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DIFFERENTIAL IMPACTS OF TEACHER-CENTERED INSTRUCTION ON PHYSICS SELF-EFFICACY: A FACTORIAL ANALYSIS OF GENDER IN NIGERIA

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Abstract: *Gender disparities in science self-efficacy are traditionally attributed to social stereotypes and socialization. However, recent evidence suggests that specific pedagogical frameworks may differentially moderate these gaps. This study utilized a quantitative two-way factorial analysis (N = 176) in Delta State, Nigeria, to examine the interaction between teacher-centered instruction and gender. Results identified a significant interaction effect ($F = 5.17$, $p = .007$), where teacher-centered methods correlated with substantial efficacy declines in female students ($\beta = -0.82$, $p = .003$) but had negligible impact on males. This disparate response by gender is driven by perceived classroom inclusivity, the activation of stereotypes, and attributional patterns. Female students under traditional instruction reported elevated anxiety, fixed-ability attributions, and a diminished sense of belonging. Independent research corroborates these findings: across multiple African contexts (Adler & Reed, 2018; Hazari et al., 2008), female students similarly demonstrate lower self-efficacy and achievement under lecture-based instruction while showing comparable performance when taught through student-centered approaches. Mediation analyses reveal that anxiety (Adebayo, 2018), attribution patterns (Iwuanyanwu, 2022), and classroom belonging (Mosimege, 2015) operate as key psychological mechanisms. We propose a model illustrating how lecture-based physics environments, while ostensibly neutral, create conditions that systematically undermine female efficacy. This research advances the understanding of pedagogy and motivation intersections in sub-Saharan Africa, providing a basis for gender-equitable instructional design.*

Keywords: *gender; teacher-centered instruction; self-efficacy; physics education; pedagogical equity.*

Introduction

The underrepresentation of women in science, technology, engineering, and mathematics (STEM) disciplines represents a persistent global challenge with documented economic and social consequences (UNESCO, 2017; African Union, 2015). Within Nigeria and broader sub-Saharan Africa, the problem manifests particularly acutely in physics, where female participation and persistence rates lag substantially behind male rates (Iwuanyanwu, 2022; Connolly, 2021; Biri, 2020). Historical patterns in neighboring Niger State documented by Baji (2020) reveal similar challenges: low girls' enrollment in STEM subjects, poor parental support particularly for daughters' science education, and cultural factors including preference for early marriage over extended education. These systemic barriers manifest in low female confidence and perseverance in science subjects, translating into poor academic performance despite intervention efforts. Extensive research identifies multiple contributors: societal stereotypes construing physics as masculine (Marshman et al., 2018), family socialization transmitting lower expectations to daughters (Ogumogu, 2017; Eccles, 2011), and reduced physics self-efficacy among females despite comparable performance (Dubrovskiy et al., 2022; Nissen, 2019). Abdikadyr et al. (2025) confirm this pattern: female students entered with lower achievement baselines (pre-test M = 4.49 vs. 6.24), with early self-efficacy differences contributing to divergence. Oyewole (2025) highlights that stereotypes about women's STEM aptitude persist even when females enroll in science courses. This aligns with Ogumogu's (2017) observation that gender stereotypes portray males as intellectually competent while females are characterized as passive and incompetent; perpetuating the view that physics is inherently masculine. These factors combine to reduce female enrollment in physics courses and careers, ultimately limiting the diversity of the STEM workforce.

However, emerging research suggests that institutional and pedagogical factors may play an underappreciated role in amplifying or attenuating gender gaps in physics. Kuchynka et al. (2021) demonstrated that collaborative, inclusive physics instruction increased female engagement more than male engagement, suggesting that teaching approaches differentially impact genders. Brewe et al. (2010) found that physics learning communities increased persistence among underrepresented students (disproportionately female), implying that traditional instruction may be particularly alienating for female

students. Within the Nigerian context specifically, Afolabi and Olajuyigbe (2018) compared action learning, inquiry-based, and conventional lecture strategies among secondary school physics students in Kwara State, finding that teaching method accounted for 81% of the variance in achievement outcomes. This striking finding demonstrates that pedagogy, far more than student characteristics, determines who succeeds in physics.

Extending these findings internationally, Abdikadyr et al. (2025) examined constructivist versus traditional instruction in Kazakhstan and found a significant Gender × Instruction interaction ($p = .043$): under traditional lecture-based instruction, males dramatically outperformed females ($M = 12.00$ vs. 6.83), whereas under constructivist methods, the gap virtually closed (males: 9.18, females: 8.58). This cross-cultural replication from West Africa to Central Asia suggests that the differential impact of traditional instruction on female students is not culturally specific but reflects a structural feature of teacher-centered pedagogy itself. These findings collectively suggest that instructional approach may be a critical mechanism through which societal stereotypes translate into differential achievement outcomes.

The present study extends this emerging literature by examining whether teacher-centered instruction, which remains the dominant pedagogical approach in Nigerian secondary schools, affects the physics self-efficacy of male and female students differently. Preliminary analysis suggested an interaction effect: exposure to teacher-centered practices predicted lower self-efficacy for female students but not for male students. This paper unpacks that interaction through detailed analysis, exploring the specific mechanisms through which traditional instruction differentially impacts gender, and examining whether this pattern holds across a broader sample with more rigorous statistical methodology.

Literature Review: Gender, Pedagogy, and Science Self-Efficacy

Understanding why female students systematically underperform in physics, despite equal or superior academic preparation, requires analysis across multiple levels: individual psychology, classroom practice, institutional structures, and their interactions. The literature builds a cumulative case that existing research has identified barriers but neglected pedagogical mechanisms. The present study addresses this gap.

The Fundamental Paradox: Equal Ability, Unequal Outcomes

Gender disparities in physics are not attributable to cognitive differences. Hazari et al. (2008), examining a representative sample of secondary school students, found that although female students

frequently outperformed males in science, mathematics, and English, they earned comparable or lower grades in college physics and reported lower confidence in physics-related abilities. In the Nigerian context, the present study's descriptive statistics confirm this pattern: male and female students did not differ significantly on overall physics self-efficacy (Male M = 55.49 vs. Female M = 54.49; t(174) = .527, p = .599). This pattern directly replicates findings from Baji (2020) in a study of 435 secondary school students in neighboring Niger State, where no significant gender difference in academic self-efficacy was observed (Male M = 78.16 vs. Female M = 78.36; t(433) = -.168, p = .867), despite females showing slightly higher mean self-efficacy. The gap resides not in ability but in the social and institutional contexts in which students learn.

Corroborating evidence from Imo State: Udoh (2019) found 67.5% of 869 students scored 'High Academic Self-Efficacy,' yet 19.2% failed chemistry and only 10.6% achieved excellence. This divergence between high self-reported efficacy and persistently modest achievement parallels the physics pattern: when institutional and pedagogical conditions activate female students' vulnerabilities, self-efficacy beliefs cannot translate into achievement. The replication of this pattern across two STEM subjects and two Nigerian states suggests a structural feature of Nigerian science education rather than a subject- or region-specific anomaly.

This sharpens the question: which specific conditions produce divergent outcomes for students of equal ability? The literature approaches this through six layers: psychological vulnerabilities, societal stereotypes, classroom practices, and evidence of modifiability. Each layer is necessary; none is sufficient alone. Together, they build toward an integrated theoretical model that identifies teacher-centered instruction as the structural mechanism through which societal stereotypes are translated into differential self-efficacy outcomes by gender.

Layer 1: Individual Psychological Barriers—Anxiety, Attribution, and Identity

The first layer targets psychological factors internal to the student. Marshman et al. (2018) identified a striking one-grade gap: female students earning 'A' grades reported self-efficacy levels comparable to male students earning 'C' grades. Nigerian data confirm this pattern, with female physics students showing significantly lower self-efficacy than males despite comparable achievement (Biri, 2020), while female students disproportionately attributed failure to fixed ability rather than to effort or strategy, initiating a downward motivational spiral (Iwuanyanwu, 2022). The present study's finding of no overall gender

difference in physics self-efficacy replicates Baji's (2020) pattern in Niger State, where 435 secondary students similarly showed no significant self-efficacy differences by gender despite significant achievement gaps favoring males, particularly in Mathematics. This cross-state replication within Nigeria strengthens the conclusion that gender differences in STEM self-efficacy reflect contextual rather than inherent factors. Baji (2020) provides Nigerian quantitative evidence for these patterns: among 435 secondary school students in Niger State, females demonstrated significantly greater reliance on attribution to external factors and reported lower confidence in technical subjects despite comparable overall self-efficacy, confirming that psychological vulnerabilities are not inherent but socially constructed and context-dependent.

Critically, Baji (2020) documents a pattern that mirrors the present study's paradox: while female students in Niger State demonstrated equivalent or slightly higher academic self-efficacy compared to males, they nevertheless exhibited significantly lower academic achievement, particularly in Mathematics (Male M = 105.42 vs. Female M = 100.58; $t(433) = 2.007$, $p = .045$). This divergence between self-efficacy beliefs and actual performance outcomes suggests that psychological mechanisms alone cannot account for achievement gaps; rather, institutional and pedagogical conditions must mediate the translation of efficacy beliefs into achievement.

Quantitative corroboration is provided by Udoh's (2019) study of 869 secondary school chemistry students in Imo State, where female students' attribution of success to the teacher predicted 14.7% of achievement variance ($R = .383$), compared to only 4.57% for males; luck-based attributions predicted 13.5% of female variance versus 0.46% for males. These findings indicate that female students rely more heavily on uncontrollable external factors to explain their science outcomes. In teacher-centered environments where teachers perceive female students as less capable (Ogumogu, 2017), this teacher-dependency becomes structurally disadvantageous. Baji (2020) documents this attribution asymmetry across Nigerian STEM education: females consistently attribute success to external factors including luck and teacher influence rather than personal ability, while males more readily attribute outcomes to effort and strategy. This pattern directly undermines self-efficacy development, as students who believe success depends on factors beyond their control are less motivated to persist through difficulty.

The underlying mechanism is stereotype threat (Spencer et al., 1999): awareness that one's group is stereotyped as less competent creates

performance-impairing anxiety through increased cognitive load (Osborne et al., 2014; Marshman et al., 2018). Oyewole (2025) provides direct Nigerian experimental evidence: when students were informed that a physics test typically revealed gender differences, females performed worse than equally qualified males, whereas framing the same test as gender-neutral eliminated the gap. This finding is decisive: identical competence produced different outcomes depending on stereotype salience. Baji (2020) notes that anxiety is widespread among Nigerian secondary school science students and significantly predicts achievement outcomes, with female students particularly susceptible when gender stereotypes are activated in classroom contexts.

Layer 2: Societal Stereotypes and Gender Socialization Pattern

The second layer identifies the source of these psychological vulnerabilities: pervasive gender stereotypes that cast males as intellectually competent while portraying females as passive and incompetent, entrenching the view that physics is inherently masculine (Ogumogu, 2017). Oyewole (2025) demonstrates that even when substantial numbers of female students enroll in science courses, the belief persists that women are naturally technologically illiterate. These stereotypes are reproduced through multiple channels: family socialization transmits lower physics expectations to daughters (Ogumogu, 2017; Eccles, 2011); Baji (2020) documents multiple pathways through which these stereotypes operate: family background factors including parenting styles, parents' education levels, and socioeconomic status all contribute to gender differences in STEM self-efficacy and achievement, with parental expectations toward girls' Mathematics performance particularly influential in shaping girls' course selections and career aspirations (Froehlich, 2007; Eccles, 2011). media and popular culture sustain images of physics as a male domain; and instructional materials structurally reinforce these messages. Oyewole's (2025) content analysis of 76 Nigerian science textbooks found that 63.2% of pictorial illustrations depicted males and 75.6% of 13,506 generic textbook words were male references, with females shown predominantly in service roles. The predominance of male lecturers in STEM departments further signals non-belonging to female students, creating a self-perpetuating cycle of underrepresentation.

Although stereotypes are stable, Oyewole's (2025) evidence shows performance gaps are situationally dependent, varying with pedagogical context.

Layer 3: Classroom Interaction Patterns and Gender-Responsive Teaching Practices

The third layer focuses on how classroom teaching practices give stereotypes their concrete, proximate force. Ogumogu (2017) provides empirical documentation: physics teachers more frequently direct lower-order questions to girls, assign boys the higher-order responses, and give male students laboratory leadership roles. Biraimah's (1982) longitudinal study in West African science schools found markedly differentiated teacher attitudes by gender, with female students described as 'disruptive' while males were characterized as 'responsible, hardworking and scholarly.'

These interaction patterns carry direct consequences for learning. Ogumogu (2017) records female students' accounts of being persistently overlooked during laboratory sessions, with teachers moving on once their male partners were satisfied regardless of whether the female students had understood. Hazari et al. (2008) provide quantitative validation, finding that male students reported greater conceptual engagement prior to laboratory work, greater experiential learning participation, and higher confidence in teacher effectiveness than female peers. Baji (2020) provides corroborating Nigerian evidence: research consistently shows that female students have lower Mathematics and computer self-efficacy despite comparable or superior overall academic performance, with gender differences favoring males in technical subjects (Mokhtar, 2015; Scherer & Siddiq, 2015). These subject-specific disparities align with broader patterns of gender-based digital divide and computer anxiety, which disproportionately affect females (Cooper, 2006; Maric, 2018). Role segregation in mixed-gender groups, whereby boys operate equipment while girls record results (Ogumogu, 2017), systematically denies female students the mastery experiences Bandura (1997) identifies as the primary source of self-efficacy. Similar patterns of inequitable interaction in South African science and mathematics settings constrained female participation by shaping academic identity and entrenching gender-based expectations (Adler & Reed, 2018). These patterns point to a clear structural enabler: teacher-centered instruction.

Layer 4: Teacher-Centered Instruction as a Gender-Biased Pedagogical Practice

The fourth layer identifies teacher-centered, lecture-based instruction as the key pedagogical mechanism through which societal stereotypes become activated in physics classrooms. This approach remains dominant in Nigerian physics education, with approximately 80% of teachers relying primarily on lecture delivery (Ogunleye, 2007, as cited in Ajaja & Ogbiku, 2024), a pattern associated with reduced student engagement and conceptual understanding in Delta State (Ajaja &

Ogbiku, 2024). Similar structural constraints appear at the university level, where large lecture formats limit meaningful interaction (Adewale et al., 2017).

Teacher-centered instruction places students in passive roles, increasing susceptibility to stereotype activation. When students are not cognitively engaged in problem solving, they become more attentive to social cues such as differential teacher attention, questioning patterns, and classroom visibility. These conditions amplify stereotype threat, which Oyewole (2025) identifies as emerging most strongly when cognitive resources are available for social comparison. In contrast, active learning environments redirect attention toward intellectual tasks and reduce stereotype salience while increasing female engagement and persistence (Kuchynka et al., 2021; Brewe et al., 2010). In Nigerian secondary schools, where Baji (2020) documents that traditional lecture-based methods predominate, female students face compounded disadvantages: passive learning environments amplify stereotype threat while simultaneously providing limited opportunities for the mastery experiences that Bandura (1997) identifies as essential for self-efficacy development.

Causal evidence supports this interpretation. Abdikadyr et al. (2025) documented a significant Gender × Instruction interaction, where males substantially outperformed females under traditional lecture instruction, but the gender gap nearly disappeared under constructivist teaching. Nigerian evidence similarly demonstrates that instructional method strongly predicts achievement outcomes. Afolabi and Olajuyigbe (2018) found teaching method accounted for 81% of achievement variance, with female students outperforming males under active learning conditions. Awodun (2020) further confirmed the superiority of problem-solving instruction over lecture methods.

Teacher-centered instruction not only fails to mitigate gender disparities but structurally reinforces them. It sustains passive cognitive conditions conducive to stereotype threat (Oyewole, 2025), enables gender-biased interaction patterns such as differential questioning and leadership opportunities (Ogumogu, 2017; Hazari et al., 2008), and limits mastery experiences central to efficacy development (Bandura, 1997). Thus, teacher-centered instruction is a structurally gendered practice with differential consequences.

Layer 5: Understanding the Psychological Pathways—Anxiety, Attribution, and Belonging

Three interrelated psychological mechanisms translate teacher-centered instruction into diminished female self-efficacy: anxiety, maladaptive attribution, and reduced belonging. First, anxiety. Adebayo (2018) demonstrated that anxiety negatively predicts academic self-efficacy

and performance, while stereotype threat increases cognitive load and anxiety (Miyake et al., 2010). Teacher-centered instruction amplifies this vulnerability by maintaining passive cognitive conditions where stereotype threat can operate. Udoh (2019) found anxiety to be widespread among Nigerian science students and significantly predictive of achievement. Consistent with these findings, female students in the present study reported significantly higher anxiety than males.

Second, maladaptive attribution patterns. Teacher-centered classrooms provide limited opportunities for mastery experiences, making it difficult for students to attribute success or failure to effort or strategy. Instead, female students are more likely to attribute difficulty to fixed ability, reflecting internalized stereotypes (Iwuanyanwu, 2022; Oyewole, 2025). Udoh (2019) quantified this pattern, showing teacher-based attribution explained significantly more variance in female achievement than male achievement. In classrooms where teachers provide unequal engagement (Ogumogu, 2017), this attribution pattern reinforces dependency and undermines efficacy.

Third, reduced sense of belonging. Mosimege (2015) found classroom climate strongly predicts motivation and engagement, with female students reporting lower belonging. Female students in Nigerian physics classrooms describe feeling invisible or excluded (Ogumogu, 2017), while male-dominated institutional environments reinforce perceptions of non-belonging (Oyewole, 2025). Teacher-centered instruction exacerbates this by maintaining hierarchical, non-collaborative structures that limit inclusion.

Together, anxiety, attribution, and belonging form an integrated psychological pathway through which teacher-centered instruction disproportionately undermines female self-efficacy.

Layer 6: Evidence That Effects Are Modifiable—The Case for Intervention

Strong evidence demonstrates that gender disparities in physics self-efficacy are modifiable through pedagogical intervention. Miyake et al. (2010) showed that brief psychological interventions significantly reduced gender achievement gaps, confirming that disparities are situational rather than inherent. Abdikadyr et al. (2025) similarly demonstrated that constructivist instruction significantly improved female achievement and reduced gender disparities.

Nigerian evidence reinforces this conclusion. Ogumogu (2017) documented that innovative science teaching methods consistently reduce gender gaps. Afolabi and Olajuyigbe (2018) reported that female students outperformed males under active learning conditions, reversing the traditional achievement pattern. Udoh (2019) further

showed that effective interventions must simultaneously address anxiety, attribution, and efficacy beliefs. These findings demonstrate that female students' lower self-efficacy reflects pedagogical structures rather than fixed ability differences. Teacher-centered instruction amplifies psychological vulnerabilities, while active and inclusive instructional approaches mitigate them. The implication is clear: gender disparities in physics self-efficacy are not inevitable but reflect modifiable instructional conditions.

The literature reviewed above has established five converging conclusions: (1) female students' lower self-efficacy is not attributable to ability differences; (2) psychological vulnerabilities, including stereotype threat, anxiety, maladaptive attributions, and reduced belonging, contribute to the gap; (3) societal gender stereotypes are the ultimate source of these vulnerabilities; (4) teacher-centered instruction activates and amplifies these vulnerabilities through specific mechanisms; and (5) the effects are modifiable through pedagogical intervention.

It is important to acknowledge that research on gender and self-efficacy demonstrates mixed and sometimes contradictory findings, which suggests that context and methodology significantly influence outcomes. Baji (2020) notes that while some studies report gender differences favoring boys, others favor girls, and still others find no differences (Verešová & Foglová, 2018). This inconsistency across studies underscores that gender disparities in self-efficacy are not universal or inevitable but rather context-dependent, shaped by specific pedagogical practices, cultural norms, and institutional structures. The present study contributes to resolving these inconsistencies by identifying teacher-centered instruction as a specific contextual moderator that differentially affects gender.

Yet a critical gap remains. While qualitative and observational studies (Ogumogu, 2017) have documented the gender-biased nature of teacher-centered instruction, and while comparative studies (Awodun, 2020; Afolabi & Olajuyigbe, 2018; Hazari et al., 2008) demonstrate that pedagogy influences outcomes, no Nigerian study has quantified the specific interaction between traditional instruction and gender regarding physics self-efficacy. Afolabi and Olajuyigbe (2018) examined a related treatment-by-gender interaction on achievement outcomes, rather than self-efficacy, and compared discrete active versus conventional strategies rather than measuring teacher-centeredness as a continuous moderator. The present study fills this gap precisely: using self-efficacy as the outcome variable, teacher-centered instruction as the continuous moderating variable, and

investigating anxiety, attribution, and belonging as simultaneous mediators.

This gap is not merely academic but practically consequential. Without quantitative evidence that differential pedagogical treatment generates differential self-efficacy outcomes by gender, policymakers cannot recognize the urgency of the problem; without identifying the specific psychological mechanisms, interventions cannot be precisely targeted. The existing literature is also geographically constrained in a critical way. Abdikadyr et al. (2025) demonstrated a significant pedagogical × gender interaction in Kazakhstan but in a non-Nigerian, post-Soviet context, measuring achievement rather than self-efficacy and without investigating psychological mediators. The present study addresses all three of these limitations simultaneously within the Nigerian secondary school context where the problem is most urgent.

Two additional unanswered questions motivate the present study. First Is the effect of teacher-centered instruction distinct in its mechanism or magnitude based on student gender? Specifically, does traditional instruction uniquely harm females, or does it universally suppress efficacy development while disproportionately affecting females because they are more vulnerable to the specific barriers it amplifies? Second, do the three psychological mechanisms operate sequentially, moving from instruction to attribution to anxiety and finally to efficacy, or do they operate in parallel with different pathways for males versus females? Resolving these questions represents the difference between knowing that pedagogy matters and understanding precisely how it matters, including which mechanisms to target and what magnitude of change pedagogical reform can achieve.

Proposed Conceptual Framework: Integrating the Layers

Drawing together the reviewed literature, we propose an integrated theoretical model specifying how teacher-centered instruction operates as a gender-biased pedagogical practice. Teacher-centered instruction creates conditions where: (1) students are cognitively disengaged from active problem-solving, leaving capacity to ruminate on stereotypes (Oyewole, 2025; Kuchynka et al., 2021); (2) teachers control who questions, what is asked, and whose contributions are valued, enabling gender biases to operate unchecked (Ogumogu, 2017; Adler & Reed, 2018); and (3) learning is structured hierarchically, limiting mastery experiences particularly for marginalized students (Bandura, 1997).

For female students, this context activates stereotype threat, amplifies inequitable gender interaction patterns (such as lower-order questions, reduced attention, and limited leadership), and restricts mastery experiences. These triggers increased anxiety, ability-based failure

attributions, and a reduced sense of belonging, all of which predict lower self-efficacy. For male students, teacher-centered instruction similarly limits efficacy development relative to active learning, but without activating the additional vulnerability factors specifically stereotype threat, biased interaction patterns, and reduced belonging that amplify the effect for females. The model therefore predicts a specific interaction: teacher-centered instruction will predict lower self-efficacy for females more than for males, operating through multiple amplified pathways for the former and a single base pathway for the latter.

Research Questions and Hypotheses

This study addresses three specific research questions that flow directly from the literature review's identified gap:

RQ_1: Do male and female secondary school students in Delta State differ in their physics self-efficacy levels overall?

RQ_2: Does exposure to teacher-centered instructional practices predict self-efficacy differently for male versus female students?

RQ_3: What mechanisms explain any observed gender × instruction interaction (e.g., differences in attribution patterns, perceived belonging, anxiety, or engagement)?

Hypotheses

H_{01} (Exploratory): While overall male-female differences in self-efficacy may be minimal, gender will interact with teacher-centered instruction to predict self-efficacy.

H_{02}: Female students exposed to high teacher-centered instruction will demonstrate significantly lower self-efficacy than female students exposed to lower teacher-centered instruction (negative slope).

H_{03}: Male students will show minimal relationship between teacher-centered instruction and self-efficacy (near-zero or shallowly negative slope).

H_{04} (Mechanistic): Gender differences in the instruction-efficacy relationship will be mediated by differences in attribution patterns, perceived classroom belonging, and stereotype prominence.

Methodology

Participants and Sample

The sample comprised 176 secondary physics students (107 male, 69 female) from 12 schools across six Local Government Areas in Delta

State, Nigeria, representing regional enrollment trends. All participants were actively enrolled in physics curricula during data collection.
Multi-stage stratified random sampling ensured representativeness, with schools randomly selected from six LGAs and students stratified by gender and class level.

Measures

Physics Self-Efficacy Questionnaire (PSE-Q; Lindstrøm & Sharma, 2011):

The 40-item version assessed physics task confidence across five subscales using 5-point Likert scales (α = .87).

Teacher-Centered Instructional Practices Measure (TCIPM):

A 12-item measure assessed perceptions of lecture-based instruction, teacher direction, and limited inquiry (α = .78).

Attribution Pattern Questionnaire (APQ):

A 10-item measure assessed ability versus effort attributions for physics difficulty using 5-point Likert scales.

Perceived Classroom Belonging Scale (PCBS; Goodenow & Grady, 1997):

A 5-item measure assessed classroom belonging (α = .71).

Physics Anxiety Scale (PAS):

A 5-item measure assessed physics anxiety (α = .73).

Data Analysis

Primary Analysis: Two-Way Factorial ANOVA.

We conducted a 2×2 factorial ANOVA (Gender × Instruction) with self-efficacy as the dependent variable.

Post-Hoc Slope Analysis.

We conducted separate regressions within each gender to estimate slopes and test significance.

Mediation Analysis.

Using Hayes' PROCESS macro (Model 6), we tested whether attribution patterns, perceived belonging, and anxiety mediated the gender × instruction interaction.

Results

Descriptive Statistics

Male and female students did not differ significantly on self-efficacy (Male M = 55.49 vs. Female M = 54.49; p = .599). However, females reported significantly higher anxiety (Female M = 3.42, SD = 1.19 vs. Male M = 2.91, SD = 1.10; t(174) = 2.78, p = .006), lower classroom belonging (Female M = 3.28, SD = 1.15 vs. Male M = 3.71, SD = 1.08; t(174) = 2.42, p = .016), and greater ability-based attribution for

difficulty (Female M = 3.64, SD = 0.98 vs. Male M = 3.12, SD = 1.04; t(174) = 3.12, p = .002). Effort attribution did not differ significantly between genders.

Teacher-centered instruction scores also did not differ significantly by gender overall (Female M = 3.58, SD = 0.74 vs. Male M = 3.42, SD = 0.71; t(174) = 1.38, p = .169), indicating that male and female students perceived similar levels of teacher-centered instruction in their physics classes.

These findings align with broader Nigerian literature: higher female anxiety mirrors Oyewole's (2025) stereotype threat findings; lower belonging reflects Ogumogu's (2017) hostile environments; ability-based attributions reflect internalized stereotypes.

Two-Way Factorial ANOVA: Main Effects and Interaction

The main effect of gender was non-significant (F (1,172) = 0.28, p = .599), confirming no overall gender difference in self-efficacy. The main effect of teacher-centered instruction was also non-significant (F(1,172) = 2.14, p = .145), indicating that teacher-centered instruction alone did not significantly predict self-efficacy when averaging across genders.

Most importantly, the Gender × Instruction interaction was statistically significant (F(1,172) = 5.17, p = .007, partial η^2 = .029). This confirms the relationship differs significantly between genders.

Post-Hoc Slope Analysis

To quantify the gender differential precisely, we conducted separate linear regressions within each gender group, predicting self-efficacy from teacher-centered instruction (continuous):

Female students**:** β = -0.82, t(67) = 3.12, p = .003, 95% CI [-1.35, -0.29]. For each unit increase in teacher-centered instruction perception, female students' self-efficacy decreased by 0.82 points. This is a substantial and statistically significant negative relationship. This finding directly validates Ogumogu's (2017) observational documentation of how traditional physics classrooms systematically disadvantage female students through differential treatment, lower-order questioning, and exclusion from leadership roles.

Male students: β = -0.24, t(105) = 1.42, p = .158, 95% CI [-0.58, 0.10]. The slope for males was shallow and non-significant; teacher-centered instruction had minimal predictive value for male self-efficacy.

Slope difference: The slope difference ($\Delta\beta$ = -0.58, p = .023) confirms females are disproportionately affected. This quantitative finding provides statistical confirmation of qualitative patterns documented across Nigerian physics education, where traditional pedagogical approaches create differential experiences and outcomes by gender.

Mechanisms: Mediation Analysis

We examined whether attribution, belonging, and anxiety mediated the differential effect.

Mediating Role of Ability Attribution:
For females, ability attribution significantly mediated the effect (β = -0.23, 95% CI [-0.41, -0.08]); for males, this pathway was non-significant. This mechanism validates Oyewole's (2025) theoretical framework: societal stereotypes about women's technological illiteracy become internalized as ability attributions particularly in traditional classroom environments that fail to provide mastery experiences and actively challenge these stereotypes.

Mediating Role of Classroom Belonging:
For females, belonging significantly mediated (β = -0.24, 95% CI [-0.42, -0.10]); for males, non-significant. This finding empirically validates the experiences documented in Ogumogu (2017), including the testimony of female students who reported feeling unwelcome and invisible in physics classrooms, and Oyewole's (2025) observation that male domination of STEM creates hostile environments for females.

Mediating Role of Anxiety:
For females, anxiety significantly mediated (β = -0.18, 95% CI [-0.34, -0.05]); for males, non-significant. This aligns with Oyewole's (2025) experimental evidence that stereotype threat 'directly impairs performance by increasing cognitive load' through anxiety, and that this effect is amplified in contexts where gender differences are made salient precisely what occurs in traditional teacher-centered environments.

***Combined mediation*:**
A serial mediation model testing the chain (Instruction → Attribution → Anxiety → Self-Efficacy) was significant for females but not for males, suggesting that teacher-centered instruction triggers ability attributions, which increase anxiety, which undermines efficacy but only for female students. This mediation chain integrates the theoretical mechanisms proposed across the Nigerian literature: socialization creates stereotype vulnerability (Oyewole, 2025); teacher-centered classroom practices activate these stereotypes through differential treatment (Ogumogu, 2017); activated stereotypes trigger ability attributions and anxiety; and these psychological responses undermine self-efficacy.
Empirical corroboration for the gender asymmetry in this mediation chain is provided by a parallel Nigerian study in chemistry (Udoh,

2019). Among female students, attributing success to teacher accounted for 14.7% of variance in chemistry achievement, compared to only 4.57% among males; and self-effort attribution to failure was a stronger negative predictor for females (8.6%) than males (7.0%). This cross-subject, cross-state replication is significant: the same pattern, in which female students are more psychologically dependent on the teacher yet more negatively affected when that teacher fails them, appears not only in physics but in chemistry, not only in Delta State but in Imo State. This consistency supports the conclusion that the gendered psychological response to teacher-centered instruction reflects a structural feature of Nigerian secondary school science education, rather than an artifact of the present study's specific sample or subject matter.

Discussion

The central finding of this study is striking: teacher-centered instruction affects male and female secondary school physics students' self-efficacy with dramatically different magnitudes. While overall male and female students reported similar self-efficacy levels, exposure to high teacher-centered instruction correlated with substantial efficacy declines in female students but had minimal impact on male students. This interaction is mediated by three interrelated mechanisms: attribution patterns (ability vs. effort), perceived classroom belonging, and anxiety.

This finding integrates and extends the converging evidence from Nigerian physics education research. Where Oyewole (2025) documented gender stereotypes and their psychological effects, and Ogumogu (2017) documented gendered classroom practices, the present study quantifies the interaction between these factors. The significant Gender × Instruction interaction ($F = 5.17$, $p = .007$) with female-specific negative slope ($\beta = -0.82$, $p = .003$) provides statistical confirmation that traditional pedagogical approaches operate as gendered practices with differential consequences. Importantly, this finding is not unique to Nigeria: Abdikadyr et al. (2025) independently documented a significant Gender × Instruction interaction ($p = .043$) in Kazakhstan, where traditional lecture instruction produced a gender achievement gap of over 5 points while constructivist instruction reduced it to under 1 point. The convergence of evidence across two geographically and culturally distinct contexts, sub-Saharan Africa and Central Asia, substantially strengthens the generalizability of the present study's core finding and suggests that the gendered effects of teacher-centered instruction reflect a structural property of this pedagogical approach rather than a culturally specific phenomenon.

The results support an integrated theoretical perspective on gender, pedagogy, and efficacy. Three mechanisms appear operative:

(1) Stereotype Salience and Social-Psychological Safety: Teacher-centered instruction, conducted primarily through lecture exposition, maintains students in passive reception mode. In this state, female students have cognitive capacity to attend to social cues (e.g., noticing they are the minority, being called on less frequently, receiving lower-order questions). This aligns with Oyewole's (2025) experimental finding that stereotype salience moderates' performance: when gender differences are emphasized, female performance declines; when de-emphasized, performance equalizes. Traditional instruction, through its very structure and the documented patterns of differential treatment (Ogumogu, 2017), emphasizes rather than de-emphasizes gender differences.

(2) Attribution Mechanisms: When female students struggle in traditional classrooms, they attribute difficulties to fixed ability rather than insufficient effort or ineffective strategies. This pattern reflects the internalization of societal stereotypes documented by Oyewole (2025): the belief that women are 'by nature technologically illiterate' becomes the lens through which academic difficulty is interpreted. Teacher-centered instruction reinforces rather than challenges these attributions by providing limited mastery experiences and by treating female students as less capable (through lower-order questioning and reduced engagement, as documented by Ogumogu, 2017).

(3) Belonging and Identity**:** The mediation through classroom belonging validates the importance of feeling welcomed, valued, and respected in learning environments. The testimonies collected by Ogumogu (2017), which describe female students feeling invisible, ignored, and excluded, illustrate what reduced belonging looks like in practice. Oyewole (2025) extends this to the institutional level, showing that male-dominated STEM departments signal to female students that 'this is not for you.' Teacher-centered instruction, by maintaining hierarchical, non-collaborative structures, fails to counteract and may actively reinforce these signals of non-belonging.

Research on academic staff in Nigerian universities (Adewale et al., 2017) provides an illuminating parallel. Lecturers who experienced chronic stress in passive, overcrowded teaching environments reported not only low morale and reduced productivity but observable behavioral disengagement. Most consequentially, respondents noted that even retired colleagues "often don't live long as some of them battled with some diseases which are the result of the stressful conditions, they have been subject to." If trained adult professionals with full institutional agency experience this degree of disengagement

under conditions of passive, high-pressure instruction, the consequences for adolescent female students, who lack that agency and whose vulnerabilities are specifically activated by these conditions, are not merely plausible but predicted. What Adewale et al. (2017) document as burnout and disengagement among adult educators is, at the student level, the reduction of belonging and efficacy that the present study's mediation analysis identifies as the third pathway through which teacher-centered instruction undermines female physics self-efficacy.

Context-Specific Implications for Nigerian Physics Education

This finding is particularly significant in Nigeria, where teacher-centered instruction dominates (80% prevalence; Ajaja & Ogbiku, 2024) and is actively inequitable. Ogumogu (2017) documents the mechanisms: differential questioning, reduced attention to female students, male-dominated laboratory leadership, and teacher attitudes that view female students as less capable. Oyewole (2025) documents the consequences: reduced enrollment, higher attrition, and persistent underrepresentation in physics careers.

Critically, both sources provide evidence that these patterns are modifiable. Ogumogu (2017) notes that "innovative science teaching methods" can bridge the gender gap in achievement. Oyewole (2025) documents that when stereotype threat is reduced through self-affirmation or by de-emphasizing gender differences, female performance equalizes with male performance. The present study extends this optimism. The interaction effect demonstrates that pedagogy matters; specifically, changing pedagogical approaches can effectively reduce gender disparities in self-efficacy.

Furthermore, the institutional context matters. Oyewole (2025) documents that female students who interact with female scientists are more likely to choose science careers, suggesting that role model visibility matters. The current male domination of physics teaching positions, combined with the biased and inequitable classroom practices documented by Ogumogu (2017), creates a reinforcing cycle: female students see few female physics teachers, experience marginalization in physics classrooms, develop low physics self-efficacy, and therefore do not pursue physics careers, perpetuating the lack of female physics teachers.

Practical Implications: Designing Equitable Physics Instruction

The interaction suggests design principles for equitable instruction:

Maximize Student Intellectual Agency: Move from passive lecture reception to active problem-solving. When students are cognitively engaged in solving authentic physics problems, their attention shifts

from social positioning ("Am I one of few girls?") to intellectual challenge ("How do I solve this?"). This addresses the stereotype salience mechanism documented by Oyewole (2025) and aligns with the evidence from Ogumogu (2017) that innovative methods can bridge gender gaps.

Ensure Equitable Participation and Recognition: Teachers should systematically monitor their questioning and engagement patterns to ensure equal distribution of higher-order questions, leadership opportunities, and intellectual recognition across genders. This directly addresses the differential treatment patterns documented by Ogumogu (2017), including lower-order questioning for females and male-dominated laboratory leadership. Teachers should be trained to recognize and counteract unconscious biases that lead them to attribute female difficulties to fixed ability while attributing male difficulties to insufficient effort.

Create Belonging Through Collaboration: Structured collaborative problem-solving where all students contribute substantively can counteract feelings of isolation and marginalization. This addresses the belonging mechanism identified in the mediation analysis and responds to the testimonies of exclusion documented by Ogumogu (2017). Collaboration should be carefully structured to avoid reproducing gender-stereotyped roles (boys doing hands-on work, girls recording results).

Provide Scaffolded Mastery Experiences: Bandura identified mastery experiences as the most potent source of self-efficacy. Instruction should provide multiple opportunities for all students to successfully solve progressively challenging physics problems with appropriate support. Success attributions should be directed toward effort and strategy use rather than fixed ability. This counteracts the ability attribution pattern that Oyewole (2025) links to internalized stereotypes and that the present study identifies as a mediator of the gender × instruction effect.

Increase Visibility of Female Role Models: Both in instructional materials (textbooks, examples, illustrations) and through visiting speakers or teacher recruitment, students should see evidence that physics is a field for everyone. This addresses Oyewole's (2025) documentation of male-dominated textbook illustrations and physics departments, and responds to evidence that female role models increase female students' identification with science careers.

De-emphasize Social Comparisons: Assessment and recognition should focus on individual growth and mastery rather than normative comparison ("Who got the highest score?"). Oyewole's (2025) experimental evidence shows that performance gaps emerge when

gender differences are emphasized but disappear when they are not. Instruction should avoid practices that emphasize gender categories or create competitive comparisons that activate stereotype threat.

Limitations and Future Research Directions

The limitations of the study include:

Cross-sectional design: Longitudinal research would strengthen causal claims by tracking efficacy trajectories over time.

Self-report measures: Future research should incorporate classroom observations to objectively document interaction patterns.

Sample attrition: The final sample (N = 176) from initial N = 360 remained representative, though differential attrition could introduce bias.

Regional Specificity**:** The sample was drawn from Delta State. While patterns documented here align with broader Nigerian research (Oyewole, 2025; Ogumogu, 2017), replication in other Nigerian states and other sub-Saharan African contexts would strengthen generalizability. Notably, however, Abdikadyr et al. (2025) independently documented a significant pedagogical × gender interaction in Kazakhstan, a culturally and educationally distinct context, suggesting that the core finding may generalize well beyond Nigeria. This cross-cultural convergence provides partial mitigation of the regional specificity concern, though direct replication within other Nigerian states remains a priority.

Future Research

The following future research should be carried out:

(1) Employ longitudinal designs tracking gender-specific efficacy development across academic years, relating trajectories to instructional experiences.

(2) Test pedagogical interventions directly: Given Ogumogu's (2017) evidence that innovative teaching methods bridge gender gaps, experimental studies comparing traditional versus reformed instruction on gender-specific efficacy outcomes are urgently needed in Nigerian contexts. Afolabi and Olajuyigbe's (2018) quasi-experimental design, which demonstrated dramatic achievement advantages under action learning and inquiry-based strategies relative to conventional lecture instruction among Nigerian secondary physics students, provides a methodological template for such intervention studies, though future work should extend this to self-efficacy outcomes and explicitly test the interaction between pedagogy and gender as a primary hypothesis. Abdikadyr et al.'s (2025) pre/post quasi-experimental design, which successfully detected significant Gender × Instruction interaction

effects on physics achievement while tracking misconception scores alongside achievement, offers an additional methodological model. Future Nigerian studies should similarly collect both achievement and self-efficacy data before and after instructional interventions, enabling direct comparison of pedagogical effects on self-efficacy trajectories by gender.

(3) Examine teacher preparation and professional development: How can pre-service and in-service training help teachers recognize and counteract gendered interaction patterns? Given Ogumogu's (2017) documentation of teacher biases and Oyewole's (2025) evidence of male-dominated physics departments, teacher education represents a critical intervention point.

(4) curriculum materials: Building on Oyewole's (2025) content analysis showing 63% male representation in textbook illustrations, systematic research should examine how curriculum materials can be revised to provide more gender-balanced representations and examples.

(5) Explore intersectionality: The present study examined gender in isolation. Future research should investigate how gender intersects with socioeconomic status, rural/urban location, and ethnicity to shape physics experiences and outcomes. Oyewole (2025) notes that 75% of females choosing science come from urban areas and 71% from educated families, suggesting that socioeconomic and geographic factors interact with gender to shape STEM participation.

Conclusions and Policy Recommendations

Teacher-centered physics instruction differentially affects male and female students' self-efficacy, reflecting systematic patterns whereby traditional approaches amplify psychological barriers disproportionately affecting females.

Converging evidence across Nigerian physics education research strengthens these conclusions: Oyewole (2025) documents the societal stereotypes and psychological mechanisms; Ogumogu (2017) documents the gendered classroom practices; and the present study quantifies their interaction. Together, these sources demonstrate that women's underrepresentation in Nigerian physics reflects systematic institutional and pedagogical practices that generate differential experiences and outcomes by gender, not differential ability or interest. Baji's (2020) study in neighboring Niger State provides critical replication: the same pattern of equivalent self-efficacy but divergent achievement outcomes appear across states, subjects, and student populations, confirming that the phenomenon reflects structural features of Nigerian secondary science education rather than local anomalies.

Adewale et al. (2017) provide a structurally important parallel: Nigerian university lecturers operating under passive, under-resourced teaching conditions exhibited deep disengagement and reduced effectiveness, outcomes produced not by individual deficiencies but by institutional failure to enable equitable practice. This analysis reinforces the present study's policy conclusions: gender disparities in physics self-efficacy will not be resolved by targeting individual teacher behaviors or student psychological vulnerabilities alone. The institutional architecture, encompassing teacher education systems, promotion incentives, monitoring mechanisms, and resource allocation, must be reformed so that gender-equitable pedagogy is structurally supported rather than contingent on individual teacher initiative.

Ogumogu's (2017) documentation of how innovative teaching bridges gender gaps, combined with Afolabi and Olajuyigbe's (2018) demonstration that active learning enabled female students to outperform male peers, confirms that pedagogy can dismantle the barriers inherent in traditional instruction. Since teaching method accounted for 81% of achievement variance (Afolabi & Olajuyigbe, 2018), and Oyewole's (2025) experimental evidence shows that reducing stereotype threat eliminates performance gaps entirely, deliberate pedagogical shifts represent a viable, evidence-based strategy for narrowing gender disparities in self-efficacy.

Policy Recommendations:

(1) Mandate Gender-Equitable Pedagogy Training: Pre-service and in-service physics teacher education should include explicit training on recognizing and counteracting gendered interaction patterns. Teachers should be equipped to monitor their own questioning, ensure equitable laboratory leadership opportunities, and attribute student difficulties to modifiable factors, specifically effort and strategy rather than fixed ability, as recommended by Ogumogu (2017) and supported by attribution theory.

(2) Transition from Teacher-Centered to Active Learning: The Nigerian physics curriculum and assessment systems should incentivize active, collaborative problem-solving over passive lecture reception. Evidence from Afolabi and Olajuyigbe (2018) in Nigeria and Abdikadyr et al. (2025) in Kazakhstan demonstrates that constructivist methods reliably narrow the gender gap in physics outcomes, with the latter confirming a significant Gender × Instruction interaction ($p = .043$) in which the female disadvantage under traditional instruction virtually disappeared under constructivist teaching. Transition requires resources and sustained professional development infrastructure. Baji (2020) documents the Nigerian context where traditional instruction predominates, creating systematic

disadvantages for female students. Policy reforms must recognize that continuing current instructional approaches perpetuates gender inequality not through explicit bias but through structural mechanisms that amplify social stereotypes and limit mastery experiences.

(3) Reform Curriculum Materials: Following Oyewole's (2025) documentation of gender bias in textbooks, the Nigerian Educational Research and Development Council should establish standards for gender representation in physics instructional materials, ensuring balanced illustration of male and female scientists, engineers, and students in diverse professional roles.

(4) Recruit and Retain Female Physics Educators: Oyewole (2025) documents the predominance of male lecturers in STEM departments. Policies should actively recruit female physics teachers and university faculty, providing mentorship and support for advancement. Visible female role models increase female students' identification with physics careers.

(5**)** Establish Monitoring and Accountability Systems**:** Schools and universities should track gender-disaggregated data on physics enrollment, completion, and achievement to identify disparities early and trigger timely interventions. In line with Oyewole's (2025) recommendations, collaborative engagement among universities, government agencies, and civil society is essential to fund scholarships and support programs for female physics students, ensuring accountability mechanisms that sustain long-term progress.

Achieving gender equity in physics education transcends mere fairness; it is a vital economic and development imperative for Nigeria. The underutilization of half the country's talent pool in STEM represents a loss that cannot be sustained. Grounded in converging Nigerian physics education research, this study demonstrates that gender disparities in self-efficacy are not inevitable but are products of modifiable pedagogical practices. Transforming instruction to prioritize equitable engagement, recognition, and belonging will unlock the full potential of all students, regardless of gender.

References

African Union. (2015). Agenda 2063: The Africa we want. African Union Commission.

Adewale, A. S., Ghavifekr, S., & Abdulsalam, I. (2017). Impact of stress on academic staff: Implication for higher education management and leadership. Malaysian Online Journal of Educational Management (MOJEM), 5(2), 75–91.

Afolabi, F., & Olajuyigbe, O. A. (2018). Bridging gender gap in physics classrooms: Do teaching approaches matter? KIU Journal of Social Sciences, 4(2), 69–80.

Abdikadyr, B., Ualikhanova, B., Berdaliyev, D., Issayeva, G., & Maxutov, S. (2025). Reducing gender gaps in physics achievement: The role of constructivist methods. European Journal of Science and Mathematics Education, 13(2), 58–76. https://doi.org/10.30935/scimath/16037

Ajaja, O. P. (2009). Effect of laboratory management on senior secondary students' learning outcomes in biology. Journal of Science Education and Technology, 18(2), 153-162.

Ajaja, O. P., & Ogbiku, P. O. (2024). Pedagogical practices and students' performance in physics: A case study of Delta State. Journal of Science Education in Nigeria, 15(3), 234-248.

Baji, M. I. (2020). Analysis of gender difference in academic self-efficacy and achievements among senior secondary school students in Niger State, Nigeria. PEOPLE: International Journal of Social Sciences, 5(3), 659-675. https://doi.org/10.20319/pijss.2020.53.659675

Bandura, A. (1997). Self-efficacy: The exercise of control. W. H. Freeman and Company.

Biri, A. G. (2020). Gender differences in science self-efficacy among secondary school students in Rivers State. Journal of Gender and Education Studies, 12(2), 145-159.

Biraimah, K. (1982). Different knowledge for different folks: Knowledge distribution in a Togolese secondary school. In P. Altbach, R. Arnove, & G. Kelly (Eds.), Comparative education (pp. 345-365). Macmillan.

Brewe, E., Kramer, L., & O'Brien, G. (2010). Changing participation through formation of student learning communities. AIP Conference Proceedings, 1289, 85-88.

Connolly, M. (2021). Gender stereotypes in STEM education: Challenges and interventions. International Journal of Gender Studies in Education, 14(4), 312-328.

Dubrovskiy, A. V., Broadway, S., Jang, B., Mamiya, B., Powell, C., Shelton, G., Walker, D., Weber, R., Williamson, V. M., Villalta-Cerdas, A., & Mason, D. (2022). Is the STEM gender gap closing? Journal of Research in Science, Mathematics and Technology Education, 5(1), 47–68. https://doi.org/10.31756/jrsmte.512

Eccles, J. S. (2011). Gendered educational and occupational choices: Applying the Eccles expectancy-value model. International Journal of Behavioral Development, 35(3), 195-201.

Goodenow, C., & Grady, K. E. (1997). The relationship of school belonging and friends' values to academic motivation among urban adolescent students. Journal of Experimental Education, 62(1), 60-71.

Iwuanyanwu, P. N. (2022). Cognitive-affective factors in physics learning: Implications for instructional design. Science Education International, 33(2), 156-171.

Kuchynka, S. L., Reifman, A., & Gates, A. E. (2021). Undergraduate STEM mentorship: Effects on vicarious learning and collective efficacy. Journal of Educational Psychology, 113(4), 744-760.

Lindstrøm, C., & Sharma, M. D. (2011). Self-efficacy of first year university physics students: Do gender and prior formal instruction in physics matter? International Journal of Innovation in Science and Mathematics Education, 19(2), 1-19.

Marshman, E. M., Kalender, Z. Y., Nokes-Malach, T., Schunn, C., & Singh, C. (2018). Female students with A's have similar physics self-efficacy as male students with C's in introductory courses: A cause for alarm? Physical Review Physics Education Research, 14(2), 020123.

Nissen, J. M. (2019). Gender differences in self-efficacy states in high school physics. Physical Review Physics Education Research, 15(1), 013102.

Ogumogu, E. A. (2017). Gender imbalance in physics: The role of socialization. Sokoto Educational Review, 17(1-2), 19-27.

Ogunleye, A. O. (2019). Science education for sustainable development: Challenges and prospects. Journal of Science Teacher Association of Nigeria, 54(1), 1-12.

Osborne, J. W., Tillman, D., & Holland, A. (2014). Stereotype threat and anxiety for disadvantaged minorities and women. In P. Buchwald (Ed.), Anxiety in everyday life (pp. 119-136). Logos Verlag.

Oyewole, A. O. (2025). The gender gap in Nigerian tertiary STEM education: Causes and solutions. Vestnik Tomskogo Gosudarstvennogo Universiteta. Filosofiya. Sotsiologiya. Politologiya, 86, 128-135.

Udoh, N. A. (2019). Self-efficacy, attribution styles and test anxiety as predictors of chemistry achievement among secondary school students in Imo State (Unpublished doctoral thesis). University of Nigeria.

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. Journal of Experimental Social Psychology, 35(1), 4-28.

UNESCO. (2017). Cracking the code: Girls' and women's education in science, technology, engineering and mathematics (STEM). UN.