

Exploring Barriers to ICT Integration and Gender Inclusivity in Physics Teaching: A Study in Teacher Training Institutions in Uganda

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DOI: <https://dx.doi.org/10.47772/IJRISS.2024.807143>

Received: 14 June 2024; Revised: 04 July 2024; Accepted: 10 July 2024; Published: 11 August 2024

ABSTRACT

This study investigates the challenges hindering the incorporation of Information and Communication Technology (ICT) and gender inclusivity in physics teaching within Teacher Training Institutions (TTIs) in Uganda. Employing a mixed-method approach, data was collected from administrators and physics lecturers through interviews, questionnaires, observation, and document analysis. Findings reveal a multitude of barriers including limited access to technology, gender stereotypes, inadequate teacher training, and institutional policies. These obstacles underscore the need for comprehensive strategies to promote ICT integration and gender equity in physics education. Recommendations are proposed to address these challenges and enhance the quality and inclusivity of physics teaching in Ugandan TTIs.

Keywords: Gender Inclusivity, Information and Communication Technology, Teaching and Learning

INTRODUCTION

In recent years, there has been a growing recognition of the pivotal role that Science, Technology, Engineering, and Mathematics (STEM) fields play in driving global economic growth and prosperity. Stemming from technological advancements, these areas have become fundamental for shaping the future of work, fostering innovation, and reducing poverty (Costa et al., 2020; Kiconco & Karyarugokwo, 2022). Consequently, governments and industry leaders worldwide have underscored the importance of physics education as a gateway to careers in STEM disciplines, emphasizing its critical role in enhancing a country's competitiveness and socioeconomic development (Maera, 2016).

In Uganda, efforts to promote growth and development have increasingly focused on a science-led strategy, recognizing the transformative potential of science education and scientific innovations (Uganda-UNESCO, 2010; Wedgwood, 2005). Since the early 2000s, Uganda has implemented various policies aimed at bolstering science education, including the compulsory teaching of sciences such as Mathematics, Chemistry, Biology, and Physics at the Ordinary level (Uganda-UNESCO, 2010). However, despite these efforts, challenges persist, particularly in the effective integration of Information and Communication Technology (ICT) into physics education.

ICT holds immense potential to revolutionize teaching and learning, offering opportunities to enhance instructional delivery, engage students, and improve learning outcomes (Heng & Jing, 2012; Narinderrit, 2020). In the context of physics education, the integration of ICT tools can simplify abstract concepts, stimulate interest, and facilitate personalized learning experiences (Ellermeijer & Tran, 2019). However, realizing these benefits requires science educators to possess the necessary technological competencies and

pedagogical skills (Abigail et al., 2020).

Teacher Training Institutions (TTIs) play a crucial role in preparing the next generation of educators equipped with the skills and knowledge needed to foster STEM education. Yet, the effective integration of ICT and gender-responsive pedagogy in physics education within TTIs remains an area of concern. It is essential to explore how physics educators in TTIs employ ICT to facilitate knowledge construction among student teachers and address gender disparities in physics achievement and enrollment.

Against this backdrop, this study aims to investigate the incorporation of ICT and gender-responsive pedagogy in the teaching of Physics Education in TTIs in Eastern Uganda. By examining the practices and challenges faced by physics educators, the study seeks to identify strategies to enhance teaching effectiveness, promote gender equity, and improve student achievement in physics.

Problem Statement

Teacher Training Institutions (TTIs) in Uganda unequivocally face significant challenges in integrating Information and Communication Technology (ICT) into the teaching of physics. Despite the proven benefits of ICT tools in enhancing physics instruction, lecturers consistently encounter obstacles that impede their effective utilization of these technologies. To decisively address this issue, it is imperative to thoroughly examine the factors impeding lecturers' use of ICT in teaching physics and thoroughly investigate the specific challenges faced by TTIs in Uganda regarding the integration of ICT in physics instruction. Teacher Training Institutions (TTIs) in Uganda unequivocally face significant challenges in integrating Information and Communication Technology (ICT) into the teaching of physics. Despite the potential benefits of ICT tools in enhancing physics instruction, lecturers encounter various obstacles that hinder their effective utilization of these technologies. To comprehensively address this issue, it is essential to examine the factors impeding lecturers' use of ICT in teaching physics and to investigate the specific challenges faced by TTIs in Uganda regarding the integration of ICT in physics instruction.

Research Objectives

This study was guided by the following research objectives:-

1. To identify the Key Barriers to ICT Integration in Physics Teaching within Teacher Training Institutions (TTIs) in Uganda.
2. To examine the Impact of Gender Stereotypes and Biases on ICT Integration in Physics Teaching.
3. To develop and propose Strategies to Overcome Barriers to ICT Integration and Promote Gender Equity in Physics Education.

Research Questions

The following research questions directed the actions of the researcher

1. What are the key barriers to ICT integration in physics teaching in TTIs in Uganda?
2. How do gender stereotypes and biases affect the integration of ICT in physics teaching?
3. What strategies can be implemented to overcome these barriers and promote gender equity in physics

education?

LITERATURE REVIEW

The integration of Information and Communication Technology (ICT) in physics teaching within Teacher Training Institutions (TTIs) in Uganda faces numerous barriers. These include limited access to technology, inadequate teacher training, restrictive institutional policies, and pervasive gender stereotypes. This literature review aims to provide a thorough understanding of these barriers and the impact of gender biases while proposing strategies to overcome these challenges and promote gender equity in physics education.

Barriers to ICT Integration

Several studies have identified significant barriers to ICT integration in education, particularly within physics teaching in Ugandan TTIs. Limited access to technology is a primary challenge, often resulting from inadequate funding and resource allocation. According to Hinojosa (2018), many institutions lack the necessary ICT infrastructure, such as computers and reliable internet access, which impedes the adoption of technology in classrooms. This lack of resources creates a significant disparity in the quality of education that can be delivered.

Inadequate teacher training is another critical barrier. Many educators in Uganda are not sufficiently trained to use ICT tools effectively in their teaching practices. Lawrence and Tar (2018) emphasize the importance of continuous professional development to equip teachers with the skills needed to integrate ICT into their pedagogy. Additionally, Ramukadev et al. (2018) highlight the necessity of establishing social routines and support systems to help educators become familiar with new technologies. Without proper training and support, teachers may struggle to incorporate ICT in a meaningful way, leading to underutilization of available resources.

Institutional policies and time constraints further complicate the integration of ICT. Kozma et al. (2004) note that busy schedules and the rigid structure of educational systems leave little room for teachers to plan and incorporate ICT into their lessons. Furthermore, traditional teaching cultures and teacher beliefs often resist the adoption of new technologies, as discussed by Valtanen et al. (2018). These cultural and systemic barriers can be as significant as the technological ones, requiring comprehensive strategies to address them.

In addition to the above, a study by Kiptalam and Rodrigues (2010) identified the lack of administrative support and policy framework as major hindrances to ICT integration in schools in developing countries. Their research suggests that the absence of clear policies and administrative commitment leads to inconsistent ICT adoption and underutilization.

Impact of Gender Stereotypes and Biases

Gender stereotypes and biases significantly affect the integration of ICT in physics teaching. Mawanga (2016) found that male teachers are more likely to use ICT tools than their female counterparts, reflecting broader societal biases that discourage women from engaging with technology. These stereotypes not only impact female teachers but also influence female students, who may feel less encouraged to pursue STEM fields. This is particularly troubling in the context of physics education, where female participation is already lower compared to other subjects.

The disparity in ICT usage among male and female educators suggests a need for targeted interventions to support and empower female teachers. Encouraging female teachers to acquire personal computers and teaching science subjects in higher classes can help bridge this gap (Mawanga, 2016). Additionally, addressing these stereotypes at the institutional level, by promoting gender-sensitive policies and practices,

is crucial for creating a more inclusive educational environment.

Further research by UNESCO (2015) highlights that gender biases in education are not only a barrier to ICT integration but also impact overall academic performance and career aspirations of female students. Promoting gender equity in education through policies that encourage female participation in STEM can significantly enhance the learning environment.

Strategies to Overcome Barriers and Promote Gender Equity

To address these barriers and promote gender equity, comprehensive strategies involving government policies, institutional reforms, and continuous professional development are necessary. The government should prioritize funding for ICT infrastructure in schools, ensuring that all TTIs have access to necessary technological tools (Bergonia, 2017). This includes not only the provision of hardware but also the establishment of reliable internet connections and technical support.

Professional development programs should be implemented to provide educators with the skills and confidence to integrate ICT into their teaching. This includes training on both the technical aspects of using ICT tools and the pedagogical strategies to effectively incorporate them into lessons (Lawrence & Tar, 2018). By fostering a culture of continuous learning, educators can stay updated with technological advancements and integrate them effectively into their teaching practices.

Institutional reforms should focus on creating supportive environments for ICT integration. This involves revising school schedules to allow for planning time, fostering a culture of innovation, and providing ongoing technical support for educators (Hinostroza, 2018). Moreover, schools should actively work to dismantle gender biases by encouraging female participation in STEM subjects and providing mentorship programs for female teachers and students.

A study by Kelleher (2016) emphasizes the importance of mentorship and role models in promoting gender equity in STEM education. By providing female students and teachers with mentors who have succeeded in STEM fields, schools can create an encouraging environment that challenges gender stereotypes.

The integration of ICT in physics teaching within Ugandan TTIs faces significant barriers, including limited access to technology, inadequate teacher training, institutional policies, and gender stereotypes. Addressing these challenges requires comprehensive strategies that involve government support, institutional reforms, and continuous professional development. Promoting gender equity in physics education is crucial for fostering a more inclusive and effective learning environment. By implementing these strategies, TTIs can enhance the quality of physics education and better prepare future educators to leverage ICT in their teaching practices.

METHODOLOGY

Research Paradigm: This study adopted a pragmatism paradigm, which allows for the integration of multiple research approaches and methods to address the research objectives effectively. Pragmatism emphasizes practical outcomes and the utilization of diverse methods to understand complex phenomena within real-world contexts.

Research Approach: A mixed-method approach was employed to gather comprehensive data, combining qualitative and quantitative techniques to provide a deeper understanding of the factors impeding the incorporation of ICT and gender in physics teaching in Teacher Training Institutions (TTIs) in Uganda.

Sampling: Purposive sampling was used to select participants, including 12 administrators and 12 physics

lecturers from various TTIs in Uganda. This sampling strategy ensured the inclusion of individuals with diverse perspectives and experiences relevant to the research objectives.

Data Collection Methods:

Interviews: Semi-structured interviews were conducted with physics lecturers to explore their perspectives on the challenges and barriers to ICT incorporation in physics teaching. Interviews were audio-recorded with participants’ consent and transcribed for qualitative analysis.

Questionnaires: Structured questionnaires were distributed to administrators to gather quantitative data on their experiences, attitudes, and perceptions regarding ICT integration in physics education.

Observation Guide: Observations were conducted in physics classrooms within TTIs to assess the actual utilization of ICT tools and gender-inclusive practices in teaching. An observation guide was developed to document the use of ICT, teaching strategies, and gender dynamics during physics lessons.

Data Analysis:

Qualitative Analysis: Thematic analysis was employed to analyze data from interviews, open-ended questionnaire responses, and document analysis. Transcripts and documents were coded and categorized to identify recurring themes and patterns related to barriers to ICT integration and gender inclusivity in physics education.

Quantitative Analysis: Quantitative data from structured questionnaires were analyzed using descriptive statistics such as frequencies and percentages. Excel and Word were utilized to summarize and interpret quantitative findings, providing insights into the prevalence of different barriers and attitudes toward ICT incorporation.

Ethical Considerations:

Ethical approval was obtained from Busitema University Faculty of Health Sciences Research Committee (BUFHSRC) and Uganda National Council for Science and Technology (UNCST) before data collection. Informed consent was obtained from all participants, and their confidentiality and anonymity were ensured throughout the research process. Participants had the right to withdraw from the study at any time without penalty.

PRESENTATION AND DISCUSSION OF FINDINGS

Factors Limiting the Incorporation of ICT and Gender in Physics Teaching

Table 1 Lecturers Responses on Factors Limiting the Incorporation of ICT and Gender in Physics Teaching

Factor	Frequency	Percentage (%)
Limited Access to Technology	08	66.7
Gender Stereotypes and Bias	11	91.7
Lack of Gender Inclusive Content	09	75
Insufficient Teacher Training	08	66.7
Cultural and Societal Norms	11	91.7
Unconscious Bias	11	91.7
Resource Constraints	11	91.7

Institutional Policies	10	83.3
Digital Divide	09	75
Resistance to Change	12	100

Source: Primary Data

In Table 1 above, factors limiting the incorporation of ICT and gender in physics teaching are detailed, revealing the primary challenges encountered by educators. Topping the list is resistance to change, reported by all surveyed lecturers. This unanimous response underscores the pervasive reluctance or opposition faced by educators when attempting to integrate ICT and address gender-related issues within physics education. Following closely behind were gender stereotypes and bias, cultural and societal norms, unconscious bias, and resource constraints, each reported by 91.7% of the participants. These factors highlight the significant influence of societal attitudes, biases, and structural limitations hindering efforts to promote gender equity and effective ICT integration in physics teaching. Institutional policies emerge as another noteworthy factor, reported by 83.3% of lecturers.

The above findings are in line with what (Valtomen et al, 2018) and (Bingmulas, 2009, Khalid, Faroque & Reid, 2016)) discovered in their earlier studies. This suggests that institutional frameworks and regulations may not sufficiently support initiatives aimed at addressing ICT incorporation and gender equity in physics education. Additionally, challenges such as limited access to technology, insufficient teacher training, lack of gender-inclusive content, and the digital divide are reported by varying proportions of respondents, ranging from 66.7% to 75% (Rumukadev et al, 2018, Lawrence & Tar, 2018). These obstacles reflect practical barriers and educational gaps that impede the effective utilization of ICT and the promotion of gender equity in physics teaching.

The data highlights the complex array of obstacles faced by educators striving to integrate ICT and address gender-related concerns in physics education. It underscores the need for comprehensive strategies addressing technological limitations, societal attitudes, institutional barriers, and educational inequalities to foster inclusive and equitable learning environments in physics classrooms. Based on the above findings, the principals of TTIs should work with the government to ensure that the necessary facilities and resources needed to adopt ICT use in teaching physics are instituted. This can be supplemented with continuous professional developments geared towards equipping lecturers with the appropriate ICT competencies as advocated by Aladejana (2007).

Role of Administrators in Overcoming Resistance to ICT Use among Lecturers

Table 2 Administrators' Role in Overcoming Resistance to ICT Use among Lecturers

Role	Frequency	Percentage (%)
Organization of continuous professional developments	12	100
Showcasing successful examples	00	00
Providing supportive resources	04	33.3
Fostering a collaborative culture	03	25
Aligning incentives and recognition	04	33.3

Source: Primary Data

The results in Table 2 above sheds light on the perceived role of administrators in overcoming resistance to

ICT use among lecturers. The most prevalent role identified by the surveyed lecturers is the organization of continuous professional development, reported by all respondents (100%). This suggests a unanimous recognition among educators that ongoing training and skill development opportunities play a crucial role in addressing resistance and enhancing the effective integration of ICT into teaching practices.

However, other roles such as showcasing successful examples and fostering a collaborative culture did not receive any reported frequencies. This absence may imply a gap in current administrative approaches, as these strategies are not being utilized to overcome resistance effectively. Nonetheless, providing supportive resources and aligning incentives and recognition were reported by 33.3% of respondents each, indicating some acknowledgment of the importance of these factors in facilitating ICT adoption among lecturers.

Tondeour et al (2011) noted that students' experiences with computers and access to technology are positively related to their ICT self-efficacy. Efforts should be made to ensure that TTIs are equipped with quality computers with a connection to the Internet (Moos& Azevedo, 2009). This will provide for students to learn from computers as tutors, interact with fellow students and lecturers, access relevant appropriate physics content, and conduct self-regulated learning (SRL) where CPDs can be attended to ensure efficiency and effectiveness (Kozma et al,2004).

Viewing the data above it can be argued, that administrators play a pivotal role in supporting lecturers in overcoming resistance to ICT use. By prioritizing continuous professional development, providing necessary resources, and aligning incentives, administrators can create an environment conducive to embracing technological innovation and fostering a culture of collaboration and growth within the educational institution. However, there appears to be room for improvement in utilizing strategies such as showcasing successful examples and fostering collaborative cultures, which could further enhance the effectiveness of efforts to promote ICT integration among lecturers.

Administrators' Role in Overcoming Resistance to ICT Integration by Students

Table 4.3 Administrators' Responses on their Role in Overcoming Resistance to ICT Integration by Students

The strategy of overcoming resistance	Frequency	Percentage (%)
Creation of inclusive learning environments	04	33.3
Students' involvement in decision making	05	41.7
Provision of support services	03	25
Promotion of role models	06	50

Source: Primary Data

The data provided in Table 4.3 outlines various strategies for overcoming resistance to ICT use among student teachers, indicating both frequencies and percentages. The strategy reported with the highest frequency is the promotion of role models, cited by 50% of respondents. This suggests that half of the surveyed educators view the demonstration of successful examples as an effective means of inspiring and motivating students to overcome resistance and embrace ICT integration in teaching practices. Following closely behind is students' involvement in decision-making, reported by 41.7% of respondents. This indicates recognition among educators that engaging students in the decision-making process regarding ICT use can foster a sense of ownership and accountability, ultimately facilitating acceptance and adoption among student teachers.

Creation of inclusive learning environments is the next most frequently cited strategy, reported by 33.3% of respondents. This suggests a recognition that fostering inclusive environments where all individuals feel

valued and respected can help mitigate resistance to ICT use by promoting a sense of belonging and collaboration. Provision of support services follows with 25% of respondents indicating its importance. This underscores the significance of offering assistance and resources to students navigating the challenges associated with ICT integration, thereby easing their transition and enhancing their confidence in utilizing technology effectively.

The above findings are in line with what Sadaf et al (2016) noted that leaders in educational institutions should take responsibility to overcome resistance to ICT integration by organizing resources and being involved in ICT integration. This calls for them to be models of the ICT integration attributes that they want teachers to emulate. This is backed by Kiven et al (2008) and Osborn & Hennessey (2022) who stressed that teachers should teach them ICT literacy and create necessary conditions for ICT use. The data suggests that promoting role models, involving students in decision-making processes, and creating inclusive learning environments are perceived as the most effective strategies for overcoming resistance to ICT use among students. However, there may be opportunities for improvement in the implementation of support services, student awareness campaigns, and feedback mechanisms to further enhance the effectiveness of efforts in this regard.

Document Analysis on ICT and Gender Integration in Teaching

The researcher tried to analyze schemes of work and teaching-learning materials in the classrooms and the following were the observations:-

The Researcher checked schemes of work and lesson plans but little attention was drawn towards using the projector to present the content to the class through normal teaching lessons. This was mainly observed in most lecturers who were associating the ICT knowledge to the use of Microsoft and PowerPoint in organizing their work mainly lesson notes. No special attention was paid to physics online electronic resources. The assessment methods or activities were mainly traditional and required the student to respond to given questions using Word or sometimes PowerPoint for class presentations.

Little attention was given to the use of ICT in responding to given questions. Similarly, there was no mention of the physics lecturer's use of learning management systems in presenting assignments to students as almost no website was given for reference in lesson conduct or access to e-resources.

The observations regarding the limited utilization of ICT in teaching physics highlight several areas where administrators could play a pivotal role in overcoming resistance from both lecturers and students. Drawing upon frameworks such as TPACK (Technological Pedagogical Content Knowledge), DOI (Diffusion of Innovations), and sociocultural theories about ICT and gender incorporation in physics teaching, administrators can implement targeted strategies to address these challenges effectively.

Firstly, administrators can facilitate professional development opportunities focusing on TPACK, which emphasizes the integration of technological knowledge, pedagogical understanding, and subject matter expertise. By providing training sessions that emphasize the diverse range of ICT tools and resources available for teaching physics, administrators can empower lecturers to expand their repertoire beyond traditional methods like Microsoft PowerPoint. Additionally, administrators can encourage the exploration of online electronic resources specifically tailored to physics education, thus enriching the content and enhancing the learning experience for students.

Secondly, by leveraging the principles of DOI, administrators can create a supportive environment conducive to innovation adoption. This involves not only providing access to technological resources but also fostering a culture of experimentation and collaboration. Administrators can encourage lecturers to explore new assessment methods and activities that leverage ICT, such as interactive quizzes or multimedia

presentations. By showcasing successful examples and providing ongoing support, administrators can help overcome resistance to change and promote the adoption of innovative teaching practices.

Furthermore, administrators can address gender disparities in ICT incorporation by incorporating sociocultural theories into their approach. This entails promoting inclusivity and diversity in both content and pedagogy, ensuring that ICT tools and resources are accessible and relevant to all students, regardless of gender. Administrators can support lecturers in designing inclusive learning experiences that cater to diverse learning styles and preferences, thus empowering all students to engage actively with ICT in their physics education. Findings confirmed that administrators have a crucial role to play in overcoming resistance to ICT use among lecturers and students in physics education (Sadaff et al, 2016). By providing targeted professional development, fostering a culture of innovation, and promoting inclusivity, administrators can facilitate the effective integration of ICT into teaching and learning processes, ultimately enhancing the quality and equity of physics education for all students.

CONCLUSIONS

The findings of this study underscore the multifaceted challenges encountered in the incorporation of ICT and gender-responsive pedagogy in physics teaching within Teacher Training Institutions (TTIs) in Eastern Uganda. Resistance to change emerges as a pervasive barrier, reflecting the entrenched reluctance or opposition faced by educators when attempting to integrate ICT and address gender-related issues. Additionally, factors such as limited access to technology, gender stereotypes, cultural norms, and institutional policies further hinder efforts to promote ICT integration and gender equity in physics education.

Administrators play a pivotal role in overcoming resistance to ICT use among both lecturers and students. By prioritizing continuous professional development, providing necessary resources, and fostering a culture of collaboration, administrators can create an environment conducive to embracing technological innovation and promoting gender-responsive pedagogy. However, there is room for improvement in utilizing strategies such as showcasing successful examples and fostering inclusive learning environments, which could further enhance the effectiveness of efforts to promote ICT integration and gender equity in physics education.

RECOMMENDATIONS

Based on the findings and objectives of this study, the following recommendations were proposed:

- 1. Enhanced Professional Development:** Administrators should prioritize continuous professional development opportunities focusing on technological pedagogical content knowledge (TPACK) for lecturers. Training sessions should emphasize the diverse range of ICT tools and resources available for teaching physics, enabling educators to expand their repertoire and effectively integrate technology into their instructional practices.
- 2. Resource Provision:** TTIs should ensure adequate provision of technological resources, including quality computers with internet connectivity, to facilitate effective ICT integration in physics education. This will enable students to engage in self-regulated learning, interact with relevant physics content, and access support services as needed.
- 3. Institutional Support:** Administrators should create a supportive environment conducive to innovation adoption by aligning incentives and recognition for lecturers who embrace ICT integration and gender-responsive pedagogy. Additionally, institutional policies should be reviewed to ensure they support initiatives aimed at promoting ICT integration and gender equity in physics education.
- 4. Promotion of Inclusivity:** Efforts should be made to foster inclusive learning environments where all students feel valued and respected, regardless of gender. Administrators should promote diversity in

both content and pedagogy, ensuring that ICT tools and resources are accessible and relevant to all students.

5. **Role Modeling and Showcasing:** Administrators should showcase successful examples of ICT integration and gender-responsive pedagogy to inspire and motivate lecturers and students. By highlighting innovative teaching practices and their impact on student learning, administrators can encourage the adoption of effective strategies across TTIs in Uganda.

By implementing these recommendations, TTIs in Uganda can overcome the challenges identified in this study and foster inclusive and equitable learning environments in physics education. This will not only enhance the quality of education but also contribute to the empowerment of future educators and the promotion of gender equity in the STEM field.

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