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Examining Gender Differences in Pre-Service-Teachers' Values in the Learning and Teaching of Mathematics

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Abstract

The study aimed to examine the values pre-service-teachers possess in the learning and teaching of mathematics in Ghana. The study population comprised all students in the 46 public CoE in Ghana. Guided by a cross-sectional survey research design, a multistage sampling strategy was used to recruit 2,460 participants for the study. The validated "What I Find Important (WIFI) in my mathematics learning" instrument was employed for data collection. A principal component analysis of the pre-service teachers' (PSTs) ratings of items in the WIFI questionnaire yielded six value dimensions about the learning and teaching of mathematics, namely, conceptual understanding, procedural knowledge, strategy, connections, ICT integration, and learner control. The PSTs' mean rating ratings of the value dimensions were further analyzed for differences in gender using Multivariate Analysis of Variance (MANOVA). The results revealed no statistically significant difference between female and male on all the PSTs' value dimensions in the learning and teaching of mathematics, suggesting gender does not influence (PSTs) values in the learning and teaching of mathematics. This study recommends mathematics teacher educators in colleges of education should create learning environments and experiences that will ensure not only the development of PSTs knowledge of mathematics for teaching but also their values in its learning and teaching.

Keywords: pre-service teachers; values in teaching mathematics; values in learning mathematics; gender differences in values

Introduction

Mathematics instruction has been recognized as primarily cognitive enterprise that ancho problem-solving, logical reasoning and procedural fluency. Research have indicated that mathematics education is embedded with value laden in the past four decades (Bishop, 1988). Values influence how mathematics is taught and learnt as well as legitimate mathematical knowledge. Teachers' classroom interaction and instructions decisions are shaped by their values and conceptions (Thompson, 1992). This make the assessing of values in mathematics education very crucial especially in the college of education context where identities of future preservice teachers are formed. Values are seen as the vital ideas that are integrated within cultural practices that include mathematical activity. Bishop (1998) conceptualized values in mathematics education into three main interconnected mathematical activity: mathematical values (e.g., rationality, control, objectivity), mathematics educational values (e.g., practice, exploration, collaboration) and general educational values (e.g., respect, perseverance, integrity). During mathematics instructions, these values are transmitted indirectly via students-teacher interaction,

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assessment practices and classroom norms. This position mathematics instruction as independent of values. However, mathematics instruction provides a channel through which epistemic commitment and certain social are communicated (Steinbring, 2015).

Globally, educational policies debates and curriculum reforms have placed much emphasis on values of education (Davis et al., 2020). As a results, education is required not only to sharpen individuals' skills and knowledge but also to shape civic responsibility, disposition and ethical awareness. In the field of mathematics education, values such as collaboration, beauty of mathematics, perseverance, appreciation of utility of mathematics as well as critical thinking are increasingly given necessary attention. Learning effectiveness and students' wellbeing are likely to be compromised when values are excluded from curricular and pedagogical considerations. As a results, embedding values into mathematics instruction promotes both societal imperative and educational imperative.

In the context of Ghana, mathematics is compulsory subject at the pre-tertiary education level that serve as a gatekeeper for career and academic progression. The standards-based curriculum for mathematics at the pre-tertiary level developed by National Council for Curriculum and Assessment (NaCCA) clearly place much emphasis on the development of values and attitudes in connection with process and knowledge skills (MOE, 2019). The document lists such core values as integrity, respect, critical thinking, collaboration, perseverance and positive dispositions towards learning

Despite these policy intentions, evidence abounds in the literature that students have negative attitude towards mathematics and inconsistence performance in mathematics among students at different level of education have raised serious concern. These challenges have been attributed to scarcity in resources, instructional strategies and cognitive factors with less attention on the values orientations learners hold about mathematics. However, studies have indicated students' motivation, academic achievement and motivation can be greatly influenced by their values orientations. For example, learners' persistence and participation in mathematics activities or lessons may decline if they see mathematics as purely procedural, irrelevant, challenging and rigid (Awofala & Ojaleye, 2018; Schukajlow, 2017). However, students valuing creativity, applicability and collaboration are likely to ehnace their engagement and resilience during instruction.

Colleges of Education (CoE) serve as a pivotal role in Ghanaian educational system and have ultimate role in addressing students' values of education (Mpuangnan, 2020). This is because CoE are training institutions that are mandated to prepare PSTs for the basic educational level. In Ghana, the basic education level serves as the foundation of all education system in Ghana which comprises of early grade level, primary education as well as junior high school level. Classroom culture and mathematical identities established at the basic level of education shapes long-term achievement and attitudes trajectories of the learners. As a results, PSTs' values that are developed during their teacher education may likely affect their mathematics instruction as well as the what they are likely to transmit to their future learners whether explicitly or implicitly.

Although, the mathematics curriculum for CoEs highlights the needs to equip PSTs skills, values and knowledge that are appropriate for mathematics instruction, yet there is dearth of empirical research on the PSTs values in the learning of mathematics. In Ghana, previous studies have explored teachers' values, students' values or attitude at the pre-tertiary level (Kasimu & Imoro, 2017; Kyeremeh & Dorwu, 2023), however, there is a limited study on the pre-service teachers' values within the CoEs in Ghana. In addition, little is known on how PSTs' mathematics values vary based on their gender within the CoEs context. With the centrality of teacher preparation in implementing national curriculum reforms, this creates empirical gap in the literature.

It is imperative to understand the values orientations of pre-service-teachers for several reasons. Firstly, how values influence how teaching should be facilitated: should it be facilitated to ensure future teachers care more about

- procedural knowledge or conceptual understanding?
- individual task completion or collaboration?
- exam results or the practical relevance of mathematics?

Secondly, pre-service-teachers' values in the subject are important in the construction of a relevant mathematics teacher education and continuing professional development curriculum. Within this context the study explores pre-service-teachers' values in the learning and teaching of mathematics. The study also examines the differences in the pre-service-teachers' values by gender. In other words, the study addresses the following research questions:

1. What values do pre-service-teachers' hold about the learning and teaching of mathematics?
2. What differences exist between pre-service female and male teachers in their values in the learning and teaching of mathematics?

The study therefore contributes to international research in learners' values in mathematics education and begins to address the knowledge gap on the subject in the Ghanaian context. Because basic education is the very foundation of the country's system of schooling it is necessary to nurture future teachers to develop such values about mathematics learning and teaching as diversity and equity in mathematics, enabling learning environments, demonstrating understanding and mastery, resilience, collaboration and respect for others.

Theoretical Framework

This research is grounded in the theory of mathematical values developed by Bishop (1988), who conceptualizes mathematics as a human activity, rich in culture and value. Bishop claims values are guiding ideals embedded in societal practice and made manifest in symbol systems such as mathematics. Mathematics, as an ideology, attitude, and sociologically defined practice, is not free of value. In mathematics education, these values determine which mathematics is taught, what counts as mathematical competency, and how learners engage with mathematical ideas.

Bishop (1988) described six contrasting pairs of values which characterizes the development of mathematics. These are: rationalism-objectivism; control-progress and openness-mystery. While rationalism focuses on proof, reasons and explanation, objectivism focuses on symbolization, generalization and abstraction; control is concerned with mastery and conformity to the existing rules and procedures, whereas progress involves new discoveries and creativity, development of ideas. The values openness and mystery focus on shared learning and explanation while mystery acknowledges the aesthetic side and wonder of mathematics. The above three pairs of values interact, although their effects may be implied in teaching, curriculum and assessment practices (Bishop, 1996).

Apart from the mathematical values which focuses on mathematics as a discipline, Bishop (1996) identified further other values relating to the teaching and learning of mathematics which he referred to as mathematics education values. This category of values is pertinent in teacher preparation as it forms the beliefs and pedagogical stances about the learning process. Seah and Bishop (1999) stated that these values serve as mediating influence between discipline ideals and community expectations of what should be taught.

The culture aspect of Bishop's framework is crucial for this study. Teaching and learning of mathematics takes place in socio-cultural context that promotes a particular set of values over another (Seah, 2003). Variation in educational tradition, emphasis within curriculum and modes of assessment is thus likely to affect the value emphasis within mathematical education. For the teaching and learning of mathematics at the CoE in Ghana, which holds the compulsory status and is a high value subject within the system, it is particularly important to ascertain the values held by pre-service-teachers as they undergo professional socialization in college.

This study is therefore an attempt to employ Bishop's (1988) six values cluster model to ascertain the values which pre-service teachers hold in the teaching and learning of mathematics. The model gives us an analytic frame through which we can attempt to probe the attitude and ideologies that mediate the values they hold. It provides researchers with an international framework while it is being interpreted in the context of Ghanaian teacher education.

Methodology

Research Design

This study employed a cross-sectional survey design to examine the mathematical values held by pre-service-teachers in Ghana. A cross-sectional survey design enables researchers to collect data from a population at a single point in time in order to describe prevailing characteristics, attitudes, or beliefs (Creswell & Creswell, 2018). This method was chosen since the research question of the pre-service-teachers' value orientations in mathematics was to be investigated, without implementing an intervention and changing variables. This design could yield a substantial amount of data from an already spread-out and consequently broadly representative student group.

This study was underpinned by Bishop's (1988, 1996) model of the value system in mathematics, and specifically his six value sets (rationalism, objectivism, control, progress, openness and mystery) from which the structure of the instrument and subsequent analyses was constructed.

Selection of Participants

The population comprised all students enrolled in the 46 public Colleges of Education in Ghana. These institutions were selected because they prepare PSTs who will teach mathematics at the basic school level. Understanding students' mathematical values at this stage is critical, as their value orientations may influence their future instructional practices.

A multistage sampling procedure was employed. First, the 46 CoEs were stratified into five geographical zones (Eastern–Greater Accra, Ashanti–Brong Ahafo, Volta, Northern, and Central–Western). Finally, thirteen Colleges of Education were drawn from each zone through proportionate stratified sampling to ensure representation across all zones. A sample size for the students of each selected CoE was calculated using the sample size determination table from Krejcie and Morgan (1970). Each sample of students for each institution was then drawn using simple random sampling (table of random numbers), making a sample size of 2460 students. This technique ensured equal probability of selection for each student, hence reducing the chances of sampling bias, making the sample representative.

Data Collection Instrument

Data were collected using a structured questionnaire. The study adopted the validated What I Find Important (WIFI) in my mathematics learning instrument developed by Seah (2013) to measure students' mathematical values. The WIFI questionnaire has 4 parts, out of which only part A was selected for this study. It included 64 Likert type items to which responses were provided on a 5-point Likert scale where 1 represented Absolutely Important and 5 represented Absolutely Unimportant. The questions in part A of WIFI measure instructional and learning related aspects that could provide insights into students' priorities in the learning of mathematics. WIFI has been widely used in many cross-cultural investigations of mathematical values and was found to be quite robust in the measure of value orientation compatible with the one specified by Bishop. Since English is the medium of instruction in Ghanaian Colleges of Education, the English version of the instrument was used without translation.

Validity and Reliability of Instruments

To ensure content and face validity of the questionnaire it was examined by 3 experts in Mathematics Education, their remarks concern the clarification of the wording of the questions, the relevancy and alignment to the aims of the study. Revisions of the questionnaire were made according to experts recommendations. A pilot study was administered to a number of CoE 300 students from a college that was not part of the actual research sample to measure the reliability of the questionnaire. The pilot test yielded a Cronbach's Alpha coefficient of 89. 70 which is greater than the bench mark value (reliability greater than 0.7) and hence the internal consistency of the questionnaire is accepted for this study (Taber, 2018). These procedures ensured that the instrument was both valid and reliable for measuring pre-service-teachers' mathematical values.

Data Collection Procedure

Ethical approval was obtained from the relevant institutional review board before data collection commenced. Letters of introduction were written and sent to the principals of the selected Colleges of Education in order to request permission for carrying out the research.

The potential participants were informed of the aims and objectives of the research and were asked to participate after they had given informed consent. They were given the assurance that their involvement was optional and their replies would be confidential. The questionnaires were administered and collected at one session so as to improve the response rate. The researcher was in attendance during the administration of the questionnaires to clarify any doubt but without interfering so as not to influence the responses.

Data Analysis

Data was coded and analyzed using SPSS (Statistical Package for the Social Sciences). Preceding analysis, data was screened to identify missing data, outliers and any data entry errors.

Principal Component Analysis (PCA) with suitable rotation was performed in an attempt to identify an underlying factor structure of pre-service-teachers' values towards mathematics. PCA was appropriate as the study aimed to identify latent constructs relating to Bishop's categories of value.

To address the second research question, a Principal Component Analysis (PCA) was carried out on the (PSTs) ratings of items in the WIFI questionnaire. For the PCA, the significance threshold was set at 0.05, and for the interpretation of the solution, the cut-off criterion component loadings of at least 0.45 were employed (Slocum-Gori & Zumbo, 2011). Using the PCA, it was determined that the data met the fundamental assumptions of the factor analysis and that six components, each having an eigenvalue larger than one, explained 58.41% of the total variance, reflecting a total of six components. The students' set of values for mathematics learning was broken down into six identified components (Seah et al., 2017).

In addition, if the Kaiser-Meyer-Olkin (KMO) sample adequacy score is more than 0.6 and the Bartlett Sphericity Test (BTS) is significant, the correlation matrix factorability is presumed to be significant. Many large correlations should produce a factorable matrix. It was believed that factorability of the correlation matrix would be present because the Kaiser-Meyer-Olkin (KMO) sampling adequacy score was more than 0.85, and the Bartlett Sphericity Test (BTS) was statistically significant at the level of 0.001.

Appendix A shows a table indicating the results of the parallel analysis of the students' values of mathematics learning and teaching. The table yielded six (6) factors whose means values (1.33, 1.3, 1.28, 1.27, 1.25, 1.24) are less than the total Eigen values (23.58, 2.70, 2.33, 1.60, 1.48, 1.28). Apart from these six values, the mean values in the parallel analysis are greater than the total Eigen values in the rest. As a result, six factors were retained after the rotation matrix. The details of the six factors retained are in Appendix B.

Descriptive statistics (means and standard deviations) were calculated for each value category to indicate the relative importance of each value to students. To examine differences in students' mathematical values across gender, one-way Multivariate Analysis of Variance (MANOVA) was conducted. MANOVA was appropriate because it allows for the simultaneous comparison of group means across multiple dependent variables. The statistical assumptions such as the normal distribution, multivariate normality, linearity and

Table 1 Summary of Multivariate Analysis of Variance (MANOVA) for Gender Variable

Effect		**Value**	**F**	**Hypothesis df**	**Error df**	**Sig.**	**Partial Eta Squared** (η^2)
Gender	Pillai's Trace	.003	1.237[b]	6.000	2453.000	.284	.003

a. Design: Intercept + Gender; b. Exact statistic; c. Computed using alpha = 0.05

multicollinearity were investigated. The results indicated that there is a presence of linearity among the variables (see Table 1).

The results $[Pilai's\,Trace = 0.003,\ F(6{,}2453) = 1.237,\ p = 0.284,\ \eta^2 = 0.003]$ indicate that there is no significance difference at a significance value of the Pillai's Trace of 0.284, suggesting that there are no discrepancies with respect to gender. The results also indicated an absence of multicollinearity. However, the multivariate normality assumption was violated. There was no evidence of a violation of multicollinearity or homoscedasticity in the variance-covariance matrices with Box's test, and the variance-covariance matrices with Box's test suggested that there was no violation of either. As a result, MANOVA was performed on the data. Due to the violation of the normality assumption, Pillai's Trace was employed in the study.

Ethical Considerations

Ethical principles guided all stages of the study. Ethical clearance was obtained from the Institutional Review Board of the University of Cape Coast prior to data collection. Voluntary participation. Students were told that they could choose not to complete the questionnaire or they could discontinue at any stage without being forced to do so. Anonymity. Responses from questionnaires would remain anonymous and would only be given a code so that they could be analyzed more easily (their name would not be recorded). Data would be kept secure and used solely for research purposes. The ethical guidelines for research in education would be adhered to, ensuring no harm would come to students and that their privacy would not be invaded.

This research question aimed to identify what pre-service-teachers value in mathematics instructions. To collect data on this, pre-service-teachers were given 64-item questionnaire to rate, on a five-point Likert-scale, about their values in mathematics. The students' ratings of the questionnaire items were subjected to an exploratory factor analysis (EFA) using principal component analysis with varimax rotation to determine the items that contribute to certain constructs in value in mathematics. Factor analysis is a statistical method used to assess if items designed to measure a certain construct are indeed assessing that construct accurately. This methodology aids in the development of a reliable and precise instrument. Principal component analysis aims to identify the linear components present in a dataset and determine the extent to which variables contribute to those components or constructs (Abdi & Williams, 2010). Table 14 shows the descriptive of the students' values of Mathematics.

Results

Research Question 1: What values do pre-service-teachers' hold about the learning and teaching of mathematics?

To address the research question, a Principal Component Analysis (PCA) was carried out on the (PSTs) ratings of items in the WIFI questionnaire resulted in six value dimensions about the learning and teaching of mathematics. The six value dimensions about the learning and teaching of mathematics generated by the PCA (see Appendix A) included: Conceptual understanding (e.g., me asking questions, examples to help me understand), Procedure (e.g., using the calculator to calculate, problem solving), strategies (e.g., teacher asking us questions, writing the solution step by step), Connections (e.g., appreciating the beauty of mathematics, connecting mathematics to real life), ICT (e.g., Learning mathematics with the computer, mathematics games) and Control (e.g., completing the mathematics work, "understanding why my solution is incorrect or correct"). The details of the six factors retained and their Cronbach Alpha reliability coefficients are presented in Table 2.

Table 2 shows the reliability test for the various mathematical values as well as the overall mathematical values. The overall reliability of 0.89 is very high indicating the consistency of the items. Research has proposed that in order for an item to be deemed reliable, it is recommended that the value of Cronbach's alpha should be equal to or greater than 0.7 (Taber, 2018). Given that every component of mathematical values exhibits a Cronbach's alpha of at least 0.7, it can be inferred that all the components of mathematical values are reliable. The highest is Conceptual Understanding which had 17 items followed by procedure and strategies with each having 7 items. The component with the least number of items was ICT. Also, the highest reliability coefficient was recorded by conceptual understanding (0.935) whiles the least was recorded by ICT (0.787).

Table 2 Value dimensions about the learning and teaching of mathematics generated by the PCA and their Reliability

Value Dimensions	**Number of items**	**Reliability Coefficients**
Conceptual Understanding (Me asking Questions)	17	0.94
Procedure (Using the calculator to calculate)	7	0.86
Strategies (Teacher asking us questions)	7	0.86
Connections (Appreciating the beauty of mathematics)	6	0.81
ICT (Learning mathematics with the computer)	3	0.79
Control (Completing the mathematics work)	5	0.84
Overall	**45**	**0.89**

Source: Field Data, 2022

Research Question 2 What differences exist between pre-service female and male teachers in their values in the learning and teaching of mathematics?

The research question sought to find out if there is a difference in valuing in mathematics between male and female pre-service-teachers. To answer the question the descriptive statistics of the PSTs' ratings of six value dimensions about the learning and

Table 3 Descriptive Statistics of the PSTs six value dimensions

Value dimension	Mean	Std. Deviation	Coefficient of Variation (%)
Conceptual understanding	4.136	.668	16.151
Procedure	4.241	.640	15.091
Strategies	4.147	.692	16.687
Connection	3.936	.731	18.572
ICT	3.954	.862	21.801
Control	3.913	.838	21.416

teaching of mathematics were obtained for each of the value dimensions (see Table 3).

Table 3 shows that the recorded mean ratings for all the value dimensions were high, that is, above 3.5. This indicates that the students agreed to most of the items on the various value dimensions.

To ascertain whether or not the differences observed are statistically significant, the descriptive statistics results were further analyzed using MANOVA to examine if any differences exist between male and female pre-service teachers' values. That is, to test the null hypothesis that "there is no statistically significant difference between male and female PSTs in their values in the learning and teaching of mathematics". Multivariate Analysis of Variance (MANOVA) was ran with the independent variable gender having two levels: female and male. The dependent variables consisted of the six value dimensions: conceptual understanding, procedure, strategy, connection, ICT and control. The results are shown in Table 3 and its between-subjects effects presented in Table 4.

The results in Table 4 showed no significant univariate main effects for all the six components with respect to gender. This resulted in zero effects size for the six value dimensions. In Table 4, the multivariate partial eta square based on Pillai's Trace was multivariate 2 = 0.099, indicating very low effect magnitude. According to Richardson (2011), the multivariate partial eta square is interpreted using the univariate eta square, which has values ranging from 0 to 1. A value of zero indicates no relationship between the independent variable and the total dependent variable score, while a value of one indicates the strongest possible relationship between the independent variable and the total dependent variable score.

Discussion of the Results

Regarding research question one, the result shows that the values of learning mathematics on six interrelated dimensions of conceptual understanding, procedure, strategy, connection, ICT and control are important for pre-service-teachers. It indicates that pre-service-teachers attach values on both the cognition aspect and the pedagogical aspect of learning mathematics. Therefore, these six values cannot be interpreted as mere preference; they reflect a driving force of learning and achievement in

Table 4 Tests of Between-Subjects Effects of MANOVA for Value Dimensions by Gender

	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Gender	Conceptual understanding	.135	1	.135	.301	.583	.000
	Procedure	.008	1	.008	.019	.889	.000
	Strategy	.054	1	.054	.112	.738	.000
	Connections	.175	1	.175	.328	.567	.000
	ICT	2.607	1	2.607	3.511	.061	.001
	Control	.416	1	.416	.592	.442	.000

a. R Squared = .000 (Adjusted R Squared = .000) b. R Squared = .000 (Adjusted R Squared = .000)
c. R Squared = .000 (Adjusted R Squared = .000) d. R Squared = .000 (Adjusted R Squared = .000)
e. R Squared = .001 (Adjusted R Squared = .001) f. R Squared = .000 (Adjusted R Squared = .00

Source: Field Data, 2022

mathematics learning. The dominance of conceptual understanding appears consistent with current trends toward a reform-based approach in math education where knowledge of structures, rather than skill and drills, becomes of primary importance. Students' valuing of conceptual understanding highlights an epistemology which views mathematics as a connected structure of concepts instead of a disjoint set of algorithms (Lagrange & Laval, 2023)). It is also in line with Kanwal et al. (2022) who consider the ability to construct conceptual knowledge, as one critical factor for higher-order cognition and problem-solving skills. For student teachers in colleges of education, it highlights an epistemology that prioritizes understanding and relation, which are necessary for being effective teachers in mathematics.

Pre-service-teachers' procedure reiterates the enduring importance of procedural fluency and mathematical competence. Procedures are defined as an organized and sequenced approach to mathematics (Lee, Joswick, & Pole, 2023) and help students complete mathematical tasks both accurately and efficiently. This finding, in that it reveals both conceptual understanding and procedural fluence to co-exist, implies that pre-service-teachers may actually hold a holistic and dualistic view of mathematics learning. The potential dualistic perspective on learning held by pre-service-teachers further appears to be consistent with Greeno (2017) perspective that mathematical problems can be effectively deconstructed into series of sequential steps and therefore facilitate enhanced understanding and performance. As such, the pre-service-teachers may perceive mathematics to be both structurally logical and computationally sound (Inganah, Darmayanti, & Rizki, 2023). That is, pre-service-teachers may seem to conceptualize of mathematics as an area of knowledge and operation, not merely one that occurs automatically in a mechanistic way, which thus necessitates awareness and reason.

This reflected student perceptions of mathematics as useful and connected to other ideas. As suggested by Sujatha and Vinayakan (2023), making connections between mathematical concepts and real-life situations helps students see the practical value of the subject and promotes transfer. Valuing connections reflects that pre-service-teachers believe mathematics is a socially located and applied discipline rather than a purely abstract one. This finding is consistent with reform conversations worldwide about placing context and applications at the forefront of meaningful mathematics learning.

The second cherished value of learning mathematics for college of education students is ICT. Today, technology is used as a tool to visualize, simulate, and investigate things. The cherishing of ICT implies that college of education students are comfortable in learning environment enriched with ICT and in tandem with 21 st -century pedagogy principles.

Valuing ICT shows that pre-service-teachers are receptive to technologically enriched learning environments and aligned with the expectations of 21st century pedagogy. Given the ongoing digitization of education in Ghana, this finding has implications for teacher education.

Finally, control, interpreted as learner autonomy and learning ownership, implies that there are affective/motivational issues involved in mathematics learning (Lugosi & Uribe, 2022). The inclusion of control among the valued aspects demonstrates that pre-service-teachers perceive mathematics learning as an active and purposeful endeavor, not simply knowledge construction.

Among the previous studies, these findings align or disagree with the findings of other studies. For example, Zhang et al. (2016) found that students in Hong Kong, Chinese Mainland, and Taiwan exhibited six values, with only ICT that overlap with the finding of the current study. such divergence may be as a result of cultural and contextual factors (Seah, 2003; Atweh & Seah, 2008). However, there was partial convergence in the results of Seah et al. (2017) who found that secondary and primary school students valued connections, ICT and strategies and these three dimensions are consistence with the finding of the current study. Similarly, Davis, Carr, and Ampadu (2019) found that Ghanaian students' values in strategies, ICT and connection. Pang and Seah (2021) identified connections and understanding among Korean students that partialy aligns with the relational and conceptual understanding found in this study. This proves that while culture may mediate certain mathematical values, others like relational understanding and ICT integration exhibits cross-contextual stability.

Considering Bishop's (1988) theory of mathematical understanding, the six elements identified can be grouped meaningfully. The notions of concept and connections relate to rationalism-objectivism, concerned with logical consistency and relational structure. Procedure, strategy and control relate to control-progress, emphasizing order and skill. ICT, alongside elements of engagement and openness can relate to mystery-openness, the area that embraces discovery and questioning. Thus, evidence has been found to support Bishop's 3 aspects of understanding, as applied in the Colleges of Education, Ghana.

Concerning the hypothesis on gender differences, no statistically significant difference was found between male and female pre-service-teachers across all six value components. Effect sizes were all very small and insignificant to indicate any gender differences in mathematical valuing. This finding implies that, perhaps, the context of Colleges of Education fosters equitable epistemic orientations to mathematics, and it may thus counter stereotypical traditional gender role beliefs toward mathematical subjects, as was observed by Chia and Zhang (2024) and Dede (2014).

However, these results are contrary to other research, which reported gender-based differences in mathematical valuing (Kaiser et al., 2012; Pang & Seah, 2021). These differences could be due to differences in socio-cultural norms regarding gender roles and the schooling of boys and girls. Else-Quest et al. (2010) assert that gender equality in mathematics should be seen within the larger social and institutional context. So, the non-significance of gender effect may also imply progress toward gender equity in Colleges of Education in Ghana.

Finally, the results on gender differences show that pre-service-teachers' mathematics valuing is multi-dimensional, theoretically coherent, and appears not to be gendered. The study, through the discussion, therefore adds to the expanding body of international research on valuing mathematics, by contextualizing Colleges of Education in Ghana within the global, conceptual, and comparative framework.

Conclusion and recommendations

Alan J. Bishop's work on mathematical values serves as a theoretical foundation for this study and applied it to assess the values held by PSTs in the Colleges of Education (CoE) in Ghana and explore gender differences. This study found that values toward mathematics held by the PSTs are indeed multifaceted and theoretically grounded. The six interrelated dimensions of conceptual understanding, procedure, strategy, connections, ICT, and control can be seen as central to these PSTs' perspectives of learning and teaching mathematics.

The importance of the conceptual understanding and connection dimensions indicates that the PSTs consider mathematics as structured and connected rather than isolated rules, while the continuing relevance of the procedure and strategy dimensions attests to the role of order and systematic thought in mathematical competence, respectively. The valuing of ICT demonstrates alignment to the modern demands of teaching with the assistance of technologies, as well as responding to current reform movements in mathematics education. The final inclusion of control demonstrates that, within the learning and teaching processes in the CoE, students find it of value to also approach mathematical learning with agency.

As a result, the findings suggest a holistic epistemological orientation whereby cognition and pedagogy interact with agency and meaning-making of mathematical learning. In addition, the study was also successful in showing there is no statistically significant difference between male and female students in any of the six mathematical values dimensions. Therefore, it is possible to assert that within the CoE context mathematical values are non-gendered; this finding may indicate a way to overcome stereotypical assumptions that there are gendered mathematical attitudes.

In conclusion, the study findings provide a new contextual support for the tripartite theory of mathematical values, rationalism-objectivism, control-progress, and openness-mystery as framed by Alan J. Bishop. Empirically the research has filled a critical void in the Ghanaian literature that have generally focus on values toward mathematics held by pre-tertiary students rather than the PSTs. Practically, these findings provide relevant information that can be used to influence curriculum and professional development in Colleges of Education; information that can inform the type of mathematical values to nurture among teacher trainees that integrate conceptual depth with fluency in procedures, ICT competence with learning agency.

By framing the research of Ghanaian pre-service teachers values within the broader literature on the mathematics education, the study contributes comparative knowledge while grounding the research on the local context of teacher preparation. Information about the value foundations being shaped within the education process for PSTs are critical to ensuring national curriculum reforms can be effective through actual classroom enactment.

Although the study has several significant findings, the following limitations should be recognized: First, being cross-sectional survey research the values orientations were measured at only one time point. Values are dynamic and change with the course of teacher education and in professional practice, suggesting a need for longitudinal studies that may explore the developmental trajectory of PSTs' mathematical values.

Second, though the sample size was large and representativeness was assured across regions, the study was based entirely on self-report through questionnaires. Self-reported data are likely subject to social desirability effects, and they may not reflect the value orientations that influence in-class practice. Future research should aim to use a qualitative approach-such as interviews, classroom observations or journals-to build a robust understanding and enhance validity of interpretations.

Third, the six dimensions were developed through Principal Component Analysis which, by definition, is an exploratory statistical method. Confirmation of factor structure with Confirmatory Factor Analysis (CFA) is expected to provide robust statistical support for the dimensions proposed, and future studies may need to test this factor structure within the specific context of teacher education in Ghana.

Fourth, only public Colleges of Education were used. This omission does not allow for a comparison with private institutions, though public CoEs are the basis for teacher education in Ghana. These kinds of studies may allow one to learn about how teacher education institutions may influence mathematical values held by teacher trainees.

Fifth, in addition to the absence of significant gender differences in mathematical values orientation, this study did not explore other personal factors that may influence values toward mathematics held by teacher trainees such as socioeconomic status, academic field of specialization, previous knowledge in mathematics, geographical location etc. These variables could be relevant and may shape values orientations differently.

Finally, despite the global acceptance of the WIFI, the questionnaire was not contextually modified to cater for any culturally specific aspects that may influence values towards mathematics held by teacher trainees in Ghana, suggesting need for further refinement of existing or construction of new instruments.

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Informed Consent Statement

Informed consent was obtained from all subjects involved in this study.

Data Availability Statement

The data presented in this study are available on request from the author since this research was conducted on students, for which their teachers gave consent.

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Appendix A *Parallel Analysis of Students Parallel Output*

	Initial Eigenvalues				
Component	Total	% of Variance	Cumulative %	Mean	Prcntyle
1	**23.58**	36.84	36.84	**1.33**	1.36
2	**2.70**	4.22	41.06	**1.3**	1.32
3	**2.33**	3.64	44.71	**1.28**	1.3
4	**1.60**	2.50	47.21	**1.27**	1.28
5	**1.48**	2.31	49.51	**1.25**	1.27
6	**1.28**	2.00	51.51	**1.24**	1.25
7	1.14	1.77	53.29	1.23	1.24
8	1.02	1.60	54.89	1.21	1.22
9	.96	1.50	56.38	1.2	1.21
10	.92	1.44	57.82	1.19	1.2
11	.88	1.37	59.19	1.18	1.2
12	.86	1.34	60.53	1.17	1.18
13	.82	1.28	61.81	1.16	1.17
14	.79	1.24	63.04	1.15	1.16
15	.77	1.20	64.24	1.14	1.15
16	.76	1.19	65.44	1.13	1.14
17	.72	1.13	66.57	1.12	1.13
18	.71	1.10	67.67	1.11	1.12
19	.69	1.08	68.75	1.1	1.1
20	.68	1.06	69.81	1.09	1.1
21	.67	1.05	70.86	1.08	1.09
22	.67	1.04	71.90	1.08	1.08
23	.63	.98	72.89	1.07	1.07
24	.61	.96	73.85	1.07	1.07
25	.59	.93	74.78	1.06	1.06
26	.58	.90	75.68	1.05	1.05
27	.56	.87	76.55	1.04	1.04
28	.55	.87	77.41	1.03	1.03
29	.54	.84	78.26	1.03	1.03
30	.54	.84	79.09	1.02	1.02
31	.53	.83	79.92	1.01	1.01
32	.52	.81	80.73	1	1
33	.50	.78	81.51	0.99	0.99
34	.49	.77	82.28	0.99	0.99
35	.48	.76	83.04	0.98	0.98
36	.48	.75	83.79	0.97	0.97
37	.47	.74	84.52	0.96	0.96
38	.45	.71	85.23	0.96	0.96

	Initial Eigenvalues				
Component	Total	% of Variance	Cumulative %	Mean	Prcntyle
39	.45	.71	85.94	0.95	0.95
40	.44	.68	86.62	0.94	0.94
41	.43	.68	87.29	0.93	0.93
42	.43	.67	87.96	0.93	0.93
43	.43	.67	88.63	0.92	0.92
44	.42	.65	89.28	0.91	0.91
45	.42	.65	89.93	0.9	0.9
46	.41	.64	90.58	0.89	0.9
47	.40	.62	91.19	0.88	0.89
48	.39	.62	91.81	0.87	0.88
49	.38	.61	92.41	0.87	0.87
50	.38	.59	93.00	0.86	0.87
51	.37	.57	93.58	0.85	0.86
52	.36	.57	94.15	0.84	0.85
53	.35	.55	94.70	0.83	0.84
54	.34	.54	95.23	0.82	0.83
55	.34	.53	95.76	0.82	0.83
56	.33	.52	96.28	0.81	0.81
57	.33	.51	96.79	0.8	0.81
58	.32	.50	97.29	0.79	0.8
59	.31	.49	97.78	0.78	0.79
60	.31	.48	98.26	0.77	0.78
61	.29	.46	98.72	0.76	0.77
62	.29	.46	99.17	0.75	0.76
63	.27	.42	99.59	0.73	0.75
64	.26	.41	100.00	0.72	0.73

Source: Field Data, 2022

Appendix B Pre-service Teachers' Components Factors (Rotated Component Matrix)

	Dimensions					
	1	**2**	**3**	**4**	**5**	**6**
Conceptual Understanding						
Me asking questions	0.67					
Feedback from my teacher	0.66					
Examples to help me understand	0.66					
Using concrete materials to understand mathematics	0.63					
Knowing which formula to use	0.63					
Getting the right answers	0.63					
Feedback from my friends	0.62					
Mathematics homework	0.62					
Mathematics tests/examination	0.619					
Using diagrams to understand mathematics	0.617					
Teacher helping me individually	0.583					
Understanding concepts/process	0.579					
Working out the mathematics myself	0.561					
Hands-on activities	0.56					
"Looking out for mathematics in real life"	0.552					
Learning through mistakes	0.551					
"Knowing the theoretical aspects of mathematics (e.g., Proofs,	0.524					
Explain where rules/formulae come from	0.501					
Procedure						
Using the calculator to calculate		0.714				
Explaining by the teacher		0.704				
Small group discussion		0.704				
Problem solving		0.668				
Working Step by Step		0.641				
Investigations		0.581				
Whole class discussion		0.544				

	Dimensions					
	1	**2**	**3**	**4**	**5**	**6**
Strategies						
Teacher asking us questions			0.584			
Writing the solution step by step			0.568			
Knowing the times table			0.547			
Doing a lot of mathematics work			0.53			
Using mathematical words			0.507			
Alternative solutions			0.502			
Given a formula to use			0.502			
Connections						
Appreciating the beauty of mathematics				0.614		
Stories about mathematics				0.6		
Relating mathematics to other subjects in school				0.585		
Connecting mathematics to real life				0.532		
Mathematics Debates				0.509		
Learning the proofs				0.506		
ICT						
Learning mathematics with the computer					0.677	
Learning mathematics with the internet					0.655	
Mathematics games					0.644	
Control						
Completing the mathematics work						0.738
Remembering the work we have done						0.711
Understanding why my solution is incorrect or correct						0.699
Mystery of mathematics (eg. 111 111 111 × 111 111 111 = 12345678987654321)						0.655
Stories about mathematicians						0.581