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BRIDGING THE GAP IN PHYSICS EDUCATION: INVESTIGATING MISCONCEPTIONS AND PEDAGOGICAL STRATEGIES IN CHONGWE DISTRICT'S SECONDARY SCHOOLS

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Abstract

Many secondary school students in Chongwe District struggle with foundational physics concepts such as motion, force, and energy, largely due to persistent misconceptions reinforced by traditional teaching methods, insufficient instructional resources, and limited student engagement. This study investigates the sources of these misconceptions and evaluates the pedagogical strategies currently employed in physics classrooms. A mixed-methods design was adopted, collecting data from 200 students and 10 physics teachers through structured questionnaires, interviews, and classroom observations across four secondary schools. The findings reveal that abstract teaching approaches, lack of practical demonstrations, and minimal use of visual aids contribute significantly to students' misunderstanding of key physics principles. Conversely, students exhibited a strong preference for hands-on, collaborative learning activities that connect scientific content to real-life experiences. The study recommends the adoption of constructivist teaching methods, targeted teacher training, and strategic investment in laboratory and digital resources. These interventions are critical to enhancing conceptual clarity, increasing motivation, and strengthening physics education outcomes in under-resourced Zambian schools.

Keywords

Physics Education, Misconceptions, Teaching Methods, Student Engagement, Constructivist Learning, Zambia, Chongwe District, Pedagogical Innovation

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1. Introduction

Physics is widely recognized as a foundational discipline within the sciences, essential for fostering technological advancement, scientific reasoning, and critical thinking. Despite its importance, the subject remains one of the most challenging for secondary school students in Zambia, particularly in under-resourced districts such as Chongwe. Persistent misconceptions in topics like motion, energy, and force have led to consistently low academic performance and diminished student interest. These misconceptions often originate from students' everyday experiences, which conflict with scientific explanations, and are further reinforced by teaching methods that prioritize rote memorization over conceptual understanding. In many Zambian classrooms, physics is taught in a highly abstract and theoretical manner, with minimal use of experiments, real-life applications, or visual aids. Consequently, learners develop fragmented or erroneous understandings of fundamental concepts. For instance, the belief that heavier objects fall faster than lighter ones is a commonly held misconception that contradicts Newtonian physics but is rarely challenged through practical demonstration. Teachers often struggle to bridge the gap between textbook content and students' lived experiences, especially when constrained by limited resources, large class sizes, and curriculum pressure. Globally, educational research has emphasized the value of constructivist approaches in science education—pedagogical models that encourage learners to construct meaning through interaction, collaboration, and hands-on exploration (Duit, 1991; Freeman et al., 2014). However, the extent to which such methods are adopted in Zambian physics classrooms remains limited. The existing gap between curriculum intentions and classroom realities necessitates a critical examination of teaching practices and their impact on student understanding. This study focuses on secondary schools in Chongwe District to explore the nature of physics misconceptions among learners, evaluate the pedagogical strategies in use, and propose innovative, context-appropriate solutions. By identifying both the barriers and opportunities present in local school environments, the study aims to contribute to national efforts in strengthening science education and preparing learners for active participation in a knowledge-driven society.

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2. Objectives

The primary aim of this study is to investigate the root causes of misconceptions in physics among secondary school students in Chongwe District and to assess the pedagogical strategies employed by teachers to address these challenges. The specific objectives are as follows:

To identify prevalent misconceptions in fundamental physics concepts—such as motion, force, energy, and mass—among Grade 10 to Grade 12 students in selected secondary schools.

To examine current teaching methods used by physics educators and analyze their effectiveness in promoting conceptual understanding and engagement.

To explore students' perceptions and learning preferences regarding physics instruction, including the use of demonstrations, group work, and real-life applications.

To propose pedagogical strategies and policy recommendations that can bridge the gap between abstract physics content and students' everyday experiences, with a focus on constructivist learning and teacher capacity building.

Methodology

This study employed a mixed-methods research design that combined both quantitative and qualitative approaches to comprehensively investigate misconceptions in physics education and evaluate instructional strategies in Chongwe District's secondary schools. The choice of a mixed-methods design was motivated by the need to triangulate findings and ensure the validity and depth of analysis. The study population consisted of Grade 10 to Grade 12 students and physics teachers from four secondary schools: Mukamambo II Girls Secondary School, Chalimbana Secondary School, Matipula Secondary School, and Village of Hope Secondary School. A total of 200 students and 10 physics teachers participated. Students were selected using stratified random sampling to ensure balanced representation across schools and grade levels. Teachers were selected purposively based on subject expertise and teaching experience. Data were collected through structured

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questionnaires, semi-structured interviews, classroom observations, and focus group discussions. The student questionnaire focused on conceptual understanding, learning preferences, and attitudes toward physics. Semi-structured interviews with teachers explored their pedagogical approaches, challenges, and views on student misconceptions. Classroom observations were used to assess the instructional environment, teaching aids, and student participation. Additionally, focus group discussions with students provided qualitative insights into the perceived effectiveness of different teaching methods. Quantitative data were analyzed using descriptive statistics and one-way ANOVA to examine variations in student understanding across grade levels. Qualitative data from interviews and observations were analyzed thematically, allowing for the identification of recurring patterns in instructional practice and learner engagement. This comprehensive methodology ensured that both the breadth and depth of the research questions were addressed effectively, yielding actionable insights for improving physics education in under-resourced school settings

4. Results and Discussion

The data collected from questionnaires, interviews, observations, and focus group discussions provided valuable insights into the extent of misconceptions in physics among secondary school students in Chongwe District, as well as the pedagogical practices contributing to or addressing these challenges.

4.1 Conceptual Understanding Across Grades: ANOVA Analysis

An analysis of variance (ANOVA) was conducted to assess differences in students' self-reported confidence in understanding the concept of force across Grades 10, 11, and 12. The mean scores revealed a progressive increase: Grade 10 ($M = 3.2$, $SD = 0.76$), Grade 11 ($M = 3.6$, $SD = 0.84$), and Grade 12 ($M = 4.0$, $SD = 0.71$). The ANOVA test showed a statistically significant difference between the groups ($F(2, 197) = 9.85$, $p < .001$), indicating that students in higher grades demonstrated better conceptual clarity, likely due to repeated exposure and preparation for examinations. However, even among Grade 12 students, residual misconceptions persisted,

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particularly in distinguishing mass from weight and interpreting Newton's laws of motion.

4.2 Misconceptions Identified

The analysis of student responses and focus group discussions identified several prevalent misconceptions. Many students believed that heavier objects fall faster than lighter ones, that energy is "used up" rather than transformed, and that mass and weight are interchangeable concepts. These findings are consistent with prior research by Halloun and Hestenes (1985), which emphasized the durability of misconceptions unless actively confronted through targeted instruction. Interviews with teachers revealed that while they were aware of some of these misconceptions, they often lacked the resources or time to correct them effectively within the constraints of the syllabus.

4.3 Teaching Practices and Instructional Gaps

Classroom observations revealed that traditional, lecture-based instruction was the dominant mode of teaching. Practical demonstrations, student discussions, and real-life applications were infrequent. Teachers cited large class sizes, limited laboratory equipment, and lack of professional development as barriers to implementing more interactive methods. However, where teachers attempted group work or visual aids, students displayed higher engagement and better retention of content, supporting the value of constructivist approaches (Duit, 1991; Freeman et al., 2014). Qualitative feedback from students indicated a strong preference for hands-on learning, use of multimedia, and lessons that connect physics to their everyday experiences. Many students expressed frustration with abstract teaching that lacked relevance, noting that it contributed to their confusion and lack of interest. These perceptions align with global studies advocating for inquiry-based and participatory science instruction (Hattie & Timperley, 2007).

4.4 Synthesis of Quantitative and Qualitative Findings

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The integration of both data streams highlights a significant disconnect between curriculum objectives and instructional realities. While the Zambian physics curriculum emphasizes conceptual understanding and scientific reasoning, its delivery in practice often fails to support these aims. Students' misconceptions are not only a result of prior beliefs but are perpetuated by didactic teaching, insufficient scaffolding, and minimal use of instructional technologies or real-life contexts. The findings underscore the urgency of aligning teaching practices with evidence-based pedagogical strategies to improve student outcomes.

5. Recommendations

Based on the findings from both the quantitative and qualitative phases of this study, several actionable recommendations are proposed to address physics misconceptions and enhance teaching effectiveness in Chongwe District's secondary schools.

5.1 Incorporate Practical Demonstrations and Experiments

Teachers should regularly integrate hands-on experiments and demonstrations into their lessons, even when laboratory equipment is limited. Improvised materials and locally available resources can be creatively used to illustrate fundamental concepts such as Newton's laws, energy transfer, and the behavior of forces. This approach not only enhances conceptual clarity but also nurtures curiosity and scientific inquiry.

5.2 Enhance Continuous Professional Development (CPD)

There is a critical need for structured and ongoing teacher training programs focused on modern pedagogical techniques, especially constructivist and inquiry-based learning. CPD should emphasize strategies to identify and correct student misconceptions, employ interactive methods, and integrate real-life contexts into instruction. Collaboration between the Ministry of Education and teacher training institutions can facilitate accessible, school-based training modules.

5.3 Promote Student-Centered and Constructivist Teaching Approaches

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Teachers should be encouraged to shift from lecture-based methods to more student-centered approaches. These may include group work, peer instruction, concept mapping, problem-based learning, and collaborative projects. Such strategies empower students to take ownership of their learning and engage actively with physics content.

5.4 Leverage Technology and Multimedia Tools

The integration of technology—such as simulations, educational videos, and physics apps—can significantly improve students' comprehension of abstract concepts. Where infrastructure permits, schools should adopt digital resources to supplement traditional instruction. In areas with limited internet access, preloaded videos or solar-powered tablets can provide viable alternatives.

5.5 Develop Contextualized and Culturally Relevant Learning Materials

Teaching resources should reflect the local environment and students' lived experiences. For example, using common tools or domestic scenarios to explain concepts of levers, friction, or energy conservation helps bridge the gap between theory and practice. Collaborating with curriculum developers to produce culturally grounded instructional aids can enhance relevance and retention.

5.6 Improve School Infrastructure and Resource Allocation

Policymakers and education stakeholders must prioritize investment in science laboratories, learning materials, and technological infrastructure. Equitable distribution of these resources across urban and rural schools is essential to close regional disparities in science education.

5.7 Engage Community and Parents in Science Education

Community-based science awareness initiatives and parent engagement programs can reinforce learning outside the classroom. Encouraging informal science clubs, outreach activities, and science fairs can stimulate interest and provide platforms for experiential learning.

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6. Conclusion

This study has illuminated the persistent challenges facing physics education in Chongwe District, with a specific focus on student misconceptions and the pedagogical strategies used to address them. The findings demonstrate that misconceptions about core concepts—such as force, motion, energy, and mass—are widespread among secondary school learners and are often reinforced by traditional, teacher-centered methods that fail to engage students meaningfully or contextually. While the curriculum emphasizes scientific reasoning and inquiry, the implementation in practice remains largely constrained by structural and resource limitations. Teachers often operate in overcrowded classrooms with insufficient access to laboratory facilities, instructional technology, or professional development opportunities. As a result, abstract and decontextualized teaching persists, failing to bridge the cognitive gap between theory and learners' lived experiences. However, the study also revealed promising opportunities for transformation. Students expressed a clear preference for interactive, hands-on, and visually supported learning. The observed impact of even modest constructivist interventions—such as group discussions, guided inquiry, and real-world analogies—suggests that pedagogical reform could lead to significant improvements in conceptual understanding and student engagement. To bridge the gap in physics education, a multifaceted approach is required. At the classroom level, teachers must be supported in transitioning toward student-centered instruction. At the institutional level, schools need improved infrastructure, teaching resources, and access to digital tools. At the policy level, ongoing investment in teacher capacity-building and curriculum contextualization is essential to ensure equitable and effective physics education. In conclusion, closing the conceptual and pedagogical gap in secondary school physics education is not only necessary for improving academic performance but also critical for nurturing a scientifically literate and technologically capable citizenry. With sustained commitment from educators, policymakers, and the wider community, Zambia can build a more inclusive and innovative future through science education

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