

FROM KNOWLEDGE TO INSTRUCTION: EXAMINING THE ROLES OF USEFULNESS AND TEACHING SELF-EFFICACY ON POSTGRADUATE STUDENTS' WILLINGNESS TO TEACH ETHNOMATHEMATICS

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ABSTRACT

Teacher education programmes invest in ethnomathematics knowledge, but its value depends on whether it is translated into instructional practice. This study examined whether ethnomathematics usefulness (EU) and teaching self-efficacy (ETSE) mediated relationships of ethnomathematics content knowledge (ECK) and pedagogical knowledge (EPK) with willingness to teach ethnomathematics (WTE) among Ghanaian postgraduate students. Guided by a pragmatic paradigm, data were collected from 159 participants through an online questionnaire and telephone interviews with eight purposively selected participants. Quantitative data were analysed using covariance-based structural equation modelling in AMOS 31 and qualitative data through reflexive thematic analysis. ECK and EPK were positively associated with EU and ETSE. WTE was positively predicted by EPK, EU, and ETSE, while ECK showed a small negative direct association but a positive total effect. EU and ETSE showed significant indirect effects in both the ECK–WTE and EPK–WTE relationships. Interviewees expressed strong willingness to use cultural artefacts in teaching while identifying curricular and assessment constraints. The findings suggest that ethnomathematics knowledge is more likely to translate into teaching willingness when accompanied by perceived usefulness and confidence, while institutional conditions may influence the feasibility of culturally inclusive mathematics teaching.

KEYWORDS

Efficiency in education, ethnomathematics, Ghanaian postgraduate education, pedagogical content knowledge, teaching self-efficacy, willingness to teach

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Highlights

- *Ethnomathematics content and pedagogical knowledge are positively associated with usefulness and self-efficacy beliefs.*
- *Perceived usefulness and self-efficacy positively predict willingness to teach ethnomathematics.*
- *Both beliefs show significant indirect effects linking knowledge and willingness.*
- *Effective preparation should build perceived value and confidence, not knowledge alone.*

INTRODUCTION

Globally, mathematics educators are expected not only to help students master abstract concepts but also to show how mathematics emerges from and functions within the social and cultural environments in which they live. This expectation has stimulated growing interest in culturally responsive approaches

to mathematics teaching that recognise learners' cultural identities, experiences, and indigenous knowledge as valuable resources for learning. Rather than presenting mathematics as a culturally neutral body of universal truths, researchers such as D'Ambrosio (1985), Rosa and Orey (2016), Owusu-Darko et al. (2023), and Kyeremeh et al. (2025) advocate

instructional practices that demonstrate how mathematical ideas are embedded in everyday activities, historical traditions, and community practices. Such approaches are intended to make mathematics more meaningful, promote equitable participation, and strengthen learners' appreciation of the discipline across diverse educational contexts. Among them, ethnomathematics—a field pioneered by D'Ambrosio (1985) that examines relationships between mathematical thinking and cultural practices—has received considerable research attention.

Ethnomathematics challenges the long-standing assumption that mathematics is exclusively a product of Western intellectual traditions by recognising that societies develop mathematical ideas in response to problems arising from their environments, occupations, technologies, and social organisation (Babbitt et al., 2015; Rosa et al., 2016; D'Ambrosio and Rosa, 2017; Owusu-Darko et al., 2023). Activities such as counting, architecture, textile design, navigation, trading, craftsmanship, agriculture, and artistic expression can embody sophisticated mathematical reasoning that has evolved over generations (Gerdes, 2005; Kyeremeh et al., 2023; Payadnya et al., 2024). Ethnomathematics therefore broadens conceptions of legitimate mathematical knowledge and encourages a more inclusive perspective on mathematics education.

The educational value of ethnomathematics extends beyond recognising cultural diversity. Research suggests that connecting mathematics instruction to learners' cultural experiences can support conceptual understanding, classroom participation, motivation, and positive attitudes towards mathematics (Babbitt et al., 2015; Sunzuma et al., 2021; Khalil, 2023). Students may engage more meaningfully with mathematical ideas when they encounter familiar cultural contexts in instruction, allowing them to connect informal knowledge acquired in their communities with formal mathematical concepts. Ethnomathematics has therefore increasingly been advocated as a component of culturally responsive and socially just mathematics education, particularly in contexts characterised by rich indigenous knowledge systems (Palhares, 2012; Rosa and Orey, 2016; D'Ambrosio and Knijnik, 2020; Wulandari et al., 2024).

Despite these recognised benefits, successful integration of ethnomathematics into formal education depends substantially on teachers' preparation. Unlike conventional mathematics instruction, ethnomathematics requires educators to identify mathematical ideas embedded in local cultural practices, evaluate their mathematical authenticity, and design learning experiences that connect indigenous knowledge meaningfully with formal school mathematics. Teachers therefore need sufficient disciplinary knowledge to recognise authentic mathematical ideas in cultural practices and the pedagogical expertise to transform those ideas into effective learning experiences. Without adequate preparation, attempts to integrate ethnomathematics may remain superficial cultural illustrations rather than mathematically meaningful learning opportunities.

The importance of teacher preparation is underscored by evidence that many educators lack confidence in implementing culturally responsive instruction. Mania and Alam (2021), for example, reported that more than 60% of mathematics teachers in their

Indonesian study perceived their training in ethnomathematics approaches as insufficient. Similarly, Kyeremeh et al. (2025) documented inadequate preparation as a barrier to integrating cultural knowledge into mathematics instruction in Ghana. These findings highlight the need to understand factors that may enable or constrain educators' willingness to adopt ethnomathematics in professional practice.

Shulman's (1986) theory of teacher knowledge provides a useful framework for explaining this requirement. According to the theory, effective teaching depends upon multiple forms of professional knowledge, particularly content knowledge and pedagogical knowledge. Content knowledge refers to teachers' understanding of the concepts, principles, and structures within a discipline, whereas pedagogical knowledge concerns the ability to organise instruction, select appropriate teaching strategies, and facilitate meaningful learning. Within the context of ethnomathematics, content knowledge enables educators to recognise mathematical ideas embedded in cultural practices, while pedagogical knowledge equips them to transform these ideas into effective classroom learning experiences. Both content and pedagogical knowledge in ethnomathematics provide the professional foundation necessary for implementing culturally responsive mathematics instruction.

However, possessing professional knowledge does not necessarily guarantee instructional implementation. Educators may understand an educational innovation yet remain reluctant to adopt it because they question either its educational value or their own capability to implement it successfully (Davis, 2003; Ponticell, 2003; Buabeng-Andoh, 2012). Understanding instructional intentions therefore also requires attention to psychological factors that may shape how professional knowledge is translated into practice. One such factor is ethnomathematics usefulness (EU), defined here as educators' beliefs about the extent to which integrating ethnomathematics can improve teaching, enhance students' mathematical understanding, strengthen cultural identity, and support meaningful learning. Educational innovations perceived as beneficial are generally more likely to be accepted and implemented than those considered ineffective or irrelevant (Papagiannis et al., 1982; Serdyukov, 2017). Educators who perceive ethnomathematics as educationally valuable may therefore express stronger willingness to incorporate culturally grounded mathematical activities into instruction. Moreover, those with stronger content and pedagogical knowledge may be better positioned to recognise these potential benefits because they understand both the mathematical richness of cultural practices and the pedagogical opportunities they provide.

In addition to perceiving ethnomathematics as useful, educators must believe that they are capable of implementing it effectively. Bandura's (1977) Social Cognitive Theory identifies self-efficacy as individuals' beliefs in their capability to organise and execute the actions required to achieve desired outcomes. In educational contexts, teacher self-efficacy has been associated with instructional innovation, persistence, instructional quality, and classroom effectiveness (Kwarteng et al., 2025; Lotey et al., 2026a). Educators with stronger self-efficacy are generally more willing to experiment with unfamiliar approaches, persist through instructional difficulties,

and sustain innovative practices. Ethnomathematics presents distinctive demands: educators must identify authentic mathematical ideas in cultural contexts, adapt curriculum materials, facilitate culturally sensitive discussions, and connect indigenous knowledge with formal mathematical reasoning (Mania and Alam, 2021; Kyeremeh et al., 2025). Ethnomathematics teaching self-efficacy (ETSE) may therefore represent an important psychological mechanism linking professional knowledge with willingness to teach ethnomathematics. Educators with stronger ECK and EPK may also report greater confidence in implementing culturally responsive mathematics instruction.

Postgraduate programmes devote limited contact hours, specialist expertise, and public resources to developing ethnomathematics knowledge. The instructional value of this investment, however, ultimately depends on whether participants are willing and able to use that knowledge in practice. Identifying the beliefs associated with the translation of professional knowledge into instructional willingness can therefore inform how teacher-preparation resources are prioritised. A mathematics education that systematically excludes the counting systems, measurement practices, textile geometries, and craft techniques of learners' communities may also fail to represent the cultural knowledge learners bring to school (Rosa et al., 2016; Sari and Yüce, 2020). Teachers occupy an important position in determining whether such knowledge is recognised in instruction. Examining knowledge, beliefs, and willingness together therefore speaks to both the effective use of teacher-preparation resources and the responsible representation of learners' cultural knowledge within school mathematics.

Although previous research has documented the educational benefits of ethnomathematics and examined teachers' knowledge, attitudes, or classroom practices separately (Babbitt et al., 2015; Ergene et al., 2020; Sunzuma and Maharaj, 2021; Khalil, 2023), limited empirical evidence has examined how ethnomathematics content knowledge and pedagogical knowledge are related to willingness to teach through EU and ETSE within a single model. Existing studies have largely focused on classroom interventions or student outcomes, leaving the psychological processes associated with educators' willingness to adopt ethnomathematics less well understood. Addressing this gap, the present study examines relationships among ECK, EPK, EU, ETSE, and WTE among Ghanaian postgraduate students in mathematics education. By integrating Shulman's Theory of Teacher Knowledge with Bandura's (1977) Social Cognitive Theory, the study seeks to clarify educators' readiness to implement ethnomathematics and to inform teacher education, curriculum development, and culturally responsive mathematics education in Ghana and comparable contexts.

THEORETICAL FRAMEWORK

The successful implementation of ethnomathematics in formal mathematics education requires considerably more than the inclusion of cultural examples in classroom instruction. Although ethnomathematics has been recognised as a culturally responsive approach capable of connecting school mathematics

with learners' lived experiences, many educators continue to encounter challenges in its implementation. Wulandari et al. (2024) observed that inadequate preparation among teachers often results in suboptimal ethnomathematics instruction, thereby limiting students' opportunities to experience culturally meaningful mathematics learning. Similarly, Sari and Yüce (2020) argued that curriculum constraints, limited instructional resources, and insufficient teacher preparation remain significant barriers to the effective integration of ethnomathematics into mathematics classrooms. While these institutional factors undoubtedly influence implementation, teachers' professional knowledge, confidence, and perceptions regarding ethnomathematics may be equally important determinants of whether they are willing to adopt culturally responsive instructional practices. Therefore, understanding the relationship among these factors may provide a stronger theoretical basis for explaining educators' willingness to teach ethnomathematics.

The present study is primarily anchored in Shulman's (1986) Theory of Teacher Knowledge, which proposes that effective teaching depends upon multiple categories of professional knowledge, particularly content knowledge and pedagogical knowledge. According to Shulman (1986), content knowledge refers to teachers' comprehensive understanding of the concepts, structures, and principles within a discipline, whereas pedagogical knowledge concerns the ability to organise, represent, and communicate subject matter in ways that facilitate students' understanding. These complementary knowledge domains enable teachers not only to master disciplinary content but also to transform that knowledge into meaningful learning experiences. Within mathematics education, Shulman's framework has become one of the most influential theoretical perspectives for explaining differences in instructional quality and teachers' classroom effectiveness. Applied to ethnomathematics, content knowledge refers to educators' understanding of mathematical concepts embedded within cultural practices, indigenous technologies, artistic expressions, architecture, traditional games, measurement systems, and other community-based activities. Teachers possessing strong ethnomathematics content knowledge are able to recognise that mathematical reasoning exists within diverse cultural contexts and appreciate how indigenous knowledge contributes to mathematical thinking. Ethnomathematics pedagogical knowledge, on the other hand, concerns teachers' ability to design culturally responsive lessons, select appropriate instructional strategies, develop authentic assessment activities, and facilitate classroom discussions that meaningfully connect cultural practices with formal mathematical concepts. These competencies enable educators to move beyond merely presenting cultural artefacts and instead engage learners in constructing mathematical understanding through culturally familiar experiences.

The importance of these professional knowledge domains is particularly evident within African educational contexts, where numerous cultural practices provide authentic opportunities for mathematics instruction. Rosa et al. (2016) demonstrated that African cultures contain abundant mathematical ideas embedded in textile weaving, traditional symbols, sculpture,

architecture, engineering, symmetry, patterns, and spatial reasoning. Such cultural resources provide meaningful contexts through which abstract mathematical concepts can be taught while simultaneously promoting learners' appreciation of their cultural heritage. However, the educational potential of these resources depends largely on teachers' ability to recognise their mathematical significance and translate them into classroom instruction. In this way, educators with stronger ethnomathematics content knowledge and pedagogical knowledge are expected to demonstrate greater readiness to implement ethnomathematics within formal education.

Nevertheless, knowledge alone may not be sufficient to explain teachers' instructional decisions. Many educators possess adequate professional knowledge but remain reluctant to implement innovative instructional approaches because they lack confidence in their own teaching capabilities (Ponticell, 2003; Ertmer and Ottenbreit-Leftwich, 2010; Buabeng-Andoh, 2012). To explain this psychological dimension, the present study also draws upon Bandura's (1977, 1997) Social Cognitive Theory, particularly the construct of self-efficacy. Bandura (1977) defined self-efficacy as individuals' beliefs about their capability to organise and execute the actions necessary to accomplish specific tasks successfully. Within educational settings, teacher self-efficacy influences instructional decision-making, persistence when encountering classroom challenges, openness to innovation, and commitment to improving student learning (Kwarteng et al., 2025; Lotey et al., 2026a). Teachers who believe they possess the capability to implement new instructional approaches are generally more willing to adopt them than teachers who doubt their own instructional competence.

Ethnomathematics presents unique instructional demands that make teaching self-efficacy particularly important. Effective implementation requires educators to identify authentic cultural examples, establish meaningful links between indigenous knowledge and formal mathematical concepts, facilitate culturally sensitive classroom interactions, and respond appropriately to students' diverse cultural experiences. These responsibilities require confidence in one's instructional abilities in addition to professional knowledge. Accordingly, this study conceptualises Ethnomathematics Teaching Self-Efficacy as educators' confidence in their ability to effectively teach mathematics through culturally relevant contexts and practices. Teachers who possess stronger ethnomathematics content knowledge and pedagogical knowledge are more likely to develop this confidence because they are better prepared to address the instructional complexities associated with culturally responsive mathematics teaching. Hence, teaching self-efficacy is expected to function as an important motivational factor that may link professional knowledge with willingness to teach ethnomathematics.

Beyond confidence in instructional capability, teachers'

willingness to implement ethnomathematics may also depend upon their perceptions of its educational value. In the context of this study, ethnomathematics usefulness refers to teachers' beliefs that integrating cultural knowledge into mathematics instruction enhances students' conceptual understanding, motivation, engagement, cultural identity, and overall learning outcomes. Teachers who perceive ethnomathematics as educationally valuable are more likely to invest time and effort in incorporating culturally responsive instructional practices into their teaching. Empirical evidence supports the educational benefits associated with ethnomathematics. Babbitt et al. (2015), for example, reported that Ghanaian students who learned geometry through Adinkra symbols demonstrated significantly higher learning outcomes than those receiving conventional instruction. Similarly, Gerdes (2005) illustrated how indigenous construction techniques and artistic practices in Mozambique provide rich mathematical contexts for classroom instruction, while Palhares (2012) highlighted the mathematical significance of professional activities such as boat construction and craftsmanship.

More recently, Payadnya et al. (2024) found that teachers viewed ethnomathematics as an effective means of stimulating learners' curiosity, increasing classroom engagement, and fostering appreciation for cultural diversity within mathematics education. Eglash et al. (2011) developed culturally situated software based on African fractal patterns, allowing students to investigate recursive mathematical structures through traditional hairstyles and jewellery designs. Lachney (2017) further demonstrated how African hair-braiding techniques inspired the development of the Cornrow Curves software, illustrating the potential of culturally grounded computational tools to enhance mathematics and computer science education. These studies reinforce the argument that ethnomathematics is not merely a cultural enrichment strategy but an educational innovation capable of supporting interdisciplinary learning and technological development. Teachers who understand the educational benefits of ethnomathematics are likely to perceive it as a valuable instructional approach, thereby strengthening their willingness to implement it.

Hypotheses

Our hypothesised model is presented in Figure 1. We hypothesise that (H1) ECK positively predicts EU; (H2) ECK positively predicts WTE; (H3) ECK positively predicts ETSE; (H4) EPK positively predicts EU; (H5) EPK positively predicts WTE; (H6) EPK positively predicts ETSE; (H7) EU positively predicts WTE; (H8) ETSE positively predicts WTE; (H9) EU mediates the relationship between ECK and WTE; (H10) EU mediates the relationship between EPK and WTE; (H11) ETSE mediates the relationship between ECK and WTE; and (H12) ETSE mediates the relationship between EPK and WTE.

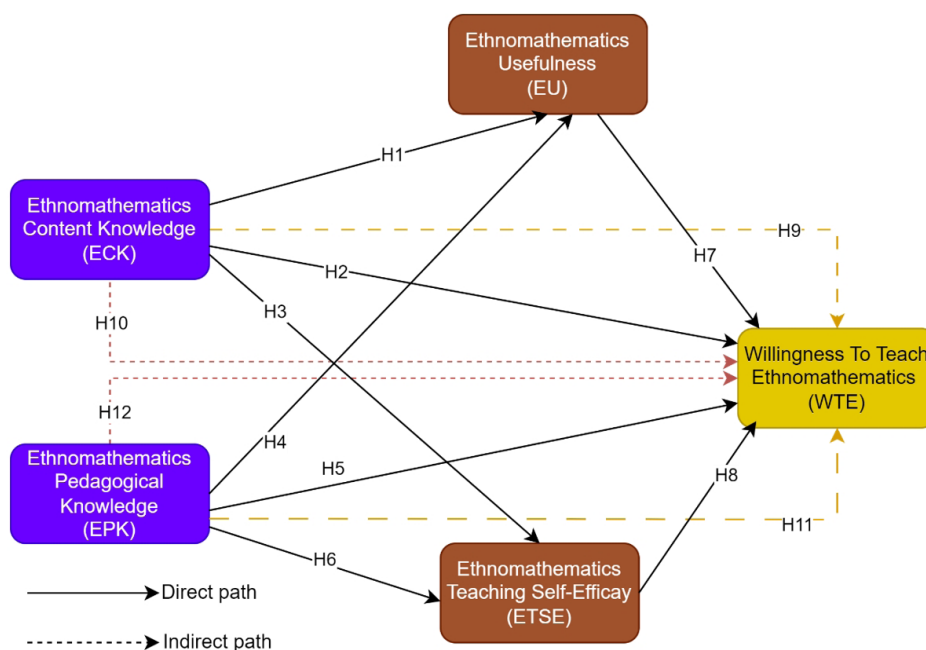


Figure 1: Conceptual model of the relationships among ethnomathematics content knowledge (ECK), ethnomathematics pedagogical knowledge (EPK), ethnomathematics usefulness (EU), ethnomathematics teaching self-efficacy (ETSE), and willingness to teach ethnomathematics (WTE) (Source: Authors' conceptualisation).

MATERIALS AND METHODS

Participants

The study involved 159 postgraduate students from mathematics education programmes at four public universities in Ghana: 141 males (88.7%) and 18 females (11.3%). Of these participants, 57 (35.8%) were enrolled in master's programmes and 102 (64.2%) in doctoral programmes. Eleven participants (6.9%) were younger than 35 years, 139 (87.4%) were aged 35–44 years, and 9 (5.7%) were older than 44 years. The study used quantitative and qualitative methods to obtain a more comprehensive understanding of factors associated with postgraduate students' willingness to teach ethnomathematics. The quantitative phase used a structured questionnaire, whereas the qualitative phase used semi-structured interviews to explore participants' experiences and provide context for the quantitative findings.

Quantitative data were collected through Google Forms using closed-ended items. Ethical review of the study was formally waived by the Institutional Ethical Review Committee of the University of Skills Training and Entrepreneurial Development (USTED), as the study constituted a PhD programme requirement by first author in a coursework titled, 'Socio-Cultural and Ethnological Foundations in Mathematics (MTE 921)' in the form of a term paper. The waiver took effect on 9 June 2025. The term paper forms part of the programme's scholarly requirements, including publication of the resulting research. Informed consent was obtained from all participants before data collection, and the data reported in this article are presented in aggregate form to protect participants' confidentiality. Participants' demographic characteristics are presented in Table 1.

Demographics		Frequency	Percentage (%)
Gender	Male	141	88.7
	Female	18	11.3
Educational level	Master's degree	57	35.8
	Doctor's degree	102	64.2
Age group (years)	< 35 years	11	6.9
	35 – 44 years	139	87.4
	> 44 years	9	5.7

Table 1: Respondents' demographic characteristics

Instruments

Items measuring Ethnomathematics Content Knowledge (ECK) and Ethnomathematics Pedagogical Knowledge (EPK) were adapted from Schmidt et al. (2009) and contextualised for ethnomathematics. ECK was operationalised as participants' self-perceived knowledge and understanding of ethnomathematical concepts, practices, and approaches

to understanding ethnomathematics. Thus, ECK concerns perceived knowledge of ethnomathematical content. Four items assessed ECK, including 'I have sufficient knowledge of ethnomathematics' and 'I know different approaches for developing my understanding of ethnomathematics.' EPK was operationalised as participants' self-perceived knowledge of approaches for integrating ethnomathematics into mathematics

teaching. In other words, EPK concerns perceived knowledge of how ethnomathematics can be taught. Four items assessed EPK, including ‘I can adapt my teaching strategies to incorporate culturally relevant mathematical practices’ and ‘I can employ a variety of instructional approaches to effectively teach ethnomathematics.’ Thus, ECK and EPK represent perceived knowledge rather than objectively demonstrated knowledge or mastery. The Ethnomathematics Usefulness (EU) scale was adapted from Khalil (2023) and comprised four items. Sample items included ‘Ethnomathematics enhances students’ understanding of the relevance of mathematics in everyday life’ and ‘Integrating ethnomathematics helps learners appreciate and value their cultural heritage.’ Ethnomathematics Teaching Self-Efficacy (ETSE) was measured using four items adapted from the teacher self-efficacy instruments developed by Tschannen-Moran and Woolfolk Hoy (2001) and contextualised for ethnomathematics instruction. ETSE was conceptualised as participants’ confidence in their capability to successfully perform specific ethnomathematics teaching tasks. In simple terms, ETSE concerns confidence in one’s capability to perform teaching tasks in ethnomathematics. Examples included ‘I am confident in my ability to teach mathematics using culturally relevant examples,’ ‘I can successfully design lessons that integrate ethnomathematics,’ and ‘I can effectively facilitate classroom discussions that connect cultural practices with mathematical concepts.’ Willingness to Teach Ethnomathematics (WTE) was measured using four items adapted from Davis (1989) and contextualised to the teaching of ethnomathematics. The adaptation involved replacing the original technology-use target behaviour with the integration of ethnomathematics into mathematics teaching, while retaining the underlying behavioural-intention content of the original items. Thus, the items were reworded to assess respondents’ willingness, intention, and readiness to incorporate ethnomathematical knowledge and practices into their mathematics teaching. The adapted items were designed to preserve the conceptual meaning of behavioural intention while aligning the measure with the specific instructional context of ethnomathematics. Sample items included ‘I intend to integrate ethnomathematics into my future mathematics teaching,’ ‘I am willing to regularly incorporate culturally relevant mathematical activities into my lessons,’ and ‘I will encourage students to explore mathematical ideas embedded in their cultural practices.’ the items were therefore intended to capture participants’ willingness or intention to incorporate ethnomathematics into their future teaching rather than their demonstrated classroom behaviour. All questionnaire items were rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

To establish content validity, the questionnaire was reviewed by a panel of ethnomathematics specialists. Their feedback addressed item clarity, relevance, appropriateness, and representativeness, and the instrument was revised accordingly before administration. The qualitative phase used a semi-structured interview guide developed from the quantitative findings and the study’s conceptual framework. Questions explored participants’ experiences of learning ethnomathematics, perceptions of its usefulness, confidence in

teaching it, factors influencing their willingness to implement it, and suggestions for improving ethnomathematics instruction in teacher-education programmes. The interviews were intended to provide contextual explanations for relationships identified in the structural equation model and to support integration of the quantitative and qualitative findings.

Data Collection Procedure

Data collection followed an explanatory sequential mixed-methods design. In the first phase, the quantitative questionnaire was administered electronically through Google Forms. With the assistance of postgraduate class representatives, the survey link was distributed through WhatsApp and Telegram to students in mathematics education programmes at the selected Ghanaian universities. Snowball sampling was used, with initial participants invited to share the survey link with other eligible postgraduate students within their institutions. Participation was voluntary, and electronic informed consent was obtained before questionnaire completion. Quantitative data collection lasted two weeks. After the quantitative analysis, eight participants were purposively selected for the qualitative phase to provide variation in reported levels of knowledge, usefulness, self-efficacy, and willingness to teach ethnomathematics. Semi-structured interviews were conducted by telephone and, with participants’ permission, audio-recorded and transcribed verbatim. Participants were informed of the study purpose, the voluntary nature of participation, their right to withdraw without penalty, and the confidentiality of the information provided. Personal identifiers were removed during analysis, and data were stored securely. The quantitative dataset contained no missing values because responses to all Google Forms items were required.

Data Analysis

Completed questionnaires were downloaded from Google Forms into Microsoft Excel for preliminary screening and data cleaning and were subsequently imported into IBM SPSS Statistics version 32 for descriptive analysis. The dataset was examined for outliers, normality, and multicollinearity before the structural analysis. Covariance-based structural equation modelling (CB-SEM) with latent variables was then conducted using IBM SPSS AMOS version 31 with maximum likelihood estimation. The measurement model was first evaluated using confirmatory factor analysis (CFA). Internal consistency reliability was assessed using Cronbach’s alpha, McDonald’s omega, and composite reliability (CR). Convergent validity was evaluated using average variance extracted (AVE) and standardised factor loadings, while discriminant validity was assessed using the Fornell–Larcker criterion. Overall model fit was evaluated using the chi-square statistic, chi-square/degrees of freedom ratio (χ^2/df), comparative fit index (CFI), Tucker–Lewis index (TLI), and root mean square error of approximation (RMSEA). Because the data exhibited evidence of multivariate non-normality (see Table 5), bootstrap procedures were employed to strengthen statistical inference. A Bollen–Stine bootstrap procedure based on 5,000 bootstrap samples was used specifically to assess the overall model fit under non-normality. The Bollen–Stine procedure was distinguished

from the bootstrap procedure used for parameter inference. Bias-corrected (BC) 95% bootstrap confidence intervals and corresponding bootstrap *p*-values were used to evaluate the statistical significance of the direct and indirect structural effects. An effect was considered statistically significant when its BC 95% confidence interval did not include zero. Thus, although conventional maximum-likelihood estimates were obtained, bootstrap confidence intervals and bootstrap-based *p*-values were used as the primary basis for testing the hypothesised structural relationships.

Qualitative data were analysed after the quantitative phase to explain and elaborate on the statistical findings in accordance with the sequential explanatory mixed-methods design. Audio-recorded interviews were transcribed verbatim and analysed using reflexive thematic analysis following the six phases proposed by Braun and Clarke (2006): familiarisation with the data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. The analysis was primarily inductive, with the study questions and quantitative findings informing the subsequent integration and interpretation of the qualitative evidence rather than serving as predetermined themes. Coding was iterative and involved repeated engagement with the transcripts, initial codes, candidate themes, and the broader dataset. Themes were developed from recurring patterns of meaning across participants' accounts rather than being constructed to correspond directly to individual SEM paths or hypotheses. Reflexivity was maintained throughout the analytic process by critically examining the researcher's assumptions, theoretical commitments, and expectations arising from the quantitative findings. The researchers documented analytic decisions and reflected on how prior expectations might influence the interpretation of participants' accounts. Integration occurred at the interpretation stage

by comparing the qualitative themes with the quantitative findings. The qualitative evidence was used to explain, elaborate on, and contextualise statistically significant or theoretically important relationships identified through SEM. Accordingly, the qualitative themes were not intended to reproduce the quantitative model but to provide contextual insight into the processes and conditions that participants associated with the development of ethnomathematics knowledge, perceived usefulness, teaching self-efficacy, and willingness to teach ethnomathematics. Table 8 therefore presents qualitative themes and explanatory categories alongside the quantitative findings to which they are relevant. The quotations are illustrative excerpts that demonstrate participants' perspectives and are not treated as evidence of statistical effects. Evidence for the statistical relationships and mediation effects is derived from the SEM analysis, whereas the interview findings provide contextual and explanatory insight into how participants understood and experienced these relationships.

RESULTS

Validity and Reliability of the Measurement Model

The measurement model was evaluated using standardised factor loadings, Cronbach's alpha, McDonald's omega, composite reliability (CR), and average variance extracted (AVE), as reported in Tables 2 and 3. EU4 was removed because its factor loading was below the threshold of 0.500. The remaining standardised loadings ranged from 0.600 to 0.900. Reliability coefficients for all constructs exceeded 0.700, supporting internal consistency, and AVE values exceeded 0.500, supporting convergent validity (Hair et al., 2017; Lotey et al., 2026b).

<i>N</i>	Variable	Cronbach's Alpha	McDonald's Omega	Composite Reliability
4	ECK	0.904	0.905	0.905
4	EPK	0.820	0.819	0.819
4	ETSE	0.895	0.895	0.902
3	EU	0.818	0.819	0.817
4	WTE	0.864	0.865	0.866

Table 2: Internal consistency reliability statistics

ECK had a Cronbach's alpha of 0.904, McDonald's omega of 0.905, CR of 0.905, and AVE of 0.704. Corresponding values were 0.820, 0.819, 0.819, and 0.536 for EPK; 0.895, 0.895, 0.902, and 0.698 for ETSE; 0.818, 0.819, 0.817, and 0.600 for EU; and 0.864, 0.865, 0.866, and 0.619 for WTE. Overall, these results indicate acceptable internal consistency and convergent validity for the retained measurement model.

Discriminant Validity and Inter-Construct Correlations

Discriminant validity was assessed using the Fornell–Larcker criterion, as recommended by Fornell and Larcker (1981) and Ab Hamid et al. (2017). Under this criterion, the square root of

the AVE for each construct should exceed its correlations with the other constructs. As presented in Table 3, the square roots of the AVEs (bold diagonal values) ranged from 0.732 to 0.839 and exceeded the corresponding inter-construct correlations, supporting discriminant validity.

All study constructs were positively correlated ($p < 0.05$). ECK correlated positively with EPK ($r = 0.297$), ETSE ($r = 0.518$), EU ($r = 0.582$), and WTE ($r = 0.392$). ETSE was also positively correlated with EU ($r = 0.646$) and WTE ($r = 0.640$), while EU correlated positively with WTE ($r = 0.641$). These bivariate associations provide preliminary support for the proposed relationships while remaining below the corresponding Fornell–Larcker thresholds.

Variable	ECK	EPK	ETSE	EU	WTE
ECK	0.839				
EPK	0.297*	0.732			
ETSE	0.518*	0.321*	0.835		
EU	0.582*	0.323*	0.646*	0.775	
WTE	0.392*	0.355*	0.640*	0.641*	0.787

*Correlation is significant at 0.05; boldface=square root of AVE

Table 3: Correlations and Discriminant Validity

Descriptive Statistics

Table 4 presents descriptive statistics for the five study constructs. Mean scores ranged from 3.58 to 4.42, indicating

generally favourable self-reported perceptions, while standard deviations ranged from 0.784 to 0.883, indicating moderate variability in responses.

N	Variable	Mean	Standard Deviation	Tolerance	VIF
4	ECK	4.086	0.784	0.687	1.456
4	EPK	4.420	0.883	0.903	1.107
4	ETSE	4.059	0.829	0.632	1.583
3	EU	3.774	0.785	0.619	1.616
4	WTE	3.576	0.846	–	–

Table 4: Mean, Standard Deviation, and Collinearity Statistics

Potential multicollinearity among the predictor variables was assessed using tolerance and variance inflation factor (VIF) statistics. Tolerance values ranged from 0.619 to 0.903 and VIF values from 1.107 to 1.616, well within the recommended thresholds of tolerance > 0.20 and VIF < 5.00 (Kwarteng et al., 2025). These results indicate that problematic multicollinearity was not evident among the predictors.

Structural Model Results

The measurement model showed acceptable overall fit to the data. The chi-square-to-degrees-of-freedom ratio was 1.799 ($\chi^2 = 251.856$, $df = 140$). The incremental fit indices were strong, with $CFI = 0.985$ and $TLI = 0.982$, while $GFI = 0.963$ indicated satisfactory absolute fit. The residual indices were also low ($RMR = 0.026$; $SRMR = 0.028$). Based on $\chi^2 = 251.856$, $df = 140$, and $N = 159$, $RMSEA$ was 0.071 (90% CI [0.057, 0.085]), with $PCLOSE = 0.009$. Thus, the $RMSEA$ indicated moderate rather than close approximate fit, whereas the remaining indices supported an acceptable measurement model. The standardised factor loadings ranged from 0.610 to 0.893, exceeding the commonly recommended minimum of 0.50. The AVE values were 0.704 for ECK, 0.536 for EPK, 0.698 for ETSE, 0.600 for EU, and 0.619 for WTE, demonstrating adequate convergent validity across all constructs. Univariate normality was examined using skewness and kurtosis. Following Kline (2023), the observed skewness values (–1.553 to –0.413) and kurtosis values (–0.280 to 2.943) were within commonly accepted limits. However, the multivariate kurtosis critical ratio ($CR = 85.379$) indicated substantial departure from multivariate normality. The analysis therefore used 5,000 bootstrap resamples for more robust inference, including bias-corrected confidence intervals for indirect effects; the Bollen–Stine procedure was also used in AMOS in relation to overall model fit. The confirmatory factor analysis is presented in Figure 2.

The final structural model showed mixed fit to the data: $\chi^2 = 397.654$, $df = 143$, $p < 0.001$, $CMIN/DF = 2.781$. $GFI = 0.944$, $AGFI = 0.926$, $CFI = 0.966$, $TLI = 0.960$, and $SRMR = 0.060$ suggested acceptable fit on several indices. However, based on $\chi^2 = 397.654$, $df = 143$, and $N = 159$, $RMSEA$ was 0.106 (90% CI [0.094, 0.119]), with $PCLOSE < 0.001$; the Bollen–Stine bootstrap p-value was also 0.001. These latter indices indicate notable approximate model misfit, and the structural coefficients should therefore be interpreted with appropriate caution. The exogenous latent variables ECK and EPK were allowed to covary freely in the structural model to avoid specification error. The standardized covariance was 0.29 ($p < .001$), consistent with their bivariate correlation ($r = 0.297$). Additionally, correlated residuals between EPK3–EPK4 and ETSE1–ETSE4 were retained in the structural model based on modification indices and overlapping item wording. These specifications are visually represented in Figure 3.

The coefficients of determination (R^2) indicated that ECK and EPK jointly explained 36.0% of the variance in EU ($R^2 = 0.360$) and 30.0% of the variance in ETSE ($R^2 = 0.300$). ECK, EPK, EU, and ETSE collectively explained 46.0% of the variance in WTE ($R^2 = 0.460$), indicating moderate explanatory power for the proposed structural model.

As shown in Table 6, ECK was positively associated with EU ($\beta = 0.551$, BC 95% CI [0.477, 0.619], $p < 0.001$) and ETSE ($\beta = 0.487$, BC 95% CI [0.415, 0.554], $p < 0.001$). ECK also showed a statistically significant negative direct effect on WTE ($\beta = -0.108$, BC 95% CI [–0.207, –0.013], $p = 0.025$). Also, EPK was positively associated with EU ($\beta = 0.168$, BC 95% CI [0.081, 0.254], $p < 0.001$) and ETSE ($\beta = 0.188$, BC 95% CI [0.109, 0.268], $p < 0.001$). EPK also had a statistically significant positive direct effect on WTE ($\beta = 0.119$, BC 95% CI [0.037, 0.193], $p = 0.005$).

MFI: <i>CMIN</i> = 251.856; <i>DF</i> = 140; <i>CMIN/DF</i> = 1.799; <i>TLI</i> = 0.982; <i>CFI</i> = 0.985; <i>GFI</i> = 0.963; <i>RMR</i> = 0.026; <i>RMSEA</i> = 0.071; <i>SRMR</i> = .028; <i>PClose</i> = 0.009	Std. Estimate	Univariate Normality	
		Skewness	Kurtosis
ECK: <i>AVE</i> = 0.704			
ECK1	0.774	-1.409	2.943
ECK2	0.893	-1.300	2.182
ECK3	0.815	-1.211	1.931
ECK4	0.870	-1.443	2.901
EPK: <i>AVE</i> = 0.536			
EPK1	0.856	-0.432	0.774
EPK2	0.754	-0.607	0.692
EPK3	0.684	-0.413	0.344
EPK4	0.610	-0.772	0.399
ETSE: <i>AVE</i> = 0.698			
ETSE1	0.833	-1.295	1.730
ETSE2	0.852	-1.329	2.173
ETSE3	0.840	-1.390	2.448
ETSE4	0.815	-1.553	2.902
EU: <i>AVE</i> = 0.600			
EU1	0.840	-0.700	0.544
EU2	0.770	-0.840	0.653
EU3	0.708	-1.123	1.738
WTE: <i>AVE</i> = 0.619			
WTE1	0.762	-0.585	-0.280
WTE2	0.848	-0.883	0.684
WTE3	0.813	-0.981	0.988
WTE4	0.717	-0.719	0.350
		Multivariate kurtosis	Critical ratio
Multivariate normality	182.321	85.379	

Table 5: Confirmatory Factor Analysis, Model fit indices, and Normality Test

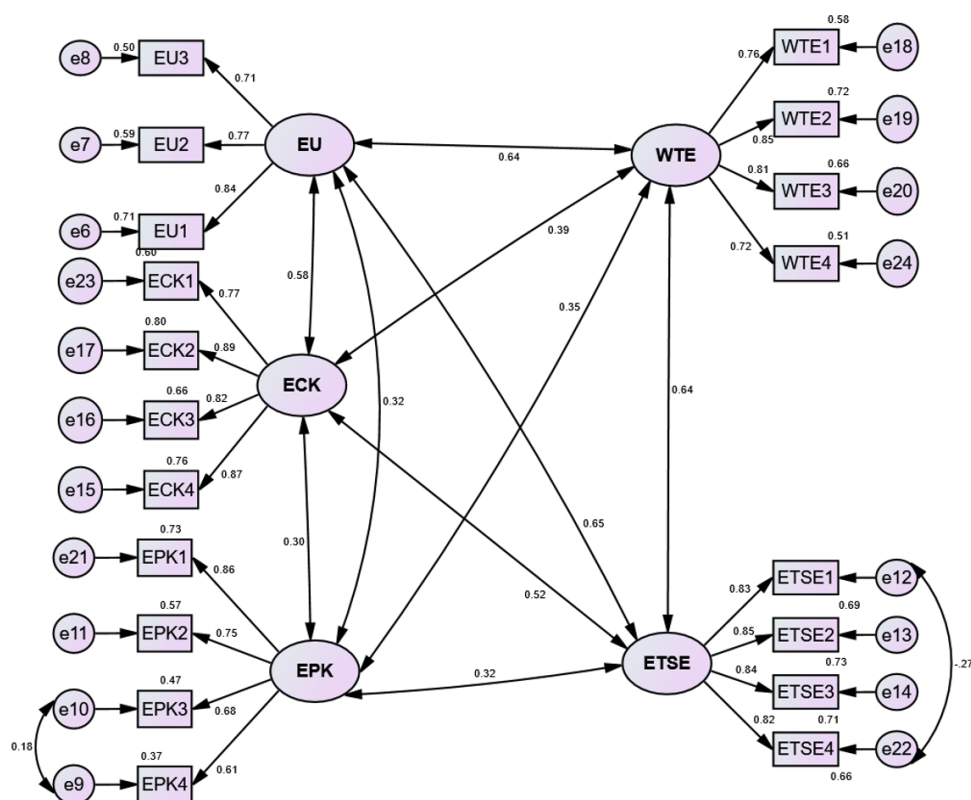


Figure 2: Confirmatory factor analysis

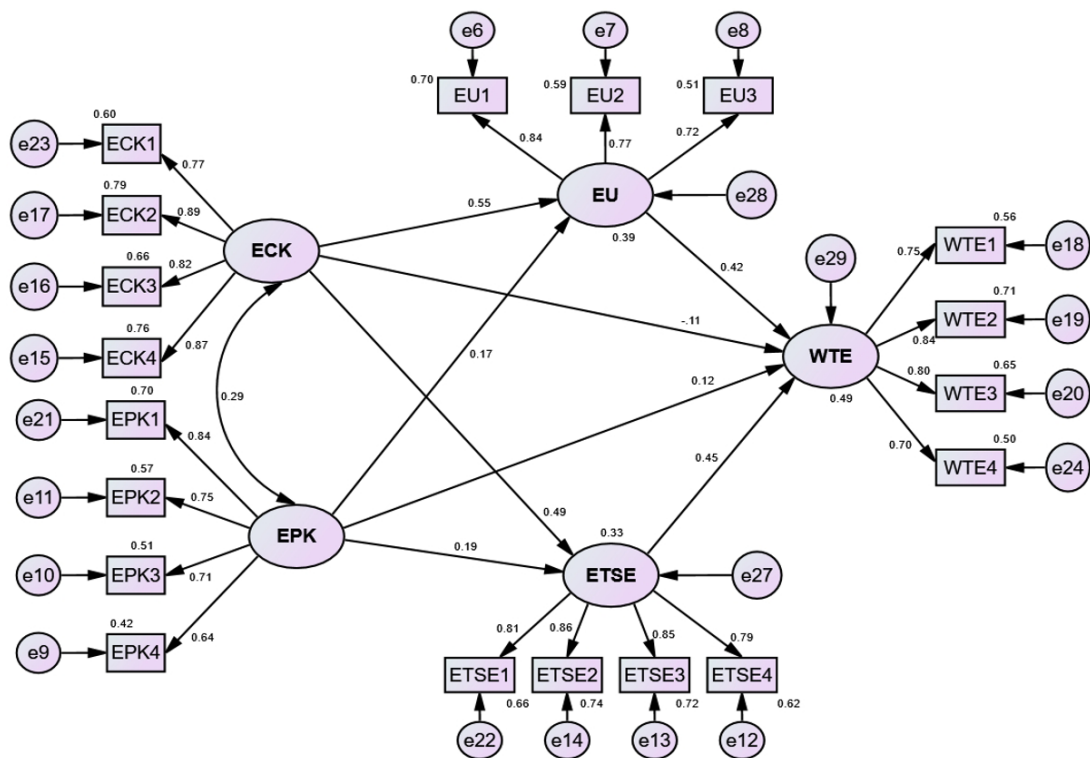


Figure 3: Structural Equation Modeling with latent variables

Test	Hypotheses	Direct effect	Total effect	BC 95% CI	Bootstrap p-value	Decision
H1	ECK→EU	0.551	0.569	[0.477, 0.619]	< 0.001	Supported
H2	ECK→WTE	-0.108	0.340	[-0.207, -0.013]	0.025	Supported
H3	ECK→ETSE	0.487	0.487	[0.415, 0.554]	< 0.001	Supported
H4	EPK→EU	0.168	0.168	[0.081, 0.254]	< 0.001	Supported
H5	EPK→WTE	0.119	0.273	[0.037, 0.193]	0.005	Supported
H6	EPK→ETSE	0.188	0.188	[0.109, 0.268]	< 0.001	Supported
H7	EU→WTE	0.419	0.419	[0.313, 0.519]	< 0.001	Supported
H8	ETSE→WTE	0.446	0.446	[0.353, 0.534]	< 0.001	Supported

Table 6: Hypothesis Testing of Direct and Total Effects ($p < 0.05$)

EU was positively associated with WTE ($\beta = 0.419$, BC 95% CI [0.313, 0.519], $p < 0.001$), indicating that participants who perceived greater educational value in ethnomathematics also reported greater willingness to use it in future teaching. ETSE was likewise positively associated with WTE ($\beta = 0.446$, BC 95% CI [0.353, 0.534], $p < 0.001$), indicating that stronger confidence in teaching ethnomathematics was associated with stronger instructional intentions.

Indirect effects were examined using 5,000 bias-corrected bootstrap resamples. As presented in Table 7, all four specific indirect effects were statistically significant. The indirect association between ECK and WTE through EU was $\beta = 0.244$ (95% BC CI [0.174, 0.326], $p = 0.001$), and the indirect association through ETSE was $\beta = 0.229$ (95% BC CI [0.173, 0.298], $p = 0.001$). For EPK, the indirect association with WTE through EU was $\beta = 0.070$ (95% BC CI [0.033, 0.118], $p = 0.001$), and the indirect association through ETSE was $\beta = 0.083$ (95% BC CI [0.046, 0.129], $p = 0.001$). The total

indirect effect of ECK on WTE was $\beta = 0.448$ (95% BC CI [0.367, 0.535], $p < .001$), and the total indirect effect of EPK on WTE was $\beta = 0.154$ (95% BC CI [0.094, 0.221], $p < .001$). This result shows that while the specific indirect effects of EPK through both EU and ETSE were statistically significant, their magnitudes ($\beta = 0.070$ and $\beta = 0.083$, respectively) were notably smaller than those observed for ECK ($\beta = 0.244$ and $\beta = 0.229$). This disparity is statistically explained by the weaker direct associations of EPK with EU ($\beta = 0.168$) and ETSE ($\beta = 0.188$) compared to the strong paths from ECK to these mediators. This suggests that ethnomathematics content knowledge may serve as the foundational cognitive basis for perceiving the approach as useful and developing confidence to teach it. While pedagogical knowledge is essential for translating that content into classroom practice, as evidenced by its direct association with WTE ($\beta = 0.119$), it may not independently drive beliefs about usefulness or self-efficacy as strongly as content knowledge does.

	Hypotheses	Indirect Effect	Lower BC	Upper BC	P-value
H9	ECK→EU→WTE	0.244	0.174	0.326	0.001
H10	EPK→EU→WTE	0.070	0.033	0.118	0.001
H11	ECK→ETSE→WTE	0.229	0.173	0.298	0.001
H12	EPK→ETSE→WTE	0.083	0.046	0.129	0.001

BC = bias-corrected confidence interval.

Table 7: Indirect Effect

DISCUSSION

ECK was positively associated with EU, suggesting that participants who reported stronger knowledge of ethnomathematical concepts were also more likely to recognise the educational relevance of connecting mathematics with culture. This finding is consistent with D'Ambrosio's (1985) argument that multiple cultural perspectives can broaden educators' conceptions of mathematics and with Rosa et al.'s (2016) emphasis on mathematical ideas embedded in communities. Interview accounts complemented this pattern: participants described greater exposure to ethnomathematics as helping them appreciate its potential contribution to conceptual understanding and cultural identity. The findings therefore suggest that teacher preparation should make the educational relevance of ethnomathematical knowledge explicit rather than treating ethnomathematics as content to be learned in isolation. Authentic local examples, such as Adinkra symmetry or Akan counting and measurement practices, may help participants connect theoretical knowledge with potential instructional use (Babbitt et al., 2015; Owusu-Darko et al., 2023).

ECK was also positively associated with ETSE, indicating that participants with greater self-reported ethnomathematics knowledge tended to report greater confidence in teaching culturally responsive mathematics. This pattern is consistent with Bandura's (1977) account of self-efficacy and with Shulman's (1986) emphasis on professional knowledge in teaching. Interview participants similarly described ethnomathematics learning as reducing uncertainty and increasing confidence in developing culturally relevant lessons. These accounts support the inclusion of applied components such as lesson planning, classroom simulation, and microteaching alongside conceptual coverage in teacher preparation (Bandura, 1997; Ertmer and Ottenbreit-Leftwich, 2010).

ECK showed a small but statistically significant negative direct effect on WTE after EU and ETSE were included in the model ($\beta = -0.108$, BC 95% CI $[-0.207, -0.013]$, $p = 0.025$), despite having a positive indirect effect ($\beta = 0.448$, BC 95% CI $[0.367, 0.535]$, $p < 0.001$) and a positive total effect ($\beta = 0.340$). This pattern indicates inconsistent mediation, whereby the direct and indirect effects operate in opposite directions. The finding should not be interpreted as evidence that greater ethnomathematics content knowledge reduces willingness to teach ethnomathematics but rather, the positive total effect indicates that the overall association between ECK and WTE remains favourable, with the positive indirect pathways through perceived usefulness and teaching self-efficacy outweighing the negative direct pathway. One possible explanation, suggested by participants' interview accounts,

is that greater knowledge may also heighten awareness of contextual conditions that could constrain the implementation of ethnomathematics, including curriculum demands, assessment expectations, limited resources, and institutional support. This interpretation is tentative, however, because the cross-sectional design does not permit conclusions about the temporal or causal mechanism underlying the negative direct effect. The finding nevertheless suggests that ethnomathematics content knowledge alone may not be sufficient to translate into willingness to teach when perceived usefulness and teaching self-efficacy are not simultaneously strengthened. The qualitative findings provide contextual insight into this possibility, with participants describing curricular and assessment conditions as potential constraints on the enactment of culturally inclusive mathematics teaching (Papagiannis et al., 1982; Sarı and Yüce, 2020).

EPK was positively associated with EU, ETSE, and WTE. Participants who reported stronger knowledge of strategies for integrating culture into mathematics lessons were more likely to value ethnomathematics, feel confident implementing it, and express stronger intentions to use it. This pattern is consistent with Wulandari et al. (2024), who emphasised the importance of both cultural knowledge and appropriate pedagogy for ethnomathematics implementation. Interview participants also described demonstrations, lesson planning, and discussion of culturally responsive strategies as increasing their appreciation of ethnomathematics and their readiness to use it. These findings suggest that pedagogical preparation is an important component of ethnomathematics-related teacher education, although the present study does not directly compare the efficiency of alternative programme designs (Shulman, 1986; Schmidt et al., 2009).

Both EU and ETSE were positively associated with WTE. Participants who perceived ethnomathematics as beneficial for conceptual understanding, learner engagement, and cultural appreciation expressed stronger intentions to integrate it into future teaching. Similarly, greater confidence in teaching ethnomathematics was associated with greater willingness to implement culturally responsive instruction. These findings are consistent with research indicating that educators' beliefs about innovations can be important alongside professional knowledge (Wallace and Priestley, 2011; Buabeng-Andoh, 2012; Serdyukov, 2017; Boudouaia et al., 2024). Guided practice, mentoring, and reflection may therefore complement existing professional knowledge by strengthening the beliefs and confidence associated with instructional intention (Davis, 2003; Ponticell, 2003).

EU and ETSE each showed significant indirect effects in the relationships of ECK and EPK with WTE. Statistically, these findings indicate that part of the association between

professional knowledge and willingness operates through participants' perceived value of ethnomathematics and their confidence in teaching it. Because the data are cross-sectional, these indirect effects should be interpreted as theoretically specified associations rather than evidence of a confirmed causal sequence. Nevertheless, the pattern highlights perceived usefulness and teaching self-efficacy as potentially important targets within teacher preparation. Content and pedagogical activities may have greater instructional relevance when they are accompanied by opportunities to recognise the value of ethnomathematics and to develop confidence in using it (Ertmer and Ottenbreit-Leftwich, 2010; Boudouaia et al., 2024). Broader curricular and assessment conditions may also determine whether such willingness can subsequently be enacted in practice.

Limitations of the Study

Several limitations qualify the interpretation of these findings. First, participants were postgraduate students in mathematics education at four public universities and were recruited through snowball sampling. The sample therefore does not represent the wider population of mathematics teachers and was disproportionately male (88.7%) and concentrated in the 35–44-year age group (87.4%). The observed levels of knowledge, usefulness, self-efficacy, and willingness should consequently not be interpreted as national estimates. The restricted composition of the sample may also have reduced variability in the constructs and affected the magnitude of observed associations. Replication with a more diverse, probability-based sample of pre-service and in-service teachers would strengthen generalisability.

Second, the cross-sectional design precludes causal conclusions. Although the structural model specifies theoretically informed directional relationships among the constructs, the data were collected at a single time point and therefore cannot establish temporal precedence or rule out reciprocal relationships among ethnomathematics knowledge, beliefs, and willingness to teach. Accordingly, the reported indirect effects should be interpreted as statistical mediation within the hypothesised SEM rather than as evidence of temporally ordered or causal mediation mechanisms. The study also cannot determine whether participants' reported willingness to teach ethnomathematics would be sustained under the curricular, assessment, resource, and institutional conditions of actual classroom practice. Longitudinal or experimental research is therefore needed to examine temporal ordering and causal mechanisms more directly (Kline, 2023).

Third, all constructs were measured by self-report at a single point in time, creating potential social-desirability and common-method bias (Podsakoff et al., 2003). Anonymity assurances may have reduced some of these risks but cannot eliminate them. Restricted sample variability could attenuate associations, whereas common-method bias could inflate them; the estimated coefficients should therefore be interpreted cautiously. More importantly, WTE represents an intention rather than observed teaching behaviour. The findings cannot establish whether participants subsequently enact culturally responsive

mathematics teaching. Classroom observations and lesson-plan analyses would provide stronger evidence of enactment (Wallace and Priestley, 2011; Buabeng-Andoh, 2012).

Fourth, the qualitative component involved only eight participants and was designed to contextualise the quantitative findings rather than generate theory. Consequently, the interpretation of the negative direct ECK–WTE association as reflecting heightened awareness of implementation constraints remains tentative. Alternative explanations, including statistical suppression, cannot be excluded. Further qualitative work focused specifically on participants with high knowledge but low willingness would provide a stronger test of this interpretation.

Finally, the model did not include contextual factors such as school leadership support, availability of culturally grounded teaching materials, or access to community knowledge holders (Mania and Alam, 2021; Wulandari et al., 2024). Although the model accounted for 46.0% of the variance in WTE, some associations attributed to individual beliefs may also reflect unmeasured institutional conditions. Future research incorporating both individual- and institution-level predictors could provide a more complete account of willingness to enact culturally responsive mathematics teaching.

CONCLUSION

This study examined relationships among ethnomathematics content knowledge (ECK), pedagogical knowledge (EPK), perceived usefulness (EU), teaching self-efficacy (ETSE), and willingness to teach ethnomathematics (WTE) among Ghanaian postgraduate students. ECK and EPK were positively associated with EU and ETSE. WTE was positively predicted by EPK, EU, and ETSE, while ECK showed a small negative direct association with WTE but a positive total effect. EU and ETSE also showed significant indirect effects linking both knowledge constructs with WTE. The qualitative findings complemented these statistical patterns by indicating that exposure to ethnomathematics and pedagogical preparation may strengthen participants' appreciation of, and confidence in, culturally responsive instruction, while curricular and assessment constraints may limit implementation. Overall, the findings suggest that knowledge acquisition should be accompanied by opportunities to develop perceived value and teaching confidence.

In practical terms, postgraduate programmes may benefit from integrating ethnomathematics content with lesson design, guided practice, and microteaching to support both competence and confidence. However, this study did not directly measure programme efficiency, contact-hour productivity, or cost-effectiveness. Therefore, claims regarding the comparative efficiency of specific preparation components are framed strictly as implications and hypotheses for future research. Curriculum developers and policymakers should consider contextual barriers, including assessment expectations and access to appropriate instructional resources. Sustainable integration of culturally responsive mathematics education is likely to require teacher preparation that addresses knowledge, beliefs, and instructional confidence alongside supportive curricular and institutional conditions.

Quantitative Finding	Illustrative Contextual Insight	Illustrative Participant Quotation	Integrated Interpretation
ECK→EU ($\beta = 0.551$)	Recognising the cultural and educational value of ethnomathematics.	<i>'The more I studied ethnomathematics, the more I realised that mathematics is deeply rooted in our culture and should be part of classroom teaching.'</i> (Participant 7)	Participants' accounts suggest that deeper knowledge of ethnomathematics can broaden teachers' recognition of its cultural and educational value, helping to explain the positive association between ECK and EU.
ECK→ETSE ($\beta = 0.487$)	Subject knowledge as a source of teaching confidence.	<i>'Understanding the mathematical concepts behind our cultural practices gave me the confidence that I could successfully teach them to students.'</i> (Participant 2)	Participants associated understanding the mathematical basis of cultural practices with greater confidence in their capacity to teach ethnomathematics, providing an experiential explanation for the positive ECK→ETSE relationship.
ECK→WTE ($\beta = -0.108$)	Knowledge-practice gap under contextual constraints.	<i>'Although I now know about ethnomathematics, I may still hesitate to teach it because I am unsure whether the curriculum and assessment system will support it.'</i> (Participant 4)	The qualitative evidence helps contextualise the small negative direct effect by suggesting that knowledge alone may not translate into willingness when teachers perceive curriculum, assessment, or institutional constraints.
EPK→EU ($\beta = 0.168$) and EPK→WTE ($\beta = 0.119$)	Pedagogical preparation and perceived classroom value.	<i>'When we learned practical ways of integrating culture into mathematics lessons, I began to see how useful ethnomathematics could be for improving students' understanding.'</i> (Participant 5)	Participants described practical pedagogical preparation as helping them recognise the instructional value of ethnomathematics and its feasibility for classroom use, providing a common explanation for the positive EPK→EU and EPK→WTE relationships.
EPK→ETSE ($\beta = 0.188$)	Instructional preparation as confidence building.	<i>'Preparing lesson plans based on cultural examples made me feel capable of teaching ethnomathematics in my future classroom.'</i> (Participant 3)	Participants' accounts indicate that opportunities to practise instructional strategies and lesson planning can strengthen perceived capability to implement ethnomathematics, supporting the positive EPK→ETSE relationship.
EU→WTE ($\beta = 0.419$)	Perceived educational relevance as a motivation for adoption.	<i>'Students learn better when mathematics reflects their own cultural experiences, so I definitely intend to use ethnomathematics whenever possible.'</i> (Participant 2)	Participants' recognition of the relevance and educational benefits of ethnomathematics was associated with stronger intentions to incorporate it into teaching, helping to explain the positive EU→WTE relationship.
ETSE→WTE ($\beta = 0.446$)	Teaching confidence and readiness for implementation.	<i>'Because I feel confident designing ethnomathematics lessons, I have no hesitation about teaching them.'</i> (Participant 6)	Participants linked confidence in lesson design and delivery with readiness to implement ethnomathematics, providing qualitative context for the positive ETSE→WTE relationship.
ECK→WTE indirect effect ($\beta = 0.448$)	Knowledge translated into willingness through perceived value and confidence.	<i>'Understanding ethnomathematics helped me appreciate its value, and that is what motivated me to teach it in the future.'</i> (Participant 8)	The quantitative analysis established a significant indirect effect of ECK on WTE. Participants' accounts suggest that developing content knowledge may increase willingness by enhancing perceived value and teaching confidence.
EPK→WTE indirect effect ($\beta = 0.154$)	Pedagogical preparation translated into willingness through value and confidence.	<i>'Practising how to teach ethnomathematics gave me the confidence to implement it when I become a lecturer.'</i> (Participant 2)	The quantitative analysis established a significant indirect effect of EPK on WTE. Participants' accounts suggest that pedagogical preparation may foster willingness by increasing perceived usefulness and confidence in implementation.

Table 8: Integration of Quantitative and Qualitative Findings

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