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Gender Differences in Teachers' Improvisation Knowledge, Implementation Challenges, and Pedagogical Impact

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Abstract

In places where resources are limited, teachers often need to improvise to teach science. This study investigates gender disparities in primary school teachers' ability to employ improvisation approaches in scientific instruction in the Zabzugu District of Ghana. A quantitative descriptive survey methodology was employed to choose 196 primary school teachers by stratified random sampling. Data were gathered using a structured questionnaire and subsequently analysed using descriptive statistics and independent-samples t-tests. The results showed that both males and females were about equally familiar with improvisation techniques. However, male teachers were far more excited about improvisation, while female teachers reported using improvised materials more often to teach science topics. There were no major differences between male and female teachers in the problems they encountered during implementation, but male teachers consistently believed that improvisation had a greater effect on student learning and engagement. These findings underscore a nuanced interaction among gender, perception, and practice in improvisation, emphasising the need for customised professional development programmes to address gender-specific strengths and challenges. The study advocates gender-sensitive teacher training and educational policy to improve science education in resource-limited settings.

Keywords: teachers' improvisation knowledge, teachers' implementation challenges, teachers' pedagogical impact, gender differences, primary school teachers

1. Introduction

Teaching children science is very important for helping them learn how to think critically, be creative, and solve problems. It also sets the stage for future scientific literacy and technological progress (Sukma, Raharjo, & Cahyono, 2022). But teachers worldwide often struggle to teach science well, especially in classes with limited resources. Improvisation, in which teachers make instructional aids from readily available materials, is one way that has gained popularity for overcoming resource shortages (Okori & Jerry, 2017).

Research has revealed that gender can substantially influence teachers' approaches to and implement improvisation strategies in science teaching. This study investigates gender disparities in primary school teachers' ability to employ improvisation approaches in science teaching in the Zabzugu District of Ghana. It focuses on their understanding of improvisational methodologies, obstacles, and the potential influence on educational achievement.

There are several reasons why it is important to know how males and females improvise differently. Different ways of improvising can lead to different learning experiences. For example, female teachers generally use storytelling to link scientific ideas to real-life situations, whereas male teachers prefer hands-on demonstrations to provide students with

real-world experience (Sawyer, 2019). Acknowledging and appreciating these methodologies can contest gender stereotypes in science education, rendering it more inclusive and attractive to all students (Kgopong & Khalo, 2023). Additionally, comprehending these disparities might enhance the specificity and efficacy of teacher training programmes (Fitria & Sufyarma, 2021) and facilitate more efficient resource distribution within educational institutions. Nonetheless, numerous issues persist in the Ghanaian context concerning gender disparities in improvisation approaches. Traditional gender roles and preconceptions can limit perceptions of suitable methodologies for male and female educators, while unequal access to resources may unintentionally favour strategies predominantly used by male teachers. Both males and females have fewer chances to improve their improvisation skills (Abakah et al., 2022), and in some cultures, female teachers may not be able to do some things because of cultural conventions. Even with these problems, there are ways to use disparities in improvisation skills between men and women to improve science education in Ghana. Getting male and female teachers to work together and share their methods could make science education complete and more useful. Creating customised training programmes that leverage the skills of both genders could improve the overall quality of teaching. Adding what we know about gender inequalities to school policies could make them more inclusive. Also, working with local communities to overcome prejudices could make it easier for all teachers to try out different improvisation tactics.

1.2 Problem to the Study

The significance of improvisation in science education, especially in resource-limited settings, is well recognized; however, the influence of gender on teachers' improvisational strategies and their efficacy is insufficiently examined, particularly in the Ghanaian context (Raheem et al., 2025 & Obianuju, 2024). This lack of understanding is especially problematic in remote areas like the Zabzugu District, where limited resources make it crucial to improvise to teach science. Studies indicate that male and female educators may engage in improvisation in distinct ways, shaped by cultural norms, educational backgrounds, and individual experiences (Yeboah et al., 2019; Quansah et al., 2019). However, these gender disparities are not uniformly addressed in teacher training programmes or educational regulations, which may result in missed opportunities to improve science instruction through varied improvisational methods.

Furthermore, the difficulties male and female educators encounter in applying improvisation approaches may vary. Segu-Essel (2016) discovered that male and female educators in Ghana had varying levels of confidence in improvisation across different science disciplines. If not properly addressed, these variations in confidence and competence may result in inequities in the quality of science education that students receive. Abakah et al. (2022) noted that the situation is worsened by the fact that teachers in rural Ghana have few opportunities to improve their skills. Teachers may not be able to fully develop and use their improvisation skills if they do not receive focused training that accounts for how males and females improvise differently. This could affect the quality of science instruction they can offer. Also, current gender preconceptions and cultural standards may make it difficult for male and female teachers to use certain improvisation methods (Ananga, 2021; Segu-Essel, 2021). This might mean that students have fewer chances to learn and could make gender prejudices in science education even stronger.

To develop effective ways to help teachers improve their use of improvisation techniques, it is important to understand these gender differences and what they mean. This knowledge can help create more focused and useful teacher-training programmes, help schools decide how to spend their money, and help develop science education policies that are more open and complete. Consequently, this study investigates the gender disparities in primary school teachers' competence in employing improvisation strategies for science instruction in the Zabzugu District of Ghana. By examining these discrepancies, the project aims to expand the understanding of how gender affects science teaching in resource-limited settings and to suggest ways to improve the effectiveness of improvisation techniques in science education.

1.3 Research Questions

1. How do male and female teachers differ in their knowledge of science improvisation techniques in primary classrooms?
2. What gender-specific challenges do teachers face when implementing improvisation skills in science education?
3. To what extent does teacher gender influence the perceived impact of improvisation on student learning and engagement in science?

1.4 Conceptual Framework

This approach examines the role of teacher gender on the comprehension and utilisation of improvisation techniques, the obstacles encountered during implementation, and the perceived pedagogical effects on student involvement and learning. Gender dynamics are especially important in places where resources are scarce and improvisation is a keyway to educate (Gabriel, 2023; Son Hing et al., 2023). Male and female teachers frequently exhibit divergent pedagogical

methodologies, influenced by cultural norms, societal expectations, and educational training possibilities (Quansah et al., 2019). By examining these distinctions, this framework provides a way to improve science education by leveraging the strengths of each gender and addressing their respective challenges.

1.4.1 Teacher Gender

A teacher's gender is very important in how they teach science and improvise. Male teachers are often perceived as more confident and enthusiastic about technical improvisation, especially in fields such as chemistry and physics (Segu-Essel, 2016). On the other hand, female teachers are great at creating materials that are relevant to students and grounded in their own experiences. They typically use stories and real-life examples to help students understand abstract ideas (Yeboah et al., 2019; Sawyer, 2019). These tendencies are not solely individual characteristics; they are significantly shaped by cultural and societal norms that delineate unique duties and expectations for male and female teachers (Githui et al., 2021). To fix the gender gaps in science education when it comes to knowing and using improvisation techniques, you need to understand how these things work.

1.4.2 Processes

Teacher gender affects three important processes: understanding improvisation, problems with execution, and its impact on teaching. Improvisation knowledge shows how well teachers know and use ways to deal with limited resources. Male teachers frequently emphasise technical improvisations, such as building models and performing experiments, capitalising on their confidence in managing equipment (Segu-Essel, 2016). Conversely, female educators generally use locally sourced, affordable materials and implement inclusive pedagogical strategies that resonate with students' everyday experiences (Achufusi & Ogechukwu, 2024). Both genders face similar implementation issues, such as insufficient resources, large class sizes, and time constraints; nonetheless, their experiences are distinct. Female teachers often face obstacles, including insufficient administrative support and the need to balance home duties, which make it harder for them to organise and implement improvisations (Quansah et al., 2019). On the other hand, male teachers typically struggle to create improvised materials for complex scientific ideas, even though they are confident (Abakah et al., 2022). Gender also affects how people think about the pedagogical effects of improvisation. Male teachers are more confident in their capacity to engage students and improve learning, possibly because they focus more on technical skills and receive more favourable student feedback (Segu-Essel, 2016). Female teachers significantly enhance student engagement by emphasising collaborative and contextual strategies; however, these contributions may be undervalued in conventional assessments (Yeboah et al., 2019). These dynamics underscore the necessity for equitable pedagogical strategies that amalgamate the talents of both genders to enhance science education outcomes.

1.4.3 Outcomes

The interplay between teacher gender, improvisation knowledge, implementation challenges, and pedagogical impact yields critical outcomes. Enhanced science education emerges when teachers utilise gender-specific strengths, balancing technical and contextual approaches to improvisation (Gabriel, 2023). Gender-sensitive training programmes that address the unique barriers and opportunities faced by male and female teachers are crucial for fostering professional growth and improving classroom resource utilisation (Abakah et al., 2022). Furthermore, these findings can inform policy design, encouraging equitable resource allocation and support systems that promote inclusivity and effectiveness in science education (Quansah et al., 2019).

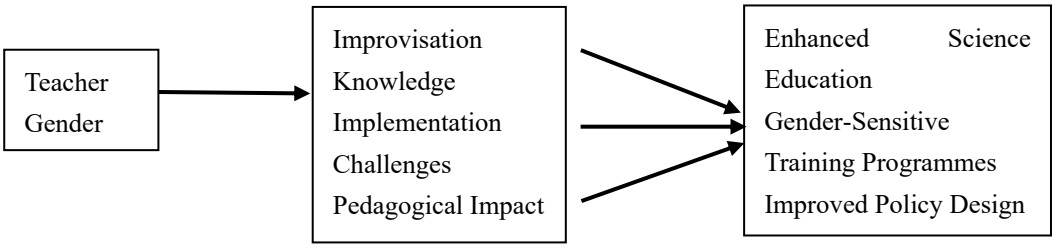

Figure1. Conceptual Framework for Gender Differences in Teachers' Improvisation Knowledge, Implementation Challenges, and Pedagogical Impact

This conceptual framework illustrates that teacher gender influences teachers' knowledge, implementation, challenges, and the pedagogical impact of improvisation, which, in turn, leads to enhanced science education, gender-sensitive training programmes, and improved policy design.

1.5 Theoretical Framework

This research is based on two important theoretical frameworks: Constructivist Learning Theory and Pedagogical

Content Knowledge (PCK). These ideas offer the basis for understanding the role of improvisation in science education and the impact of gender differences on its application.

1.5.1 Constructivist Learning Theory

Jean Piaget and Lev Vygotsky developed the Constructivist Learning Theory, which holds that people learn by interacting with their surroundings and through experience (Piaget, 1954; Vygotsky, 1978). This approach is especially important for improvisation in science education, as it emphasises the value of learning by doing. Constructivism posits that in the realm of improvisation, when educators generate improvised materials, they furnish learners with tangible, manipulable objects that facilitate the connection between abstract scientific principles and concrete experiences. This corresponds with Piaget's concept of cognitive schemas and their evolution and alteration through engagement with the physical environment (Piaget, 1954). Vygotsky's social constructivism enhances this paradigm by underscoring the significance of social interaction in the learning process. This element is particularly pertinent when examining the divergent approaches of male and female educators to collaborative learning experiences via improvisation (Vygotsky, 1978).

1.5.2 Pedagogical Content Knowledge (PCK)

Pedagogical Content Knowledge, a concept introduced by Lee Shulman, refers to the unique knowledge teachers possess that blends content expertise with the ability to teach that content effectively (Shulman, 1986). PCK is crucial in understanding how teachers, regardless of gender, adapt their teaching methods and materials to make complex scientific concepts accessible to students. In improvisation, PCK is particularly relevant, as it encompasses the teacher's understanding of scientific concepts and their ability to creatively represent them using locally available materials (Sarkar et al., 2024). This framework explains why teachers with similar content knowledge might approach improvisation differently, depending on their pedagogical strategies and understanding of students' learning needs.

1.5.3 Alignment of the Study to the Theoretical Framework

This research on gender disparities in teachers' ability to employ improvisational strategies in science education aligns closely with Constructivist Learning Theory and Pedagogical Content Knowledge (PCK). This study utilises a quantitative research design, specifically a descriptive survey methodology, to investigate gender disparities in primary school teachers' skill in employing improvisation approaches for scientific instruction in the Zabzugu District of Ghana. A stratified random sampling method was used to select participants from the district's target group of primary school educators. A questionnaire, developed from the research questions and grounded in the theoretical and empirical frameworks, was used to collect data. The questionnaire asked about demographic information, how well teachers know improvisation techniques, the problems they have while using them, the types of techniques they utilise, and how effective they think they are. An expert evaluation and a pilot study ensured the results are valid, and Cronbach's alpha coefficient was used to assess the results' dependability. We used SPSS software to analyse the data. This included descriptive statistics, independent-samples t-tests, the Pearson correlation coefficient, one-way ANOVA, and multiple regression. Ethical considerations encompassed securing Institutional Review Board approval, obtaining informed consent from participants, and safeguarding anonymity and confidentiality. The study recognises constraints about generalisability and the possibility of social desirability bias in self-reported data.

1.6 Empirical Framework

The empirical basis for this study is an expanding corpus of research investigating gender disparities in pedagogical methods, especially in science education and in limited-resource settings. This approach contextualises the present study and underscores the deficiencies in existing knowledge that this research seeks to rectify.

1.6.1 Global Studies on Gender and Teachers' Improvisation

Empirical research across international contexts yields conflicting results on how gender affects teachers' use of improvisation in science classes. In an American study, Sawyer (2019) found that female science teachers had stronger improvisational skills when incorporating narrative and real-world situations into their improvised teaching materials. These methods improved students' involvement and understanding, especially in abstract science subjects. The study ascribed this strength to the higher propensity of female educators to use collaborative and learner-centred teaching methods. In contrast, a study conducted in the United Kingdom by Bevan (2017) found that male teachers were more confident when conducting impromptu experiments and demonstrations, especially in physics and technical science classrooms. It was discovered that male educators were more at ease with electrical and mechanical tools, enabling quicker improvisation of experimental equipment. Prior exposure to technical training and cultural views of masculinity connected to technical proficiency were linked to this advantage.

Gender inequalities in teachers' improvisation techniques were less noticeable in countries with stronger gender-equality legislation, according to a larger European comparative study by Tanner and McCloskey (2023), which was conducted

across several countries with different gender equity indices. The researchers concluded that structural elements, including institutional support, fair resource allocation, and professional development opportunities, were more important than gender alone in determining teachers' capacity for improvisation. These results imply that, whereas improvisation methods may be influenced by gender, these impacts are mitigated by larger structural and policy factors.

1.6.2 African Studies on Gender and Teachers' Improvisation

Cultural conventions, a lack of educational resources, and varied governmental contexts all influence how gender and improvisation interact in the African context. In a study conducted in rural Tanzania, Kambuga (2024) found that female teachers were more inclined to incorporate indigenous knowledge and locally acquired resources into their makeshift science classes. These resources, which included natural objects, farming implements, and household goods, improved students' contextual learning and cultural relevance. The study found that female teachers were more familiar with local resources because of their family responsibilities. Gabriel (2023) found that secondary school science teachers in Nigeria had a notable gender-based specialisation in their improvisational techniques. For physics sessions, male teachers were more likely to make do with homemade mechanical and electrical equipment. In contrast, female teachers were better at creating biological specimens and visual models for biology and chemistry classes. The results were ascribed to subject specialisation influenced by social norms and gendered academic socialisation.

In a similar vein, Githui, Koech, and Thinguri (2021) found that community gender norms in Kenya significantly impacted teachers' improvisational techniques. According to their research, female educators were better at illustrating scientific ideas with everyday objects such as plastic containers, cloth, and food. In contrast, male educators favoured building elaborate models and equipment from wire, metal, and wood. Nonetheless, the authors noted that both groups faced issues such as insufficient funding, overcrowded classrooms, and a lack of administrative support. In contrast, Mushimiyimana, Kampire, and Dushimimana (2022) found minimal gender disparities in teachers' improvisational practices in Rwanda. The researchers attributed this result to Rwanda's robust gender-sensitive educational policy and to the equal access of male and female teachers to professional development opportunities. This implies that progressive gender mainstreaming initiatives can successfully eliminate gender differences in teaching methods.

1.6.3 Ghanaian Studies on Gender and Teachers' Improvisation

Gender disparities in science education and improvisation have been the subject of numerous studies conducted in Ghana, especially in underprivileged and rural areas. In their article, Yeboah, Abonyi, and Luguterah (2019) discovered that female primary school teachers in rural Ghana were more likely to use learner-centred activities, role-playing, and storytelling. These techniques improved students' engagement and understanding of challenging subjects. Conversely, male educators were more likely to use locally available resources to build tangible models and conduct hands-on demonstrations. Quansah, Sakyi-Hagan, and Essiam (2019) examined gender disparities and implementation issues related to improvisation in Ghanaian rural junior high schools. According to their findings, time constraints, a lack of administrative assistance, and increasing family duties were the main obstacles faced by female teachers, which reduced their ability to create improvised lesson plans. Although they encountered difficulties with student discipline during practical exercises, male teachers reported comparatively fewer obstacles.

Segu-Essel (2016) also found that confidence levels in many science subjects varied between Ghanaian male and female teachers. While female teachers expressed greater confidence in life science and environmental science subjects, male teachers showed greater confidence in creating improvised materials for physics and chemistry classes. The study found that access to training and subject expertise had a greater impact on improvisation confidence than gender alone. Teachers in rural Ghana had few opportunities for ongoing professional development in improvisation approaches, according to Aboagye et al. (2022) and Abakah et al. (2022). Both studies underlined that the absence of organised, gender-sensitive training programmes limited teachers' capacity to fully hone their improvisational skills. Some teachers were further prevented from experimenting with specific improvisational techniques by cultural preconceptions and stringent gender norms, especially in technical science fields.

2. Method

This study utilised a quantitative research design, specifically a descriptive survey approach, to examine gender differences in primary school teachers' use of improvisation strategies in scientific instruction within the Zabzugu District of Ghana. This method facilitated the acquisition of quantitative data amenable to statistical analysis and the discernment of correlations among variables (Creswell, 2014). The next section provides more detail on the participants, how they were selected, the research methodology, the tools used, how the data were collected, and the ethical issues that arose.

2.1 Research Design

This study utilised quantitative research design, specifically a descriptive survey methodology, to investigate the associations among variables and to gather numerical data for statistical analysis (Creswell, 2014). The design is appropriate for delineating current situations, perspectives, and the methodologies educators employ to integrate improvisational techniques into science education.

2.2 Participants (Population, Sample, and Sampling Procedure)

The target population consisted of all elementary school teachers in Zabzugu District. To ensure that both male and female teachers were represented in the appropriate proportions at each school, a stratified random sampling method was used. We used Krejcie and Morgan's (1970) sample size determination table to find the sample size. This table provides statistics based on population size. Stratification made sure that the study sample had a good mix of both gender and school-level traits.

2.3 Data Collection Methods

We used a standardised questionnaire based on the research goals and theoretical framework to collect data. The researchers personally administered the instrument to improve response rates and facilitate explanation of questions as needed. This method ensured that all answers were full and less likely to be misunderstood.

2.4 Instrumentation

There were five key parts to the questionnaire: demographic information; teachers' understanding of improvisation techniques; problems they encountered when utilising improvisation; the types of improvisation techniques they used; and how effective they thought the approaches were. Most of the items were assessed using a 5-point Likert scale to allow responses and ease statistical analysis. To ensure content validity, specialists in science education and gender studies evaluated the instrument, and a pilot study was conducted with a limited number of teachers to refine the questionnaire and data collection methodologies (Mokkink et al., 2025).

2.5 Data Analysis Methods

We used the Statistical Package for the Social Sciences (SPSS) to analyse the data we collected. We employed descriptive statistics, such as means, standard deviations, and frequencies, to aggregate demographic information and Likert-scale responses. To examine the inferential dimensions of the research topics, independent-samples t-tests were performed to compare male and female teachers' familiarity with and difficulties in employing improvisation techniques.

2.6 Ethical Considerations

The Ethics Committee for the Humanities (ECH) granted ethical clearance under reference number ECH 124/22-23. Participants were informed of the purpose and procedures of the study, and informed consent was obtained before participation. Participants' identities and information were guaranteed to remain private, and they could leave the study at any time without consequences.

2.7 Limitations

The research focused exclusively on primary school educators in the Zabzugu District, potentially limiting the applicability of the results to other districts or educational levels. Furthermore, because the study relied on self-reported data, responses may have been influenced by social desirability bias or participants' subjective perceptions.

2.8 Validation and Reliability

The instrument's content validity was confirmed via expert evaluation in science education and gender studies. Using Cronbach's alpha, we found a value of 0.78, which exceeds the acceptable level of 0.70 (Nunnally, 1978). This shows that the questionnaire has good internal consistency.

3. Results

This part shows what the data collected and analysed, with respect to the study's goals, revealed. It covers the results of the instrument validation process and the statistical analyses conducted to assess the reliability and consistency of the questionnaire used in the study.

3.1 Research Question One - How Do Male and Female Teachers Differ in Their Knowledge and Application of Science Improvisation Techniques in Primary Classrooms?

The study examined gender differences in teachers' Knowledge and application of science improvisation techniques in primary classrooms. Table 1 and Table 2 present the results of this analysis. Table 1 shows the group statistics comparing male and female teachers' responses.

Table 1. Group Statistics of Gender Differences between Teachers Knowledge and Application of Science Improvisation Techniques in Primary Classrooms

Statements	Gender	N	Mean	Std. Deviation	Std. Error Mean
I am enthusiastic about improvisation skills.	Female	29	3.93	.884	.164
	Male	167	4.21	.638	.049
I often use improvisation skills to teach science subjects.	Female	29	4.07	.884	.164
	Male	167	3.96	1.017	.079
I have taught several science topics with improvised materials.	Female	29	4.21	.675	.125
	Male	167	3.86	1.177	.091
Improving basic materials can be an alternative to teaching and learning science.	Female	29	4.48	.634	.118
	Male	167	4.56	.509	.039
I encourage students to improvise	Female	29	4.24	.689	.128
	Male	167	4.35	.514	.040
I know the quality of improvisation skills that can be used for teaching and learning science.	Female	29	4.14	.915	.170
	Male	167	4.31	.569	.044
I have attended several improvisation skills workshops since I started my teaching career.	Female	29	3.14	1.505	.280
	Male	167	2.93	1.453	.112
Do I have access to books on improvisation skills from several sources?	Female	29	3.10	1.263	.235
	Male	167	3.29	1.290	.100
Familiarity Total	Female	29	3.914	.526	.0977
	Male	167	3.9349	5.579	.0448

Male teachers generally reported higher mean scores for enthusiasm about improvisation skills (M=4.21 vs. M=3.93), awareness of improvisation as an alternative (M=4.56 vs. M=4.48), encouraging students to improvise (M=4.35 vs. M=4.24), and awareness of quality improvisation skills (M=4.31 vs. M=4.14). Female teachers reported higher mean scores for teaching science topics with improvised materials (M=4.21 vs. M=3.86) and attending improvisation workshops (M=3.14 vs. M=2.93).

Table 2 presents the results of the independent samples t-tests. Statistically significant differences were found between male and female teachers in their enthusiasm for improvisation skills ($t(194)=-2.038$, $p=0.043$) and teaching science topics with improvised materials ($t(62.412)=2.224$, $p=0.030$). No other significant differences were found between genders in their knowledge and application of science improvisation techniques (all $p>0.05$).

Table 2. Independent Samples Test of science improvisation techniques in primary classrooms

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
I am enthusiastic about improvisation skills.	Equal variances assumed	1.679	.197	-2.038	194	.043	-.279	.137	-.548	-.009
I often use improvisation skills to teach science subjects.	Equal variances assumed	2.473	.117	.522	194	.602	.105	.201	-.292	.501
I have taught several science topics with improvised materials.	Equal variances not assumed	4.872	.028	2.224	62.4	.030	.345	.155	.035	.654
Improving basic materials can be an alternative to teaching and learning science.	Equal variances assumed	7.219	.008	-.646	34.6	.523	-.080	.124	-.332	.172
I have taught several science topics with improvised materials.	Equal variances are not assumed.	4.866	.029	-.790	33.6	.435	-.106	.134	-.378	.167
I am aware of the quality of improvisation skills to be used for teaching and learning science	Equal variances assumed	2.034	.155	-1.366	194	.173	-.173	.127	-.424	.077
I have attended several improvisation skills workshops since I started my teaching career.	Equal variances assumed	.100	.752	.694	194	.489	.204	.294	-.376	.783
Do I have access to books on improvisation skills from several sources?	Equal variances assumed	.241	.624	-.711	194	.478	-.184	.259	-.694	.326
Familiarity Total	Equal variances assumed	1.188	.277	-.183	194	.855	-.0211	.115	-.248	.206

According to constructivism, the fact that both male and female educators demonstrated a comparable level of general knowledge and used improvisational approaches points to a shared understanding of the importance of experiential learning in science classes (Piaget, 1954; Vygotsky, 1978). The notable gender disparities in certain areas, however, such as the greater improvisational enthusiasm of male teachers and the more frequent use of improvised materials and teaching of multiple topics by female teachers, suggest that students are exposed to various forms of knowledge construction depending on the teacher. When interpreted through PCK, these patterns indicate that although both sexes have conceptual knowledge of improvisation, they differ in how they use improvised materials to transform science content into teachable forms. Female teachers emphasise topic coverage and sustained classroom use, while male teachers emphasise motivational and promotional aspects (Shulman, 1986). This supports PCK as a more potent explanatory lens than content knowledge alone by pointing to pedagogical rather than cognitive gender disparities in improvisation.

3.2 Research Question 2 - What Gender-specific Challenges Do Teachers Face When Implementing Improvisation Skills in Science Education?

The study investigated gender-specific challenges teachers face when implementing improvisation skills in science education. The results of this analysis are presented in Table 3 and Table 4.

Table 3 displays the group statistics comparing male and female teachers' responses to various challenges. Male teachers reported higher mean scores for lack of proper funding (M=4.56 vs. M=4.41), issues of large classes (M=4.35 vs.

M=4.28), and students' reluctance to adopt improvisation skills (M=3.66 vs. M=3.52). Female teachers reported higher mean scores for limited time planning (M=4.48 vs. M=4.42) and insufficient teaching materials (M=4.38 vs. M=4.34).

Table 3. Group Statistics of Gender-Specific Challenges Teachers Face when Implementing Improvisation Skills in Science Education

Statement	Gender	N	Mean	Std. Deviation	Std. Error Mean
Limited time planning for practical projects.	Female	29	4.48	.738	.137
	Male	167	4.42	.634	.049
Lack of proper funding for teaching materials.	Female	29	4.41	.682	.127
	Male	167	4.56	.741	.057
Issues of a large class	Female	29	4.28	.591	.110
	Male	167	4.35	.720	.056
Need more materials for teaching.	Female	29	4.38	.677	.126
	Male	167	4.34	.942	.073
Students need to be more active in adopting improvisation skills.	Female	29	3.52	.949	.176
	Male	167	3.66	1.144	.089
Poor academic performance of students while using improvisation skills.	Female	29	3.14	1.274	.237
	Male	167	3.05	1.436	.111
Students need help understanding improvisation skills.	Female	29	3.24	1.380	.256
	Male	167	3.53	1.191	.092
Challenges Total	Female	29	3.92	.526	.0976
	Male	167	3.99	.568	.0439

Table 4 shows the results of independent samples t-tests. No statistically significant differences were found between male and female teachers regarding any challenges faced when implementing improvisation skills in science education (all $p>0.05$). This suggests that male and female teachers experience similar challenges in implementing improvisation techniques.

Table 4. Independent Samples Test of gender-specific challenges teachers face when Implementing improvisation skills in science education

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Limited time planning for practical projects.	Equal variances assumed	.612	.435	.487	194	.627	.064	.131	-.194	.321
Lack of proper funding for teaching materials.	Equal variances assumed	.004	.951	-1.012	194	.313	-.149	.147	-.440	.142
Issues of a large class	Equal variances assumed	.983	.323	-.547	194	.585	-.077	.141	-.356	.202
Need more materials for teaching?	Equal variances assumed	.868	.353	.241	194	.810	.044	.183	-.316	.404
Students need to be more active in adopting improvisation skills.	Equal variances assumed	1.330	.250	-.656	194	.513	-.147	.225	-.591	.296
Poor academic performance of students while using improvisation skills.	Equal variances assumed	2.593	.109	.295	194	.768	.084	.284	-.477	.645
Students need help understanding improvisation skills.	Equal variances assumed	2.545	.112	-1.188	194	.236	-.292	.245	-.776	.193
Challenges Total	Equal variances assumed	.002	.968	-.599	194	.550	-.0677	.113	-.291	.155

Both male and female teachers work in similarly limited learning situations, as evidenced by the lack of statistically significant gender variations in the difficulties encountered when applying improvisation. From a constructivist standpoint, these typical obstacles—limited time, insufficient resources, big class sizes, and learner challenges—undermine the development of rich, practical learning experiences that are essential to the formation of

scientific knowledge (Piaget, 1954; Vygotsky, 1978). When viewed through the PCK lens, the results indicate that the main barriers to teachers' capacity to use their pedagogical repertoires are institutional and contextual issues rather than gender. In other words, shortages in contextual and curricular knowledge supports (such as time, resources, and structural backing), which are essential components of PCK, rather than a lack of pedagogical understanding, limit teachers' ability to effectively transform content into improvised representations (Shulman, 1986).

3.3 Research Question 3: To What Extent Does Teacher Gender Influence the Perceived Impact of Improvisation on Student Learning and Engagement in Science?

The study examined how teacher gender influences the perceived impact of improvisation on student learning and engagement in science. The results are presented in Table 5 and Table 6.

Table 5 shows the group statistics comparing male and female teachers' perceptions. Male teachers consistently reported higher mean scores across all statements: promoting student learning (M=4.54 vs. M=4.07), motivating student learning (M=4.46 vs. M=4.07), and student interest in utilising improvisation skills (M=4.41 vs. M=30.

Table 5 - Group Statistics of gender influence the perceived impact of improvisation on student learning and engagement in science

Statements	Gender	N	Mean	Std. Deviation	Std. Error Mean
Procedures in improvisation skills in teaching and learning science promote students' learning.	Female	29	4.07	.884	.164
	Male	167	4.54	.609	.047
Procedures in improvisation skills in teaching and learning science motivate students learning?	Female	29	4.07	.704	.131
	Male	167	4.46	.524	.041
Do students have an interest in utilizing improvisation skills in the learning of science?	Female	29	3.76	.988	.183
	Male	167	4.41	.713	.055
Procedure Total	Female	29	3.9655	.72564	.13475
	Male	167	4.4711	.44997	.03482

Table 6 presents the results of independent samples t-tests. Statistically significant differences were found between male and female teachers in all areas: promoting student learning ($t(194)=-3.564$, $p<0.001$), motivating student learning ($t(194)=-3.524$, $p=0.001$), and student interest in utilizing improvisation skills ($t(194)=-4.286$, $p<0.001$).

Table 6. Independent Samples Test of Gender Influence on the Perceived Impact of Improvisation on Student Learning And Engagement In Science

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Procedures in improvisation skills in teaching and learning science promote students' learning.	Equal variances assumed	.332	.565	-3.564	194	.000	-.470	.132	-.730	-.210
Procedures in improvisation skills in teaching and learning science motivate students learning?	Equal variances assumed	1.735	.189	-3.524	194	.001	-.392	.111	-.612	-.173
Do students have an interest in utilizing improvisation skills in the learning of science?	Equal variances assumed	2.643	.106	-4.286	194	.000	-.655	.153	-.956	-.353
Procedure Total	Equal variances are not assumed.	4.504	.035	-3.632	31.840	.001	-.506	.139	-.789	-.222

The overall procedure total also significantly differed ($t(31.840)=-3.632$, $p=0.001$). These results suggest that male teachers perceive a more positive impact of improvisation on student learning and engagement in science than female teachers.

Gender differences in teachers' perceptions of the pedagogical power of their improvised practices are suggested by the much higher ratings male teachers give to improvisation's impact on students' learning, motivation, and interest. From a

constructivist perspective, this would indicate that male educators are more confident in planning obvious, hands-on, demonstration-focused activities that support active knowledge creation and visible participation in science classes. According to PCK, these findings suggest that when employing improvised materials, male teachers believe they are more successful at coordinating representation, content, and instructional practices (Shulman, 1986). The high mean ratings for female teachers, however, also show that improvisation is valued pedagogically by both sexes; the difference lies more in perceived influence than in outright rejection. Once more, this indicates variations in self-efficacy and pedagogical enactment rather than fundamental theoretical support for experiential learning.

4. Discussion

Using Pedagogical Content Knowledge (PCK) (Shulman, 1986) and Constructivist Learning Theory (Piaget, 1954; Vygotsky, 1978), this part analyses the study's results in light of the research questions. The results showed no significant difference in overall awareness of improvisation in science instruction between male and female teachers. There were, nevertheless, differences in the ways this knowledge was used in actual classroom settings. This result implies that although both sexes have a conceptual understanding of improvisation, they apply it differently, a trend also observed in studies conducted in Ghana and Africa (Yeboah et al., 2019; Gabriel, 2023; Githui et al., 2021). According to constructivist theory, improvisation facilitates learning by allowing students to actively interact with tangible objects and build scientific knowledge through practical experiences (Piaget, 1954; Vygotsky, 1978; Okori & Jerry, 2017). The demonstration of improvisational skills by both male and female educators suggests a mutual understanding of the value of hands-on learning in science instruction. However, as noted by Kambuga (2024) and Mushimiyimana et al. (2022), variations in application imply that students may be exposed to various types of knowledge production based on the teacher's gender and preferred improvisational technique. These results show variations in instructors' capacity to use improvised materials to convert science content into teachable forms, as viewed through the lens of Pedagogical Content Knowledge (PCK). Although both male and female teachers conceptually recognised improvisation, their differing applications reflect variations in topic-specific pedagogy, representational methods, and instructional explanations (Shulman, 1986; Sarkar et al., 2024). This backs up Shulman's (1986) claim that understanding a subject is not enough; teachers also need to know how to present it in a way that students can comprehend. In contrast to how improvisation is theoretically understood, the observed pattern is consistent with earlier Ghanaian and African studies that demonstrate that gender affects how improvisation is operationalised in classrooms (Yeboah et al., 2019; Quansah et al., 2019; Gabriel, 2023; Githui et al., 2021). The results thus imply that gender disparities in improvisation are pedagogical rather than cognitive, supporting PCK's applicability as a more potent explanatory framework than content knowledge alone (Shulman, 1986).

Analysis of research question 2 revealed no statistically significant gender differences in the problems faced when using improvisational skills in science teaching. This similarity stands in direct contrast to some previous research. For instance, while Quansah et al. (2019) found female educators in rural Ghana struggled more due to time constraints and lack of administrative support, and male educators struggled with technical aspects, this study uncovered no such gender-specific barriers in the Zabzugu District. Instead, both groups reported facing similar obstacles, such as insufficient planning time, inadequate funding, and large classes, findings similar to those of Abakah et al. (2022). This contrast is further nuanced: though not statistically significant, male teachers reported slightly more trouble with funding and large class sizes. The study also showed that when it came to incorporating improvisation into science instruction, male and female teachers had comparable difficulties. These issues included students' inability to use makeshift resources, large class sizes, a lack of supplies, a lack of funding, and insufficient preparation time. According to earlier research conducted in Ghana (Quansah et al., 2019; Abakah et al., 2022), the lack of statistically significant gender differences in overall implementation issues suggests that contextual restrictions impact both genders equally. Constructivists believe that conducive learning settings that permit unrestricted interaction between students and instructional materials are necessary for effective learning (Piaget, 1954; Vygotsky, 1978). Creating such learner-centred, activity-based environments is hampered by common issues identified in the survey, such as packed classrooms and a lack of resources. The quality of constructivist learning experiences in science classrooms is thus weakened by institutional hurdles that teachers, irrespective of gender, must overcome (Okori & Jerry, 2017; Abakah et al., 2022). These difficulties indicate a lack of contextual information, an essential element of PCK according to the PCK framework (Shulman, 1986). The external conditions of practice, such as school infrastructure, administrative support, and resource availability, limit teachers' capacity to implement their instructional strategies rather than a lack of pedagogical expertise (Quansah et al., 2019; Abakah et al., 2022). This explains why the improvisational challenges faced by male and female teachers were similar. The results demonstrate that without concurrent enhancements to school-level support structures, gender-sensitive training is ineffective on its own. This highlights how crucial it is to align policy and infrastructure changes with teacher professional development, a viewpoint held firmly by Quansah et al. (2019) and Abakah et al. (2022).

The findings also revealed that male teachers felt improvisation had a greater influence on their students' involvement and learning than did female teachers. When it came to encouraging learning, inspiring pupils, and igniting their interest, male teachers consistently gave improvisation higher ratings. In other parts of Africa, similar gender variations in perception have been documented (Gabriel, 2023; Githui et al., 2021). According to a constructivist interpretation, this data suggests that male educators may be fostering more demonstration-based and discovery-oriented learning environments, which are well aligned with the principles of experiential learning (Piaget, 1954; Vygotsky, 1978). Increased usage of kinaesthetic and visual learning experiences using improvised apparatus, which improve learners' cognitive engagement, may be linked to the perceived larger effect (Sawyer, 2019; Bevan, 2017). According to PCK, this result may reflect variations in representational ability and awareness of instructional strategies (Shulman, 1986; Sarkar et al., 2024). Stronger impact perceptions among male teachers might be a sign of greater confidence in their capacity to match content to suitable instructional representations, particularly in scientific subjects that require a high level of technical proficiency (Bevan, 2017; Gabriel, 2023). This supports Shulman's (1986) assertion that PCK encompasses both instructors' knowledge and their confidence in using it effectively. This perceived disparity, however, does not necessarily mean that female educators are less successful. Instead, it might represent variations in classroom feedback loops, self-efficacy, and pedagogical orientation (Tanner & McCloskey, 2023; Mushimiyimana et al., 2022). According to related studies, female teachers are more likely to engage in learner-centred improvisation, which may result in learning outcomes that are more significant within a constructivist framework but less readily apparent through traditional performance indicators (Yeboah et al., 2019; Kambuga, 2024).

5. Conclusion

This study examined the perceived pedagogical impact, implementation difficulties, and improvisational knowledge of primary school teachers in Ghana's Zabzugu District regarding science teaching. The results showed that although male and female teachers had similar conceptual understandings of improvisation, they varied in how they applied these understandings in the classroom. It was also found that implementation issues were similar for male and female teachers, primarily due to contextual factors such as resource shortages, time constraints, and large class sizes. Nonetheless, compared to their female colleagues, male teachers reported a greater perceived impact of improvisation on students' learning, motivation, and engagement. The results, when interpreted in light of constructivist learning theory, confirm that improvisation remains a potent tool for fostering socially mediated, active, and experiential learning in science classrooms with limited resources. Although disparities in pedagogical enactment shape learners' engagement with scientific concepts, the shared understanding of improvisation across genders suggests a similar enjoyment of learning through tangible experiences. The findings show that gender differences in improvisation are mainly pedagogical rather than cognitive from the standpoint of Pedagogical Content Knowledge (PCK), reflecting differences in representational strategies, instructional explanations, and confidence in converting content into teachable forms. Overall, the study demonstrates that gender has a greater impact on how improvisation is operationalised and considered effective than on how it is conceptually understood. Simultaneously, the consistency of implementation challenges underscores the significant role of environmental and institutional factors in shaping teachers' improvisational techniques. These results highlight the need for PCK-based gender-responsive professional development, alongside improved policy and infrastructure support, to enhance the effectiveness of improvisation in primary science education, especially in Ghana's rural, resource-constrained environments.

Recommendation

The study's results indicate the need for customised professional development programmes to address the distinct strengths and challenges male and female teachers face in employing improvisation techniques. Mentoring programmes that connect male and female teachers could help make the classroom more collaborative. More research should examine why male teachers have a better understanding of how improvisation affects learning, and how to help female teachers feel more confident in this area.

Implication

The results suggest that teacher training programmes should integrate additional practical training in improvisation techniques to address gender-specific strengths and challenges. When planning to promote science education in places with limited resources, policymakers should consider how gender differences affect the situation. Ongoing professional development should help people feel more confident and improve their improvisation skills, especially in areas where there were discrepancies between men and women.

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Authors contributions

Dr Eliot Kosi Kumassah and Nassam Inusah conceptualised the study, developed the research design, and led the methodological refinement. Prof. Kwaku Darko Amponsah conducted field data collection and coordinated data management. Dr Godwin Kwame Aboagye drafted the initial version of the manuscript and organised the results and discussion sections. Dr Ebenezer Appah Bonney reviewed and revised the manuscript for intellectual content, clarity, and coherence. All authors participated in the final review of the manuscript and approved the version submitted for publication.

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