

Gender Differences in Interpersonal Relationship Patterns and Classroom Interaction Styles among STEM Pre-Service Teachers

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Abstract

This study examined gender differences in interpersonal relationship patterns and classroom interaction styles among STEM pre-service teachers in Ghana, drawing on Social Role Theory and Communities of Practice Theory. Using a cross-sectional survey design, we collected data from 185 male and female STEM pre-service teachers enrolled in teacher education programmes. Quantitative analyses revealed small but statistically significant gender differences in specific dimensions of interpersonal relationships and classroom interaction styles. Female pre-service teachers demonstrated slightly stronger tendencies toward relational and supportive interactions, while male pre-service teachers showed higher scores on selected task-oriented and control-related interaction dimensions. However, when we combined interpersonal relationship patterns and classroom interaction styles into a single construct, no statistically significant gender difference was observed. These findings suggest that while gender may influence particular aspects of classroom interaction, overall interactional competence among STEM pre-service teachers is shaped more by professional socialisation within teacher education than by gender alone. The study highlights the importance of gender-sensitive and inclusive pedagogical practices that promote equitable participation and professional development in STEM teacher education in Ghana.

Keywords: gender differences, interpersonal relationship patterns, classroom interaction styles, STEM pre-service teachers, Ghana, social role theory, inclusive pedagogy, teacher education, classroom dynamics, professional socialisation

1.0 Introduction

Over the past two decades, science, technology, engineering, and mathematics (STEM) education has assumed a central role in Ghana's national development agenda, reflecting global recognition of STEM as a driver of scientific advancement, technological innovation, and sustainable economic growth (UNESCO, 2017; Akon-Yamga et al., 2024). National policy frameworks increasingly position STEM education as critical to workforce development, industrialisation, and the achievement of long-term socio-economic goals. Within this broader agenda, teacher education occupies a strategic position, as the effectiveness of STEM education in schools is closely tied to the quality of teacher preparation. Teachers are not only responsible for transmitting disciplinary knowledge but also for creating classroom environments that foster engagement, collaboration, and equitable participation among learners (Amponsah et al., 2014; Darling-Hammond, 2017; Lewin, 2009).

Contemporary perspectives on STEM teaching emphasise that effective instruction extends beyond mastery of content and pedagogical techniques to include interpersonal competencies and classroom interaction skills. These competencies shape how teachers communicate with learners, manage classroom discourse, distribute opportunities for participation, and support learners' identity development in STEM fields. Classroom interaction styles influence students' motivation, confidence, and sense of belonging, particularly in disciplines that are often perceived as competitive or exclusionary (Sadker & Zittleman, 2009). In Ghanaian science education contexts, research has shown that students' conceptual engagement and confidence in complex STEM topics are closely linked to how teachers structure interaction, discussion, and collaborative learning opportunities. For instance, studies on electrochemistry learning have demonstrated that learners' misconceptions and conceptual difficulties persist when classroom discourse is predominantly teacher-centred and interactionally restrictive (Amponsah, 2024). These findings underscore the importance of interaction-rich pedagogical environments in STEM classrooms. As a result, teacher education programmes are increasingly expected to prepare pre-service teachers who can enact inclusive and socially responsive classroom practices that support diverse learners.

Despite sustained efforts to expand access to STEM education in Ghana, gender-related disparities persist within teacher education contexts, particularly in patterns of classroom participation, interaction, and relational engagement (Osman, 2021; Sakyi-Hagan & Hanson, 2022). While enrolment gaps between male and female students in some STEM-related teacher education programmes have narrowed, inequities continue to manifest in less visible but equally consequential ways. Research indicates that male and female students often experience classroom interactions differently, with implications for confidence development, leadership opportunities, and collaborative engagement (Tannen, 1990; Sadker & Zittleman, 2009). These interactional differences are not confined to academic performance outcomes but also extend to relational dynamics, such as communication styles, peer collaboration, and the exercise of classroom authority, all of which are critical to effective teaching practice.

In STEM teacher education specifically, gendered expectations may shape how pre-service teachers engage with peers, contribute to classroom discourse, and assume instructional roles during collaborative activities. Empirical studies conducted in Ghana and comparable contexts suggest that male pre-service teachers are more likely to adopt assertive, task-oriented, or directive interaction styles, while female pre-service teachers often demonstrate relational, supportive, and facilitative approaches to classroom engagement (Ampofo, 2013; Morley, 2010; Osman, 2021). These tendencies reflect broader sociocultural norms regarding gender roles and communication patterns, which influence perceptions of competence, leadership, and authority in educational settings.

However, gendered interaction patterns do not operate in isolation from institutional contexts. Within teacher education programmes, professional socialisation processes play a critical role in shaping how pre-service teachers learn to interact, collaborate, and position themselves as future professionals. Coursework, teaching practice, peer interaction, and mentorship expose pre-service teachers to shared pedagogical norms and expectations that can either reinforce or moderate socially ascribed gender differences (Darling-Hammond, 2017). Consequently, classroom interaction styles observed during teacher preparation may reflect an interplay between gendered social expectations and the professional norms promoted within teacher education institutions.

Understanding these dynamics is particularly important because pre-service teachers' classroom interaction styles are not only reflective of their current learning experiences but also predictive of how they are likely to teach in the future. Research suggests that interactional practices developed during teacher preparation are often reproduced in school classrooms, influencing learners' participation, engagement, and access to learning opportunities (Morley & Lugg, 2009). For example, teachers accustomed to dominant or exclusionary interaction patterns may unintentionally marginalise certain learners. In contrast, those who adopt inclusive, collaborative interaction styles are more likely to foster equitable learning environments. In STEM classrooms, where participation and confidence are closely linked to learners' long-term engagement with the discipline, these interactional practices are particularly significant.

Within the Ghanaian context, examining gender differences in interpersonal relationships and classroom interaction styles among STEM pre-service teachers is especially relevant given ongoing reforms in teacher education. Recent shifts toward learner-centred pedagogy, inclusive education, and competency-based approaches require teachers to manage classrooms in ways that promote dialogue, collaboration, and shared authority. These pedagogical expectations place increased emphasis on interactional competence and relational skills, raising questions about how gendered interaction tendencies intersect with contemporary teacher education goals.

Although existing research has documented gender disparities in STEM education broadly, much of this work has focused on access, achievement, and representation rather than the relational and interactional processes that underpin teaching and learning. In Ghana, studies have tended to examine gender differences in enrolment patterns,

academic performance, or career trajectories, with comparatively limited attention to how interpersonal relationships and classroom interaction styles develop during teacher preparation. This represents a significant gap, as interactional behaviours formed during pre-service training are likely to shape future classroom practices and influence the inclusivity of STEM education at the school level.

Furthermore, empirical findings on gender and classroom interaction present a complex picture. While many studies report gender differences in specific interactional behaviours, others suggest that such differences diminish when interactional competence is examined holistically or when professional socialisation processes are taken into account (Farago et al., 2022). This raises important questions about the extent to which gender influences classroom interaction styles independently, rather than through teacher education practices, institutional culture, and shared professional norms.

Against this backdrop, there is a need for empirical research that systematically examines gender differences in both interpersonal relationship patterns and classroom interaction styles among STEM pre-service teachers, while also considering their combined expression. Such an approach allows for a more nuanced understanding of how gender operates across multiple interactional dimensions and whether observed differences translate into meaningful distinctions in overall interactional competence.

This study responds to this need by examining gender differences in interpersonal relationships and classroom interaction styles among STEM pre-service teachers in Ghana. Drawing on Social Role Theory and Communities of Practice Theory, the study explores how socially constructed gender expectations and professional socialisation processes shape interactional behaviours within teacher education contexts. By focusing on relational and interactional dimensions rather than academic performance alone, the study contributes to ongoing discussions on equity, professional identity formation, and inclusive pedagogy in STEM teacher education.

The findings of this study are intended to inform teacher education policy and practice by identifying areas where gender-sensitive approaches can support more balanced, collaborative, and inclusive classroom environments. In doing so, the study offers insights that are relevant not only to Ghana but also to other contexts seeking to strengthen the social and interactional dimensions of STEM teacher preparation in pursuit of equitable and high-quality education.

1.1 Statement of the Problem

Despite ongoing efforts to strengthen STEM education in Ghana, gender-related disparities continue to shape classroom participation and interaction within teacher education programmes. Existing studies indicate that male pre-service teachers often dominate classroom discussions and assume technical or leadership roles, while female pre-service teachers are more likely to adopt supportive or secondary roles (Osman,

2021; Sakyi-Hagan & Hanson, 2022; Sadker & Zittleman, 2009). Such interactional patterns have implications not only for immediate learning experiences but also for the professional identities and pedagogical practices that pre-service teachers develop and later reproduce in school classrooms.

Although research in Ghana has largely focused on gender differences in access, achievement, and representation in STEM education, relatively little empirical attention has been given to interpersonal relationship patterns and classroom interaction styles within pre-service teacher education. This issue represents a critical gap, as interactional behaviours formed during teacher preparation are likely to influence classroom management, inclusivity, and collaborative learning in future teaching practice.

Without a clear understanding of how gender shapes interpersonal relationships and classroom interaction styles among STEM pre-service teachers, teacher education programmes may unintentionally perpetuate inequitable participation patterns and reinforce gendered norms in classroom practice. Addressing this gap is essential for informing gender-sensitive pedagogical strategies and supporting the development of inclusive, collaborative, and effective STEM teaching in Ghana.

1.2 Purpose of the Study

The purpose of this study was to examine the influence of gender on interpersonal relationship patterns and classroom interaction styles among STEM pre-service teachers in Ghana. Specifically, the study sought to determine whether male and female pre-service teachers differ in their relational behaviours and interactional approaches within classroom contexts, and to assess the implications of these differences for inclusive and effective STEM teacher education.

1.3 Objectives

The following objectives guided the study:

1. To examine gender differences in interpersonal relationship patterns among STEM pre-service teachers in Ghana.
2. To determine gender differences in classroom interaction styles among STEM pre-service teachers.
3. To identify the classroom interaction dimensions that are associated with gender differences among STEM pre-service teachers.
4. To assess whether gender influences the combined expression of interpersonal relationship patterns and classroom interaction styles among STEM pre-service teachers.

2.0 Literature Review

2.1 Theoretical Review

2.1.1 Social Role Theory (SRT)

Social Role Theory (SRT), originally advanced by Eagly (1987) and later developed by Eagly and Wood (2012), explains gender differences in behaviour as products of socially constructed roles and expectations rather than biological determinism. According to the theory, societies allocate distinct roles to women and men, and these role distributions shape behavioural norms, skills, and expectations, including how individuals communicate, relate to others, and exercise authority within institutional settings such as education.

Within STEM teacher education, Social Role Theory provides a useful lens for understanding gender-related differences in interpersonal relationship patterns and classroom interaction styles. Male pre-service teachers are often socialised to exhibit assertiveness, task orientation, and leadership, which may manifest in more dominant participation in classroom discourse or preference for technical roles (Eagly & Karau, 2002). In contrast, female pre-service teachers are often socialised to value cooperation, emotional sensitivity, and relational cohesion, leading to more supportive and collaborative interaction styles (Ridgeway & Correll, 2004).

Importantly, Social Role Theory frames these behavioural tendencies as socially mediated rather than as fixed personal attributes. This perspective allows gendered interaction patterns observed in STEM classrooms to be interpreted as outcomes of cultural and institutional expectations, rather than as individual deficiencies. However, a limitation of the theory is its limited attention to individual agency and learners' capacity to negotiate or transform prescribed social roles over time (Rudman & Glick, 2008). Despite this limitation, Social Role Theory remains appropriate for this study because it highlights how gendered expectations may shape interpersonal relationships and interactional behaviours within teacher education contexts.

2.1.2 Communities of Practice Theory (CoP)

Communities of Practice (CoP) Theory, developed by Wenger (1998) and expanded by Wenger, McDermott, and Snyder (2002), conceptualises learning as a social process that occurs through participation in shared practices within a community. According to this theory, individuals develop knowledge, skills, and professional identities through sustained interaction, collaboration, and engagement with others in a social setting.

In the context of teacher education, classrooms function as communities of practice in which pre-service teachers learn not only disciplinary content and pedagogy but also the social norms, interactional patterns, and professional identities associated with

teaching (Lave & Wenger, 1991). Patterns of classroom interaction, including who speaks, who leads, and whose contributions are valued, influence access to participation and the distribution of power within the learning community (Wenger et al., 2002).

From a gender perspective, Communities of Practice Theory helps explain how repeated participation in gendered interaction patterns may shape pre-service teachers' professional socialisation. If certain interaction styles are privileged within classroom communities, these practices may be normalised and later reproduced in professional teaching contexts (Boud & Middleton, 2003; Fuller et al., 2005). A limitation of CoP Theory is its limited explicit engagement with structural inequalities such as gender, which necessitates its integration with complementary frameworks that foreground social power relations (Handley et al., 2006).

2.1.3 Theoretical Alignment with the Study

Together, Social Role Theory and Communities of Practice Theory provide a complementary framework for examining gender differences in interpersonal relationship patterns and classroom interaction styles among STEM pre-service teachers in Ghana. Social Role Theory offers insight into how culturally embedded gender expectations shape interactional behaviours. At the same time, Communities of Practice Theory explains how these behaviours are enacted, reinforced, or moderated through participation in classroom communities.

The integration of these theories allows the study to examine gendered interaction patterns as both socially constructed and contextually sustained through professional socialisation. This combined framework supports an analysis that recognises the influence of gender without treating it as a deterministic factor, thereby aligning with the study's focus on relational dynamics, interaction styles, and the role of teacher education in fostering inclusive classroom practices.

2.2 Empirical Review

2.2.1 Gender Differences in Interpersonal Relationship Patterns among STEM Pre-Service Teachers

Empirical studies consistently indicate that gender plays a meaningful role in shaping interpersonal relationship patterns within STEM teacher education contexts, particularly in Sub-Saharan Africa. Research conducted in Ghana and comparable African settings shows that female pre-service teachers are more likely to form supportive peer networks characterised by cooperation, emotional affiliation, and mutual academic assistance (Osman, 2021; Ampofo, 2013; Akon-Yamga et al., 2024). These relational structures often manifest through joint study groups, peer mentoring, and collaborative problem-solving, which foster social cohesion and emotional safety

within learning environments. Such relational orientations have been associated with greater peer support, reduced conflict, and collective responsibility for learning outcomes.

In contrast, male pre-service teachers have been found to engage more frequently in competitive relational patterns, often organised around ranking, performance comparison, and status differentiation (Osman, 2021; Sakyi-Hagan & Hanson, 2022). These interactional tendencies tend to prioritise task completion, individual recognition, and technical proficiency over relational maintenance. While such patterns may promote assertiveness and confidence, they can also contribute to relational distance and unequal participation within classroom communities, particularly when competition overshadows collaboration.

Evidence from Ghanaian junior high school contexts further suggests that teachers' relational orientations influence the extent to which inquiry-based science teaching is enacted in practice. Research examining teachers' and educational administrators' conceptions of inquiry indicates that supportive interpersonal relationships and collaborative classroom cultures are more likely to promote inquiry-oriented pedagogy. In contrast, authoritative or control-driven interaction patterns tend to constrain it (Mohammed & Amponsah, 2021). This highlights the centrality of relational dynamics in shaping classroom interaction styles in STEM education.

The gendered nature of these relational patterns has important implications for professional identity formation among pre-service teachers. Female pre-service teachers' emphasis on cooperation and relational harmony has been shown to support inclusive peer environments. However, it may also limit visibility and recognition in contexts where assertiveness and dominance are implicitly valued (Morley, 2010). Conversely, male pre-service teachers' relational assertiveness may reinforce perceptions of competence and leadership, even when such behaviours marginalise alternative forms of participation. These dynamics suggest that interpersonal relationship patterns are not neutral but are embedded within broader social expectations that shape how competence and professionalism are recognised within STEM education.

Importantly, empirical evidence cautions against interpreting these patterns as fixed or biologically determined. Instead, studies highlight the role of sociocultural norms, institutional practices, and professional socialisation in reinforcing or moderating gendered relational behaviours (Akon-Yamga et al., 2024). Within teacher education programmes, relational patterns developed during training are likely to be carried forward into future classroom practice, influencing how teachers engage with learners, manage group work, and foster inclusive learning environments. Understanding gender differences in interpersonal relationships among STEM pre-service teachers is,

therefore, critical for designing teacher education interventions that promote balanced, inclusive, and professionally adaptive relational competencies.

2.2.2 Gender Differences in Classroom Interaction Styles among STEM Pre-Service Teachers

Beyond interpersonal relationships, empirical research has documented systematic gender differences in classroom interaction styles within STEM education. Classroom interaction styles encompass patterns of participation, communication strategies, leadership behaviours, and approaches to classroom control. Studies conducted in Ghana and internationally indicate that male pre-service teachers are more likely to dominate classroom discourse, initiate discussions, interrupt peers, and assume directive roles during group activities (Sadker & Zittleman, 2009; Holmes, 2006; Sakyi-Hagan & Hanson, 2022). These behaviours are often interpreted as indicators of confidence and authority, particularly in STEM contexts where assertiveness is culturally associated with competence.

Female pre-service teachers, by contrast, tend to adopt interaction styles characterised by listening, turn-taking, facilitation, and supportive engagement (Tannen, 1990; Morley & Lugg, 2009). Empirical evidence from Ghana also suggests that teachers' classroom interaction styles are closely associated with their attitudes toward inquiry-based science teaching. Studies of junior high school teachers have shown that positive dispositions toward inquiry are often accompanied by facilitative interaction styles that encourage student participation, questioning, and dialogue. In contrast, negative or ambivalent attitudes are associated with more restrictive classroom control (Mohammed & Amponsah, 2021). These findings reinforce the relevance of examining classroom interaction styles during pre-service teacher preparation. While these styles contribute to classroom harmony and collective understanding, they may also result in reduced visibility and fewer opportunities to influence classroom decision-making. Research suggests that female students are less likely to challenge peers openly, question authority, or claim leadership roles, particularly in mixed-gender STEM classrooms where dominant interaction norms favour assertive discourse (Osman, 2021).

These gendered interaction styles extend beyond verbal participation to include non-verbal communication, responsiveness to feedback, and classroom management preferences. Male pre-service teachers are often associated with directive and control-oriented interaction styles, while female pre-service teachers are more frequently linked to learner-centred and relational approaches (Haase, 2010; Martino & Rezai-Rashti, 2012). Such differences shape classroom climate, influence student engagement, and affect the distribution of instructional authority.

However, empirical findings also reveal considerable overlap between male and female interaction styles, particularly within teacher education programmes that emphasise reflective practice and inclusive pedagogy. This suggests that while gendered tendencies exist, classroom interaction styles are not exclusively determined by gender but are shaped by pedagogical training, institutional culture, and exposure to alternative teaching models. As a result, examining gender differences in classroom interaction styles among STEM pre-service teachers requires attention to both social norms and the moderating influence of teacher education.

2.2.3 Interaction Dimensions Associated with Gender Differences in STEM Teacher Education

Empirical studies have further identified specific classroom interaction dimensions through which gender differences become most visible. These dimensions include frequency of participation, interruption patterns, feedback reception, leadership allocation, and role distribution during instructional activities (Osman, 2021; Morley, 2010). Research consistently shows that male pre-service teachers receive more public and corrective feedback, are more frequently assigned technical or leadership roles, and are encouraged to take instructional risks. In contrast, female pre-service teachers are more likely to receive private feedback and be assigned organisational or supportive roles, such as coordination and documentation (Sakyi-Hagan & Hanson, 2022; Akon-Yamga et al., 2024).

These differentiated interaction patterns contribute to unequal recognition of competence and reinforce gendered professional identities. Male pre-service teachers' frequent engagement in visible, authoritative roles enhances perceptions of technical expertise and leadership potential, whereas female pre-service teachers' contributions, though essential to group functioning, may be undervalued in performance-oriented STEM contexts. Over time, these interactional asymmetries shape confidence, self-efficacy, and career aspirations within STEM education pathways.

Importantly, empirical evidence suggests that these interaction dimensions do not operate independently but interact in complex ways. For example, reduced opportunities for female pre-service teachers to participate can limit access to feedback, which, in turn, affects confidence and the willingness to engage assertively. Similarly, male pre-service teachers' repeated exposure to leadership roles can reinforce dominance and entitlement within classroom discourse. These cyclical processes highlight how interaction dimensions function as mechanisms through which gendered advantages and disadvantages are reproduced within teacher education settings.

At the same time, studies emphasise that such patterns are sensitive to instructional design and pedagogical intervention. Structured group work, role rotation, and explicit

attention to participation equity have been shown to reduce gender disparities across interaction dimensions (Darling-Hammond, 2017). This suggests that identifying interaction dimensions associated with gender differences is a necessary step toward designing pedagogical strategies that disrupt inequitable participation and support balanced professional development among STEM pre-service teachers.

2.2.4 Gender and the Combined Expression of Interpersonal Relationships and Classroom Interaction Styles

While many studies document gender differences across specific relational and interactional dimensions, emerging evidence suggests that gender does not necessarily exert a strong influence on the combined expression of interpersonal relationship patterns and classroom interaction styles. Research indicates that when relational and interactional competencies are examined holistically, differences between male and female pre-service teachers tend to diminish (Farago et al., 2022; Mammoun & Nfissi, 2023). This convergence is often attributed to the effects of professional socialisation within teacher education programmes, where shared pedagogical norms and expectations shape interactional behaviour.

In teacher education contexts that emphasise reflective practice, collaborative learning, and inclusive pedagogy, pre-service teachers are exposed to common frameworks for classroom interaction regardless of gender. These shared experiences can mitigate socially ascribed gender differences and promote the development of adaptive interactional competencies (Korthagen, 2017). As a result, while gender may influence how specific behaviours are enacted, it does not consistently predict overall interactional effectiveness or professional readiness.

Empirical findings also suggest that institutional culture and pedagogical structure play a more decisive role than gender in shaping the combined interactional profiles of pre-service teachers. Programmes that prioritise learner-centred instruction, peer collaboration, and equitable participation tend to produce more uniform interaction patterns across gender groups (Al-Shibel, 2021). This reinforces the argument that gender effects in STEM teacher education are contextual rather than deterministic.

Taken together, the empirical literature highlights the importance of moving beyond binary comparisons of male and female behaviour toward a more integrated understanding of how interpersonal relationships and classroom interaction styles develop within professional learning environments. Such an approach supports the design of teacher education programmes that recognise diversity in interactional approaches while fostering shared standards of professional competence and inclusivity.

3.0 Methodology

3.1 Research Design

This study adopted a cross-sectional survey design with a descriptive-correlational approach (Creswell, 2018; Kumar, 2019). The design was appropriate for examining gender differences in interpersonal relationship patterns and classroom interaction styles among STEM pre-service teachers without manipulating any variables. Gender was treated as a non-manipulable grouping variable.

The cross-sectional design enabled data collection at a single point in time, providing a snapshot of participants' relational and interactional behaviours in teacher education contexts. The descriptive-correlational approach further supported the examination of group differences, associations among variables, and combined effects relevant to STEM teacher education.

3.2 Participants (Population, Sample, and Sampling Procedure)

The study population comprised 267 STEM pre-service teachers enrolled in Bachelor of Science in Education (Science) and Bachelor of Science in Education (Mathematics) programmes in Ghana. From this population, 185 pre-service teachers participated in the study.

A combination of convenience, purposive, and stratified sampling techniques was employed. Convenience sampling facilitated access to participants, while purposive sampling ensured the inclusion of pre-service teachers enrolled specifically in STEM-related teacher education programmes. Stratified sampling by gender was used to ensure adequate representation of male and female participants. This multi-stage sampling approach enhanced the sample's representativeness and enabled meaningful gender-based comparisons within the study.

3.3 Data Collection and Instrument

Data were collected using a structured online questionnaire administered to STEM pre-service teachers. The instrument measured interpersonal relationship patterns and classroom interaction styles using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire items were adapted from established instruments used in previous research on classroom interaction and relational dynamics (Cohen et al., 2018).

The survey was administered over two weeks, allowing participants sufficient time to complete the questionnaire at their convenience. Online data collection was selected for its efficiency, cost-effectiveness, and suitability for quantitative analysis (Brace, 2004; Billings & Halstead, 2005).

3.4 Ethical Consideration

Ethical principles of voluntary participation, informed consent, confidentiality, and anonymity were observed throughout the study. Participants were informed about the purpose of the study, their right to withdraw at any stage without penalty, and the intended use of the data for research purposes. Informed consent was obtained electronically prior to participation.

No personally identifiable information was collected, and all data were stored securely and used solely for academic purposes. In line with institutional and journal expectations, the study involved minimal risk to participants and did not require formal ethical clearance, as it relied on anonymous survey data from adult participants (SurveyLegend, 2023; Qualtrics, 2020).

3.5 Validity and Reliability

The internal consistency reliability of the study instruments was assessed using Cronbach's alpha coefficient (Hair et al., 2014). The results indicated high reliability for both scales. The interpersonal relationship scale yielded a Cronbach's alpha of .902 (13 items), and the classroom interaction scale yielded a Cronbach's alpha of .913 (48 items), both demonstrating excellent internal consistency.

These reliability coefficients indicate that the instrument was suitable for measuring interpersonal relationship patterns and classroom interaction styles among STEM pre-service teachers.

Table 1: Cronbach's Alpha Coefficient for the Variables

Variables	N	%	Cronbach's Coefficient	Alpha	No of items
Interpersonal Relationship	185	100.0	.902		13
Classroom Teacher Interaction	185	100.0	.913		48

4.0 Results and Discussion

4.1 Results

To examine the gender differences in interpersonal relationship patterns among STEM pre-service teachers in Ghana.

An independent-samples *t*-test was conducted to examine gender differences in interpersonal relationship patterns among STEM pre-service teachers. The results indicated a statistically significant difference between male and female participants, $t(183) = -2.124, p = .035$. Female pre-service teachers ($n = 97, M = 37.53, SD = 11.26$) scored higher than their male counterparts ($n = 88, M = 34.00, SD = 11.27$).

Table 2: Gender Differences in Interpersonal Relationship Patterns among STEM Pre-Service Teachers

Gender	N	Mean (M)	SD	T-value	df	P-value
Male	88	34.00	11.27			
Female	97	37.53	11.26	-2.124	183	.035

Mean Difference: Female - Male

The observed mean difference of 3.53 suggests a modest gender effect, indicating slightly stronger interpersonal relationship patterns among female pre-service teachers.

To determine the differences in classroom interaction styles between male and female STEM pre-service teachers.

We conducted a multivariate analysis of variance (MANOVA) to examine the effect of gender on classroom interaction styles across eight dimensions. The analysis revealed a statistically significant multivariate effect of gender, Wilks' Lambda = .844, $F(8, 176) = 4.057, p < .001$, partial $\eta^2 = .156$.

Table 3: Differences in Classroom Interaction Styles Between Male and Female STEM Pre-Service Teachers

Effect	N	Wilks Lambda	F	df1	df2	P- value	Partial (n2)
Gender	165	.844	4.057	8.0	176.0	<.001	.156

This indicates that gender accounted for approximately 15.6% of the variance in classroom interaction styles when the dimensions were considered collectively, warranting further examination of individual interaction dimensions.

Follow-up univariate analyses revealed several statistically significant gender differences across specific classroom interaction dimensions. Female pre-service teachers scored higher on Leadership and Understanding, indicating greater engagement in leadership-oriented and comprehension-focused interactions. Male pre-service teachers scored higher on Uncertain, Admonishing, Student Freedom, Dissatisfied, and Strictness dimensions, reflecting greater endorsement of control-oriented and authority-related interaction styles. No statistically significant gender difference was observed for the Helpful dimension.

Table 4: A Comparison of Male and Female Students' Classroom Interaction Styles

Dimensions	Male		Female		df	F	P- value	Partial n ²
	M	SD	M	SD				
Leadership	18.426	4.169	19.756	4.546	1	4.273	.040	.023
Understanding	17.312	4.427	19.213	4.725	1	7.925	.005	.042

Uncertain	14.636	4.398	11.226	4.987	1	24.111	< .001	.116
Admonishing	13.856	4.098	11.053	4.914	1	17.547	< .001	.087
Helpful	20.556	5.584	21.587	5.584	1	1.575	.211	.009
Student Freedom	15.388	4.424	13.723	4.632	1	6.218	.014	.033
Dissatisfied	14.359	4.819	10.908	5.227	1	21.654	< .001	.106
Strictness	16.704	4.167	14.957	4.330	1	7.186	.006	.041

Effect sizes ranged from small to medium, with the largest effects observed for Uncertain (partial $\eta^2 = .116$) and Dissatisfied (partial $\eta^2 = .106$), suggesting that gender explained a meaningful proportion of variance in these specific interaction dimensions.

To identify the dimensions of classroom interaction styles that predict gender-based differences among STEM pre-service teachers.

A binary logistic regression analysis was conducted to examine whether classroom interaction dimensions significantly predicted gender among STEM pre-service teachers. The results indicated that none of the interaction dimensions emerged as statistically significant predictors of gender ($p > .05$). The Uncertain dimension approached significance ($p = .058$). However, the effect did not reach the conventional threshold for statistical significance.

Table 5: Logistic Regression of Classroom Interaction Styles

		Variables in the Equation					Exp
		B	S.E.	Wald	df	Sig.	(B)
Step 1 ^a	Leadership	-.083	.066	1.564	1	.211	.921
	Understanding	.113	.065	3.004	1	.083	1.120
	Uncertain	-.101	.053	3.591	1	.058	.904
	Admonishing	-.020	.051	.162	1	.687	.980
	Helpful	.023	.045	.251	1	.617	1.023
	Student_Freedom	-.013	.051	.062	1	.803	.987
	Dissatisfied	-.028	.049	.323	1	.570	.972
	Strict	-.044	.046	.916	1	.338	.957
Constant		1.934	1.092	3.139	1	.076	6.920

a. Variable(s) entered on step 1: Leadership, Understanding, Uncertain, Admonishing, Helpful, Student_Freedom, Dissatisfied, Strict.

Overall, the odds ratios for all predictors were close to unity, indicating minimal predictive power. These findings suggest that gender differences observed at the dimension level do not translate into reliable gender classification based on classroom interaction styles.

To assess the extent to which gender influences the combined expression of interpersonal relationship patterns and classroom interaction styles among STEM pre-service teachers.

An independent-samples *t*-test was conducted to examine whether gender influences the combined expression of interpersonal relationship patterns and classroom interaction styles among STEM pre-service teachers. Levene’s test for equality of variances was not statistically significant ($F = 1.963, p = .163$); therefore, the assumption of equal variances was met.

Table 6: Independent Samples T-Test

Gender	N	F	Mean (M)	SD	T-value	df	P-value
Male	88	1.963	107.123	11.27			
Female	97		105.579	11.26	.658	183	.163

The results indicated no statistically significant difference between male and female pre-service teachers on the combined measure, $t(183) = 0.658, p = .511$. Male participants ($M = 107.12, SD = 11.27$) recorded slightly higher scores than female participants ($M = 105.58, SD = 11.26$), although the observed mean difference of 1.54 was small. The 95% confidence interval for the difference (-1.80 to 4.88) included zero, and the effect size was negligible (Cohen’s $d = 0.14$), indicating that gender did not meaningfully influence the combined construct.

4.2 Discussion

The findings of this study provide nuanced insights into gender differences in interpersonal relationship patterns and classroom interaction styles among STEM pre-service teachers in Ghana. Consistent with prior research, female pre-service teachers demonstrated slightly stronger interpersonal relationship patterns, suggesting a greater tendency toward relational engagement and supportive interaction. The observed gender differences in relational engagement may also be interpreted in light of research on emotional and interpersonal competencies among pre-service teachers in Ghana. Previous studies have shown that female pre-service teachers tend to demonstrate higher levels of emotional intelligence, particularly in dimensions related to empathy, emotional regulation, and social awareness (Mintah et al., 2020). These competencies are closely aligned with supportive and relational classroom interaction styles, providing a plausible explanation for the modest gender differences observed in interpersonal relationship patterns in this study. These findings align with earlier studies indicating that female educators often emphasise empathy, collaboration, and relationship-building in classroom contexts (Rathbone et al., 2020; Van Petegem et al., 2005). Within the Ghanaian context, such tendencies may reflect culturally reinforced expectations that associate teaching and nurturing roles with women, particularly in social and educational settings (Akhmetova et al., 2017).

At the dimension level, observed gender differences in classroom interaction styles suggest that male and female pre-service teachers may approach classroom engagement in distinct yet overlapping ways. Female participants scored higher on leadership and understanding dimensions, suggesting a relationally grounded form of leadership that emphasises comprehension and group cohesion. In contrast, male participants scored higher on dimensions such as strictness, dissatisfaction, uncertainty, and admonishing, which may reflect a greater reliance on authority-oriented or control-based interaction strategies. These patterns are consistent with studies that associate male teachers with more directive classroom management styles (Haase, 2010; Martino & Rezai-Rashti, 2012).

However, it is important to note that the effect sizes for these differences ranged from small to moderate, indicating that gender accounts for only a portion of the variability in classroom interaction behaviours. Notably, the absence of significant gender differences in the combined measure of interpersonal relationship patterns and classroom interaction styles suggests that overall interactional competence among STEM pre-service teachers is not strongly determined by gender. This finding is further reinforced by the logistic regression results, which showed that none of the classroom interaction dimensions reliably predicted gender. Together, these results suggest that while gender may shape specific interactional tendencies, it does not define a consistent or deterministic interactional profile among pre-service teachers.

From a theoretical perspective, these findings support the combined application of Social Role Theory and Communities of Practice Theory. Social Role Theory helps explain why certain gendered interaction patterns persist at the dimension level, as pre-service teachers may draw on socially learned expectations when engaging in classroom interactions. At the same time, Communities of Practice Theory offers insight into how professional socialisation within teacher education programmes may moderate these tendencies by promoting shared norms, pedagogical practices, and interactional expectations. The convergence of interaction styles observed in the combined measure suggests that participation in teacher education communities may reduce the salience of gender over time.

Overall, the findings highlight the importance of focusing on teacher education practices that promote inclusive, reflective, and participatory classroom environments rather than attributing interactional competence primarily to gender. By providing structured opportunities for collaboration, role-sharing, and reflective practice, teacher education programmes may play a critical role in shaping balanced and equitable interaction styles among future STEM teachers.

5.0 Conclusion

This study examined the influence of gender on interpersonal relationship patterns and classroom interaction styles among STEM pre-service teachers in Ghana. The findings indicate that gender differences exist at the level of specific relational and interactional dimensions. Female pre-service teachers demonstrated slightly stronger interpersonal relationship patterns and higher scores on leadership and understanding dimensions. In contrast, male pre-service teachers recorded higher scores on selected control-oriented interaction dimensions, including strictness, dissatisfaction, and admonishing. However, when interpersonal relationship patterns and classroom interaction styles were combined into a single construct, no statistically significant gender difference was observed.

Furthermore, classroom interaction dimensions did not reliably predict gender. These findings suggest that although gender may shape particular interactional tendencies, overall interactional competence among STEM pre-service teachers is not strongly determined by gender alone. From a theoretical perspective, the results support the relevance of Social Role Theory in explaining dimension-level gendered interaction tendencies, while also highlighting the role of Communities of Practice in moderating these tendencies through professional socialisation within teacher education programmes. Participation in shared pedagogical practices and classroom communities contributes to the convergence of interaction styles among male and female pre-service teachers.

Overall, the study underscores the importance of focusing on inclusive and reflective teacher education practices that promote equitable participation and collaborative engagement, rather than attributing classroom interaction effectiveness primarily to gender. Strengthening pedagogical approaches that emphasise role-sharing, reflective practice, and inclusive classroom management may contribute to the development of balanced and adaptive interaction styles among future STEM teachers in Ghana.

5.1 Recommendation

Based on the findings of this study, several recommendations are proposed to support inclusive and equitable classroom interaction among STEM pre-service teachers in Ghana. First, there is a need to integrate gender-sensitive pedagogical training into STEM teacher education programmes. Teacher education curricula should explicitly address classroom interaction patterns, role distribution, and participation equity. Incorporating structured learning activities such as role rotation, collaborative leadership tasks, and guided reflection will enable pre-service teachers to recognise and manage implicit gendered interaction tendencies, thereby fostering more inclusive classroom environments.

Second, strengthening reflective practice on classroom interaction and professional identity is essential. Pre-service teachers should be supported to engage in systematic reflection on their interaction styles through strategies such as peer observation, reflective journals, and supervised teaching practice. These reflective processes will help them critically examine their behaviours and develop balanced interaction strategies that encourage equitable student participation.

Finally, it is important to promote inclusive classroom management approaches during teaching practice. Teaching practice supervision should not only focus on content delivery but also emphasise interactional competence. Supervisors and mentors should provide targeted feedback on classroom communication, student engagement, and interaction styles. Such support will help pre-service teachers develop adaptive, learner-centred approaches that enhance participation and inclusivity in STEM classrooms.

5.2 Implications

5.2.1 Implications for Educational Policies

The findings suggest that gender equity in STEM education policy should extend beyond access and representation to encompass the interactive and relational dimensions of teaching and learning. Policymakers should support teacher education frameworks that promote gender-sensitive pedagogical practices and encourage equitable participation within classroom interactions. Embedding interactional competence into national teacher education standards may help ensure that future STEM teachers are prepared to manage diverse and inclusive classrooms.

5.2.2 Implications to Educational Practices

For teacher educators and institutions, the results highlight the importance of creating learning environments that model inclusive interaction practices. Classroom activities that encourage collaboration, shared leadership, and respectful dialogue can reduce the salience of gendered interaction patterns. Emphasising professional socialisation through collaborative learning and reflective engagement may further support the development of adaptive interaction styles among STEM pre-service teachers.

5.2.3 Implications to Educational Theories

The study contributes to theoretical discussions by demonstrating how Social Role Theory and Communities of Practice Theory can be applied jointly to understand gendered interaction patterns in teacher education. While Social Role Theory helps explain dimension-level gender tendencies, Communities of Practice Theory provides insight into how professional socialisation can moderate these tendencies over time. This integrated perspective underscores the importance of considering both social

expectations and learning contexts when examining gender dynamics in educational settings.

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