching and learning.
3. The study found that teacher trainees at Level 400 showed higher mean scores in understanding the links between culture and mathematical knowledge. This

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suggests a deeper understanding of the relationship between culture and mathematical knowledge. The higher mean scores level 400 suggests a mature understanding of mathematics pedagogy developed during the final year of training.

4. Finally, the study found that cultural awareness in mathematics education is developed progressively throughout the teacher training programmes, with Level 400 being a peak in this development. Targeted interventions or curricular enhancements at this level could further strengthen cultural awareness. Generally, teacher trainees' perceptions about mathematical concepts increases across grade levels, emphasising the importance of a sustained focus on cultural relevance in mathematics education. Therefore, in general, grade level has significant effect on teacher trainees' receptiveness to cultural relevance of mathematics

The research hypothesis of the study stated, *Ho: "there is no significant difference between the mean scores of teacher trainees' and their mathematics tutors' receptiveness to cultural relevance of mathematics"*. The following findings were obtained:

1. The hypothesis formulated to explore the differences in the mean scores of teacher trainees and their mathematics tutors' receptiveness to cultural relevance of mathematics was addressed by qualitative comparison and the use of MANOVA. The results of the study revealed the five areas of perceptions about (Mathematical knowledge, Mathematics pedagogy, links between Ghanaian culture and Mathematical knowledge, links between Ghanaian culture and Mathematics pedagogy, and links between Ghanaian culture and Mathematics curriculum) were held by both teacher trainees and their

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mathematics tutors. By comparing qualitatively, the views held by both teacher trainees and their mathematics tutors were different.

2. The results indicated significant differences across several of the dependent variables, suggesting that the perceptions of participants vary notably on these measures. Mathematics tutors' showed a stronger trends toward cultural-related perceptions and more culturally related perceptions than teacher trainees. This differences in the mean scores indicated that there was statistically significant difference between teacher trainees and their mathematics tutors in terms of their combined perceptions about the cultural relevance of mathematics. This suggests that there are notable variations in how each group perceives the importance of cultural context in mathematics education.
3. The study's findings indicated that mathematics tutors were slightly more accustomed to the interplay between culture and mathematics, possibly due to recent exposure to contemporary educational theories or newer training programmes that emphasise cultural relevance. On the other hand, mathematics tutors, who may have more teaching experience, might view these connections with a slightly different perspective, perhaps rooted in more sociocultural approaches.
4. Finally, the study revealed that, the result does not support the null hypothesis Ho: "there is no significant difference between the mean scores of teacher trainees and their mathematics tutors' receptiveness to cultural relevance of mathematics."

Conclusions

The study revealed that both teacher trainees and their mathematics tutors' perceptions about mathematical knowledge, perceptions about mathematics

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pedagogy, and perceptions about links between Ghanaian culture and mathematical knowledge showed trends toward cultural related perceptions, while perceptions about links between Ghanaian culture and mathematics pedagogy, and perceptions about links between Ghanaian culture and mathematics curriculum indicated cultural-related perceptions. The results and findings from the study revealed that the mean scores and standard deviations for the observed held views for the teacher trainees showed a trend towards cultural–related perceptions about mathematics. The study indicated that a majority of teacher trainees view mathematics as culturally relevant suggests that they are likely to integrate real-life examples and practical applications into their teaching. This could lead to more engaging and relevant mathematics instruction, making the subject more accessible to students. The results showed that the most cultural–related perception was links between Ghanaian culture and mathematics curriculum, followed by links between Ghanaian culture and mathematics pedagogy. The mean scores for the three remaining variables showed the trends to cultural-related perceptions about mathematics.

The study again, revealed that teacher trainees' perceived mathematics as subject deeply connected to real-life problem-solving, emphasising numerical values, analysis, and critical thinking skills. This aligns with modern educational approaches, making mathematics relevant and meaningful to students. The study further showed that majority of teacher trainees preferred the use of local language for teaching, learning, and designing of mathematics curricula in school.

The study further revealed that mathematics tutors showed three trends toward cultural-related perceptions for perceptions about (mathematical knowledge, mathematics pedagogy, and links between culture and mathematical knowledge)

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and strongly cultural-related perceptions for perceptions about (links between culture and mathematics pedagogy, and links between culture and mathematics pedagogy). The results of the study indicated complex and evolving perceptions about mathematical knowledge among mathematics tutors, with a notable trend toward recognising the cultural dimensions of the subject. This shift highlights the importance of understanding mathematics not just as a universal discipline but as one that is intertwined with cultural practices and real-world applications.

The results revealed that mathematics tutors generally held open-minded views on mathematics with a strong emphasis on cultural relevance, learner engagement, and inclusivity. Their recognition of the importance of language and the rejection of rote learning and narrow views of intelligence suggest a commitment to fostering a rich, supportive, and inclusive learning environment for all students. They recognise that mathematical knowledge and practices are influenced by cultural contexts and that these influences should be reflected in the teaching and learning of mathematics. This cultural awareness is crucial for developing a more inclusive and relevant mathematics education that respects and integrates diverse cultural perspectives. Additionally, the tutors' acknowledgment of the moral and ethical dimensions of mathematics suggests a holistic approach to mathematics education that goes beyond technical proficiency to include consideration of values and societal impact

In addition, the results indicated that mathematics tutors have a broad and inclusive understanding of the sources of mathematical knowledge. Their unanimous agreement that cultural and societal activities can generate mathematics, along with their identification of various specific activities, demonstrates a recognition of the diversity and richness of mathematical knowledge outside the

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formal classroom setting. This perspective is crucial for developing a mathematics curriculum that is both culturally responsive and relevant to students' lives. By integrating cultural activities into mathematics teaching, educators can make the subject more engaging, accessible, and meaningful, thereby fostering a deeper understanding and appreciation of mathematics among students.

As with teacher trainees, mathematics tutors recognised the local language as important in classroom mathematics instruction. They appreciate the relevance of local aspects of mathematics in school mathematics.

The study revealed that male teacher trainees' views on cultural relevance of mathematics were slightly higher than their female counterparts in the five selected Colleges of Education. Findings from the study showed that sex has a statistically significant effect on teacher trainees' receptiveness to cultural relevance of mathematics, particularly in the areas of mathematical knowledge, links between culture and mathematics pedagogy, and the links between culture and mathematics curriculum. These findings indicated that males tend to hold more trends toward cultural-related views about mathematical knowledge, and little higher culturally related than females. The statistically significant difference in their perceptions indicates that sex does play a role in influencing how trainees view the cultural relevance of mathematical knowledge.

The results showed that male teacher trainees were more inclined to see connections between culture and mathematics pedagogy, with their views being more culturally related than those of females. The statistically significant difference suggests that sex influences how trainees perceive the integration of cultural elements into mathematics teaching methods. This difference, which is also statistically significant, indicates that male trainees are more likely to recognise and

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value the integration of Ghanaian culture within the mathematics curriculum. The tendency for male trainees to show more culturally related views in specific areas could be influenced by various factors, such as differences in socialisation, educational experiences, or exposure to culturally relevant teaching practices.

Then again, the study findings revealed that generally, sex has statistically significant effect on teacher trainees' receptiveness to cultural relevance of mathematics.

The results of the study showed that there was no statistical significant difference between the mean scores of any perceptions about mathematics held by both female and male mathematics tutors. The results indicated that tutors exhibited similar trends toward cultural-related perceptions on three dependent variables. Both male and female tutors showed a trend toward recognising the influence of culture on mathematical knowledge, mathematics pedagogy, and perceptions about links between culture and mathematical knowledge. The findings further indicated similar cultural-related perceptions about links between culture and mathematics pedagogy and links between culture and mathematics curriculum, as both male and female tutors recognised a strong connection between cultural context and the way mathematics is taught, suggesting that they believe pedagogy is influenced by cultural factors, strongly associated the mathematics curriculum with cultural influences, reflecting a shared understanding that the curriculum should or does integrate cultural elements. Therefore, the study revealed that, sex has no significant effect on mathematics tutors' receptiveness to cultural relevance of mathematics.

The findings from the study indicated that there was a statistically significant difference amongst the programmes of study (B.Ed. Early Grade Education, B.Ed.

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Primary Education, and B.Ed. JHS Education) for the combined dependent variables (Perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between culture and mathematical knowledge, perceptions about links between culture and mathematics pedagogy, and perceptions about links between culture and mathematics curriculum). The significant difference among programmes of study implies that the specific programme a teacher trainee is enrolled in does influence their receptiveness to the cultural relevance of mathematics. The fact that the programme of study has a statistically significant effect on teacher trainees' receptiveness suggests that the educational environment, curriculum, and possibly the pedagogical approaches associated with each programme could be shaping how teacher trainees perceive and value culturally relevant mathematics. The JHS Education programme teacher trainees had more culturally related perceptions about the links between culture and mathematics pedagogy than those in the Primary and Early Grade Education programmes. The JHS Education programme also demonstrated more cultural-related perceptions compared to the Early Grade programme, which had the least cultural-related views. The JHS Education programme trainees' perceptions were more culturally related than those of the Primary Education trainees. This suggests that trainees in the JHS programme may be more attuned to the cultural aspects of mathematics teaching and learning. The Early Grade Education group, while showing trends toward cultural-related perceptions, reported the lowest mean score, indicating a weaker emphasis on the links between culture and mathematics pedagogy. JHS Education teacher trainees' views on the links between culture and the mathematics curriculum were more culturally related than those in the other two programmes. The evidence of the Early Grade Education group having the least

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cultural-related views, suggests a potential gap in the curriculum's emphasis on cultural integration in mathematics at this level.

The significant differences across the programmes underscore the importance of the specific training programme in shaping how teacher trainees perceive the integration of culture into the mathematics curriculum. Therefore programme of study has a significant effect on teacher trainees’ receptiveness to the cultural relevance of mathematics teaching and learning.

The findings from the study showed that there were statistically significant differences amongst the grade levels for the combined dependent variables (Perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between culture and mathematical knowledge, perceptions about links between culture and mathematics pedagogy, and perceptions about links between culture and mathematics curriculum). The statistically significant difference amongst grade levels suggests that grade level is an important factor influencing the combined dependent variables. The study indicated that there were significant differences in the mean scores of teacher trainees’ perceptions about mathematical knowledge, mathematics pedagogy, the links between culture and mathematical knowledge, links between culture and mathematics pedagogy, and the links between culture and mathematics curriculum. The study indicated that grade level significantly influences cultural relevance in mathematics education, highlighting the need for a consistent and cohesive approach to integrating cultural perspectives in teacher training programmes.

The study again, indicated that cultural awareness in mathematics education develops gradually throughout teacher training programmes, with Level 400 being the peak, possibly reflecting the cumulative impact of education. The study

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highlighted the impact of grade level on teacher trainees' perceptions of mathematics pedagogy and cultural connections, with Level 400 being a particularly influential stage. It suggests targeted interventions could enhance cultural awareness. Therefore, the study found that grade level has a significant effect on teacher trainees' receptiveness to the cultural relevance of mathematics teaching and learning.

The study revealed significant difference in the mean scores of perceptions about the cultural relevance of mathematics between teacher trainees and mathematics tutors. Teacher trainees and mathematics tutors had distinct perspectives on the cultural relevance of mathematics, an indication of significant differences in their understanding of the importance of cultural context in mathematics education. The result indicated that significant differences in mean scores between teacher trainees and mathematics tutors were observed, with mathematics tutors indicate slightly higher mean scores in five perception areas than teacher trainees. This revealed a subtle divergence in their views about cultural integration in mathematics teaching and learning. Mathematics tutors might be more familiar with the relationship between culture and mathematics, possibly due to recent exposure to contemporary educational theories or newer training programmes, and with more teaching experience, may view these connections, possibly rooted in sociocultural perspectives differently from teacher trainees.

The study generally revealed the significant differences in the mean scores of the views held by both teacher trainees and their tutors. This difference in the mean scores does not support the null hypothesis, *Ho*: *"there is no significant difference between the mean scores of teacher trainees and their mathematics tutors' receptiveness to the cultural relevance of mathematics"*.

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Recommendations

The following recommendations are made for teaching and learning based on the findings of the study;

1. The affiliate mentoring universities should make the ethnomathematics and sociocultural perspectives in mathematics education mandatory by introducing it as courses in the Colleges of Education mathematics curricula.
2. Curriculum planners and developers should consider incorporating sociocultural issues associated with sex in the development of the mathematics curricula for public Colleges of Education.
3. Mathematics tutors should use materials that incorporate cultural objects in their mathematics teaching to identify the pedagogical activities that align with the interest of teacher trainees in all the three programmes of study.
4. Mathematics instructors should pay attention to cultural aspects of mathematics teaching and learning at lower levels.
5. Mentoring universities should conduct regular in-service training and workshops for teacher trainees and mathematics tutors to effectively incorporate cultural objects in their lessons.
6. Mathematics tutors should make sure that their views of mathematics align with teacher trainees' in order to communicate effectively in their mathematics teaching and learning.

Suggestions for future research

This study was conducted with one thousand, one hundred and sixty (1,160) first – through fourth – year teacher trainees and their thirty–four (34) mathematics tutors. A further related study is recommended to explore in–service mathematics

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teachers' views of cultural relevance of mathematics in their teaching and learning at pre–tertiary level.

Again, this study was conducted in only one PRINCOF zone (ASHBA zone). Therefore, it is recommended that this study be replicated in other zones to present the national representation on teacher trainees' and their mathematics tutors' receptiveness to cultural relevance of mathematics teaching and learning at the Colleges of Education in Ghana.

Finally, further studies should be conducted to explore how views held about cultural relevance of mathematics teaching and learning might reflect teacher trainees' teaching practices at the Colleges of Education in Ghana.

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APPENDICES

APPENDIX ‘A’

UNIVERSITY OF CAPE COAST

FACULTY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF MATHEMATICS AND ICT EDUCATION

QUESTIONNAIRE FOR Ph.D. (MATHEMATICS EDUCATION) THESIS

Exploring Teacher Trainees’ and Their Mathematics Tutors’ Receptiveness to Cultural Relevance of Mathematics in the Colleges of Education in Ghana

(UCCIRB/CES/2022/55)

Questionnaire for Trainee Teachers

This questionnaire is designed to seek your responses to the items indicating your level of agreement to items on “cultural relevance of mathematics.” There is no wrong or right answer. Be assured that, your response will be appreciated, valued, treated confidential, and will be used only for academic purposes. Please provide your candid response to items of the questionnaire.

PART A: BIOGRAPHICAL DATA

For items 1 to 5, tick (√) the box that applies to you.

College

Al-Faruq College of Education ☐

Atebubu College of Education ☐

Berekum College of Education ☐

St Ambrose College of Education ☐

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St Joseph's College of Education ☐

Gender: Female ☐

Male ☐

Age (in years): Less than 23 years ☐

23 – 28 years ☐

29 – 34 years ☐

35 years and above ☐

Programme of Study: B.Ed. Early Grade Education ☐

B.Ed. Primary Education ☐

B.Ed. JHS Education ☐

If you are doing JHS education, indicate your specialty:

Mathematics Major ☐

Mathematics Minor ☐

Other (Specify) …………………

Grade Level: Level 100 ☐

Level 200 ☐

Level 300 ☐

Level 400 ☐

PART B: PERCEPTIONS ABOUT "MATHEMATICS"

Directions: This inventory consists of statements on your beliefs and attitudes to mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about the items and rate how strongly you disagree or agree with each of the following statements by circling in the appropriate box. **Note: Strongly Disagree (SD) = 1, Disagree (DA) = 2, Agree (A) = 3**, and **Strongly Agree (SA) = 4.**

S/N	**Statement**	**SD**	**DA**	**A**	**SA**
1	Mathematical truth is certain and infallible	1	2	3	4
2	Mathematical knowledge is objective knowledge	1	2	3	4
3	Doing mathematics requires rules which has little to do with indigenous culture	1	2	3	4

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4	Mathematical knowledge is the same everywhere	1	2	3	4
5	Mathematical knowledge is useful	1	2	3	4
6	Mathematical knowledge has many applications in life	1	2	3	4
7	Mathematical truth can be rejected based on sound logical argument	1	2	3	4
8	Mathematics is an easy subject	1	2	3	4
9	Learners success in mathematics depends on their intellectual abilities	1	2	3	4
10	Mathematical practices differ from culture to culture	1	2	3	4
11	Use of out – of – school mathematics practices in school mathematics will facilitate learners' understanding of school mathematics	1	2	3	4
12	Mathematical practices in our indigenous culture can support children's learning in school mathematics	1	2	3	4
13	Mathematics is interesting	1	2	3	4
14	Culture plays an important role in mathematics learning	1	2	3	4
15	Mathematics should be made an optional subject at all levels including colleges of education level	1	2	3	4
16	Learning mathematics basically requires memorizing facts	1	2	3	4
17	Incorporating cultural experiences into school mathematics will help students learn mathematics meaningfully	1	2	3	4
18	Teaching and learning mathematics involves active participation of learners throughout the lesson	1	2	3	4
19	Learning mathematics is all about ensuring accuracy in the application of algorithms in class exercise	1	2	3	4
20	Mathematics lessons and activities should relate and reflect the socio cultural practices of the learner	1	2	3	4
21	Teachers' use of out– of – school mathematics practices in school mathematics will better equip children to use out–of –school mathematics more effectively	1	2	3	4
22	Learners perform better when mathematics activities are related to their socio cultural background	1	2	3	4
23	Indigenous culture practices has no place in mathematics teaching and learning	1	2	3	4
24	Mathematics is not free from (moral, ethical, religious etc.) values	1	2	3	4
25	Every culture has its own way of doing mathematics	1	2	3	4
26	Mathematics should only be studied by bright people in the society	1	2	3	4
27	Nature of school mathematics makes the introduction of out-of-school mathematics practices in-school mathematics impossible	1	2	3	4
28	Mathematics learning is all about practicing a given task over and over again	1	2	3	4
29	Mathematics is boring	1	2	3	4

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30	Mathematics is a difficult subject	1	2	3	4
31	Values such as moral, ethical or religious are present in mathematics teaching and learning	1	2	3	4
32	Mathematics has very little relevance to indigenous culture	1	2	3	4
33	Language has nothing to do with mathematical thinking	1	2	3	4
34	Children are very likely to understand mathematics better when they are taught in the language they understand best	1	2	3	4
35	Teachers' knowledge of mathematical practices in learners' culture may help in mathematics teaching and learning	1	2	3	4
36	Teaching mathematics requires using children's mathematical practices in their culture to help them understand the lesson	1	2	3	4
37	Teaching mathematics requires application of what children already know, including mathematical practices in their homes to help them to understand the lesson	1	2	3	4
38	Mathematics curriculum should be seen by students as relevant to their future lives	1	2	3	4
39	Mathematics curriculum should be incorporated with elements of cultural events of people in a community	1	2	3	4
40	Mathematics curriculum should be experienced as "real" by all students	1	2	3	4
41	Mathematics curriculum should be resonated, as far as possible, with diverse home cultures	1	2	3	4

42. Do you believe that one's cultural practices have a place in mathematics teaching and learning in a college? (Tick the one that applies to you)

Yes ☐

No ☐

43. If your answer to question 42 is yes, indicate by ticking which of the topics below allows for inclusion of out-of-school mathematical practices (You may tick[√] more than one)

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Measurement ☐

Lines and space ☐

Fractions ☐

Data handling ☐

Game of chance ☐

Operation on numbers ☐

Word problem solving ☐

Other (specify): ……………………………………………………

44. Do you believe that the activities we carry out daily in society generates "Mathematics" which may not be the same as the school mathematics?

(Tick the one that applies to you)

Yes ☐

No ☐

45. If your answer to question 44 above is yes, which of the following activities in your opinion may generate "mathematics" (you may tick [√] more than one)

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Counting ☐

Measuring ☐

Locating ☐

Playing ☐

Designing ☐

Explaining ☐

Other (specify) ……………………………………………………

46. If your answer to question 44 above is no, why not?

……………………………………………………………………………..

………………………………………………………………………………

47. What comes into your mind when someone mentions "mathematics" to you?

……………………………………………………………………………..

………………………………………………………………………………

48. Briefly explain what mathematics means to you?

…………………………………………………………………………….

………………………………………………………………………………

49. The National Festival of Arts and Culture (NAFAC) was celebrated in November 2019 in Koforidua as a way of preserving our rich Ghanaian culture. Do you believe mathematics education can also be a vehicle for the preservation of our rich culture? (Tick the one that applies to you)

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Yes ☐

No ☐

50. Give reason(s) for your answer to question 49 above

……………………………………………………………………

……………………………………………………………………

Thank you for taken part

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APPENDIX 'B'

UNIVERSITY OF CAPE COAST

FACULTY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF MATHEMATICS AND ICT EDUCATION

QUESTIONNAIRE FOR Ph.D. (MATHEMATICS EDUCATION) THESIS

Exploring Teacher Trainees' and Their Mathematics Tutors' Receptiveness to Cultural Relevance of Mathematics in the Colleges of Education in Ghana

(UCCIRB/CES/2022/55)

Questionnaire for Mathematics Tutors

This questionnaire is designed to seek your responses to the items indicating your level of agreement to items on "cultural relevance of mathematics." There is no wrong or right answer. Be assured that, your response will be appreciated, valued, treated confidential, and will be used only for academic purposes. Please provide your candid response to items of the questionnaire.

PART A: BIOGRAPHICAL DATA

For items 1 to 8 (√) the box that applies to you.

College:

Al – Faruq College of Education ☐

Atebubu College of Education ☐

Berekum College of Education ☐

St. Ambrose College of Education ☐

St. Joseph's College of Education ☐

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Gender:

Female ☐

Male ☐

Age (in years): Less than 29 years ☐

30 – 39 years ☐

40– 49 years ☐

50 years and above ☐

Highest Academic Qualification: BSc. / B.Ed. ☐

MPhil. / MSc/ M.Ed. ☐

PhD. ☐

Working Experience: Below 5 years ☐

5 -10 years ☐

11years and above ☐

Programme teaching: Early Grade Education ☐

Primary Education ☐

JHS Education ☐

If you are teaching JHS programme indicate the specialty:

Mathematics Major ☐

Mathematics Minor ☐

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Other Specify ………………………

A native of this community in which you teach?

Yes ☐

No ☐

Communicating with students in their own dialects:

Yes ☐

No ☐

PART B: PERCPTIONS ABOUT "MATHEMATICS"

Directions: This inventory consists of statements on your beliefs and attitudes to mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about the items and rate how strongly you disagree or agree with each of the following statements by circling in the appropriate box.

Note: Strongly Disagree (SD) = 1, Disagree (DA) = 2, Agree (A) = **3**, and **Strongly Agree (SA) = 4.**

	Statement	**SD**	**DA**	**A**	**SA**
1	Mathematical truth is certain and infallible	1	2	3	4
2	Mathematical knowledge is objective knowledge	1	2	3	4
3	Doing mathematics requires rules which has little to do with indigenous culture	1	2	3	4
4	Mathematical knowledge is the same everywhere	1	2	3	4
5	Mathematical knowledge is useful	1	2	3	4
6	Mathematical knowledge has many applications in life	1	2	3	4

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7	Mathematical truth can be rejected based on sound logical argument	1	2	3	4
8	Mathematics is an easy subject	1	2	3	4
9	Learners success in mathematics depends on their intellectual abilities	1	2	3	4
10	Mathematical practices differ from culture to culture	1	2	3	4
11	Use of out – of – school mathematics practices in school mathematics will facilitate learners' understanding of school mathematics	1	2	3	4
12	Mathematical practices in our indigenous culture can support children's learning in school mathematics	1	2	3	4
13	Mathematics is interesting	1	2	3	4
14	Culture plays an important role in mathematics learning	1	2	3	4
15	Mathematics should be made an optional subject at all levels including colleges of education level	1	2	3	4
16	Learning mathematics basically requires memorizing facts	1	2	3	4
17	Incorporating cultural experiences into school mathematics will help students learn mathematics meaningfully	1	2	3	4
18	Teaching and learning mathematics involves active participation of learners throughout the lesson	1	2	3	4
19	Learning mathematics is all about ensuring accuracy in the application of algorithms in class exercise	1	2	3	4
20	Mathematics lessons and activities should relate and reflect the socio cultural practices of the learner	1	2	3	4
21	Teachers' use of out – of – school mathematics practices in school mathematics will better equip children to use out – of – school mathematics more effectively	1	2	3	4
22	Learners perform better when mathematics activities are related to their socio cultural background	1	2	3	4
23	Indigenous culture practices has no place in mathematics teaching and learning	1	2	3	4
24	Mathematics is not free from (moral, ethical, religious etc.) values	1	2	3	4
25	Every culture has its own way of doing mathematics	1	2	3	4
26	Mathematics should only be studied by bright people in the society	1	2	3	4
27	Nature of school mathematics makes the introduction of out-of-school mathematics practices in-school mathematics impossible	1	2	3	4
28	Mathematics learning is all about practicing a given task over and over again	1	2	3	4

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29	Mathematics is boring	1	2	3	4
30	Mathematics is a difficult subject	1	2	3	4
31	Values such as moral, ethical or religious are present in mathematics teaching and learning	1	2	3	4
32	Mathematics has very little relevance to indigenous culture	1	2	3	4
33	Language has nothing to do with mathematical thinking	1	2	3	4
34	Children are very likely to understand mathematics better when they are taught in the language they understand best	1	2	3	4
35	Teachers' knowledge of mathematical practices in learners' culture may help in mathematics teaching and learning	1	2	3	4
36	Teaching mathematics requires using children's mathematical practices in their culture to help them understand the lesson	1	2	3	4
37	Teaching mathematics requires application of what children already know, including mathematical practices in their homes to help them to understand the lesson	1	2	3	4
38	Mathematics curriculum should be seen by students as relevant to their future lives	1	2	3	4
39	Mathematics curriculum should be incorporated with elements of cultural events of people in a community	1	2	3	4
40	Mathematics curriculum should be experienced as "real" by all students	1	2	3	4
41	Mathematics curriculum should be resonated, as far as possible, with diverse home cultures	1	2	3	4

42. Do you believe that one's cultural practices have a place in mathematics teaching and learning in a college? (Tick the one that applies to you)

Yes ☐

No ☐

43. If your answer to question 42 is yes, indicate by ticking which of the topics below allows for inclusion of out-of-school mathematical practices (You may tick more than one)

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Measurements ☐

Lines and space ☐

Fractions ☐

Data handling ☐

Game and chance ☐

Operation on numbers ☐

Word problem solving ☐

Other (specify): ………………………………………………………

44. Do you believe that the activities we carry out daily in society generates 'Mathematics' which may not be the same as the school mathematics?

(Tick the one that applies to you) Yes ☐

No ☐

45. If your answer to question 44 above is yes, which of the following activities in your opinion may generate "mathematics" (you may tick more than one)

Counting ☐

Measuring ☐

Locating ☐

Playing ☐

Designing ☐

Explaining ☐

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Other (specify): …………………………………………….

46. If your answer to question 53 above is no, why not?

……………………………………………………………………………..

………………………………………………………………………………

47. What comes into your mind when someone mentions „mathematics" to you?

………………………………………………………………………………

………………………………………………………………………………

48. Briefly explain what mathematics means to you?

……………………………………………………………………………….

……………………………………………………………………………….

49. The National Festival of Arts and Culture (NAFAC) was celebrated in November 2019 in Koforidua as a way of preserving our rich Ghanaian culture. Do you believe mathematics education can also be a vehicle for the preservation of our rich culture?

(Tick the one that applies to you)

Yes ☐

No ☐

50. Give reason(s) for your answer to question 49 above

…………………………………………………………………………………
…………………………………………………………………………………

Thank you for taken part

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APPENDIX 'C'

UNIVERSITY OF CAPE COAST

FACULTY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF MATHEMATICS AND ICT EDUCATION

INTERVIEW GUIDE FOR Ph.D. (MATHEMATICS EDUCATION) THESIS

Exploring Teacher Trainees and Their Tutors' Receptiveness to Cultural Relevance of Mathematics in the Colleges of Education in Ghana

(UCCIRB/CES/2022/55)

Interview Guide for Teacher Trainees

This interview session is a follow up to the perception questionnaire you responded to earlier and it is meant to find out reasons or explanations to your views in mathematics teaching and learning. Please, provide your genuine response to each of the items that will be asked. Be assured that the information you provide would be treated confidential and will be used only for academic purposes. Hence, your permission to audio record views is sorted by your agreement to participate in this interview session. Thank you for your participation.

NOTE: These interview guide items are follow-up to the questionnaire items that you responded to earlier on perceptions about nature mathematics teaching and learning. The themes that would be emerged from the interview would be analysed qualitatively to support the earlier held views on cultural relevance of mathematics.

PART I

College……………………………

Gender (Male or Female) ………………

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PART II: Interview Items:

1. (a). What is mathematics? …………………Follow-up question(s) may apply)

   (b). Why do we teach or learn mathematics in school?

   (c). What role does mathematics education play in the educational development of Ghana?

2. What language would you prefer to use in teaching and learning of mathematics?

3. Do you consider other cultural objects such as artifacts, ideas, songs, dance, games etc. important in your mathematics learning? ……….Why?

4. Do Ghanaian cultural practices have a place in mathematics teaching and learning? …………… (Follow up question(s) may apply)

5. How do the following topics (measurement, lines and space, fractions, data handling, game of chance, operations on numbers, and word problem solving) allow for inclusion of out – school mathematical practices? ……… (Other topic(s) may be specified)

6. The activities we carry out daily in society generates "Mathematics" which may not be the same as the school mathematics. How does each of the following activities (Counting, Measuring, Locating, Playing, Designing, and Explaining) in your view generates mathematics? ………

7. (a). Does the current college mathematics curriculum incorporate cultural events of all the people in the community? Why?

   (b). Considering the multilingual state of Ghana, what kind of mathematics curriculum should be developed that caters for the needs of diverse students?

Thanks for your participation.

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APPENDIX 'D'

UNIVERSITY OF CAPE COAST

FACULTY OF SCIENCE AND TECHNOLOGY

INTERVIEW GUIDE FOR Ph.D. (MATHEMATICS EDUCATION) THESIS

Exploring Teacher Trainees and Their Tutors' Receptiveness to Cultural Relevance of Mathematics in the Colleges of Education in Ghana

(UCCIRB/CES/2022/55)

Interview Guide for Mathematics Tutors

This interview session is a follow-up to the perception questionnaire you responded to earlier and it is meant to find out reasons or explanations to your views in mathematics teaching and learning. Please, provide your genuine response to each of the items that will be asked. Be assured that the information you provide will be treated confidential and will be used only for academic purposes.

Hence, your permission to audio record views is sorted by your agreement to participate in this interview session. Thank you for your participation.

NOTE: These interview guide items are follow-up to the questionnaire items that you responded to earlier on perceptions about nature mathematics teaching and learning. The themes that will be emerged from the interview would be analysed qualitatively to support the earlier held views on cultural relevance of mathematics.

PART I

College…………………………….

Gender (Male or Female) ………………

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PART II: Interview Items

1. (a). What is mathematics? …………………Follow-up question(s) may apply)

   (b). Why do we teach or learn mathematics in school?

   (c). What role does mathematics education play in the educational development of Ghana?

2. What language would you prefer to use in teaching and learning of mathematics?

3. Do you consider other cultural objects such as artifacts, ideas, songs, dance, games etc. important in your mathematics learning? ……….Why?

4. Do Ghanaian cultural practices have a place in mathematics teaching and learning? …………… (Follow up question(s) may apply)

5. How do the following topics (measurement, lines and space, fractions, data handling, game of chance, operations on numbers, and word problem solving) allow for inclusion of out – school mathematical practices? ……… (Other topic(s) may be specified)

6. The activities we carry out daily in society generates "Mathematics" which may not be the same as the school mathematics. How does each of the following activities (Counting, Measuring, Locating, Playing, Designing, and Explaining) in your view generates mathematics? ………

7. (a). Does the current college mathematics curriculum incorporate cultural events of all the people in the community? Why?

   (b). Considering the multilingual state of Ghana, what kind of mathematics curriculum should be developed that caters for the needs of diverse students?

Thanks for your participation

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APPENDIX 'E'

Test of Normality for Teacher Trainees and their Tutors

Variable	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Teacher Trainees' Overall Views	.081	1160	.000	.940	1160	.000
Mathematics Tutors' Overall Views	.130	34	.158	.915	34	.012

a.Lilliefors Significance Correction

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
PMK	.016	1	1158	.899
PMP	.944	1	1158	.331
PGCMK	.506	1	1158	.477
PGCMP	2.919	1	1158	.088
PGCMC	5.433	1	1158	.020

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + hypo

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Box's M	21.131
F	1.331
df1	15
df2	12332.854
Sig.	.173

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a Design: Intercept + hypo

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
TTPMK	.007	1	1158	.935
TTPMP	1.960	1	1158	.162
TTPGCMK	.097	1	1158	.756
TTPGCMP	.327	1	1158	.567
TTPGCMC	5.048	1	1158	.025

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Design: Intercept + Sex

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
MTPMK	.387	1	32	.538
MTPMP	1.156	1	32	.290
MTPGCMK	1.083	1	32	.306
MTPGCMP	.582	1	32	.451
MTPGCMC	4.279	1	32	.047

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Design: Intercept + S

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Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
TTPMK	1.617	3	1156	.184
TTPMP	1.935	3	1156	.122
TTPGCMK	11.247	3	1156	.000
TTPGCMP	.728	3	1156	.535
TTPGCMC	2.824	3	1156	.038

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Grade Level

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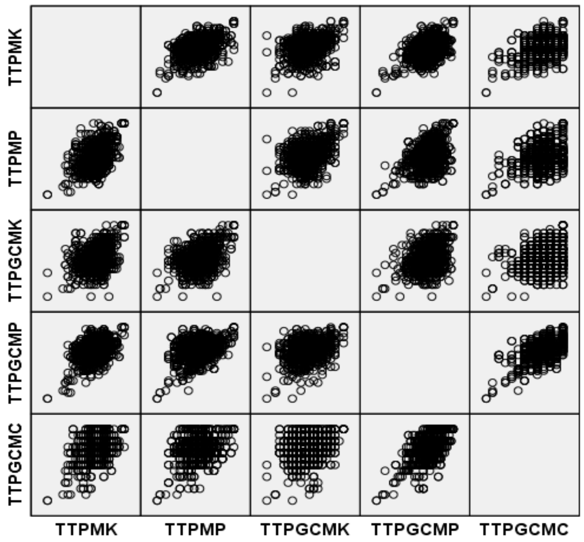
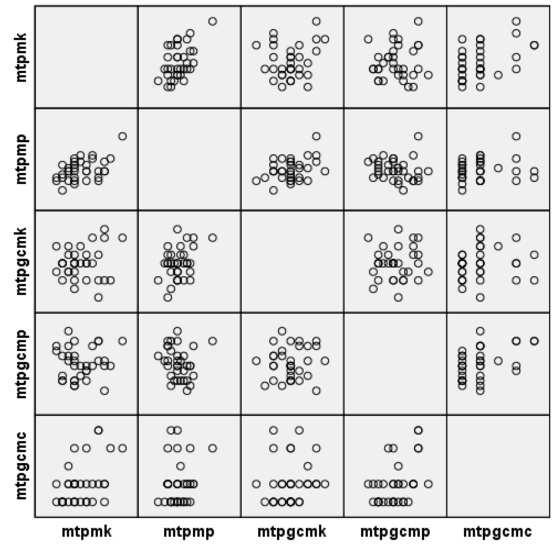
APPENDIX "F"

Teacher Trainees Matrix



Mathematics Tutors' Matrix



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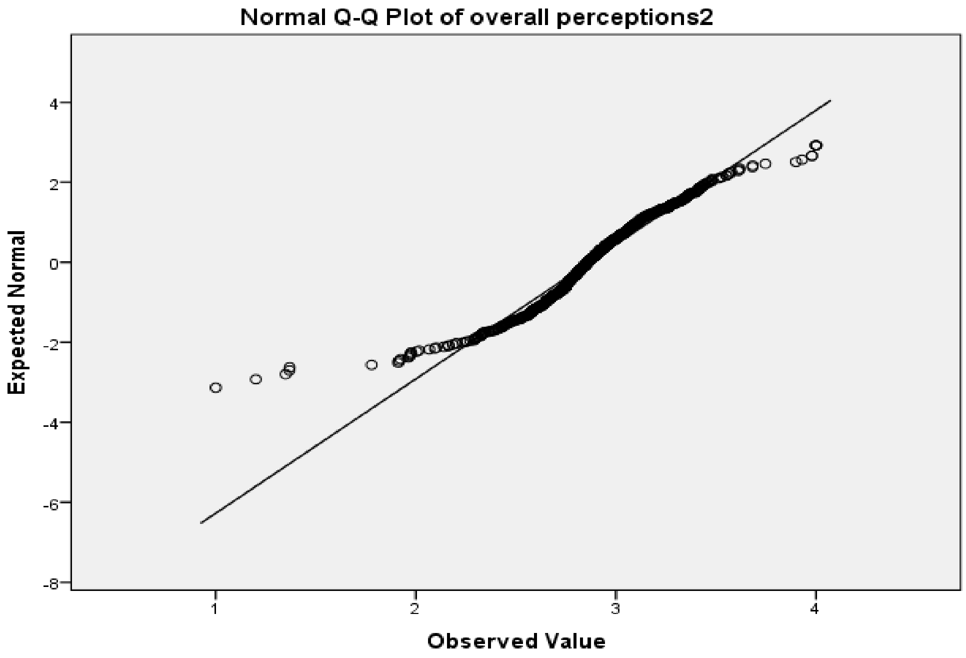
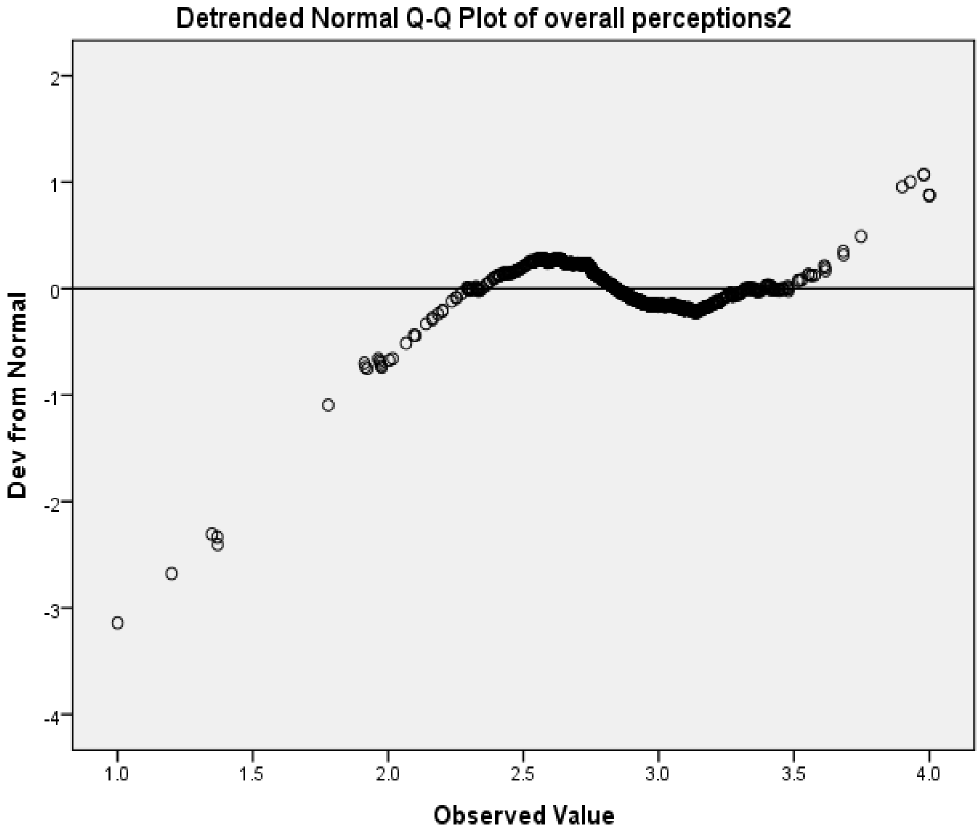
APPENDIX 'G'

Teacher trainees





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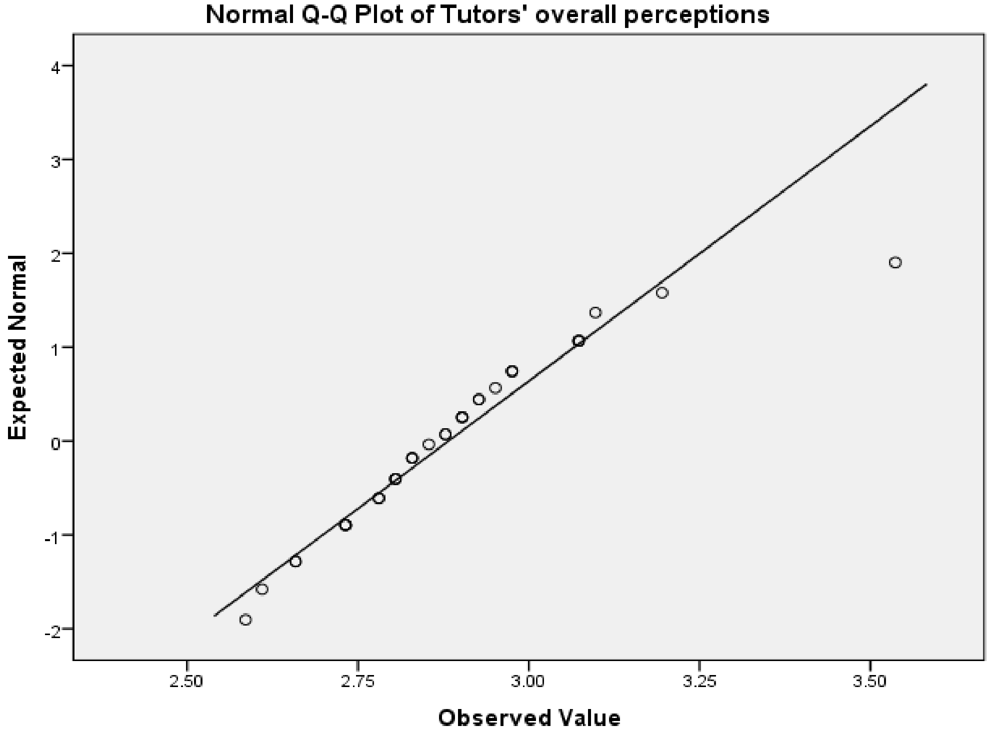
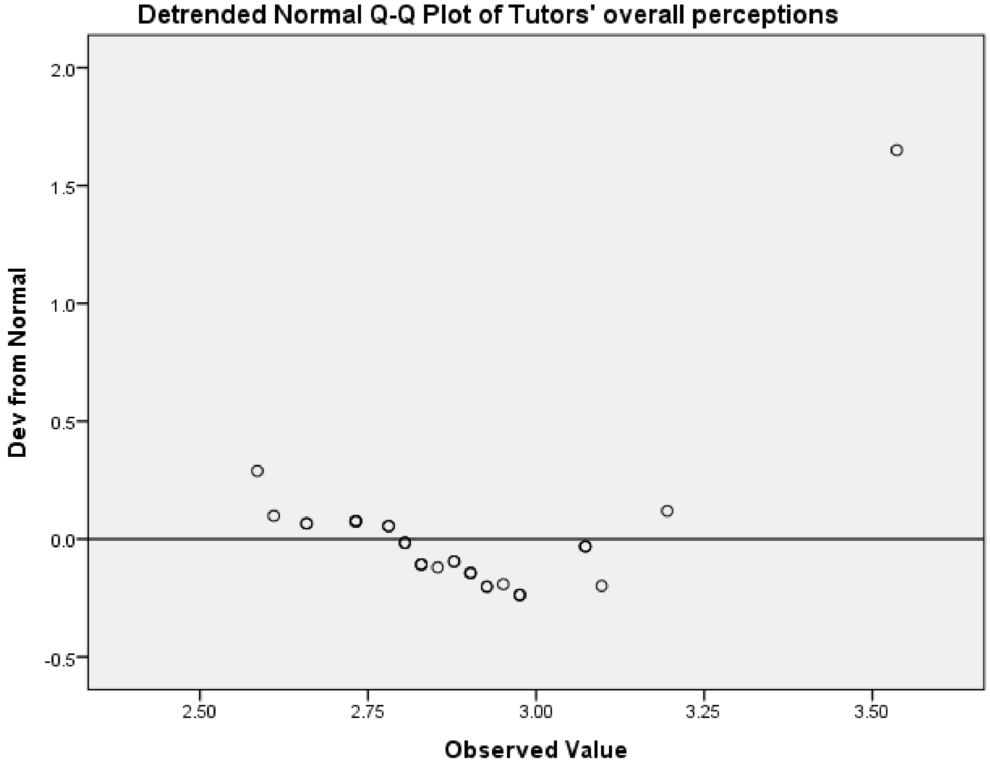
Mathematics tutors





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APPENDIX "H"

A sample Ghanaian drums (Fontomfrom)

A sample Ghanaian drums (donno)

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APPENDIX "I"

Sample Letter for Data Collection from Head of Department

UNIVERSITY OF CAPE COAST
COLLEGE OF EDUCATION STUDIES
FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF MATHEMATICS AND I.C.T EDUCATION

Telephone: 0332096951
Telex: 2552, UCC, GH
Telegrams & Cables: University, Cape Coast
Email: dmicte@ucc.edu.gh

University Post Office
Cape Coast, Ghana

Your Ref:

Our Ref: DMICTE/P.3/V.1/0100

Date: 10th October, 2022

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

RESEARCH VISIT

I write to introduce Joseph Kofi Asiedu, a PhD (Mathematics Education) student with registration number ET/DME/19/0006 of the Department of Mathematics and ICT Education, College of Education Studies, University of Cape Coast.

As part of the requirement for the award of a doctorate degree, he is required to undertake a research on the topic "**EXPLORING TEACHER TRAINEES' AND THEIR MATHEMATICS TUTORS' RECEPTIVENESS TO CULTURAL RELEVANCE OF MATHEMATICS IN THE COLLEGES OF EDUCATION IN GHANA**".

I would be grateful if you could give him the necessary assistance he may need.

Thanks for your usual support.

Yours faithfully,

Dr. Forster D. Ntow
HEAD

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APPENDIX 'J'

Ethical Clearance for the Study

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 0558093143 / 0508878309
E-MAIL: irb@ucc.edu.gh
OUR REF: UCC/IRB/A/2016/1515
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096

24TH AUGUST, 2022

Mr. Joseph Kofi Asiedu
Department of Mathematics and ICT Education
University of Cape Coast

Dear Mr. Asiedu,

ETHICAL CLEARANCE – ID (UCCIRB/CES/2022/55)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted Provisional Approval for the implementation of your research **Exploring Teacher Trainees' and their Mathematics Tutors' Receptiveness to Cultural Relevance of Mathematics in the Colleges of Education in Ghana.** This approval is valid from 24th August, 2022 to 23rd August, 2023. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.

Please note that any modification to the project must be submitted to the UCCIRB for review and approval before its implementation. You are required to submit periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

Samuel Asiedu Owusu, PhD

UCCIRB Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST

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APPENDIX “K”
VITA

Name: Joseph Kofi Asiedu

Address: Department of Mathematics and ICT Education
Faculty of Science and Technology Education
University of Cape Coast. Ghana

Educational Background (Institution, Qualification, and Date)

University of Cape Coast, PhD. (Mathematics Education)	Submitted
Kwame Nkrumah University of Science and Technology (Kumasi), Master of Science (Industrial Mathematics)	June, 2014
University of Cape Coast, Bachelor of Education (Mathematics Education)	June, 2010
Berekum Teacher Training College, 3–Year Post–Sec Certificate ‘A’	June,2003
Twene Amanfo Senior Secondary and Technical School, S.S.S.C.E. Certificate	Dec., 1994
Nsoatre Presby Junior Secondary School, B.E.C.E. Certificate	July, 1991

Employment Records

Teaching Positions	**Date**
Tutor at Al - Faruq College of Education	2018 – to date
Teacher at Notre Dame Girls Senior High School (Fiapre-Sunyani)	Sept., 2010 – April., 2018
Goaso S.D.A Primary School (Class teacher)	Sept., 2003 – July, 2006

Administrative Positions	**Date**
Academic Affairs Officer (Al – Faruq College of Education)	Jan., 2022 – date
Quality Assurance Officer (Al– Faruq College of Education)	Oct., 2018 - Dec., 2021
Head of Mathematics Department (Notre Dame Girls SHS)	Sept., 2015 – April, 2018
Form Master(Notre Dame Girls SHS)	Sept., 2010 – Aug., 2015

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Recent Publications

Asomah, R. K.[1], Crankson S.[2], Asiedu, K. J.[3] & Dapaah, A. B.[4] (2022). A Correlation Analysis of Ghanaian Junior High School Pupils' Perception and Attitude towards Mathematics. *African Journal of Educational Studies in Mathematics and Sciences* Vol. 18, No. 1. 2022

Asiedu, J.K. (2020). Factors That Affect Students' Performance in College Algebra in Some Selected Colleges of Education in Ghana. *International Journal of Scientific and Research Publications, Volume 10, Issue 10, October 2020 145issn 2250-3153*

Asomah, K. R., Dennis, H., Alhassan3, M. N., & Asiedu, J. K. (2019). Ghanaian Public and Private Junior High School Mathematics Classroom Learning Environment: *A Look at Students' Attitudes*. *African Journal of Educational Studies in Mathematics and Sciences Vol. 15, 2019*

Asiedu, J. K. (2019). Optimum Production Planning Problem (A Case Study of Aspect Water Company Limited in Techiman Municipality). *Journal of Information Engineering and Applications. ISSN 2224-5782 (Print) ISSN 2225-0506 (Online) DOI: 10.7176/JIEA Vol.9, No.4, 2019*

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Membership of Professional Body:

Colleges of Education Teachers Association of Ghana (CETAG);

Mathematics Association of Ghana (MAG);

Registered Member Researchgate.com;

Registered Member Academia.com.

Registered Member Google Scholar.com

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