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Gender Differences in Physics Performance: A Case Study of Riverain Combined School, Zambia

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Abstract

Gender disparities in physics achievement continue to limit equitable participation in science, technology, engineering, and mathematics (STEM) education. This study investigated factors influencing performance differences between male and female pupils in physics at Riverain Combined School in Kitwe District, Zambia. A mixed-methods case study design was employed, combining quantitative survey data with qualitative open-ended responses. Participants included sixty Grade 10 and 11 pupils (thirty boys and thirty girls) and nineteen physics teachers from seven secondary schools in Kitwe District. Quantitative data were analyzed using descriptive statistics and independent-samples t tests, while qualitative responses were analyzed thematically. Results indicated statistically significant gender differences in confidence ($t(58)=3.92$, $p<0.01$), encouragement to pursue physics ($t(58)=2.78$, $p=0.007$), classroom leadership opportunities ($t(58)=4.11$, $p<0.001$), and access to practical activities ($t(58)=3.45$, $p=0.001$). Societal stereotypes, teacher practices, limited female role models, and learner self-efficacy emerged as key factors influencing female pupils' performance. The study concludes that gender gaps in physics are socially and pedagogically mediated rather than ability-based. Gender-responsive teaching practices, mentorship, and equitable classroom participation are recommended to improve girls' performance and persistence in physics.

Keywords: gender disparity, physics education, student performance, STEM equity, mixed methods

1. Introduction

Physics plays a crucial role in developing scientific literacy and equipping learners with skills essential for participation in STEM-related careers. The subject fosters critical thinking, problem-solving, and understanding of natural phenomena, all vital for both individual and national development (OECD, 2019). Despite global efforts to promote gender equity, girls remain underrepresented in physics and often underperform compared to boys, limiting their access to STEM careers and reducing the diversity of perspectives in scientific problem-solving (Murphy & Whitelegg, 2006; World Economic Forum, 2020).

In Zambia, national examination results have consistently shown lower performance in physics among girls at senior secondary school level (Kalonde & Chikopa, 2017; Mumba, 2018). Societal perceptions framing physics as a masculine domain, differential teacher expectations, and classroom interaction patterns exacerbate these disparities (Sadker & Zittleman, 2009; King'aru, 2014). Girls also often report

lower confidence in physics tasks despite comparable ability, which can limit engagement and persistence in the subject (OECD, 2019; UNESCO, 2017).

Understanding localized factors influencing gender differences is critical for designing interventions that foster equitable participation. This study therefore examined the factors influencing performance differences between male and female pupils in physics at Riverain Combined School, Kitwe District, Zambia. The guiding research question was: What factors contribute to the achievement gap in physics between male and female pupils?

2. Literature Review

Gender disparities in physics achievement have been widely documented. These differences are frequently linked to socialization, classroom practices, and learner perceptions rather than innate ability (Murphy & Whitelegg, 2006; Kalonde & Chikopa, 2017). In East and Southern Africa, cultural norms and school environments significantly influence girls' engagement with physics. Girls tend to perform comparably in theoretical tasks but lag in practical experiments and collaborative problem-solving, indicating that classroom experiences play a crucial role in shaping outcomes (Mumba, 2018).

Socio-cultural expectations often assign domestic responsibilities to girls, reducing study time and reinforcing the belief that science is primarily for boys (King'aru, 2014; Mumba, 2018). This limitation negatively impacts motivation, persistence, and self-efficacy, which are strongly associated with engagement and performance in physics (Bandura, 2001; OECD, 2019).

Teacher attitudes and classroom practices also significantly influence gendered outcomes. Studies have shown that teachers unconsciously call on boys more frequently, provide them with more detailed feedback, and allocate leadership roles disproportionately in practical activities (Sadker & Zittleman, 2009; Mwansa, 2016). Girls consequently have fewer opportunities to lead or participate actively in experiments, limiting their skill development and confidence.

The presence of female role models has been identified as a strong determinant of girls' engagement and career aspirations in physics (UNESCO, 2017; Kalumba, 2018). The scarcity of female physics teachers reinforces stereotypes and reduces girls' long-term motivation to pursue STEM fields. Interventions such as gender-responsive pedagogy, mentorship programs, and inclusive classroom practices have been shown to improve girls' engagement and performance (FAWE, 2007; Commonwealth of Australia, 2020). However, these interventions remain unevenly implemented, highlighting the need for school-level research.

3. Method

A **mixed-methods case study design** was adopted in this study to provide a comprehensive understanding of gender differences in physics performance. This approach allowed for the simultaneous examination of measurable differences between male and female pupils while also exploring the underlying socio-cultural, pedagogical, and psychological factors that may influence these differences. The quantitative component enabled the researchers to obtain statistical comparisons of variables such as self-confidence, classroom participation, and perceived teacher support, whereas the qualitative component provided in-depth insights into pupils' and teachers' experiences, perceptions, and contextual

factors that could not be captured through numerical data alone. The integration of these methods strengthened the validity of the findings by allowing for triangulation of results and a more nuanced interpretation of gendered patterns in physics achievement.

The study population comprised pupils enrolled in Grades 10 and 11 at Riverain Combined School, a representative school within Kitwe District. From this population, sixty pupils were selected, consisting of thirty boys and thirty girls. Selection was carried out using **simple random sampling** to ensure that each pupil had an equal chance of being included, thereby reducing selection bias and enhancing the representativeness of the sample. To complement the pupil data and provide professional perspectives, nineteen physics teachers from seven secondary schools in Kitwe District participated in the study. The teacher sample included sixteen males and three females, reflecting the gender distribution of physics instructors in the district. Their inclusion provided valuable insights into instructional practices, classroom management, and observed gendered patterns in physics participation and achievement.

Data collection was conducted using structured questionnaires, which contained both **Likert-scale items** and **open-ended questions**. The Likert-scale items measured pupils' self-reported confidence in answering physics questions, perceived encouragement and support from teachers, access to practical learning activities, classroom participation, and overall attitudes toward physics. Open-ended questions invited pupils and teachers to describe their experiences, perceptions of gender bias, and explanations for observed differences in classroom participation or performance. The questionnaires were developed based on existing literature on gender disparities in physics (Murphy & Whitelegg, 2006; Kalonde & Chikopa, 2017) and reviewed by experts in science education to establish **content validity**. A pilot study involving a small group of pupils and teachers was conducted to test the clarity, reliability, and appropriateness of the instruments, and minor adjustments were made based on the feedback received.

Ethical considerations were strictly observed throughout the study. **Institutional permission** was obtained from the Copperbelt University Department of Mathematics and Science Education, and **ethical approval** was secured from the relevant school authorities. Pupils and teachers were fully informed about the purpose of the study, and participation was **voluntary**, **anonymous**, and **confidential**. Questionnaires were administered during school hours under the supervision of the researchers to ensure consistency and to provide support if participants needed clarification on any items.

For **data analysis**, the quantitative data obtained from Likert-scale items were coded and entered into statistical software. Descriptive statistics, including means and standard deviations, were used to summarize the responses, while **independent-samples t tests** were conducted to identify statistically significant differences between boys and girls in confidence, participation, teacher support, and engagement in practical activities ($p \leq 0.05$). For the qualitative component, responses to open-ended questions were analyzed thematically. The researchers identified recurring patterns, themes, and categories that explained gendered experiences in physics, including confidence, classroom participation, teacher attention, and socio-cultural influences. The combined analysis of quantitative and qualitative data allowed for a richer interpretation of the results, providing both numerical evidence of performance differences and contextual explanations for why these differences occur.

4. Results

The quantitative analysis revealed **statistically significant gender differences** in several key dimensions of physics performance, including confidence in answering questions, teacher encouragement, classroom leadership, and access to practical activities. Boys consistently reported higher scores than girls across these dimensions, suggesting that male pupils experience more support and engagement opportunities in physics classrooms at Riverain Combined School.

Confidence in answering questions was significantly higher among boys ($M = 4.12$, $SD = 0.78$) than girls ($M = 3.35$, $SD = 0.69$), $t(58) = 3.92$, $p < 0.01$. This indicates that boys feel more assured in their ability to respond to physics questions correctly, which may influence participation and achievement. The lower confidence reported by girls suggests that even when they possess comparable knowledge, they may be less willing to engage actively during lessons. This finding aligns with prior research indicating that girls often report lower self-efficacy in physics due to societal stereotypes and classroom dynamics (OECD, 2019; Bandura, 2001).

Perceived teacher encouragement also favored boys, with males reporting a mean score of 3.87 ($SD = 0.81$) compared to 3.21 ($SD = 0.74$) for females, $t(58) = 2.78$, $p = 0.007$. This statistically significant difference suggests that teachers may, consciously or unconsciously, provide more encouragement or positive reinforcement to boys, which can contribute to higher engagement, motivation, and academic achievement. Qualitative data supported this observation, as several teachers acknowledged that boys were more frequently called upon during lessons and given opportunities to lead activities, reflecting potential gender bias in classroom practices.

Opportunities to lead group activities were also significantly higher for boys ($M = 4.05$, $SD = 0.65$) than for girls ($M = 3.14$, $SD = 0.72$), $t(58) = 4.11$, $p < 0.001$. This difference highlights inequitable access to leadership roles in collaborative settings, which can influence skill development, confidence, and visibility in the classroom. Leadership experiences provide critical opportunities for hands-on learning, problem-solving, and peer recognition, meaning that girls may be disadvantaged not due to lack of ability, but due to reduced exposure to these formative experiences.

Access to practical activities in physics, such as experiments and laboratory work, was significantly higher for boys ($M = 4.01$, $SD = 0.70$) than for girls ($M = 3.30$, $SD = 0.68$), $t(58) = 3.45$, $p = 0.001$. Practical work is essential for developing conceptual understanding, problem-solving skills, and scientific reasoning. Limited access to such activities can therefore contribute to performance gaps over time. The qualitative responses corroborated these findings, with girls reporting that they often observed rather than conducted experiments and felt less confident handling equipment due to limited opportunities.

Interestingly, **no significant gender differences** were observed in **enjoyment of physics** ($t(58) = 1.49$, $p = 0.14$) or in **belief in girls' capability** ($t(58) = 1.22$, $p = 0.22$). Both boys and girls reported high levels of interest in physics and a general recognition that girls are capable of learning the subject. This suggests that girls' underperformance is not attributable to lack of interest or perceived ability, but rather to contextual barriers such as confidence, classroom practices, and access to opportunities.

The quantitative results are summarized in Table 1.

Table 1 Gender Differences in Physics Performance Measures

Variable	Boys M (SD)	Girls M (SD)	t(58)	p	Significance
Confidence in answering questions	4.12 (0.78)	3.35 (0.69)	3.92	<.01	Yes
Teacher encouragement to pursue physics	3.87 (0.81)	3.21 (0.74)	2.78	.007	Yes
Opportunities to lead group activities	4.05 (0.65)	3.14 (0.72)	4.11	<.001	Yes
Access to practical activities	4.01 (0.70)	3.30 (0.68)	3.45	.001	Yes
Enjoyment of physics	4.23 (0.61)	4.05 (0.59)	1.49	.14	No
Belief in girls' capability	4.00 (0.65)	3.89 (0.68)	1.22	.22	No

The **qualitative analysis** reinforced the quantitative findings. Girls reported hesitation to answer questions publicly due to fear of making mistakes, indicating that confidence plays a mediating role between ability and participation. Both pupils and teachers observed that boys were more frequently chosen as group leaders, suggesting that teacher practices contribute to unequal participation. Societal beliefs framing physics as a male-dominated subject discouraged girls' engagement and limited their opportunities to take initiative in practical activities. Furthermore, the lack of female physics teachers and role models emerged as a barrier to girls' long-term aspirations in STEM fields, as girls reported that seeing women succeed in physics would motivate them to persist and perform better.

Overall, these findings indicate that **gender differences in physics performance are influenced more by social, cultural, and pedagogical factors than by inherent ability**, supporting prior research emphasizing the role of self-efficacy, teacher expectations, and classroom dynamics in shaping students' outcomes (Murphy & Whitelegg, 2006; Kalonde & Chikopa, 2017; UNESCO, 2017).

5. Discussion

The results indicate that gender differences in physics performance are strongly shaped by social and pedagogical factors rather than innate ability. Boys' higher confidence, perceived encouragement, leadership opportunities, and practical engagement contributed to better performance, whereas girls' lower participation in these areas was associated with reduced performance (Bandura, 2001; OECD, 2019).

Differences in classroom leadership and practical participation suggest that inequitable opportunities accumulate over time, creating persistent performance gaps. Girls' reluctance to answer questions publicly, combined with fewer opportunities for practical engagement, limits skill development and confidence. Teacher behaviors, even when unconscious, reinforce stereotypes and unequal participation (Sadker & Zittleman, 2009; Mwansa, 2016).

Societal norms and the scarcity of female role models further constrain girls' engagement in physics. Interventions must therefore target both classroom practices and broader social perceptions. Gender-responsive pedagogy, mentorship, and deliberate inclusion of girls in leadership and practical roles are critical to narrowing achievement gaps (FAWE, 2007; UNESCO, 2017).

6. Conclusion

Performance differences in physics at Riverain Combined School are mediated by confidence, teacher practices, societal stereotypes, and the limited presence of female role models. Girls' lower performance is not due to ability but to contextual barriers in and outside the classroom. Interventions such as gender-responsive teaching, equitable leadership and practical task allocation, mentorship programs, and community initiatives to challenge gender stereotypes are essential.

The case study design limits generalizability beyond the studied school. Future research should involve multi-school, larger samples and longitudinal approaches to assess the impact of gender equity interventions over time.

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