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Multimedia integration in Physics education in Tanzania secondary schools: challenges and opportunities

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Abstract. This study investigates the integration of multimedia in Physics education within Tanzania secondary schools, focusing on challenges and opportunities in a resource-constrained context. Grounded in Mayer's cognitive theory of multimedia learning and Vygotsky's social constructivism, the research employed a qualitative case study design, involving semi-structured interviews and classroom observations with eight participants (four Physics teachers and four heads of schools) from four government secondary schools in Mbeya Region. Findings reveal significant barriers, including inadequate infrastructure (e.g., lack of projectors, computers, and electricity), limited teacher training, large class sizes, and gaps in lesson planning and curriculum integration. These constraints force reliance on traditional teaching methods, reducing student engagement and science literacy. However, teachers demonstrate adaptability by using their personal smartphones and low-cost technologies to deliver multimedia content and contextualise Physics concepts, enhancing relevance and motivation. Opportunities for improvement include targeted professional development, structured curriculum guidelines, and partnerships with NGOs for sustainable resource provision. The study highlights the need for infrastructure investment and teacher support to scale these efforts, aligning with global recommendations for inclusive integration of educational technology to improve Physics learning outcomes.

Keywords: multimedia integration, Physics education, secondary schools, infrastructure challenges, teacher training

1. Introduction

In the 21st century, the integration of multimedia into education has emerged as a vital approach for improving student engagement and comprehension, particularly in science subjects such as Physics [8, 25]. The development of 21st century skills requires students' active participation in discovering concepts, analysing problems, communicating and discussing ideas, and reading and writing observation reports [11]. Multimedia, by its very nature, supports these processes by combining text, sound, images, animations, and videos into coherent instructional resources [25]. Examples include simulations, virtual laboratories, virtual field trips, and interactive videos, which not only diversify but also offer flexibility in how they engage with learning tasks [19].

Evidence from previous studies demonstrates that multimedia integration can significantly enhance students' conceptual understanding in science and mathematics [20]. It allows learners to visualise and manipulate abstract or complex processes such as motion, diffusion, and atomic bonding in ways that would otherwise be impractical, costly, or unsafe in traditional classrooms [12]. Further, multimedia has been found to stimulate classroom dialogue, foster critical thinking, and improve clarity of instructional materials [35]. When applied constructively, it also facilitates the development of essential 21st-century skills, including creativity, reflection, and problem-solving [19, 37].

Research in African contexts also highlights these benefits. For example, studies in Nigeria have shown that a multimedia-enriched lecture method significantly improves students' retention of Physics concepts compared to conventional lectures, and that audiovisual media is particularly effective

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for the academic achievement of kinesthetic learners [2]. In Kenya, an Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach was found to positively affect students' motivation to learn Physics when compared to conventional methods [28]. Similarly, research in Rwanda demonstrated that students taught astrophysics using video-based multimedia performed significantly better than those taught with usual methods [45]. Another study in Rwanda found that using PhET simulations increased students' conceptual understanding and learner autonomy in Physics [38]. These findings from various African nations underscore that multimedia integration is a significant and effective strategy for addressing diverse challenges in science education across the continent. Nonetheless, these benefits are often discussed in general terms, with relatively limited examination of their applicability in resource-constrained contexts such as Sub-Saharan Africa, where infrastructural, pedagogical, and policy barriers persist.

In Tanzania, persistent challenges in student participation and performance in science subjects have been widely documented [14]. Physics in particular has recorded poor performance in national examinations, coupled with declining enrolment as students progress through secondary school [43, 48]. Research links these trends to students' limited conceptual understanding and the inadequate use of teaching aids to clarify abstract concepts [27]. The problem extends beyond pedagogy and is systemic in nature, as the shortage of skilled science professionals limits Tanzania's ability to achieve its socio-economic and technological development goals [18, 27]. Although multiple interventions have been proposed, including the use of ICT and multimedia tools, the extent to which these solutions are effectively integrated into teaching remains unclear.

Similar challenges with integrating technology in education have been observed in other countries. For instance, a study in Rwanda [44] found that video-based multimedia is used infrequently in physics teaching and learning. Major factors impeding its use include poor infrastructure, inadequate teacher training in effective multimedia integration, pressure on teachers to prepare students for exams, and a lack of time for preparation. Likewise, in Uganda, Gumisirizah, Nzabahimana and Muwonge [10] revealed that inadequate infrastructure and low digital literacy among teachers constrained the integration of e-learning tools. Such findings resonate with the Tanzania context, showing that systemic issues are widespread across the region.

Several studies highlight the potential of multimedia for enhancing students' scientific knowledge in Tanzania [15, 24–26]. In alignment with this, the national policy frameworks, the Education and Training Policy of 2014, 2023 edition, emphasises ICT as a key enabler of educational quality. The government has pledged to work with stakeholders to create enabling environments for ICT integration across all levels of education [36, 41]. However, evidence suggests a misalignment between policy ambitions and classroom realities. For instance, while teacher training colleges have been equipped with computers, many teachers remain reluctant or unprepared to integrate technology into their teaching practices [14]. Similarly, despite rising awareness of multimedia tools, their practical application in science classrooms remains sporadic and underdeveloped [1].

This disconnect highlights a deeper issue: multimedia is widely recognised for its pedagogical potential, yet little empirical research has explored its effectiveness in addressing Physics-specific challenges in Tanzania. Much of the existing literature provides descriptive accounts of multimedia use, but less attention has been paid to the contextual barriers, such as infrastructure gaps, teacher readiness, and curriculum alignment, that mediate its effectiveness. Furthermore, the decline in students' enrollment and persistent underperformance in Physics [40, 43, 48] suggest that current strategies have not sufficiently bridged the gap between policy goals and classroom realities.

Against this backdrop, the present study examines the challenges and opportunities of integrating multimedia into Physics education in secondary schools in Tanzania. By focusing on teachers' struggles and strategies within resource-constrained contexts, the research addresses an important knowledge gap: the lack of context-specific evidence on how multimedia integration can be both practical and effective in enhancing students' scientific understanding and engagement. The study aims to generate actionable insights for educators, policymakers, and stakeholders, thereby improving Physics education and fostering students' problem-solving skills in an increasingly complex world.

2. Research questions

This study focuses on responding to two research questions:

1. What challenges are faced in the effective integration of multimedia into Physics education in secondary schools?
2. What opportunities can be explored to improve multimedia integration in Physics education within these schools?

3. Theoretical framework of the study

3.1. Cognitive theory of multimedia learning

This study is grounded in Richard Mayer's cognitive theory of multimedia learning (CTML), which posits that students learn more effectively when both words and images are used together rather than words alone [22]. The theory provides a valuable framework for understanding how multimedia integration can enhance Physics education by aligning instructional design with how the human mind processes information. It highlights the importance of dual-channel processing (visual and auditory), limited cognitive capacity, and the necessity for active processing to facilitate meaningful learning. In the context of secondary schools in Tanzania, this theory is especially relevant, as it supports the development of multimedia resources, such as videos and animations, that can simplify complex Physics concepts. These multimedia materials will be carefully developed in accordance with CTML principles, ensuring that extraneous cognitive load is minimised, essential content is clearly presented, and students are encouraged to actively construct understanding by integrating prior knowledge. This alignment is crucial in addressing existing instructional challenges and enhancing learner engagement and comprehension in Physics classrooms.

3.2. Social constructivism theory

The social constructivism theory, advanced by Vygotsky [50], underscores the role of social interaction and experiential learning in knowledge construction. This theory is particularly applicable to the integration of multimedia in Physics education in Tanzania secondary schools, where resource limitations and traditional teaching methods often constrain collaborative learning opportunities. Social constructivism promotes learning environments where students engage in dialogue, practical activities, and group tasks, allowing them to co-construct knowledge through shared experiences. In this study, multimedia was used alongside interactive teaching strategies that fostered peer discussion, hands-on experimentation, and joint problem-solving. By creating a supportive, socially rich learning context, the study aims to overcome key challenges in Physics instruction, such as passive learning and low student motivation, while also exploring effective strategies for multimedia integration that align with the principles of social engagement and active participation.

4. Methodology

In this study, a qualitative research approach was adopted. This approach enabled an in-depth exploration of the complex, context-dependent realities of multimedia integration in Physics classrooms. This approach was instrumental in capturing rich, descriptive data that reflected participants' thoughts, practices, and challenges.

A case study design was employed to enable a holistic examination of multimedia integration within real-life school settings [7]. Specifically, a multiple-case study design was used to capture variations across different school environments. Four government secondary schools within one district in Mbeya Region, Tanzania, were purposively selected. The district was chosen as it has a large enrolment number in secondary school compared to other districts, and reflects a common challenge in science education, i.e., underperformance in physics, and availability of multimedia facilities, thereby providing a relevant context for the study.

The study population consisted of eight participants: four Physics teachers and four heads of schools. Purposive sampling, a non-probability technique, was used to select individuals based on their knowledge and direct involvement in multimedia integration. Selection criteria included at least 3 years of teaching experience and direct responsibility for teaching Physics or for school leadership. The sample size was considered sufficient because it allowed for data saturation, where recurring themes emerged without the need for additional participants [7]. This ensured the information gathered was both relevant and grounded in actual classroom practice.

Data were collected through semi-structured interviews and classroom observations. Interviews were conducted with physics teachers and school heads to explore their perceptions, experiences, and challenges in integrating multimedia into Physics teaching. Each interview lasted between 30 and 45 minutes; audio recordings were obtained with consent, and transcripts were analysed. Classroom observations complemented interviews by verifying and contextualising responses. At least two Physics lessons per teacher were observed, focusing on the use of multimedia tools, student engagement, teacher-student interaction, and classroom dynamics. Notes were systematically recorded using a structured observation guide.

Thematic analysis was employed to interpret the qualitative data [6]. The analysis followed the six-step process outlined by Braun and Clarke [5]: familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report. Data were coded manually, allowing close engagement with the material. This approach supported the interpretivist aim of understanding meaning from participants' perspectives.

Trustworthiness was ensured through multiple strategies. Triangulating interviews and observations enhanced credibility, while dependability was supported by maintaining a clear audit trail of procedures. Member checking was also employed, with participants reviewing summaries of their interview responses to verify accuracy. Peer debriefing with two colleagues in science education further refined the interpretation. Instruments were reviewed by experts from the University of Dodoma and the University of Dar es Salaam to ensure clarity and relevance. A pilot study with three participants was also conducted. As a result of the pilot, several interview questions were rephrased for clarity, and additional probes were included better to capture teachers' experiences with specific multimedia tools.

5. Results and discussion

5.1. Challenges in integrating multimedia in Physics education

The integration of multimedia in physics education holds promise but faces significant barriers in secondary schools. Several challenges, such as poor infrastructure, limited teacher training, large class sizes, and financial constraints, which hinder its effective use, have been identified in this study.

5.1.1. Inadequate infrastructure and resources

A lack of essential infrastructure significantly constrains the integration of multimedia into Physics teaching in secondary schools. Across the sampled schools, teachers reported a severe shortage of digital teaching tools, including projectors, computers, and reliable electricity. Observations revealed that only one or two classrooms in each school had electricity, and functional multimedia equipment was often completely absent. Consequently, teachers often reverted to traditional chalk-and-talk methods, relying on blackboard illustrations rather than videos or simulations. One head of school (HoS) remarked:

> We make every effort to encourage our teachers to incorporate multimedia into their lessons, but significant challenges persist, particularly the lack of essential facilities like

> computers, projectors and reliable electricity in classrooms, which limits our ability to fully embrace these teaching tools. (Interview, HoS, School A, August 2024)

Similarly, a Physics teacher from School C highlighted the impracticality of relying on a mobile phone to teach large classes:

> There is no projector available, and the number of computers is very limited. We are left with only mobile phones as teaching tools. For example, with Form Two having nearly seven streams, how can one realistically go from class to class showing videos using just a phone? It's simply not feasible. As a result, we end up reverting to traditional teaching methods. (Interview, Physics teacher, School C, August 2024)

While interviews captured teachers' self-reported challenges and practices, classroom observations verified these accounts in real teaching contexts. For instance, although several teachers expressed willingness to integrate multimedia, observations revealed limited practical application, exposing a clear gap between intention and practice. In many cases, teachers were observed relying heavily on chalk-and-talk methods with minimal use of visual aids or multimedia resources. The lack of essential infrastructure, such as electricity and digital equipment, severely limits the effective integration of multimedia in Physics teaching. As a result, teachers are forced to rely on traditional methods, thereby reducing opportunities for interactive, visually supported learning.

5.1.2. Limited teacher training and technological confidence

Another major challenge is the limited digital competence among teachers. Many respondents reported not having received formal training in multimedia use and felt unprepared to incorporate such tools into their lessons. Interviews revealed that many respondents are unfamiliar with the various formats and applications of multimedia in teaching physics. Some teachers expressed feelings of inadequacy when integrating technology into their classrooms, which further erodes their confidence and willingness to experiment with new teaching methods. As one respondent explained:

> Most of us were never trained to use these digital tools. Sometimes, even opening certain programmes feels challenging. Without proper support, it's hard to feel confident, so we end up sticking to the methods we already know. (Interview, HoS, School C, August 2024)

Another HoS also confirmed:

> Indeed, a significant number of teachers do not possess the required skills or training to utilise multimedia tools effectively in their teaching. Consequently, we tend to rely on the few teachers who are both competent and confident in using such resources. (Interview, HoS, School A, August 2024)

Observations showed that teachers struggled with basic technology use, often hesitating to incorporate any multimedia element into their lessons.

This implies that limited digital competence among teachers poses a significant barrier to effective multimedia integration. Without adequate training and support, many teachers lack the confidence and skills to use multimedia tools, leading to continued reliance on traditional teaching methods and uneven adoption of technology in classrooms.

5.1.3. Logistical barriers in the classroom

Classroom size and organisation pose further obstacles to effective multimedia integration. Large class sizes, averaging 50 to 60 students, make it difficult for teachers to employ multimedia tools efficiently. A Physics teacher at School D described the challenge:

> Each stream has about 50 to 60 students. That's why it is time-consuming to apply multimedia; it takes a lot of time to cover a topic. Also, I am the only teacher, and the shortage of staff is another issue that makes it difficult to incorporate multimedia. If we had enough teachers, it would be easier to use these methods. (Interview, Physics teacher, School D, August 2024)

Similarly, a teacher from school B commented:

> But our environments, and our school conditions, we don't have the projector, so you're supposed to pass a tablet or phone in groups, for something that you can just display for five minutes, you're supposed to use almost the whole period, or the double period for you to deliver what you intended to deliver. That is very difficult to practice. (Interview, Physics teacher, School B, August 2024)

These findings imply that large class sizes and inadequate staffing make it difficult to manage time and resources effectively when using multimedia tools. Without sufficient equipment and teaching personnel, multimedia integration becomes inefficient and burdensome, limiting its practical use in daily instruction. This situation emphasises the need for better infrastructure to support multimedia use in crowded classrooms.

5.1.4. Gaps in lesson planning and curriculum integration

Teachers also reported challenges in embedding multimedia into their formal lesson plans. Time constraints, heavy workloads, and a lack of structured guidance often led to multimedia components being omitted from planning documents. Observations confirmed that lesson plans frequently lacked any mention of digital tools, resulting in a disconnect between teaching intentions and classroom practices. A teacher at School A acknowledged:

> Preparing lesson plans has been quite challenging for us due to the heavy workload, resulting in insufficient planning. Consequently, we often neglect to document multimedia integration, which is essential for improving teaching quality and effectively incorporating diverse resources into our lessons. (Interview, Physics teacher, School A, August 2024)

Similarly, a teacher from School C acknowledged the lack of documentation regarding multimedia integration in their lesson plans, despite understanding its significance. The respondent stated:

> I don't want to be dishonest. If you read my lesson plans, you won't find details about multimedia. However, it's crucial to have guidelines for planning lessons that integrate multimedia. Without a clear plan, it can be challenging to know what to do in the classroom. (Interview, Physics teacher, School C, August 2024)

This disconnect between classroom practices and lesson planning highlights a significant barrier to effective multimedia use. Observation data revealed that teachers did not include multimedia elements in their lesson plans, reflecting a gap between intention and practice. This inconsistency points to a broader issue of implementation fidelity, suggesting the need for more robust curriculum guidelines that promote and support multimedia use in lesson planning.

5.1.5. Financial constraints and policy limitations

Lastly, financial constraints limit schools' ability to invest in essential multimedia resources. Heads of schools reported that government funding primarily covers operational costs, leaving no allocation for technological equipment. As one respondent explained:

> According to our budget, we rely entirely on government funding. However, none of this budget is specifically allocated for purchasing multimedia facilities, such as computers. As a result, we are unable to independently acquire the necessary technology for teaching. (Interview, HoS, School C, August 2024)

This indicates that the lack of designated funding for multimedia resources hinders schools from advancing technology integration independently. As a result, their reliance on government budgets that prioritise basic operations restricts progress towards modern, technology-enhanced teaching and learning.

Consequently, schools often rely on donations or individual initiatives to acquire resources, reflecting a reactive rather than proactive approach to improving multimedia integration in education.

> Our computers were donated. We received some from Dr Y and others from a company, Telecom Co. They also gave us a router, which worked well at first. However, it no longer functions, and there's no internet connection now. They promised they would return to repair the router, but up to today, they haven't come back. (Interview, HoS, School B, August 2024)

This situation highlights the unsustainable nature of relying on external donations without consistent technical support or maintenance plans. Without a proactive strategy and reliable infrastructure, schools struggle to maintain long-term use of multimedia tools in teaching and learning.

The findings reveal that the challenges to multimedia integration are not isolated but rather interlinked. Financial constraints affect infrastructure and training; limited training affects lesson planning; and large class sizes amplify these limitations. The combination of these factors leads to low teacher morale, minimal use of multimedia, and continued reliance on outdated teaching methods. As such, addressing these issues requires a holistic approach that includes investment in infrastructure, comprehensive teacher training, supportive curriculum frameworks, and sustainable funding models.

5.2. Opportunities for effective multimedia integration

Despite the many challenges facing multimedia integration in Physics education, teachers in secondary schools demonstrate adaptability and resilience in identifying creative ways to engage students through available technological means.

5.2.1. Use of personal devices and low-cost technologies

One prominent opportunity lies in teachers' use of personal devices such as smartphones and tablets to deliver digital content. In several schools, teachers downloaded animations, simulations, and videos from the internet to explain difficult concepts, often using these resources in real time during lessons.

A teacher from School A described:

> I frequently use my phone as a teaching aid, accessing Physics content online and sharing it with students during lessons. I occasionally use a projector when available, which significantly enhances students' understanding by making complex concepts clearer and more engaging. (Interview, Physics teacher, School A, August 2024)

In even more resource-constrained settings, teachers resorted to low-tech alternatives. For example, portable Bluetooth speakers or small radios were used to amplify audio content for group learning. A teacher at School C explained:

> Usually, I ask a few students to bring a small Bluetooth-enabled radio, which I use as a speaker. I play the video from my tablet and connect it to the radio for better sound, moving around the classroom so each group gets a chance to follow along. (Interview, Physics Teacher, School C, August 2024)

These practices demonstrate a proactive approach and a commitment to maintaining engaging and inclusive instruction despite systemic constraints.

5.2.2. Contextualising multimedia content to real-life applications

Teachers also highlighted the value of using multimedia to connect abstract Physics concepts to students' daily experiences. This approach makes learning more relevant and meaningful and supports the development of scientific literacy.

One teacher from School B shared:

> Once the video has been shown, I go through it thoroughly with the students, explaining each section in detail to ensure a clear understanding. I then relate the concepts to real-life examples, helping students recognise the relevance and practical use of what they are learning. (Interview, Physics teacher, School B, August 2024)

Similarly, school A teacher commented:

> When concepts are explained in an abstract way, students often struggle to understand them. However, when they are shown in real-life situations through videos, it becomes much clearer and more engaging. This encourages students to develop a greater interest in studying Physics. (Interview, Physics teacher, School A, August 2024)

These insights imply that contextualising multimedia content helps bridge the gap between theory and practice, making Physics more accessible and relatable for students. By linking lessons to real-life applications, students become more engaged and motivated to learn, thereby enhancing scientific literacy.

5.2.3. Professional development as a gateway to broader integration

Another opportunity identified by both teachers and school heads is the potential for targeted professional development. Many respondents expressed a strong desire to improve their digital competencies, acknowledging that technology and teaching methods are continually evolving.

One teacher observed:

> To be honest, ongoing training is essential because knowledge keeps changing. Different facilitators offer different insights; you might find someone more knowledgeable than the previous one. Also, technology is constantly evolving; it's not static. New tools and methods are emerging all the time, and what we knew before may no longer be enough. So, it's not true to say one training is sufficient. We need continuous professional development, especially in multimedia integration, to keep improving our teaching. (Interview, Physics teacher, School A, August 2024)

This implies that ongoing professional development is vital for equipping teachers with up-to-date skills in multimedia integration. As digital tools and pedagogical practices continue to evolve, regular training enables teachers to adapt effectively, improving both their confidence and the quality of Physics instruction.

5.2.4. Need for formal guidelines and institutional support

Teachers and administrators consistently noted the lack of clear guidelines for integrating multimedia into teaching and planning. When asked what would help them most, many teachers called for structured support in the form of templates, standardised lesson formats, or curriculum-embedded multimedia expectations. One teacher suggested:

> Having these guidelines helps us as teachers clarify where to start, how to structure the lesson, and how to use resources effectively. This ensures that students not only enjoy the subject and the videos but also truly understand the concepts being taught. So, I think it is very important to have the guidelines because they will also help us. It will simplify the activity for us to deliver what we are supposed to deliver. (Interview, Physics teacher, School B, August 2024)

The development of institutional frameworks at both school and national levels could provide clearer direction for multimedia integration and ensure consistency across classrooms.

Although constrained by infrastructure and funding, secondary school teachers are demonstrating innovation and adaptability in their use of multimedia. Their willingness to experiment with mobile devices, low-cost technologies, and context-driven instruction represents a strong foundation on which to build. With improved training, curriculum alignment, and institutional support, these grassroots practices can be scaled and systematised to yield more impactful learning experiences. These findings support global recommendations, e.g., UNESCO [47] that call for inclusive, scalable, and locally responsive approaches to educational technology integration.

6. Discussion

The assessment of multimedia integration in Physics education in secondary schools in Tanzania has revealed various challenges and opportunities that align with existing scholarly literature. These findings reflect both context-specific and universal themes in educational technology integration.

A primary challenge identified is inadequate infrastructure and resources. This issue is widely supported by scholars such as Ngeze [29], who highlight the scarcity of multimedia tools, such as projectors and reliable electricity, which forces teachers to rely on traditional methods. Similarly, Mtebe, Mbwilo and Kissaka [25] note that limited access to functional computers and internet connectivity hampers multimedia use, a situation reflected in the study's findings, in which teachers use personal smartphones because institutional equipment is absent. Internationally, UNESCO [47] emphasises that inadequate infrastructure is a global barrier to achieving the Education 2030 goals, particularly in low-resource settings, and advocates scalable investments in digital tools, which aligns with the study's recommendation to equip classrooms with projectors and electricity.

While inadequate infrastructure is a well-documented challenge in Sub-Saharan Africa [3, 25], its implications extend beyond the lack of physical resources. From a Vygotskian social constructivist perspective, the absence of multimedia tools limits opportunities for collaborative, interactive, and scaffolded learning experiences. Without such tools, classrooms tend to remain teacher-centred, restricting peer interaction and the co-construction of knowledge. This, in turn, undermines the development of higher-order thinking skills such as problem-solving and critical reasoning, which are central to 21st century science literacy [47]. The finding thus underscores the material and pedagogical consequences of infrastructural deficits and underscores the need for integrated policy and practice responses.

Another significant issue is the limited training of teachers and their corresponding technological confidence. Kafyulilo et al. [14] argue that teachers often lack technological pedagogical content knowledge (TPACK), leading to low confidence in using multimedia. This was evident in the study, where teachers associated multimedia narrowly with hardware like computers. Mayer and Girwidz [21] further validates this, noting that Physics teachers' acceptance of multimedia depends on

TPACK, which remains underdeveloped without training. Nihuka and Bussu [30] report that targeted professional development programs, like SEQUIP, enhance teachers' multimedia skills, aligning with the study's observation of increased confidence among trained teachers despite the widespread lack of training reported in many schools. Tanzania UR. Ministry of Education and Vocational Training and UNESCO Office in Dar-es-Salaam [39] emphasises the need for competency standards for teachers in ICT integration, supporting the study's call for continuous professional development to build digital competence.

Logistical barriers, including large class sizes and inadequate staffing, represent another significant challenge. Onah and Nzewi [33] identifies classroom overcrowding as a barrier to multimedia integration in science education, reflecting the study's findings where teachers struggle to manage 50-60 students with limited devices. Tugirinshuti, Mugabo and Banuza [46] highlights similar issues in Rwanda, where time constraints due to large classes hinder the use of video-based multimedia, a finding that resonates with teachers' reports of time-consuming device-sharing practices. However, Pricilia, Abdurrahman and Herlina [34] suggests that interactive multimedia can be adapted for large classes through group-based activities, a strategy partially employed in the study but limited by resource scarcity. The World Bank, as written by Vivek and Bhattacharjee [49], recognises large class sizes as a challenge in low-income countries, advocating for teacher support systems and infrastructure investments to enhance multimedia delivery, which reinforces the study's recommendations.

The gap in lesson planning and curriculum integration is another critical issue revealed in the study. Mtebe, Mbwilo and Kissaka [25] note that teachers in Tanzania rarely document multimedia in lesson plans due to workload and the absence of clear guidelines. This aligns with the study's findings, which show that teachers often use multimedia informally, without structured planning or alignment with curriculum objectives. Such practice limits the consistency and effectiveness of multimedia integration in classroom instruction. In contrast, Delima et al. [8] argues that with proper pedagogical guidance and resources, multimedia modules can be systematically embedded into school curricula. However, this approach has yet to be adopted in the schools involved in the study, thereby missing an opportunity for structured integration. UNESCO [47] supports the implementation of curriculum-embedded ICT strategies to ensure more effective and standardised use of digital tools in education, reinforcing the study's recommendation for the development of pedagogical guidelines and standardised lesson templates to support multimedia use in Physics teaching.

Financial constraints and policy limitations identified in the study are also discussed in the literature. Barakabitze et al. [4] emphasises that reliance on donor-funded equipment, like computers from NGOs, is unsustainable without maintenance plans, corroborating the study's findings of non-functional donated routers and computers. Kibona, Ndabi and Kibona [17] highlights the lack of government budget allocations for ICT, aligning with the study's reports of schools' inability to purchase multimedia tools independently. However, The United Republic of Tanzania Ministry of Education, Science and Technology and Tanzania Commission for Science and Technology (COSTECH) [42] suggests that Tanzania's strategic plans for science and technology could prioritise educational ICT investments, indicating a policy-practice disconnect not evident in the study. The UK Digital Development Strategy [9] emphasises the need for sustainable funding models for educational technology, supporting the study's recommendation for government and NGO funding to address financial barriers.

Despite these challenges, the study also identifies opportunities for multimedia integration, such as the use of personal devices and contextualised content. Teachers' use of smartphones, portable radios, and downloaded simulations mirrors international initiatives like the PhET Interactive Simulations, which have been successfully used in low-resource contexts to demonstrate Physics concepts [23]. Such practices suggest that locally adaptable mobile applications and offline platforms could play a critical role in bridging the infrastructure gap, an area deserving of further research and pilot interventions in schools.

Nyirahabimana et al. [32] report that multimedia, such as videos, enhances student engagement in quantum physics, aligning with the study's findings that teachers use smartphones to deliver engaging content. Kiat et al. [16] highlights the effectiveness of multimedia in improving academic achievement, supporting the study's observation of increased student interest through real-life applications. However, Ntawiha et al. [31] suggests that structured multimedia use requires institutional support, which the study indicates is lacking, underscoring the need for systemic scaling of these grassroots efforts. UNESCO [47] and International Telecommunication Union and United Nations Educational, Scientific and Cultural Organization [13] advocate for inclusive, locally responsive ICT integration, endorsing the study's emphasis on low-cost technologies and professional development as viable strategies for enhancing multimedia use in resource-constrained settings.

7. Conclusion

The integration of multimedia in Physics education within secondary schools presents both significant challenges and promising opportunities. The study reveals that inadequate infrastructure, limited teacher training, and logistical barriers such as large class sizes hinder effective multimedia use in classrooms. Teachers often revert to traditional methods due to resource constraints, which diminishes student engagement and interest in science subjects. Additionally, the lack of structured lesson-planning guidelines further complicates the integration of multimedia tools, leading to inconsistent implementation across schools. These findings highlight a pressing need for comprehensive support, including investments in infrastructure, targeted professional development, and clearer curriculum guidelines.

The study also uncovers innovative practices among teachers who leverage personal devices and contextualise multimedia content to enhance learning experiences. By utilising smartphones and low-cost technologies, educators demonstrate adaptability and creativity in engaging students with complex Physics concepts. Furthermore, teachers strongly desire ongoing professional development to improve their digital competencies. With proper institutional support and a commitment to fostering a culture of multimedia integration, these grassroots efforts could be scaled to enhance student learning outcomes significantly. Ultimately, addressing the identified challenges while capitalising on existing opportunities is crucial for improving Physics education in Tanzania and equipping students with essential 21st-century skills.

However, since the study was limited to a qualitative approach and focused on one district, which may limit the generalizability of the findings, future research may employ mixed-methods or quantitative approaches to measure the direct impact of multimedia on student performance and to compare urban and rural schools.

8. Recommendation

Based on the findings of this study, it is recommended that education authorities prioritise the establishment of a robust infrastructure for multimedia integration in Physics education by investing in essential resources, including projectors, computers, and reliable electricity within schools. Furthermore, targeted professional development programs should be implemented to enhance teachers' digital competencies and pedagogical skills for the effective use of multimedia tools. Additionally, clear guidelines and frameworks for lesson planning that incorporate multimedia should be developed to ensure consistency and alignment with curriculum objectives. Also, fostering partnerships with non-governmental organisations (NGOs) and the private sector could create sustainable funding models to support the acquisition and maintenance of multimedia resources, thereby significantly improving student engagement and learning outcomes in Physics education. Lastly, future initiatives should explore low-cost, mobile-based platforms such as PhET simulations, YouTube educational channels, and other academy resources that can be downloaded and used offline in resource-limited contexts. Policymakers should also support pilot projects testing these tools in classrooms, with rigorous evaluation of their effectiveness in improving student outcomes. Partnerships with NGOs and ed-tech providers could ensure sustainable access to these resources.

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