

2026

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Editorial

Papers in Education and Development at 50 (1975–2025): Legacy, Relevance, and Future Directions

The year 2025 marks a historic milestone for *Papers in Education and Development (PED)* as the Journal celebrates fifty years since its establishment in 1975. This Golden Jubilee is not only a moment of celebration but also one of reflection and renewal—an opportunity to look back on a rich intellectual legacy, engage critically with present realities, and chart future directions for educational scholarship in Tanzania, Africa, and beyond. As Abel G. Ishumi aptly reflects in this commemorative issue, if PED were a human being, it would now stand as a mature and respected elder—one who has traversed multiple phases of life, accumulated wisdom, and earned a place of authority within the community. This metaphor captures both the longevity and the responsibility that come with such a milestone. For five decades, PED has grown as a "house-born and house-grown" journal of the School of Education at the University of Dar es Salaam, while simultaneously evolving into a platform of national, regional, and increasingly international significance.

Historically, PED stands among the earliest academic journals within the University of Dar es Salaam, alongside *UTAFTITI*, *Taamuli*, and *The African Review*. Its trajectory mirrors the broader evolution of education in Tanzania—from post-independence nation-building and the philosophy of Education for Self-Reliance, to contemporary engagements with globalisation, digital transformation, and decolonisation. Throughout this journey, PED has remained committed to advancing scholarship that is contextually grounded, critically engaged, and socially relevant. This Jubilee Issue exemplifies that commitment. The contributions assembled here reflect a diverse yet interconnected body of scholarship that collectively interrogates the epistemic, structural, and pedagogical dimensions of education in the 21st century. While varied in focus and methodology, the papers converge around four broad and interrelated themes: epistemic relevance and decolonisation; system integration and partnerships; equity and inclusion; and pedagogical transformation and professional practice.

Relevance, Decolonisation, and the Question of Knowledge

A central thread running through this issue concerns the question of what constitutes legitimate and relevant knowledge in African education systems. Haule and Kinyota's contribution critically examines the exclusion of African Indigenous Knowledge from science curricula in Tanzania. Their analysis highlights how the continued privileging of Western epistemologies reproduces colonial hierarchies of knowledge while marginalising locally grounded ways of knowing. By linking this exclusion to students' disengagement and underperformance, the paper calls for a fundamental rethinking of science education—not merely as content delivery, but as an epistemic project. This concern is reinforced by Maliva's analysis of the language of instruction in vocational education. Drawing on policy documents and linguistic imperialism theory, the study demonstrates how the use of English as a medium of instruction can undermine meaningful learning and

skills acquisition. The argument that cognitive development is more effective in familiar linguistic contexts challenges long-standing policy assumptions and foregrounds the role of language as both a pedagogical and epistemic medium. Overall, these contributions move beyond surface-level reforms to engage deeper questions of knowledge, language, and power. They position decolonisation not as an additive process, but as a structural and epistemological reorientation of education systems.

Bridging Institutional and Community Divides

A second theme emerging from this issue is the fragmentation of educational systems and the need for stronger linkages across institutions and communities. Shirima and Mmbando's study on university–community engagement (UCE) illustrates the transformative potential of collaborative initiatives in promoting STEM education. Their findings demonstrate that mentorship programmes, co-teaching, teacher capacity-building, and resource support can enhance teaching quality and student motivation, particularly in underserved contexts. However, these gains remain constrained by limited funding, weak coordination, and fragmented policy frameworks. Similarly, Irafay's study on parental engagement in physical education reveals a narrow conceptualisation of parental involvement among teachers, largely confined to material support. This limited understanding restricts opportunities for more meaningful collaboration between schools and families, thereby constraining students' participation and learning. Notably, these studies highlight the limitations of siloed educational practices and underscore the need for more integrated, system-level approaches that connect schools, higher education institutions, families, and communities.

Equity in Contemporary Contexts: Gender and Digital Access

The issue also engages critically with evolving forms of educational inequality. Nkwamah and colleagues' study on access to digital technologies reveals that while a significant proportion of students report moderate levels of access, disparities persist across socio-demographic characteristics such as school type, parental background, and location. Notably, access remains uneven between home and school environments, pointing to persistent infrastructural and institutional gaps. Complementing this structural perspective, Balogun and Ayegbusi's study on gender disparities in engineering education in Nigeria shifts attention to internal dimensions of inequality. Their findings show that female students' lower engagement in practical work is primarily linked to differences in self-efficacy rather than external conditions such as resources or teaching quality. This insight underscores the importance of addressing not only structural barriers but also the psychological and socio-cultural dimensions of participation. Generally, these contributions reveal that educational inequality is multidimensional, encompassing access, participation, confidence, and the quality of learning experiences.

Pedagogy, Professional Learning, and Cognitive Foundations

At the heart of educational transformation lies the question of pedagogy and professional practice. Sumani and colleagues' study on experiential education facilitators in Uganda conceptualises professional development as a recursive and reflective process. By demonstrating how competence evolves through cycles of readiness, action, and reflection,

the study challenges linear models of teacher training and highlights the importance of sustained, reflective practice. This focus on learning processes is further deepened by Chacha and Njiku's study on probability language skills. Their findings reveal a significant relationship between students' linguistic competence in probability and their academic achievement, while also showing that conceptual understanding remains limited despite familiarity with terminology. This underscores the critical role of language in shaping cognitive engagement and meaningful learning. These contributions collectively bring the discussion back to the core of education—the processes through which knowledge is constructed, understood, and applied.

Looking Forward: PED as a Living and Future-Oriented Platform

The Jubilee Issue fittingly concludes with Pesambili's reflection on the current realities, emerging challenges, and future directions of PED. Drawing on editorial experience, the paper situates the Journal within a rapidly changing scholarly publishing landscape characterised by challenges such as reviewer fatigue, ethical concerns, digital transitions, artificial intelligence, and the complexities of open-access models. Importantly, the paper does not merely diagnose challenges; it outlines strategic pathways for strengthening PED's internationalisation, editorial rigour, and contribution to knowledge sovereignty. In doing so, it positions PED as a dynamic and future-oriented platform capable of shaping educational research, policy, and practice in Africa and beyond.

Conclusion: Continuity and Transformation

The contributions in this Jubilee Issue reflect an educational landscape marked by both continuity and transformation. Longstanding concerns, such as curriculum relevance, equity, and system integration, remain central, even as new challenges emerge from digitalisation, globalisation, and shifting epistemic debates. What distinguishes this collection is its ability to engage these enduring issues within contemporary contexts, offering both critical reflection and forward-looking insight. In doing so, it reaffirms PED's role not only as a repository of knowledge but as a vital intellectual space for interrogating and shaping the future of education. As we celebrate fifty years of *Papers in Education and Development*, we extend our sincere appreciation to all authors, reviewers, editors, and readers who have contributed to this journey. This milestone is a collective achievement. Looking ahead, we remain committed to advancing rigorous, relevant, and transformative scholarship that speaks to the needs and aspirations of our societies.

Prof. Eustella P. Bhalalusesa
Chief Editor, *Papers in Education and Development (PED)*

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Papers in Education and Development (PED)

A Journal of the School of Education at 50 Years of Age: A Brief Note on Its Long Journey

A note coinciding with the *International Conference on Education Policy and Curricular Reforms* (March 25-27, 2026) at the University of Dar es Salaam, Dar es Salaam, Tanzania

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By Abel G. Ishumi
School of Education
University of Dar es Salaam

March 25-27, 2026

1. Introduction

If *Papers in Education and Development* were a human being, it would—as of today—be a fully grown-up adult of only a few months past 50 years of age. It would be a long-married adult, a full-career officer in office nearing retirement, and, by East African cultural traditions, he or she would have been long married for some 20 to 25 years. At that age, this adult would be taking a seat alongside respectable elders in the community, judging, counselling, or reprimanding a youth gone astray.

It was for this very reason of a 50-year mark in life that the School of Education thought of giving its Journal, PED, a deserving recognition at its 50th year of running and operation since its inauguration way back in 1975. So, we beg the indulgence of this august Conference here today to simply allow us to say only a few "congratulatory, if nostalgic" things about this "house-born and house-grown" Journal of the School of Education.

Papers in Education and Development is one of the *earliest-and-oldest* four (4) journals published within this University system—ranking, historically, along with ***UTAFITI****, Journal of the Arts and Social Sciences* published by the-then Faculty of Arts and Social Sciences, ***Taamuli*** and ***The African Review****: Journal of African Political Development and International Affairs*, both these published by the Department of Political Science and Public Administration.

2. A Modest Start, Yet a Determined Beginning

When PED was inaugurated, the current School of Education was then a Department of Education in the-then Faculty of Arts and Social Sciences (FASS), where the Department of Education was one among eleven (11) departments that constituted the Faculty of Arts and Social Sciences [— these eleven departments were History, Geography, Sociology (and Social Anthropology), Political Science (and Public Administration), Theatre Arts, Foreign Languages and Linguistics, Economics, Literature, Statistics, Kiswahili and Education**]**.

The Journal was founded in 1975 in a clearly modest way, yet in a highly determined spirit. In 1974, the Department of Education established a postgraduate programme called "Master of Arts in Education (MAEd)", and, in fact, this programme was the primary impetus for founding the Journal. In a loudest voice sent out by the Head of Department on its day of inauguration, the Head, then Professor Geoffrey V.R. Mmari, said that the drive was "to encourage postgraduate students to discuss and analyse issues not only in an oral classroom environment alone but also in a practical, well-documented form for the sake of wider debate and practical articulation.

This idea of the purpose for a journal emerged from a four-day research tour [from the mainland] to Zanzibar in 1974 by the postgraduate class [who were only 7], together with one or two of their class tutors, including Professor James Breeden, a visiting professor on sabbatical leave from the Harvard Graduate School of Education. The visit to Zanzibar at that time was both soul-taking and mind-opening. At that time, any entry into Zanzibar— even the Mainland, which was the sister part of the Union— you were required to have a visa and a weeklong wait for clearance, with the safety-and-ethics requirements of the Isles Government. Surprisingly, for a "merely small" – Department on behalf of its maiden postgraduate class, things worked within a matter of one day. And when they visited the Isles, the class was given an open cheque to choose what they wanted to see and investigate!!

I suspect that, too, was one of the reasons for the unanimous agreement at the next Departmental Meeting to endorse a formal academic **Journal** for publishing research findings arising from unbiased, unhidden sources. With contingent plans for action—in terms of appointing an Editorial Committee to vet research papers, of justifying a budgetary line for the Department's expenditure, as well as for soliciting wider and comparative research materials—a first, *maiden issue* of the Journal was launched in April 1975 – a year after the Zanzibar episode.

That maiden issue of the Journal carried ***four scrupulously*** selected articles—one of which, as had originally been pledged, was a student research-based article. The research student in the very first cohort of the Master's programme, who contributed one of the four articles, was none other than our current professor on retirement, Victor Mlekwa: now retired, even though *not quite* tired! Prof: Mlekwa – there you are! The subject of his article was "Policy and Practice in Adult Education: A Research Report from Kahama". The other three articles were written by staff researchers.

The other three articles of the maiden issue were:

- The Role of Formal Education in Developing Countries: The Tanzanian Case (*by* Geoffrey V.R. Mmari);
- The Struggle for Socialist Education in Tanzania (*by* James P. Breeden); and
- Language Policy in Education: An Historical View (*by* Martha M. Mvungi).

3. The Journal's Editorial Policy and Activity over Time

At the beginning, the work of scouting for possible papers, seeking would-be article contributors, and editing such papers was **entrusted to one appointed colleague** on the Departmental Editorial Committee, informally assisted by

one or two members of the staff. The appointed colleague was, at that time, known as editorial coordinator-cum-convener. Soon afterwards, he or she was formally termed Editor, at the Head of a team of three or four colleagues making up an Editorial Committee. Some years later, this position of Convener/ Coordinator was formally elevated to Chief Editor, reporting to the Head of an Editorial Board.

For all the years, well until 2019, the School produced one issue per year, but allowed the possibility of producing two issues if material and financial resources permitted. It was only after 2029 that the publication rate was fixed as a matter of policy at **two issues** per year, allowing for greater space for researchers and writers, a wider readership, and a broader range of issues emanating from the expanded discipline of education.

Producing one issue per year was due to several constraints and challenges. For about 8 or 9 years (from 1975—1983), the Journal was published on mimeographed paper and, no doubt, hand-bound on tape, with hand-trimmed covers made with industrial knives borrowed from the University's Library printing unit. This was, literally speaking, a "manual" production, with limited copies in a time of shortage of writing and printing paper, particularly in the late 1970s and '80s.

Yet, for the departmental staff members, this did not matter and did not deter the spirit of writing, of open debate and 'publishing'—a spirit of subjecting publicly generated information and knowledge to tests for innovation and public utility in an open social system. That was the joy of "write-and-enable-others-to-know", a spirit that owes itself to the times of educational philosophers, not least the 17th-century Czech educator and theologian John Amos Comenius (1592-1670), and his dictum, "*Teach All Things to All Men*".

4. A Special Tribute to the Editorial Teams (1975-2026)

The School of Education's Journal has, in its history, been managed by nine (9) editorial boards, each serving for three to five years or more, with board members serving over different periods. The first two or three presiding editors were known then as "**Convener** or Coordinator" of the Editorial Committee, who later were termed Chief Editor of the Editorial Board. Table 1 shows the nine (9) chief editors to date, and their tenure.

Table 1: Chief Editors of Papers in Education and Development (PED) Journal, 1975-2026

1st	Laura Okumu	Institute of Education	Caribbean-Kenyan	1975→1977
2nd	Marjorie Mbilinyi	Dept. of Education	American Tanzanian	1978→1981
3rd	Janaki Tschannerl	Dept. of Education	Indian-German	1982→1984
4th	Donatus Komba	Faculty of Education	Tanzanian	1985→1989
5th	Justinian Galabawa	Faculty of Education	Tanzanian	1989→1993
6th	Issa Omari	Faculty of Education	Tanzanian	1994→1996
7th	Justinian Galabawa	Dept. of Education	Tanzanian	1997→2008
8th	Abel Ishumi	School of Education	Tanzanian	2008→2017
9th	Eustella Bhalalusesa	School of Education	Tanzanian	2018→present

Table 2 lists the entire roll of the editorial leader and the respective members of the committee/board for the period of the editorial leader's tenure.

Table 2: Convener/Chief Editor and respective Committee/Editorial Board members (1975-2026)

Under Laura **Okumu** (1975→1977)	1)Geoffrey R.V. Mmari 2) Marjorie Mbilinyi 3) Abel G. M. Ishumi	4) Gomo M.P. Michongwe 5) Simon Jiboku 6) James Breeden
Undder Marjorie **Mbilinyi** (1978→1981)	1)Martha Mvungi 2) S.T. Mahenge 3) Abel Ishumi	4) Moses P. Besha 5) Issa M. Omari 6) Geoffrey V. Mmari
Under Janaki **Tschannerl** (1981→1982)	1) Geoffrey V. Mmari 2) John Pendaeli 3) Abel G. M. Ishumi	4) D. Komba 5) Ruth Besha
Under Donatus **Komba** (1983→1989)	1) Abel G. M. Ishumi 2) John Pendaeli 3) Yosiah D. M. Bwatwa	4) Naomi B. Katunzi 5) H.J. Mosha 6) Kalafunja M. Osaki

Under Justinian **Galabawa** (1989→1993)	1) Abel G. M. Ishumi 2) John Pendaeli 3) Herme J. Mosha	4) Akundaeli S. Mbise 5) Julian G. Tetlow 6) Kalafunja M. Osaki
Under Issa M. **Omari** (1994→1996)	1) Akundaeli S. Mbise 2) Kalafunja M. Osaki 3) Philemon A. K. Mushi 4) Abel G. Ishumi	5) Suleman A. Sumra 6) George A. Malekela 7) Mwajabu K. Possi
Chief Editor Justinian **Galabawa** (1997→2008)	1) Abel G. M. Ishumi 2) Herme J. Mosha 3) Philemon A.K. Mushi 4) Rebecca Sima	5) C. Rubagumya 6) Willy Komba 7) J. Shehu 8) Kalafunja M. Osaki
Under Abel **Ishumi** (2009→2017)	1) Kitila Mkumbo 2) Mwajuma Vuzo 3) Blackson Kanukisya 4) Herme J. Mosha 5) Mwajabu Possi 6) Philemon A.K. Mushi	7) Daniel Sifuna 8) Peter Baguma 9) Peter N. Chonjo 10) Willy Komba 11) William Anangisye
Under Eustella P. **Bhalalusesa** (2017 →)	1) Blackson Kanukisya 2) Stephen Mabagala 3) Philipo L. Sanga 4) Albert Tarmo 5) Mpoki Mwaikokesya *PLUS* 6 *Advisory Editorial Panel members (internationals):* Daniel Sifuna (Kenya), Peter Baguma (Uganda), Francis Indoshi (Kenya), Des Hewitt (UK), Maria Hallitzky (Germany), Hanna Posti-Ahokas (Finland), Abel Ishumi (Tanzania)	6) Nkanileka L. Mgonda 7) Rose Upor 8) William A. Anangisye 9) Rebecca Sima 10) George Kahangwa

5. Thematic Trends in Educational Thought between the 1970s and 2000s

As one might notice, PED has travelled a long way, from modest beginnings to its current stature. Very, very broadly thinking, from the 1970s to the present, one could categorise much of the paper submissions and publications in PED into several major stages of educational thought and policy evolution in Tanzania.

From the 1975s to the 1980s, PED's article publishing focused on understanding, analysing, interpreting, and advocating national educational policy, namely *Education for Self-Reliance* [ESR].

Articles in Issue Number 1 (in 1975) —the maiden issue—focused squarely on matters, at that time, mostly troubling the conscience of the community in Tanzania. These conscience-troubling matters included a reform-conscious education sector, issues in the philosophy of 'Education for Self-reliance', the need for a socialised provision of formal education, a struggle for a clear national language policy, the need for equity through a reshaped adult and community education policy and administration in the largely rural sector in Tanzania, etc. Treatises on some of these issues were articulated in this maiden issue and in the ensuing issues for a long period thereafter. The first issue in 1975, as has been noted, looked at:

- The Role of Formal Education in Developing Countries: The Tanzanian Case (*by* G. Mmari);
- The Struggle for Socialist Education in Tanzania (*by* J. P. Breeden)
- Language Policy in Education: An Historical View (*by* M. Mvungi); and
- Policy and Practice in Adult Education: Research Report from Kahama (*by* Victor M. Mlekwa).

Issue # 6 (of April 1978) carried wider-ranging papers that reflected such concerns as:

- Approaches to Curriculum (*By* J. Pendaeli)
- Epistemology of Action Research (*By* Paul Oquist)
- Experimentation and Use of Statistical Techniques (*by* I. M. Omari);
- Implications of the Colonial Examination System in Secondary Schools and Tanzanian Underdevelopment, 1946—1961 (*by* F. B. Mukyanuzi);
- Problems of Primary School Radio Broadcasts in Tanzania Mainland (*by* S. T. Mahenge);
- Colonial Education in Tanganyika (*By* A. D. Mwampeta)
- A Book Critique: *Education and the Rise of the Corporate State* by J. H. Spring (Boston: Beacon Press, 1972) (*By* E. L. Nchimbi).

From 1980 to 1989, many papers critically analysed and interrogated national education issues and policies. The Journal itself was becoming increasingly visible across the country and the region (in Uganda, Kenya, Rwanda, and Burundi). Journal issues No. 9 and No. 10 had actually been processed and entirely produced on a sophisticated industrial linotype printing machine [at that time available at a Printing Press in Morogoro]. That printing-publishing facility in Morogoro had been imported into the country (from India) by a well-established company, whose chief executive was so nice and sympathetic that, during one of the print runs, he gave the Department a remission of one-eighth of the total bill for the entire production job. We were greatly "elevated" and thankful.

From the 1990s-early 2000s and thereafter, the papers submitted and published *moved more and more towards* analytical investigation and interrogation of a range of issues that authors considered critical to development, connected in Tanzania with the *Tanzania Development Vision 2025*.

From 2005/6, *PED* entered a much more sophisticated era of publishing of highly scrutinised and vetted submissions, along with an expanding internationalisation of its editorial forum, when both academics from Kenya and from Uganda (Professors Daniel Sifuna and Peter Baguma, respectively) were appointed onto the editorial board in order to expand the base of submissions as well as diversify circulation of journal messages. With effect from 2018, internationalisation of PED was facilitated further with the addition to its board of editors an increased group of international professionals to the *International Advisory Panel,* as it stands today (Daniel Sifuna, Professor in Kenya, sadly now late), Peter Baguma (Professor in Uganda), Francis Indoshi (Professor in Kenya), Des Hewitt (Professor in the UK), Maria Hallitzky (Professor in Germany), Hanna Posti-Ahokas (Senior Lecturer in Finland) and Abel Ishumi (Professor in Tanzania).

6. The Status of PED Today

Currently, PED ranks among some of the 'sister' journals in education (and in the social sciences in general) in Tanzania and eastern-southern Africa, including:

- *Eastern Africa Social Science Research Review* **[**EASSRR**]** published by the Organisation for Social Science Research in Eastern Africa (OSSREA) – based at the University of Addis Ababa in Ethiopia;
- *Southern Africa Review of Education* **[**SARE**]** – the official Journal of the

Southern African Comparative and History of Education Society (SACHES), based in South Africa – http://www.saches.co.za)

- *International Journal of Educational Development* [IJED], based in the UK, published by ELSEVIER – http://www.elsevier.com;
- *Educational Research Review* – published by the European Association for Research on Learning and Instruction (EARLI), published by ELSEVIER, and others.

On a latest score, PED has (since June 2025) been published under the imprint of the Netherlands-based Brill Academic Publishers [now part of De Gruyter Brill]. To us, this is a positive development in terms of further scrutiny of submissions, greater demand for quality outputs, and a wider readership.

7. Has PED Played Its Role as Per Its Original Vision?

One key and yet genuine question that might be asked by anyone and from any quarter stands: 'Is PED today playing the role as it pledged in its original vision of the April 1974 staff meeting of the Department of Education?

I humbly leave this question in the hands of the-now School of Education. It is, in the final analysis, a question for readers. For, as everyone would agree, no physician would ever be a competent professional to diagnose himself. However, let me mention some of the prime principles the PED Editorial Board established early in its work in order to bolster the quality of the Journal as part of its Vision and Mission:

(1) The principle of acceptance or non-acceptance of submissions based on "**scientificity**" and "**originality"** of the research paper;

(2) The principle of **peer-reviewing** [having the submission read and reviewed by more than one person in order to avoid bias, favouritism or subjectivism]; *and*

(3) The principle of a "**doubly-blind**" review [where identities of both the author and the reviewers (referees) are hidden [i.e. where author and reviewer do not know each other for purposes of hiding personal human factors in judgement].

8. Conclusion

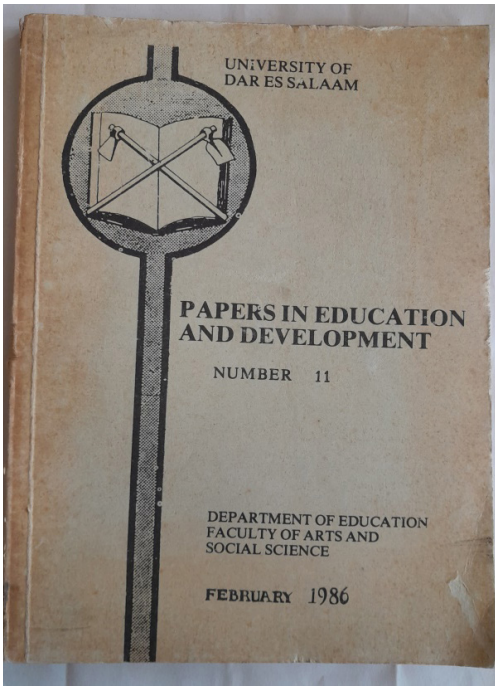
In brief, this is enough on the modest beginnings and journey of PED in the last 50 years. Martin Luther King Junior, the late American Baptist minister and civil rights crusader, used to say: "If I cannot do great things, I can [still]

do small things in a great way". The *PED* Editorial Board has laboured on many fronts to grow and adapt an indigenous journal towards directions that would work and show impact within a rapidly changing society and a rapidly changing education system. It was not always easy to achieve this. Its resolve, at 50 years of age, is to continue trudging on and improve itself where it falters to survive another 50 years and beyond. Hence, a quiet and meek celebration today. Happy birthday, PED!

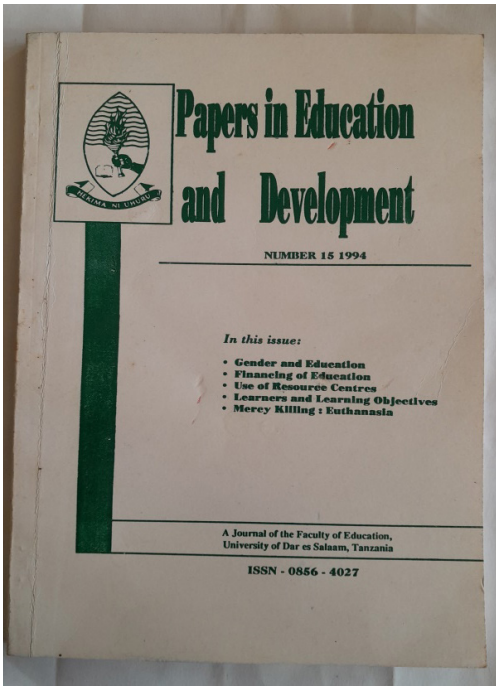
APPENDICES

A Random sample of the PED Journal book cover designs over the years

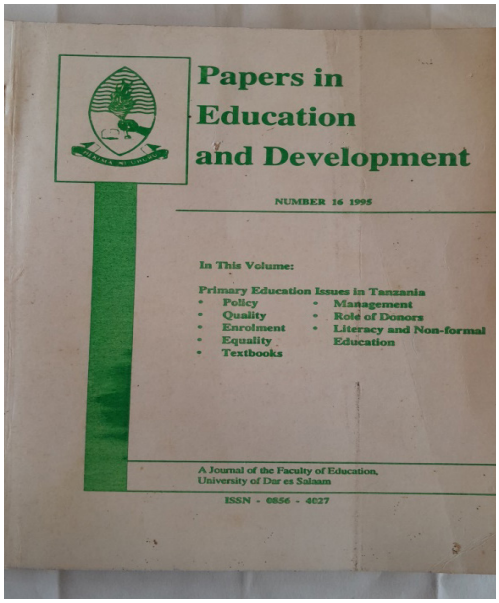
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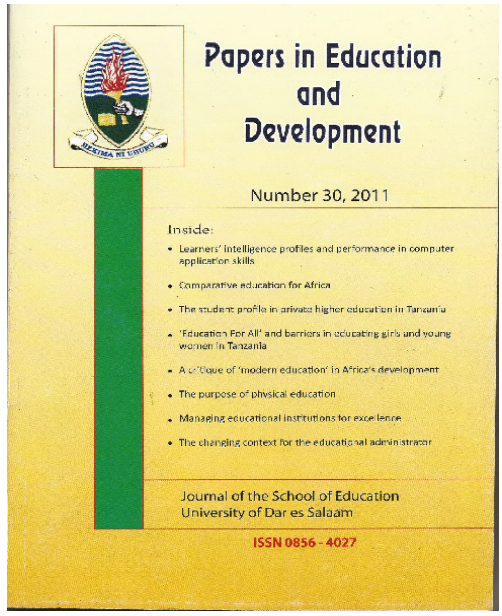
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PED No. 16 (1995)



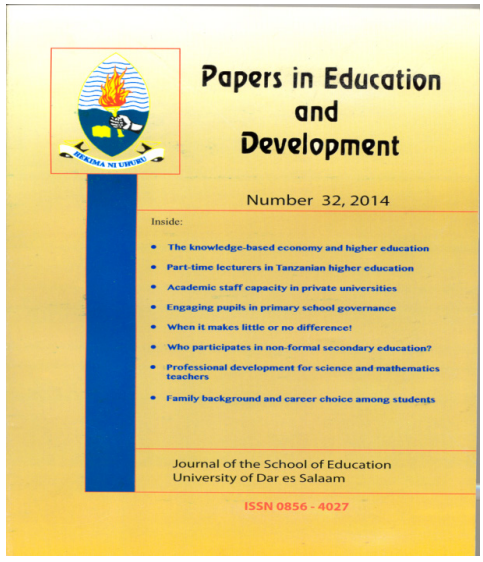
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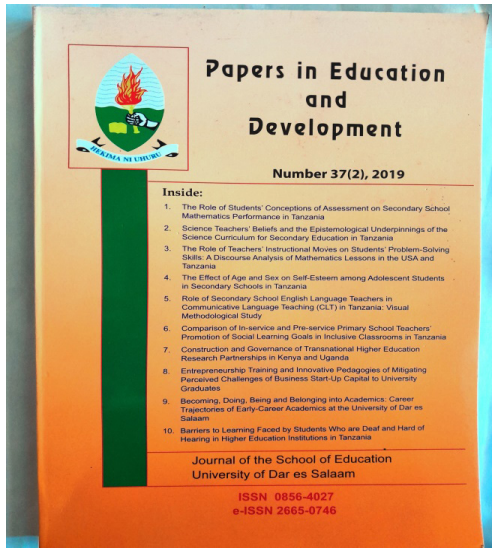


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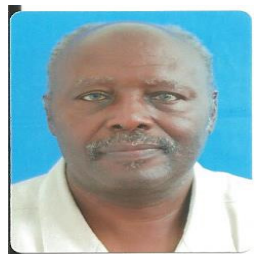


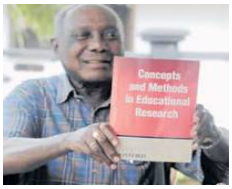
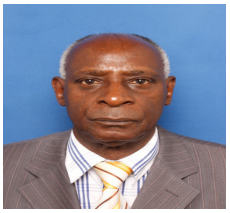
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A Time to Build? Decolonising Education through Integrating African Indigenous Knowledge in the Science Curricula in Tanzania

Kondrada Flowin Haule & Mjege Kateko Kinyota

Dar es Salaam University College of Education, Dar es Salaam, Tanzania
Corresponding Author[1]: kondrada.haule@duce.ac.tz
Email[2]: mjege.kateko@duce.ac.tz

Abstract

This study aimed to critically examine the implications of excluding African indigenous science knowledge from the Tanzanian science curriculum. Grounded in critical pedagogy, the paper interrogates how the overreliance on Western science in curriculum policy and classroom practices replicates colonial power relations while marginalising indigenous ways of knowing. Drawing on documentary review, the paper draws on indigenous scholarship, curriculum studies, and cognitive science to explain how students' underperformance in science may be linked to the abandonment of indigenous knowledge systems. The paper argues that integrating indigenous knowledge into science curricula can improve students' learning, support sustainability, and challenge existing power over what counts as scientific knowledge. Rather than suggesting instructional or technical solutions, this paper seeks to provoke a critical rethinking of what constitutes legitimate scientific knowledge in Tanzanian education by situating the discussion within contemporary geopolitical tensions and shifts.

Keywords: *critical pedagogy, indigenous science, science curriculum, sustainability, western science*

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1. Introduction

The role of Indigenous Knowledge Systems (IKS) in promoting science learning and sustainable development is well acknowledged (Shizha, 2020). Nonetheless, IKS is a neglected aspect in the science education discourse. For instance, a closer look at the current policy discourse on science education in Tanzania reveals sentiments of human capital theory. That is, according to the Tanzania Development Vision (TDV) 2050, the country is aspiring to educate a science workforce that will help it compete in a technology-driven world of work (United Republic of Tanzania [URT], 2025). Indeed, this aspiration

is well justified given that competition in the global economy favours those who control and invent technological innovation. For instance, variances in social and economic development among countries tend to associate with their variances in the development of science and technology (Kasongo & Makamu, 2024; Stromquist, 2002; Torres, 2002).

Consequently, many interventions in science education in Tanzania and similar contexts have tended to adopt best practices from countries that have prospered at the expense of indigenous science knowledge, raising the possibility of dissonance between how science is applied in daily life and what is taught in science classrooms. For instance, the 2014 revised 2023 Tanzanian Education and Training Policy (ETP) emphasises the use of relevant tools to comply with "the requirements of modern science and technology" (URT, 2014, p. 31). Indeed, the phrase "indigenous," as well as other similar terms (e.g., traditional; native; ethnoscience), is not mentioned anywhere in the ETP, which guides the provision of education in the country.

Moreover, there is a lack of coherence among the national vision, policy documents, and the science curriculum. For instance, while the Tanzania Development Vision 2050 emphasises the decolonisation of education, policy, and curriculum documents remain silent on the matter. Consequently, this effect is attributed to the conduct of science education research, in which there is a paucity of studies on indigenous science knowledge. Despite sustained investments in science education reform, current practices remain anchored in Western epistemological traditions that prioritise abstract, decontextualised scientific concepts, standardised assessments, and Eurocentric histories of scientific discovery. These practices rarely engage learners' indigenous knowledge. As a result, a critical link is missing between school science and students' everyday experiences, raising questions about epistemic justice, relevance, and meaningful participation in science learning.

1.1 Statement of the Problem

Despite efforts made to improve students' performance in the country, the performance rates for science subjects have remained unpromising for many years. For instance, students' pass rates in the Certificate for Secondary Education Examination (CSEE) are 47.8 and 46.5 for biology and physics, respectively, over 13 consecutive years from 2008 to 2020 (MoEST, 2021). In other words, more than half of the students who complete secondary education score less than 30 marks (out of 100) in these science subjects according to the grading system in the country (URT, 2014). Previous studies have been conducted in this regard, highlighting instructional and material flaws within the education

system. A review of the literature using databases such as Scopus, Web of Science, and ERIC suggests a paucity of studies associating poor performance in science with little emphasis on IKS. In this paper, we draw on cognitive science research to argue that these unpromising performances in science may partly be due to the abandonment of indigenous science knowledge. Nonetheless, the need to adopt indigenous knowledge should not be justified solely in terms of academic performance. Rather, the paper argues that for students to feel like fully contributing members of the scientific community, they need opportunities to engage with their local environments. This would somehow add to their sense of belonging and, so to speak, open the possibility of a fulfilled life and empowerment for these students. Indeed, critical approaches to science education which intend to interrogate structures associated with colonialism, oppression, and maintenance of other exploitative regimes are widely emphasised for building a sustainable future (Bazzul, 2014). It is now time to build the science curriculum around indigenous knowledge, which is often taken for granted. However, it may have a tremendous impact on the generation of scientists that a country would wish to have. In particular, we employ critical pedagogy as a framework to understand how overreliance on Western science can be dehumanising to Tanzanians as natives.

1.2 Purpose and Research Questions

The purpose of this paper is to critically examine the implications of excluding African indigenous science knowledge from the Tanzanian science curriculum. Grounded in critical pedagogy, the paper attempts to interrogate how the overreliance on Western science in curriculum policy and classroom practices replicates colonial power relations while marginalising indigenous ways of knowing. Specifically, the study illuminates how the neglect of indigenous science reinforces epistemic injustice, undermines students' sense of belonging in science, and disconnects school science from learners' lived socio-cultural experiences. That is to say, the paper discusses how the neglected indigenous science reproduces the colonial legacy, which our founding father, Mwalimu Nyerere, fought against at all costs. The paper attempts to respond to a broader question: Why is African indigenous science knowledge largely excluded from the Tanzanian school science education pipeline, and how does this exclusion reflect enduring colonial and Eurocentric power relations in curriculum policy and practice? This broader question leads to the following two specific research questions:

i) What are the educational, cognitive, and socio-cultural implications of the overreliance on Western science in Tanzanian science education, particularly for students' learning, identity, and sense of belonging?

ii) How can critical pedagogy offer a framework for decolonising science education by integrating indigenous science knowledge in the context of contemporary geopolitical and epistemic shifts?

Essentially, this paper views a geopolitical shift from the age of liberal optimism, when the West assumed moral legitimacy, to the era of populism and the rise of China as a great opportunity to adopt Southern epistemologies (e.g., indigenous science knowledge systems). This is not to suggest that the country should lean more towards China in the light of science education policy. Rather, the geopolitical shift should be a point of reference as the country embarks on policy changes in this regard. Drawing on insights from curriculum studies, cognitive science, and indigenous science scholarship, the paper concludes that abandoning IKS may partially explain persistent challenges in students' science performance. Rather than suggesting instructional or technical solutions, this paper seeks to provoke a critical rethinking of what counts as legitimate scientific knowledge in Tanzanian education by situating the discussion within contemporary geopolitical tensions and shifts.

1.3 Significance of the Study

This study contributes to the science education scholarship by positioning indigenous science knowledge within the critical pedagogy debate, thereby moving beyond narrow, performance-oriented explanations of science curriculum reforms. Drawing on indigenous scholarship, cognitive science, and curriculum studies, the paper deepens our understanding of how students' cultural capital, prior knowledge, and lived experiences shape and are shaped by science learning and meaning-making. Thus, the paper offers theoretical discussions on epistemic justice by interrogating the universality and neutrality of Western science. At the practice and policy levels, the study offers a critical lens for identifying inconsistencies between Tanzania's development visions, educational policy, and curriculum documents. It highlights the need to maintain coherence among the national vision, curriculum reform, and instructional practices, while encouraging educators and practitioners to recognise indigenous science knowledge as legitimate. Generally, the paper positions science education as a pathway to empowerment and sustainability, thereby contributing to ongoing efforts to decolonise education in the country and other postcolonial contexts.

2. Literature Review

The years after 1960 were pivotal in Tanzania's history. Notably, soon after independence from the British in 1961, Tanzania (then Tanganyika) embarked on a serious effort to transform its education system. Particularly, there was,

among political leaders and policy circles, a sense that true independence should be accompanied by educational transformations that would liberate colonial education (Nyerere, 1968). The establishment of the University College, Dar es Salaam (now the University of Dar es Salaam) in 1961 is one such effort. It was envisioned that the university would prepare post-independent intellectuals to lead the targeted liberation struggles. The Education for Self-Reliance (ESR) (Nyerere, 1968) was introduced with tenets such as making education more practical through instituting vocational education. These radical shifts emphasised the nationalisation of education, notably the use of Swahili as a medium of instruction in basic education. Socialism was the prevailing ideology; thus, education had to reflect its tenets, such as free and universal primary education. Generally, the decolonisation message dominated much of the 1960s and 1970s. By then, decolonisation entailed shying away from donor dependency in both financial and technical support, colonial education, and the occupation of various political and administrative posts by Tanzanians.

During the 1980s, Tanzania, like many other countries, was swept by globalisation, which led to the introduction of Structural Adjustment Programs (SAPs) among other things. The SAPs aimed to prepare a workforce that could compete in the global science– and technology–driven world, a competition associated with socio-environmental injustices. That is, it introduced noticeable shifts from socialism to capitalism (URT, 2000). In particular, neo-liberal policies of privatisation, cost-sharing, capital accumulation, and democratisation took hold. The development of human capital was also an important aspect during this wave (URT, 2000). To complicate matters, the fall of the Berlin Wall in 1989 heightened geopolitical tensions, further reinforcing convergence in development and education. Indeed, the 1990s marked the age of liberal optimism when the West assumed moral legitimacy. Likewise, the Cold War and arms race resulted in convergence in science and technology (Voda & Havlík, 2021). Further, humanitarian interventions have become a powerful tool for transferring best practices in development and education. Therefore, it is not surprising that the Tanzania 1995 and 2014 revised in 2023 educational policies identified science and technology as a strategic goal of science education in the country (URT, 1995; 2014).

Marked by the introduction of Western science subjects as compulsory in basic education (URT, 2014), the shifts have opened a new page in science education as we know it today. Since then, science education has been seen as a vehicle for preparing scientists to lead technological innovation efforts. The school curriculum has also reflected this noble emphasis. For example,

science is a significant section of the school curriculum from kindergarten to university (URT, 2014). At the primary school level, students learn science as an integrated subject called science and technology. The subject is compulsory for students in Standard Three to Six of the primary education cycle. Meanwhile, at the secondary school level, science is taught in separate subjects: physics, chemistry, and biology (URT, 2014). The supremacy of science is also reflected in tertiary education, where programmes in science and technology are highly advertised and even categorised as national strategic priorities for student loan allocations. Indeed, these programmes do enjoy a high esteem in society.

As in other countries, the curriculum for science subjects in Tanzania reflects the hegemonic influence of Western science as a universalised body of knowledge that emphasises universal scientific laws, laboratory-based experimentation, and examination-driven content coverage. While such practices align with global standards, research consistently shows that they marginalise indigenous modes of inquiry such as observational learning, community-based experimentation, and orally transmitted ecological knowledge (Zidny et al., 2020). As a result, learners are positioned to engage with science as an abstract and decontextualised body of knowledge rather than as a lived practice embedded in their socio-cultural environments (Ogunniyi, 2008). Moreover, curriculum materials and textbooks in science education continue to foreground Western scientists and Eurocentric trajectories of scientific discovery, while African and local contributions remain largely absent (Kinyota & Kavenuke, 2018). In such curricular representations, Western knowledge systems are seen as universal while indigenous knowledge is rendered invisible or inferior (Handayani et al., 2018).

A study analysing the curricula for science subjects in Tanzania, South Africa, and the United States (Kinyota, 2020) revealed similarities in the content of science across the three countries, suggesting convergence in science content and processes. Likewise, analysis of science textbooks in Tanzania (Kinyota & Kavenuke, 2018) indicated that only Western science philosophers are featured in the textbooks, implying an imposed hegemonic universality of Western science knowledge. This convergence is indeed a reflection of the effects of globalisation, which neglects local cultures, in this case, indigenous science and its associated knowledge systems. This imbalance reinforces a narrow image of who produces legitimate scientific knowledge, thereby marginalising indigenous ways of knowing and perpetuating epistemic injustice within formal schooling. According to Apple (2004), knowledge involves a selective tradition, in which knowledge from the ruling class is selected and emphasised for a purpose, while other knowledges are neglected, diluted, excluded, or

reinterpreted. Even research in science education has overlooked indigenous science as a possibility for improving science learning, instilling a sustainability culture, and decolonising the curriculum. For instance, earlier studies on the challenges facing science education in Tanzania (e.g., Kafyulilo & Tilya, 2019; Kinyota, 2020; Mkimbili et al., 2017; Semali & Mehta, 2012) have referred to Western science currently taught in schools without suggesting the means to decolonise it. Meanwhile, indigenous science is known for promoting the sustainable use of the environment.

Globalisation involves convergence such that societies are subjected to 'the same forces' (Arnove, 1980, p. 49) with the faith that cultural hybridisation (Torres, 2002) is possible. As a consequence of globalisation, people's (e.g., policymakers, students, and teachers) attitude towards science has continued to be that of Western science as universal. That is to say, very few are concerned that cultural infrastructures (e.g. indigenous scientific practices and methods of knowledge production) are diminishing as globalisation intensifies. Seen from this light, the inclusion of indigenous knowledge in science curricula is neglected altogether. However, there has been debate over teaching science subjects in Swahili, assuming that Swahili is understood by many students and is rooted in Tanzanian culture. While this assertion is still contested, the debate has tended to overlook indigenous science knowledge as a special language in its own right.

This paper attempts to bring to light the issue of indigenous knowledge and how it could lead to improved science learning, sustainability, and the decolonisation of the curriculum. In the present paper, indigenous science is defined as systems of scientific knowledge developed by a given culture or society as part of human survival (e.g., traditional medicine). Indigenous science knowledge is associated with specific ways through which indigenous peoples view their world. It has also been referred to as Ethnoscience or native science (Abonyi et al., 2014; Zidny et al., 2020), meaning knowledge systems rooted in a specific culture. With specific reference to Africa, Shizha (2020) refers to African indigenous knowledge systems (AIKS) as local knowledge unique to a specific cultural group in each locale. It has been termed as people's knowledge/community-generated knowledge/experiential knowledge/tacit knowledge/situational knowledge (Emeagwali & Shizha, 2016; Shizha, 2020). Western science is used to refer to a colonially imposed, hegemonic body of Western ways of viewing the natural world.

3. Critical Pedagogy: A Theoretical Lens

The study is anchored in critical pedagogy, drawing primarily on the works of Paulo Freire and critical theorists. Critical pedagogy provides a relevant lens for examining how power, ideology, and history shape what counts as legitimate scientific knowledge in schools. It challenges the neutrality and universality claims of Western science and emphasises dialogue, problem-posing, and the validation of learners' lived experiences. In particular, critical pedagogy enables us to move away from simplistic and descriptive thinking about school science (such as studying why students fail in science subjects) to normative thinking (such as questioning the essence of science itself). In this case, questions such as why science should be learned in school and whose science knowledge is legitimate are as important as the study of science itself. Critical pedagogy is linked to critical theory, which can be traced back to the works of Karl Marx, Paulo Freire, and the Frankfurt School. In particular, the Frankfurt school is credited with making critical theory popular. Critical theory is concerned with how entities (e.g. what is learned in school science) are shaped by power relations. Hence, it seeks to confront all forms of power domination in order to bring about a just society (Apple, 2004; Apple & Au, 2009; Zembylas, 2019).

Critical pedagogy draws on critical theory and is more of a Brazilian movement championed by Paulo Freire. After being disappointed by the aftermath of colonial rule in Brazil, Freire sought a just society built on principles of shared knowledge and dialogue. In educational sciences, Freire coined the phrase' banking education', which he described as education that treats students as having nothing to contribute to the learning process, as well as one that reproduces existing power structures. Freire was strongly opposed to banking education (e.g., learning a prescribed body of science) and saw it as both dehumanising and unjust. Instead, '… people in marginalised positions have the opportunity to collectively struggle against oppression, to voice their concern, and create their own representations' (Kellner & Share, 2007, p. 61). As Apple and Au put it:

> Freire's critical pedagogy … seeks to be a pedagogy that enables students and teachers to be 'subjects of their own history'. … who can look at reality, critically reflect upon that reality, and take transformative action to change that reality, thereby deepening their consciousness and working toward a more just world. By using the teaching methods of problem posing and dialogue, Freire's critical pedagogy aims to challenge all hierarchical power relationships, including the student–teacher relationship. In this way, Freire's critical pedagogy invites students and teachers to become change agents both in their classrooms and in the world around them (Apple & Au, 2009, p. 997).

Apple and Au (2009) argued that Freire's critical pedagogy calls on educators to be conscious of how scientific knowledge and its production relate to and reproduce power structures. Critical pedagogy encourages students in science classrooms to be critical of what they learn and of what is considered legitimate science knowledge. In other words, science classrooms become avenues for critiquing science knowledge and its sources. Further, it encourages students and teachers to go beyond mere recitation of theories and principles, such as Archimedes' principle, Newton's laws of motion, and Darwin's theory of evolution. Instead, they should also actively engage in the debate of whose knowledge should be taught in schools. For instance, it can be applied to challenge the dominance of white male scientists in science textbooks used in Tanzanian schools. Essentially, critical pedagogy treats scientists and scientific knowledge as products of a particular culture while rejecting the claim that science is objective, universal, and uninfluenced by individual perspectives.

4. Methodology

4.1 Research Design

The study adopted qualitative document review as its key methodology. Document analysis was considered relevant given that the study seeks to cross-examine how knowledge, ideology, and power are embedded within the science education pipeline, that is, in policy and curriculum documents, as well as in scholarly discourse. In other words, the study thoroughly scrutinises existing documents to offer a critical assessment of the exclusion of African indigenous knowledge from the science curriculum.

4.2 Sampling of Documents

Documents were purposefully selected to ensure alignment with the study's focus on science education, indigenous knowledge systems, curriculum policy, and critical pedagogy. Thus, the review included national vision and policy documents, as well as peer-reviewed scholarly materials. Scholarly materials were identified through targeted databases such as ERIC, Google Scholar, Scopus, Web of Science, using key search phrases such as critical pedagogy, indigenous science, science education in Tanzania/Africa, science curriculum, and indigenous knowledge systems.

4.3 Inclusion and Exclusion Criteria

Documents were included in the review based on the criteria detailed in Table 1

Inclusion Criteria	Exclusion Criteria
Direct relevance to science education, science curriculum policy, or critical pedagogy	Addresses science education solely from a technical perspective without referring to knowledge production, ideology, or power
Explicit engagement with indigenous knowledge, indigenous science, ethnoscience, or indigenous knowledge systems.	Exclusively focusing on indigenous knowledge in non-educational settings.
Focus on Tanzania, sub-Saharan Africa, or comparable postcolonial contexts.	Opinion pieces and non-scholarly sources lack academic rigour
Peer-reviewed journal articles, authoritative books, policy documents, or officially endorsed curriculum materials.	Duplicates or those providing insufficient theoretical or methodological details
Published in English.	Published in languages other than English

4.4 Analysis of Documents

Selected documents were analysed using critical discourse analysis and thematic analysis, focusing on the identification of recurring themes related to the supremacy of Western science, the sidelining of indigenous science knowledge, and assumptions about the supremacy and universality of science. The analysis also focused on themes that highlight the implications of the marginalisation of indigenous science to learners' identity, epistemic justice and sense of belonging. Guided by critical pedagogy as a theoretical lens, the analysis scrutinised how curriculum and policy texts challenge or reinforce colonial power relations and how the role of indigenous science is conceptualised in scholarly literature. Insights from selected documents were synthesised to develop a coherent critical narrative.

5. Findings and Discussion

5.1 What Does Research in Cognitive Science Say Regarding Indigenous Science in Relation to Students' Performance?

Cognitive scientists have devoted time and resources to studying how learning occurs at the mental level. Indeed, cognitive science has had a tremendous influence on science education, in particular, on how science should be taught to enhance students' understanding. In this paper, we focus on the domain of cognitive science, which examines how conceptions are formed and their

effects on students' understanding of science concepts and, consequently, their performance in science subjects. This focus is selected to understand persistent students' failures in science subjects in relation to how conceptions are formed. It is well acknowledged that students come to school with some preconceptions about science (DiSessa, 2015; Stylos et al., 2021). For instance, how we feel when we approach hot objects becomes the genesis of our knowledge of heat and energy, even before we are exposed to these fancy concepts taught in schools. These preconceptions can either support or be in variance with accepted scientific knowledge (DiSessa, 2015). As we interact with the environment and one another, we engage in a continuous and often unconscious process of meaning-making.

Through this process, new meanings are formed, others reinterpreted, while others are discarded altogether (DiSessa, 2015; Tapia et al, 2019). As such, the ideas that students bring into science classrooms tend to be context-dependent. They also tend to be personal and resistant to change (Champagne et al., 1982). Further, it is important to note that students use these preconceptions or prior knowledge to make sense of new knowledge, so that successful learning depends on reconciling pre-conceptions with new knowledge. In other words, learning new scientific knowledge depends on how that new knowledge will be reorganised in mental structures. That is, students' preconceptions influence their conceptual understanding of science concepts. As societies engage in solving daily-life problems, they can produce scientific knowledge that can be considered indigenous science. Endeavours such as children's play, the extraction of local medicine by local healers, and even the building of houses by local constructors involve the use and production of scientific knowledge. As products of society, much of what students bring into science classrooms is influenced by their interactions with these indigenous sources of science knowledge and forms an essential part of their preconceptions.

To better understand the influence of indigenous science on students' learning of science, it is very important to review the two opposing views of the concept which has emerged from cognitive science. First, there is the classical view of the concept, in which students' preconceptions are seen as mistakes or false ideas that must be discarded before meaningful learning of accepted science concepts can take place (Von Aufschnaiter & Rogge, 2010). In other words, students must unlearn what they already know before they can learn new knowledge, especially when students' preconceptions contradict accepted scientific knowledge. When translated into indigenous science, this view entails that, for meaningful understanding of accepted scientific knowledge to take

place, students should be helped to unlearn their preconceptions of science, which they acquired before joining formal schooling. That is to say, the science knowledge acquired by students from the local environment is considered a misconception which acts as a barrier to understanding science (Gilbert & Watts, 1983). Educators who hold this view of the science concept emphasise identifying topic-specific preconceptions and correcting them using relevant instructional design. Unfortunately, there is evidence suggesting that the classical view of concepts overlooked many important aspects, thereby being less effective in developing conceptual understanding of science (Champagne, 1982; Tapia et al., 2019).

Moreover, it places less value on students' prior knowledge and treats the concept as static and unchanging. On the contrary, the actional view of science can address this oversight by the classical view of the concept. The actional view discourages the use of the phrase 'misconceptions'; instead, it emphasises the use of phrases such as 'alternative conceptions' (Gilbert & Watts, 1983). Proponents of the actional view have shown that students' preconceptions are highly diverse and context-dependent, making them difficult to detect and confront. Concepts are thus dynamic and active, such that new ones reorganise existing experiences (in this case, pre-conceptions). That is to say, preconceptions (including those contradicting accepted science) are valued and viewed as constituting the natural process of conceptual development. Thus, they are not to be replaced; rather, they are used as building blocks for acquiring new knowledge. Preconceptions are viewed as immature and less developed concepts (DiSessa, 2015; Tapia et al, 2019).

In relation to science education and indigenous science, the actional view treats indigenous science knowledge, which students bring into science classrooms, as building blocks of new accepted science knowledge. Indeed, cognitive science research has shown that preconceptions and new conceptions cannot be easily separated. Instead, they complement each other (DiSessa, 2015). This being the case, a meaningful understanding of science concepts depends greatly on how students' preconceptions, in this case, their indigenous science knowledge (Handayani et al., 2018; Zidny et al., 2020), are complemented by the learning of accepted science concepts. Indeed, Abonyi et al. (2014) found that integrating indigenous knowledge improved science learning in Nigeria. Essentially, integrating indigenous science into the school curriculum is likely to improve students' learning of science by providing an authentic context for learning. However, the aim of integrating indigenous science into the curricula should not only be to improve science learning but also to foster empowerment and a sense of belonging to a science community among students. It also

involves empowering the natives by ensuring their voices are heard in relation to scientific knowledge.

5.2 Indigenous Science Versus Western Science: Towards Decolonising the Science Curriculum

The historical development of scientific discovery, and much of what later came to inform science education, is dominated by Eurocentric worldviews, hence the popularisation of Western science (Ogunniyi & Ogawa, 2008; Zidny et al., 2020). That is to say, science education has, to a greater extent, ignored a multiperspectival approach to scientific knowledge that respects indigenous knowledge systems (Zidny et al., 2020). This tendency continues to the present day. For instance, current policy discussions in Tanzania are silent on indigenous science knowledge. Even discussions on reforming the basic education curriculum have tended to overlook the issue. This is not, by any means, surprising, given that education is seriously considered a means to achieve social and economic development, as defined using a neo-liberal perspective (Misiaszek, 2015). As a consequence, there is convergence regarding best practices in science education, particularly the science curriculum. Science has also enjoyed the status of being universal. Hence, masking any discussion about the historical contexts associated with the production and popularisation of scientific knowledge.

The 'politics of constructing scientific knowledge' (DeJong-Lambert, 2004, p. 129) can be traced back to the late 1950s when the Soviet Union and the West were struggling for technological supremacy. Nonetheless, the fall of the Berlin Wall in November 1989 marked an explosion of the age of liberal optimism, in which the United States of America (USA) and its Western allies assumed moral legitimacy. During this time, we had entered a world in which the USA remained unchallenged. It was an era of convergence in development and education. Science and technology were considered important tools for waging economic prosperity and competition (Stromquist, 2002). There were at least four pillars that dominated the 1990s and which are closely associated with convergence in science education. First, there was the notion of consensus, which held that politics and democratic elections are intertwined. That is to say, it was assumed that there was an indisputable connection between democracy and prosperity. The idea being that as a country grows economically, it becomes a democracy and vice versa.

Secondly, there was a clear vision of prosperity that is driven by the global free market. This pillar is closely connected to the third, which concerns the moral legitimacy of the West. This was marked by humanitarian intervention, such

as that in Liberia during the late 1990s. State sovereignty was broken in the name of human rights, while in some cases, military intervention was used. The fundamental idea was that people do not want to live in shackles, while the West is there to help. Essentially, the West assumed moral legitimacy that other countries wished and/or were somehow forced to be like the West. This pillar was associated with deliberate efforts to borrow best practices in science education from the West (DeJong-Lambert, 2004). Approaches to teaching science, such as inquiry-based instruction, the scientific method, and problem-based learning, are among the examples of this convergence. Finally, it was assumed that there is a universal liberal global order. Indeed, one impact of this global order has been the blurring of the national state's powers to decide on matters considered global (Stromquist, 2002). As a consequence, science and technology, as important features of globalisation, have converged, which in turn has led to convergence in science education.

Throughout history, many societies have invented scientific knowledge as humans struggled to master their environment. For example, the Dogon of Mali are among the early discoverers of astronomical knowledge. (Akpan, 2011). Also, the Great Pyramids of Egypt represent early discoveries in mathematics and engineering. Knowledge and discovery of iron smelting in Nigeria, metallurgy in ancient Sudan, the concept of time in Zimbabwe, and traditional medicine across many African countries were documented before the popularisation of Western science (Emeagwali & Shizha, 2016). Likewise, different societies in Tanzania had developed many ways to combat diseases, such as treating snake bites with special stones. Also, indigenous ecological knowledge is widely used to interpret environmental changes and guide agricultural decision-making. For instance, by using plant phenology, animal behaviour, and wind patterns, local communities are reported to predict rainfall and plan cultivation cycles (Chang'a et.al., 2010).

Unfortunately, these indigenous science discoveries are rarely acknowledged or featured in formal science curricula in Tanzania. In response, there has been a huge movement to promote indigenous science knowledge. Numerous writers (e.g. Abonyi et al., 2014; Misiaszek, 2015; Ogawa, 1995; Ogunniyi & Ogawa, 2008; Snively & Corsiglia, 2000) have advocated for the inclusion of other perspectives (e.g., Buddhism, Ubuntu) in science education discourse. In particular, the recognition that other cultures have their ways of viewing the natural world. While others (e.g., Abonyi et al., 2014) have taken a radical view that considers replacing western science with indigenous science, others (Ogawa, 1995; Ogunniyi & Ogawa, 2008; Zidny et al., 2020) have taken a soft stance that emphasises the integration of indigenous science knowledge

with Western science. Others have noted that overreliance on western science disempowers local communities and continues the Western colonial mindset.

Table 1

Featured Western Scientists in Tanzanian Science Textbooks

Scientists' names	Sex	Race/ Nationality	Science concept/topic	Grade
Michael Faraday	Male	White-United Kingdom	Electrolysis	Physics, Form 3
Robert Bunsen	Male	White-Germany	Heat sources and flames	Chemistry, Form 1
Gregor Mendel	Male	White-Czech Republic	Genetics	Biology, Form 4
Isaac Newton	Male	White-United Kingdom	Laws of motion and astronomy	Physics, Forms 2 and 3
Charles Robert Darwin	Male	White-United Kingdom	Evolution and natural selection	Biology, Form 4
Henry Louis Le Chatelier	Male	White-France	Chemical equilibrium	Chemistry, Form 3
Jean-Baptiste Lamarck	Male	White-France	Evolution and natural laws	Biology, Form 4
Archimedes of Syracuse	Male	White-Greece	Archimedes' principle	Physics, Form 1
Friedrich Gustav Jakob Henle	Male	White-Germany	Anatomy and loop of Henle	Biology, form 3
Robert Hooke	Male	White-United Kingdom	Theory of elasticity	Physics, Form 2
Democritus	Male	White-Greece	Atomic theory	Chemistry, forms 1 and 2
John Frederic Daniell	Male	White-United Kingdom	Electrochemistry and Daniell Cell	Physics, Form 3
Amedeo Avogadro	Male	White-Italy	Molecular theory and Avogadro's constant	Chemistry, Form 3
Georg Ohm	Male	White-Germany	Electrochemistry or Ohm's law	Physics, Form 3
Georges Leclanche	Male	White-French	Electrical Cells	Physics, Form 3
Robert William Boyle	Male	White-Ireland	Boyle's law or Gas law	Physics, Form 2 and Chemistry, Form 3
Wilebrord Snellius	Male	White-Netherlands	Astronomy and laws of refraction	Physics, Form 3
Nicolaus Copernicus	Male	White-Poland	Astronomy and Copernicus law	Physics, Form 3
James Prescott Joule	Male	White-United Kingdom	Thermodynamics	Physics, Form 3

Source: Extracted and modified from (Kinyota & Kavenuke, 2018)Indeed, the convergence in science education is reflected in the content of school science curricula in many countries, including Tanzania. Notably, homogeneity in

curriculum content is alarming. In education systems, including Tanzania's, textbooks constitute essential curriculum materials that are derived from the syllabus. As shown in Table 1, science textbooks are dominated by knowledge discovered by white male Western scientists. Further, analysis of science textbooks in Tanzania reveals that indigenous science knowledge almost never featured in the secondary education curriculum (Kinyota & Kavenuke, 2018). Nonetheless, teachers have an opportunity to integrate indigenous science by using indigenous knowledge as a context for learning science (Zidny et al., 2020). However, given the pressure on teachers and students to prepare for high-stakes examinations (Vavrus & Bartlett, 2012), there is little hope that it will happen. Thus, integrating indigenous science content in the science curriculum remains a promising path. There is a need to identify indigenous science knowledge in Tanzania and to research the best way to integrate it into the school curriculum. Several models for integrating indigenous science have been proposed elsewhere. For instance, the science education for sustainability model (Zidny et al., 2020). Likewise, Handayani et al. (2018) describe a four-step model used to integrate indigenous knowledge into the science curriculum in Japan.

5.3 Decolonising the Curriculum Using Critical Pedagogy

The dominance of white-male Western scientists in the school curriculum is, according to critical pedagogy, very disempowering and is nothing less than the continuation of Western domination in every sphere of life. In particular, students from other races, as well as women, may pick up a negative message about who is capable of producing scientific knowledge. Critical pedagogy calls for analysing how the production of scientific knowledge is linked to Western supremacy. Further, learning that only white-male Western scientists are capable of discovering scientific knowledge serves as a hidden curriculum that may lower the self-efficacy of science among non-white and female students. Indeed, the hidden curriculum is as powerful as the formal curriculum and should be taken seriously (Alsubaie, 2015). There comes the need for critical pedagogy in science classrooms in Tanzania. Critical pedagogy can help teachers offset the impacts of the hidden curriculum associated with the dominance of Western scientific knowledge in the curriculum.

A science classroom should be a place where students are aware of how scientific knowledge is constructed, including the historical contexts that surround its construction. Students should be taught that science is far from universal; rather, scientific knowledge is theory-laden and a product of a particular culture. Thus, students should engage in active dialogue to challenge power relations that are associated with the construction of scientific knowledge.

DeJong-Lambert (2004) has suggested that students should be exposed to the biographies of scientists so that they can learn science in relation to the contexts that surrounded its discovery. Further, students should be aware of notable scientific discoveries which took place in their communities (Abonyi et al., 2014) to enhance their sense of belongingness to science. According to Anderson (2002), science is both a body of knowledge and a way of thinking and the two are intertwined. Seen from this light, depending on Western science as the sole body of scientific knowledge has the effect of instilling in students a sense of Western scientific thinking, thus further reproducing a generation which does not value native ways of thinking about the natural world. Critical theorists view this overreliance on Western science as a serious mistake because it results in the maintenance of the Western colonial legacy.

5.4 De-globalisation As an Opportunity to Adopt Indigenous Science in Tanzania

This discussion treats geopolitical shifts instrumentally, not as determinants of curriculum reform, but as contextual developments that challenge assumptions about the universality of Western scientific authority. As discussed earlier, the shift from the age of liberal optimism, when the West assumed moral legitimacy, to the era of populism and the rise of China offers an opportunity to adopt indigenous science and its associated knowledge systems. As noted earlier, the 1990s marked a period of intensified globalisation and liberal optimism. Pillars such as the global free market, democracy and prosperity, and the moral legitimacy of the West led in convergence in many spheres of life, including the best practices for advancing science and technology. However, the 2000s saw rapid shifts that almost refuted many of the 1990s' pillars. These shifts have fuelled the rise of Southern and Eastern epistemologies (Voda & Havlík, 2021). In the same vein, they offer an opportunity for Tanzania and other developing countries to reform their science curricula by adopting indigenous science. First, the 2008 economic crisis resulted in many challenges to the global economic order. The crisis had a tremendous impact on many Western economies, many of which have entered a period of stagnation.

Second, 2014 marked the rise of populism (DeHanas & Shterin, 2018). This era has been marked by many people, including those in the West, questioning the moral legitimacy of the West to engage in humanitarian intervention. Indeed, the rise of Donald Trump and Brexit in the UK in 2016 marked a shift towards nationalism and ushered in an era that prioritises the interests of the national state over globalisation (DeHanas & Shterin, 2018). This era can be considered a period of de-globalisation that restores the power of the nation-state and is

fuelled by nationalist sentiment. Indeed, it is a great opportunity to consider adopting indigenous science. Furthermore, the negative effects of military intervention in countries such as Iraq began to surface, thereby challenging the idea of humanitarian intervention. Third, the rise of China as an economic superpower has not only challenged the global order but also challenged the superiority of the West. The fact that China has risen without turning to a liberal democracy has also challenged most of the 1990s pillars. Indeed, a bipolar world is emerging that offers opportunities for national states to rethink their development strategies, including educational policies.

Finally, the rise of autocracy in countries such as Turkey, India, China, Brazil, and Russia has led to diminished trust in the free-market global order. Thus, populism can, in a way, be a decolonisation and disruptive approach that advances the postcolonial indigenisation educational programs in Tanzania and Africa in general. The rise of populism and alternative development models, particularly China's state-led approach to science and innovation, challenges the assumption that Western epistemologies are the sole pathway to scientific legitimacy, thereby enabling national education systems to assert greater epistemic autonomy. Ultimately, the integration of indigenous science in Tanzanian education remains a matter of local curricular agency, shaped by national policy frameworks, educational priorities, and classroom realities rather than by external geopolitical alignments.

6. Summary and Conclusion

The arguments presented in this paper offer a framework for rethinking science education in Tanzania. While the paper does not provide details on specific strategies for integrating indigenous science in the science curriculum, it raises important questions about why that integration has not happened in the first place. Furthermore, the paper highlights that the current curriculum is a complete representation of Western science worldviews, which has the effect of separating students from their native environment. The paper also notes a lack of coherence among the national vision, policy documents, and the science curriculum regarding decolonising the curriculum, which needs to be addressed. An argument is given that integrating indigenous science in science curricula can serve at least three roles. First, it will enhance students' learning of science according to research in cognitive science. Second, it will promote sustainable development, given that indigenous science is associated with a sustainability culture. Finally, it is going to empower the students, and indeed the country, by valuing science knowledge which is rooted in their native environment.

Indeed, in Africa, the learning spaces for indigenous knowledges have always been the socio-cultural and physical/natural environments. Meanwhile, efforts to integrate indigenous knowledge in the science curriculum have shown promising results in countries such as Nigeria (Abonyi et al., 2014) and Japan (Handayani et al., 2018). In these countries, indigenous science integration has targeted three aspects of knowledge, attitudes, and skills. Further, integration did not take a radical shift approach. Instead, it was done incrementally following rigorous research. In Japan, for instance, integrating indigenous science in science curricula involved four distinct phases/steps (Handayani et al., 2018). More importantly, the geopolitical shift discussed in this paper has expanded learning spaces beyond the four walls of a classroom, thus creating the possibility of shifting the indigenous agenda into these spaces. Specifically, advances in information and communication technologies, notably social media and journalism, provide new and powerful learning spaces. Another possibility would be to emphasise the critical component in higher education programs, a stage at which students are mature enough to engage in a more advanced geopolitical debate. Therefore, the study recommends contextual integration of indigenous science within existing curricula and targeted teacher preparation to support epistemic mediation in science classrooms. Integrating indigenous science in schools' science curricula can be adopted in Tanzania. It is time to build, to improve deteriorating science performance, and to decolonise the school curriculum.

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The Illusion of Relevance: English as Language of Instruction in Vocational Education Centres in Tanzania

Wakati Maliva
Department of Educational Psychology and Curriculum Studies, Mkwawa University College of Education, Iringa, Tanzania
Email: wakati.maliva@muce.ac.tz; mwamaliva105@hotmail.com
ORCID No: 0000-0001-8810-7459

Abstract

This paper reviews Tanzanian key policy documents, namely, Education for Self-Reliance (1967), the Education and Training Policy, the Technical Education and Training Policy (1996), and the Tracer Study Report for 2010–2015 VET Graduates (2019), to assess the suitability of English as a medium of instruction in Vocational Education and Training centres. Linguistic imperialism theory is used to examine whether using a foreign language supports effective skills acquisition. Findings indicate that cognitive skills are effectively developed when instruction occurs in a familiar language. Consequently, the intended benefits of vocational education are undermined by language barriers. The paper recommends adopting Kiswahili to achieve vocational education objectives.

Keywords: *vocational education and training, foreign language, English, Tanzania, linguistic imperialism*

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1. Introduction

Vocational education has been defined as post-compulsory education and training, excluding degrees and higher-level programmes delivered by higher education institutions, that provide people with occupational or work-related knowledge and skills (Klassen, 2024). Vocational education has the potential to alleviate poverty and improve youth employment in both low – and middle-income countries worldwide (Shi & Bangpan, 2022). This potential has led to close cooperation between public vocational centres and enterprises to acquire skilled employees (Dettmann & Gunther, 2013). Furthermore, participation in vocational education has helped youth build cultural and social capital and foster aspirations, alongside the economic consequences that are primary to youth participation in national development.

Worldwide, vocational training aims to equip its trainees with the skills necessary for the development of the society in which they live. Despite the massive support that general education receives from international organisations such as UNESCO, the World Bank, and UNICEF, vocational education has largely been financed by individual nations (Klassen, 2024; Li & Pilz, 2023). Despite interest in vocational education, international organisations have not been directly involved in its provision. Vocational education receives little emphasis from international organisations because it involves more youths who could not excel in general education (King, 1993). In many parts of Africa, parents and society view vocational training colleges as places where failures go. It is from this orientation that vocational education receives less attention than general education, even though it provides direct and immediate benefits to both the individual recipient and society.

In Africa, vocational training colleges take the majority of youth who have completed primary and secondary education. Those who join vocational training colleges after secondary education may not have made it through formal education and take it as their last resort. One reason students are unable to pursue formal education is the use of foreign languages (UNESCO, 1997). The belief that a foreign language is best for educational provision in secondary education and beyond extends to vocational training colleges in some African nations. This paper evaluates the use of foreign language as a language of instruction in vocational training colleges in terms of the value the language adds to skills acquisition in students, whether foreign language is needed by the people these students serve after they graduate and the impact of the foreign language, particularly English, in the provision of vocational education and training in Tanzania.

2. Historical and Contemporary Context of Vocational Education in Africa and Tanzania

2.1 Precolonial Vocational Training in Africa

Precolonial Africa was marked by rich vocational education practices tailored to the specific needs and socio-economic activities of different communities. These practices were informal but highly effective, rooted in apprenticeship, community involvement, and the transfer of indigenous knowledge. In Egypt, vocational education focused on advanced skills in agriculture and engineering, as evidenced by the construction of monumental structures such as the pyramids, which required expertise in quarrying, masonry, and irrigation techniques for the Nile River's fertile plains (Diop, 1987). In Tanzania, the agricultural Bantu communities trained youth in farming techniques, iron smelting, and

fishing practices, ensuring survival in the fertile regions around Lake Victoria (Kimambo, 1969).

Similarly, in Ethiopia, where terraced farming in the highlands was a crucial practice, knowledge of soil conservation and livestock management was passed down from generation to generation. Additionally, traditional craft industries such as weaving and pottery were vital to local economies (Pankhurst, 1968). Zimbabwe was renowned for its stone construction techniques, exemplified by the Great Zimbabwe ruins, where young artisans learned masonry and architectural skills under the guidance of master builders (Beach, 1994). In Ghana, the Ashanti Kingdom fostered apprenticeship in goldsmithing, weaving, and blacksmithing, which were integral to trade and cultural expression (Boahen, 1975). Across these regions, vocational training was practical, community-based, and intertwined with cultural and spiritual values. Elders and specialists served as teachers, ensuring continuity of essential skills and promoting societal cohesion. While informal, this system of education laid the foundation for economic and social stability.

2.2. Vocational Education in Tanzania

Vocational education in Tanzania began before colonialism, when children were taught by their parents what a particular society considered its main economic activity through practice. If societies engaged in agriculture, fishing, or animal husbandry, children in those societies would be oriented to them. More advanced vocational activities involved preparing equipment to facilitate the main economic activities, such as making hoes and other agricultural tools or making fishing equipment. Other vocational education during the time involved medicine, where few people in society were oriented to it. Generally, vocational education during the precolonial era aimed to help society conduct its economic activities smoothly by providing the necessary equipment.

Vocational and training in Tanzania are under the supervision of the Vocational Education and Training Authority (VETA). The importance of vocational education and training in Tanzania is to prepare vocational graduates with the skills and knowledge needed for employability in both formal and informal establishments (VETA, 2019). Three of the functions of VETA are: "to provide vocational training opportunities, and facilities for such training; to establish a vocational education and training system which includes both basic and specialised training to meet the needs of both the formal and the informal sectors; to satisfy the demands of the labour market for employees with trade skills in order to improve production and productivity of the economy" (VETA, 2019, p.3). Table 1 indicates the potential candidates for vocational education

and training from primary schools.

Table 1

Number and Percentage of Potential Candidates for Vocational Education from Primary Schools (2004–2016)

Year	Standard Seven Students	Joined Secondary School (n)	(%)	Did Not Join Secondary (n)	(%)
2004	449,241	180,239	36.1	269,002	63.9
2005	493,946	243,359	49.3	250,587	50.7
2006	664,263	448,448	67.5	215,815	32.5
2007	773,553	433,904	57.5	339,649	42.5
2008	1,017,865	524,784	51.6	493,081	48.4
2009	999,070	438,827	43.9	560,243	56.1
2010	894,889	467,155	53.6	427,734	46.4
2011	973,812	522,379	59.5	451,433	40.5
2012	865,534	514,592	52.0	350,942	48.0
2013	844,938	439,816	52.5	405,122	47.5
2014	792,118	451,332	57.0	340,786	43.0
2015	763,603	538,835	70.6	224,768	29.4
2016	789,479	553,742	70.1	235,737	29.9
Total	**10,322,311**	**5,757,412**		**4,564,899**	

Source: President's office, Regional Administration and Local Government (PROLAG, 2018)

From Table 1, of the 10,322,311 candidates who sat for the Primary School Leaving Examination (PSLE) from 2004 to 2016, 4,564,899 did not manage to join secondary education. This number is approximately 44.22% of all candidates in the said period, a group that is potentially suitable for vocational education and training centres. In addition, after completing four years of secondary education, some candidates are unable to attend high school. This group adds to the number of potential candidates for vocational training colleges.

Furthermore, a tracer study conducted between 2010 and 2015 found that those who joined vocational education and training centres came from primary education, secondary education, high school, other formal employment establishments, self-employment, formal apprenticeship, and informal apprenticeship, as shown in Table 2.

Table 2

Sources From Which Vocational Education and Training Candidates Come

Activity Before Joining VET	n	%	Cumulative %
Primary education	377	12	12
Secondary education	2,197	68	80
High school	35	1	81
Employed in formal establishments	158	5	86
Self-employed	326	10	96
Formal apprentice	31	1	97
Informal apprentice	89	3	100

Source: VETA, 2019

Table 2 shows that most candidates joined vocational education and training centres after secondary education, accounting for 68%. Other sources from which students came included primary education (12%), self-employment (10%), formal employment (5%), informal employment (3%), high school (1%), and formal apprenticeship (1%) (VETA, 2019). Although this data comes from a tracer study and does not include all students in vocational education and training, they provide a picture of the sources from which students come before they join vocational education and training.

In Tanzania, secondary education is offered in English as the medium of instruction in all compulsory subjects except two: Kiswahili and *Historia ya Tanzania na Maadili*. There has been a debate over whether to continue using English as the medium of instruction, as poor performance in secondary education has been partly attributed to its use. Several researchers have suggested that Kiswahili should replace English in secondary education (Vuzo, 2010; Qorro, 2012; Kawonga & Maliva, 2018). Building on this argument, Kawonga & Maliva (2018) recommend that Kiswahili should replace all foreign languages in the East African education system. They argue that Kiswahili is a Bantu language that developed from a combination of many East and Central African languages. They further argue that if Kiswahili replaced foreign languages in education provision in the region, education would be more meaningful, and what is learnt in school would easily diffuse into and benefit societies, resulting in development. The call to use Kiswahili in place of foreign languages in East Africa is made with the awareness that both teachers and students have limited mastery of English and French. Low mastery of foreign languages not only deprives learners of their cultural rights but also hinders smooth teaching and

learning processes. The Tanzanian education and training policy states that teaching and learning are more beneficial when the language used is familiar to both learners and teachers (URT, 2023).

The policy contradicts itself by giving English the same weight in both teaching and learning processes in Tanzania. This provision makes the public more inclined to English than to Kiswahili. Statement 3.10.3 of the policy regarding English in education states that "The National Language, Kiswahili, will be used to teach subjects aimed at building and developing the ethics, traditions, customs, and culture of Tanzanians at all levels of education and training". From the year 2024, the secondary education in Tanzania offers four subjects in Kiswahili, two of which are compulsory, namely Historia ya Tanzania na Maadili (Tanzanian History and Ethics [author's translation]) and Kiswahili itself; the other two, Elimu ya Dini ya Kiislamu (Islamic Knowledge) and Fasihi ya Kiswahili (Kiswahili Literature) are optional (URT, 2023). This can be seen as a move towards making Kiswahili be used in secondary schools.

3. Theoretical Framework

This paper uses Phillipson's linguistic imperialism theory to explain the use of English, a foreign language, in teaching vocational education students in Tanzania. Phillipson, quoting Praisework (1980) argues that linguistic imperialism manifests itself through racist affirmation by means of self-exaltation on the part of the dominant group which creates an idealistic image of itself; devaluation of the dominated group and the suppression and stagnation of its culture, institutions and ideas; and finally, the dominant culture systematically rationalises the relationship between both groups, always favourable to the dominant group. Additionally, linguistic imperialists use terms such as 'ethnic', 'dialect' and 'vernacular' to refer to dominated languages. Speakers of the dominant language feel inferior in the presence of speakers of the dominant language (Phillipson, 2012). Dominant language speakers use these strategies to advance their cultural and linguistic domination.

Phillipson (2012) reiterates that the use of one language generally implies the exclusion of others, and that dominant languages strive at the expense of other languages in Africa, Latin America, and Australia. For example, English linguistic imperialism forges itself into society and individuals who are bilingual and multilingual by nature. Many linguistically rich countries have their languages dying due to English influence, as people neglect their languages in favour of English. By so doing, former British colonies are made to believe that English is the only language that can best be used to deliver knowledge. The influence of educated people in dominant-language societies

leads the whole society to believe that education provision is impossible without the use of foreign languages. As a result, policies developed by the elite continue to favour English even in places where indigenous languages would work best (Klassen, 2024).

The use of English as the medium of instruction in vocational education exemplifies linguistic imperialism. Although the choice of language for education is made by authorities in the respective countries, those who decide which language should be used were educated in the same foreign languages. Decision makers, throughout their exposure to British culture and education, were led to believe that knowledge and skills are best acquired when offered in English (Beiler, 2022). The belief that English must be used in education has dominated education in many former British colonies, including Tanzania, Kenya, Uganda, Zambia, Zimbabwe, Ghana, Nigeria, and many others. English is retained as the language of education despite the challenges learners face when using a foreign language (Vuzo, 2010; Masala, 2021; Fussy & Iddy, 2024). One of the reasons given for the decision to use English is to make education recipients global citizens. There is another misconception about English because many other international languages are spoken around the globe. Therefore, a language that is familiar to learners is suitable for deep learning (Pinxteren, 2022). Good examples exist in our midst where we see the Chinese scattered all over Africa in construction sites, and none of them speaks English, nor do they speak our languages.

In the context of vocational training, language serves not only as a medium of instruction but also as a critical tool for accessing technical knowledge and performing practical tasks. Theories of multilingualism suggest that learning a foreign language can have cognitive challenges. For example, Cummins (2000) discusses the Cognitive Academic Language Proficiency (CALP) required for academic success in a second language, which can be more demanding than Basic Interpersonal Communicative Skills (BICS). With a particular interest in Tanzania, Adamson (2020) argues that English-medium education dominates in postcolonial countries and that the use of an unfamiliar medium of instruction has negatively affected learning. Along those lines, Phillipson (2012) concludes that the continued use of dominant languages in education results in sustained underdevelopment of the dominated languages and cultures. Therefore, the continued use of foreign languages in Africa, and Tanzania in particular, contradicts the massive efforts to fight poverty and underdevelopment.

Regardless of many factors that contribute to students' performance, failure in education is always attributed to the individual. This occurs regardless of

whether the system itself caused the failure. In general education, for example, the use of a foreign language may lead to poor performance, but all the blame is shouldered on students (Qorro et al., 2012; Phillipson, 2012). In defence of linguistic imperialism, Copland, Davis, Garton and Mann (2016) claimed that English is a global language of engineering, science, trade, finance and diplomacy. However, their claim is made despite English being spoken by fewer than 20 per cent of the world's population. This raises a critical question: which languages are used for these functions by the remaining 80 per cent? In response, Phillipson (2016, p. 83) strongly refutes this assertion, stating, "The claim that English is the sole language worldwide in which such functions are carried out is nonsense, reflecting British ignorance and ethnocentrism".

4. Methodology

This study adopted a narrative literature review to synthesise existing knowledge and generate new insights (Snyder, 2019). When conducted rigorously, literature reviews serve as a powerful methodological approach for consolidating and advancing knowledge in a specific research area (Palmatier et al., 2018). Narrative or semi-systematic reviews are particularly useful for shaping future research agendas on focused topics (Mgaiwa, 2021). Guided by the aim of examining the relevance of language of instruction in vocational education, the review focused on key policy and institutional documents: *Education for Self-Reliance* (1967), the *Education and Training Policy* (2023 edition of the 2014 policy), the *Technical Education and Training Policy in Tanzania* (1996), and the *Tracer Study Report for 2010–2015 Vocational Education and Training Graduates* (2019). The review sought to determine whether the use of a foreign language supports or undermines vocational education goals and to recommend an appropriate language policy for instruction. The findings are intended to inform future research and policy discussions in Tanzania and other contexts where foreign languages dominate vocational education. To integrate and interpret the reviewed materials, a thematic analysis was employed following Braun and Clarke's (2022) framework. Thematic analysis enables systematic identification, examination, and reporting of patterns within textual data (Braun & Clarke, 2013). Using this approach, the selected documents were coded and organised into themes that address the relevance of foreign language use in vocational education and training.

5. Findings

5.1 Language of Instruction in General Education

Monolingual countries do not have problems with the choice of language of

instruction. In multilingual countries like Tanzania, the choice of language of instruction is usually determined by the country's language policy (Adamson, 2020). Since most African countries were under colonial rule, many adopted the language of their former colonial masters. The influence of these foreign languages has deep roots in education, making it almost impossible to abandon them. Clinging to these foreign languages has more tangible reasons; English, for example, is no longer the language of a single country, and educating citizens in it makes graduates more globally accepted in the world employment market. Countries opt for these foreign languages to make their citizens more employable worldwide. Despite the good intentions of the idea, a forgotten fact is that the number of people who get employment and other opportunities abroad where these foreign languages are spoken is too small to require all learners to learn them. Research has also consistently shown that learning in an unfamiliar language negatively affects learning (Brock-Utne, 2007a; Kawonga & Maliva, 2018; Adamson, 2020). Within the African countries, the way foreign languages are used is striking. Many professions, such as engineering, law, and medicine, are taught in foreign languages, and the use of those languages ceases as graduates enter the workforce. The question is, 'why would they learn in a foreign language when they work and serve people who speak the same language that is mastered by both?' This scenario is better explained by linguistic imperialism, in which one language and culture dominate others (Phillipson, 2012).

Kiswahili is used as the language of instruction in Tanzania's primary schools, and English is taught as a subject (MoEVT, 2023). Less than 10% of all primary schools offer primary education in English, and the majority are privately owned (URT, 2020). The education and training policy states that both English and Kiswahili can be used as media of instruction in primary education (URT, 2023). This provision, which allows either language to be used as the language of instruction, confuses the public about the government's position on the language of instruction. The confusion intensifies when ordinary citizens see the political and educational elite educating their children in English-medium primary schools. This makes society believe that English is a better language and that children are educated when they can speak English well. This belief is held strongly by parents in many postcolonial countries. To parents, educating children in English-medium primary education prepares them to smoothly navigate secondary education and beyond. Parents in urban areas where English-medium primary schools are available feel inferior for their inability to educate their children in Kiswahili-medium schools, believing that good education is offered in English-medium schools.

Secondary and post-secondary education programmes, such as diplomas and degrees, are offered in English. Despite English being used in secondary and higher education, its use among people in Tanzania is limited to communicating with foreigners who do not speak Kiswahili. Limited English proficiency could explain why mastery of English is low among many people. The situation is worse for those who could not make it through secondary education and beyond. There has been an outcry over the low mastery of English among Tanzanian primary school pupils (Qorro, 2012) and secondary school students (Emmanuel, 2020; URT, 1984; Vuzo, 2007, 2010). Similarly, university students have been found to have English proficiency below the required level for many years (Qorro, 1999; Komba, 2012). Given the low English proficiency among graduates at various levels of education, there have been practices that use Kiswahili in teaching and learning English (Abdala, 2025). Whether this practice is successful remains a subject of discussion. In a more advanced evolution, teachers in Tanzania have resorted to translanguaging pedagogy as a coping strategy to enhance English language learning among secondary school students (Masala, 2021; Abdala, 2024; Fussy & Iddy, 2024). All these efforts have emerged as a way to facilitate learning both the English language and the content taught through it. Given that learning English in secondary education becomes this difficult, it is expected that matters are worse in vocational education centres where primary school graduates are enrolled.

5.2 Reasons for Choice of Language of Instruction

The choice of language of instruction in the education system is an important policy decision that impacts learners' academic experiences and long-term educational outcomes. Mastery of the content may be affected due to the language used. It will be difficult to master content when students learn in a language, they are not familiar with. Research has demonstrated that cognitive development and understanding are enhanced when students use their native language (Brock-Utne, 2010; Vuzo, 2012; Pinxteren, 2022). Cultural norms and values are also believed to be integrated when students' native languages are used in instruction. It has also been consistently found that students achieve better literacy and comprehension when they are taught in their native languages (Vuzo, 2012; Brock-Utne, 2010). It is further argued that materials and teachers can be easily found in the language most commonly used in the community where education is provided. In linguistically diverse contexts such as Tanzania, pedagogical, cognitive, sociocultural and policy factors govern the choice of language of instruction. The following subsections explain the factors that determine the language used in education.

5.3. Comprehension and Cognitive Development

Everything else being equal, choosing a language of instruction is based on its impact on learners' understanding and cognitive development. Research has consistently shown that students learn better when taught in the language they speak and understand (Hameso, 2001; Brock-Utne, 2007b; Qorro, 2013; Ellis, 2016). When this is the case, learners can understand complex and abstract ideas and concepts, think critically and engage meaningfully in classroom activities. A familiar language improves foundational literacy and reduces the cognitive load of learning content and new language concurrently (Maliva, 2024; Nakamura et al., 2023). Besides, learning in a familiar language supports deeper cognitive processing and can enhance students' academic performance.

5.4. Educational Equity and Access

The choice of language of instruction can either broaden or restrict access to quality education. Over the years, education has been provided primarily to the political elite and people in urban areas (Qorro, 2013). Learners from rural or linguistically marginalised backgrounds are more likely to participate and succeed academically if their first languages are used in education provision. On the contrary, providing education in a language unfamiliar to students may result in educational disparities across the country, disadvantaging those from underprivileged families and societies (Kisumbe et al., 2025). Unfamiliar language in education may lead to increased dropout rates and educational inequality. In multilingual societies, the choice of language of instruction is not solely a pedagogical but a social justice tool for development.

5.5. Sociocultural Identity and Inclusion

Language is strongly linked to cultural identity and self-esteem. The language of instruction learners prefer makes them feel honoured and reflects their cultural backgrounds. A familiar language of instruction also fosters a sense of belonging among students. This sociocultural dimension of language choice has been highlighted across contexts where the prestige and societal valuation of languages influence educational decisions. In many African settings, social prestige attached to former colonial languages such as English or French has shaped language policy and learners' aspirations, even when this choice does not align with optimal educational outcomes for all students (Hameso, 2001; Brock-Utne, 2007a; Vuzo, 2010). The choice of English for vocational education in Tanzania violates the sociocultural identity and excludes some learners from the training.

5.6 Transition to Higher Education and Global Competence

Policymakers usually adopt a foreign language of instruction and justify their decision by citing the need to prepare students for participation in higher education and the global labour market. Internationally dominant languages such as English, French, Portuguese and Spanish may be favoured on these grounds. African societies are also proud that their educated citizens speak those foreign languages proficiently. Proponents of this idea argue that proficiency in internationally dominant languages facilitates access to scientific knowledge, technology, and competitive employment opportunities (Babaci-Wilhite, 2013). This rationale can explain why many countries maintain English or other widely used languages as primary instructional languages in secondary and tertiary education, aiming to enhance students' competitiveness beyond local contexts (Hameso, 2001; Brock-Utne, 2007a; Nakamura et al., 2023). However, vocational training colleges train artisans who work with local communities that neither speak nor need the language.

Although it may be appropriate for general education to use a foreign language, vocational education and training should be allowed to use a familiar language. In vocational education and training centres, aligning education with international standards or global competitiveness is not a concern. For vocational education and training college students, a local language would meet their needs, given their level of formal education. Their low proficiency in foreign languages, which hindered their progression to higher education, should not resurface in vocational education centres. It is therefore irrelevant to use a foreign language in vocational education and training if we want students to complete their studies successfully.

5.7 Vocational Education and Language of Instruction

Worldwide, vocational education plays a role in creating manpower for internal use, such as in building construction and maintenance. That means the language of instruction in vocational education is the students' native or national language, since they do not aim to work outside their countries of origin. In Tanzania, where the national language is Kiswahili, a language mastered by more than 95 per cent of the population, it was ideal to use as the language of instruction in vocational education. Surprisingly, a foreign language is used. This practice led the researcher to try to answer the question: "What makes Tanzania use a foreign language in vocational education?" To answer this question, the linguistic imperialism theory was used to explain the dominance of foreign languages in education in postcolonial Africa, focusing specifically on English in Tanzania.

Following the launch of the Arusha Declaration in 1967, Tanzania adopted an education-for-all programme. Every education level was required to be independent and terminal; that is, primary education was to be complete and not a preparation for secondary education (URT, 1967). To prepare the nation's labour force, many vocational education centres were established to train youths in areas considered important to the nation. Folk Development Colleges (FDCs) were opened in many parts of the country. In these colleges, there were both short courses lasting a week or several months and long-term programmes spanning a year to three years. Farmers in the neighbouring villages would be trained on the better farming methods for a week or so.

VETA is a responsible organisation to oversee vocational education centres. The authority develops the curriculum, monitors its implementation, and decides which language to use as the language of instruction in these colleges. The authority is offering thirteen trades, namely: mechanical, electrical, civil and building engineering, automotive, commercial and business support, clothing and textile, transport, extractive industry, printing, cosmetology, agriculture and food processing, hospitality, tourism and travel agency, and fine and performing arts (VETA, n.d). These are available at various centres across the country. These trades are not found in every centre. Each centre specialises in three, four or five of these trades. There have been changes in the language of instruction in vocational education centres, where Kiswahili and English have been alternating. As of now, English is used as the medium of instruction.

Several challenges and barriers exist in implementing foreign language instruction in vocational training colleges. Language proficiency of both students and instructors is a significant factor in many parts of the world (Wilson & Komba, 2012; Andersen, 2024). Many students enter vocational training with limited proficiency in the foreign language, which hinders their ability to understand and engage with the course materials. Episodes of codeswitching, codemixing and translanguaging are evidence of low English proficiency in educational institutions (Masala, 2021; Fussy & Iddy, 2024; Abdulatief & McKinney, 2025). Low proficiency in a foreign language lead to difficulty in understanding technical concepts and procedures, resulting in gaps in knowledge and skills acquisition (Vuzo, 2010). Students need both theoretical knowledge and hands-on practical activities. To execute practical tasks, students need to master the language used to give instructions. In a foreign-language context, they need additional cognitive energy to translate or interpret materials taught in that language. Energy spent on translation and interpretation redirects attention from skills acquisition to attempts to

master the language. Moreover, language proficiency is not only a problem for students; instructors also lack the necessary language skills to effectively teach complex technical content in a foreign language (Qorro, 2012). Andersen (2024) reports on the frustrations vocational educators face in Norway due to a language barrier, as they become interpreters without formal training in language education issues in vocational education.

Cultural and contextual factors also pose barriers to skills acquisition in vocational training centres. Students from diverse linguistic backgrounds may experience varying degrees of difficulty, influenced by their prior exposure to the foreign language and the similarity between their native language and the language of instruction (Li & Pilz, 2023; Abdulatief & McKinney, 2025). Foreign languages may lack some culturally relevant terminology and expressions (Fussy & Iddy, 2024), a factor that can alienate students and diminish the contextual relevance of their training. Again, if students fail to understand instructions due to a language barrier, their participation in practical tasks becomes less effective, resulting in incomplete or incorrect execution of procedures. In vocational training centres, some machines require a precise understanding of their functions to operate; faulty operation due to an inability to comprehend the language may pose safety risks to students. Any operational inaccuracy may result in poor performance or fatal accidents. The use of English in vocational education centres reflects what Beiler (2022) terms as Anglonormativity in education. Beiler reiterates that the overemphasis on English usage in education has adversely affected educational provision in many countries. Anglonormativity has deeper roots in former British African colonies despite low proficiency among the majority of citizens. In that view, Abdulatief and McKinney (2025) suggest that training that may be better delivered in a native or familiar language should not be offered in English.

Institutional challenges, such as a lack of resources and support for language learning, further intensify the problem (Amani, 2021). The lack of accessible materials tailored to learners' language level widens knowledge gaps, particularly in understanding technical terminology and the procedures involved in learning a skill. The majority of teaching and learning materials, including books, are not locally prepared; they were prepared at the level of native English speakers. Their use in foreign language contexts makes it difficult for vocational education students to comprehend. The use of a foreign language in vocational education training centres can promote unnecessary inequalities. Variations in foreign language proficiency among students will ultimately lead to variations in skill acquisition, providing an advantageous position to those with a stronger

background over those with a weaker one. Some students will struggle more to acquire skills because of the language barrier. Although practical skills require hands-on practice that is demonstrated visually, the theoretical understanding of concepts requires mastery of the language used in instruction to comprehend manuals and books students read. Since students learn a foreign language, an intensive language-learning programme is needed to enable them to understand content delivered in that language.

Most of those who join vocational education and training institutions come from secondary education and could not make it to high school due to, among other factors, poor performance at that level. Since English is the language of instruction, failure in secondary schools is attributed to many factors, including lower English proficiency among students. While those who join vocational training centres from secondary schools find it hard to learn their trades in English, those who join vocational education from primary schools where Kiswahili is a medium of instruction find it more difficult to survive in English-medium vocational education. Given this situation, using English as the medium of instruction in vocational training exposes students to the same language paradox they have been unable to cope with in mainstream education. Maro (2023) found that skill acquisition was ineffective when English was used as the language of instruction in vocational education. Furthermore, using a foreign language in vocational education makes students spend more time learning the language than mastering the trade. While it may be assumed that these decisions are made with little information about the impact of foreign languages in education, Bernstein (1961) argues that vocational training colleges are aware of the importance of students' social background but continue to offer training in the languages that students are not conversant with. Using a foreign language diminishes students' chances of mastering the skills they need in vocational education centres. This may finally make them exit vocational training without achieving what they previously set out to achieve.

6. Conclusion and Way Forward

Given the position of English in the world today, it may be futile to attempt any check against it. Many nations learn English due to commerce, transportation, and globalisation. Moreover, English is used by powerful nations worldwide, such as the USA and the UK, and, as such, is seen as a language of power (Lasern-Freeman & Anderson, 2011). Therefore, many nations want to associate themselves with these powerful nations through the language. In China, for example, more candidates each year sit for English proficiency tests to gain admission to English-speaking countries. They do so to acquire the science

and technology found in these English-speaking nations to develop their own country. It is, therefore, not surprising to see countries such as Mozambique, a former Portuguese colony, joining the Commonwealth in their attempt to gain the advantages of the English-speaking giants of the world. Rwanda has also switched from French to English as its official language. Although there may be other reasons for such a shift, the power of English may have played a role.

Despite its importance in world affairs, English in vocational training colleges in Tanzania acts as a hindrance to knowledge and skills acquisition. It slows the rate at which youth acquire skills. Again, these skills may not be fully acquired when delivered in a foreign language that neither the students nor the teachers have sufficient mastery of. This results in half-prepared artisans. More importantly, vocational training graduates do not need English to learn their trade. The people VET graduates serve neither need English nor do they speak it. This makes English in vocational education an unnecessary burden on students, as it contributes nothing to the trade they learn. Therefore, English as the medium of instruction in vocational education centres acts as a hindrance to achieving the objectives of vocational education among the youth. Strict use of English in these colleges does more harm to these students. It is recommended that a bilingual language-of-instruction approach be implemented, using both English and Kiswahili. The bilingual approach will have two advantages. First, students will acquire the skills with average effort because the language used is familiar to them. Second, the students will have an opportunity to learn English in a low-anxiety context, as noted by Krashen (1985), since language will not be used as a condition for determining skill acquisition.

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Bridging the Academia-Secondary School Gap: Promoting STEM Education Through University-Community Engagement Initiatives in Tanzania

Gennes Hendry Shirima[1] & Holliness Godlisten Mmbando[2]

Department of Educational Foundations, Management and Lifelong Learning, School of Education, University of Dar es Salaam, Dar es Salaam, Tanzania[1&2]
Corresponding Author[1]: shirimagh@gmail.com

Abstract

This study examined the University-Community Engagement (UCE) initiatives employed by the University of Dar es Salaam (UDSM) to promote STEM education in Tanzanian secondary schools. Using a qualitative case study design, data were collected through semi-structured interviews with 27 purposively selected participants, including district education officers, secondary school heads, science and mathematics teachers, school board members, and university lecturers. Documentary analysis of institutional policies, strategic plans, and outreach programme guidelines complemented the interview data. The findings revealed five key UCE initiatives: teacher capacity-building in improvisation and innovative pedagogy; student mentorship programmes; student-teacher co-teaching initiatives; research collaborations; and teaching and learning resource support. The findings demonstrate that while these initiatives enhance teaching quality, motivate students, and improve resource access, particularly in underserved areas, their long-term impact is constrained by limited funding, fragmented coordination, weak policy frameworks, and inconsistent stakeholder collaboration. The findings highlight the need for stronger institutional coordination and balanced collaboration among academia, government, industry, and communities to sustain university–community engagement in STEM.

Keywords: *university-community engagement, STEM education, teacher capacity building, quadruple helix model, secondary schools, Tanzania*

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1. Introduction

Education is a fundamental pillar of socioeconomic development, fostering knowledge acquisition and skills development that are essential for holistic

societal progress. Globally, universities play a crucial role in advancing education through teaching, research, and consultation, in addition to fostering active engagement with communities, a recent additional core function. The latter function, known as University-Community Engagement (UCE), represents a collaborative approach that allows higher education institutions to work with communities to address local challenges, including those in the education sector (Málovics et al., 2022). Indeed, UCE is increasingly serving as a means of bridging the gap between academia and society by ensuring that universities contribute directly to solving real-world problems through varied means, including promoting Science, Technology, Engineering, and Mathematics (STEM) at different levels of education.

Despite national policy commitments to strengthen STEM education in Tanzania, secondary schools continue to face critical challenges. These include shortages of qualified teachers, inadequate laboratory facilities, low student motivation in science subjects, and persistent gender disparities in STEM participation (Matete, 2021; Mgaya, 2024). These challenges at the secondary level directly affect higher education institutions, including the University of Dar es Salaam (UDSM), which depend on a steady flow of adequately prepared STEM students. The problem, therefore, is twofold: secondary schools struggle to deliver quality STEM education, and universities lack empirical evidence on how their community engagement initiatives can effectively address these foundational gaps.

In the global context, STEM education has become a key driver of technological and economic development. STEM refers to an integrated and interdisciplinary approach to education that focuses on science, technology, engineering, and mathematics—fields essential to solving complex problems in today's world (McDonald, 2016). Through UCE initiatives, universities in developed countries have established structured partnerships with schools, governments, and non-governmental organisations to enhance the quality and accessibility of education, including mentorship programmes, curriculum updates, and access to advanced scientific resources (Harkavy et al., 2015; Freeman, 2024). The African higher education landscape has increasingly embraced UCE as a mechanism to address educational challenges, particularly in STEM fields. Universities across the continent have initiated projects focusing on teacher training, curriculum development, and the promotion of science and technology (Wabike, 2023). However, UCE in Africa remains less structured than in developed contexts, often operating through informal partnerships with limited policy guidance (Harkavy et al., 2015). Challenges such as inadequate funding, weak institutional frameworks, and limited community participation hinder the full realisation of UCE's potential across the continent.

In Tanzania, the University of Dar es Salaam (UDSM), the University of Dodoma (UDOM), and Sokoine University of Agriculture (SUA)—all public institutions—have initiated UCE programmes to bolster the quality of education. These programmes include teacher capacity-building initiatives, school outreach programmes, and educational policy research (Nanyazi, 2023). At UDSM specifically, UCE has been increasingly embraced as a strategic approach to addressing educational challenges. UDSM has implemented various UCE initiatives to strengthen STEM education in secondary schools, including teacher professional development programmes, mentorship and student science camps, collaborative research with schools, and community-based STEM outreach activities (Mmbando, 2025). The university also partners with government agencies, schools, and non-governmental organisations to enhance science education through the provision of laboratory equipment, the development of localised STEM curricula, and training workshops that equip educators with modern pedagogical skills.

While previous studies have examined university-community partnerships in Tanzania (cf. Mtawa & Wangenge-Ouma, 2022; Nanyazi, 2023), they have tended to focus on broad conceptualisations of engagement or on private-good dimensions of university outreach. What remains underexplored is a systematic examination of the specific UCE initiatives universities employ to promote STEM education, their effectiveness in addressing key challenges, and the sustainability mechanisms that underpin them. For instance, Mtawa and Wangenge-Ouma (2022) question the private-good-driven nature of university-community engagement but do not specify the types of engagement initiatives or their impact on STEM education outcomes. Similarly, Kafyulilo (2013) highlights professional development through teacher collaboration, yet does not address how universities engage with the broader community to tackle STEM learning challenges. This gap is particularly significant given the urgent need to strengthen the STEM connection from secondary to higher education. This study, therefore, sought to answer two overarching research questions: *What UCE initiatives does UDSM employ to promote STEM education in Tanzanian secondary schools?* And, *in what ways are these UCE initiatives effective in addressing key challenges in STEM education, including teaching quality, student participation, and resource availability?* By addressing these questions, the study aims to generate empirical insights that can inform more effective collaboration among universities, schools, government, and other stakeholders in improving STEM education outcomes. The focus on UDSM is particularly appropriate given its strategic commitment to outreach and its long history of engagement with schools and communities.

2. Literature Review and Theoretical Framework

2.1 Conceptualising University-Community Engagement

University-Community Engagement (UCE) has been conceptualised differently across global contexts, reflecting varied historical, social, and institutional circumstances. In Europe, UCE is broadly understood as a civic responsibility of higher education institutions, rooted in principles of knowledge democratisation and social accountability. European universities have embraced models such as engaged scholarship, service-learning, and science shops, which provide platforms for collaborative research between academics and communities (Compare, 2023). These approaches emphasise knowledge co-creation, mutual benefit, and long-term partnerships. The European University Association encourages universities to institutionalise engagement through policy frameworks and strategic plans, highlighting UCE's role in addressing societal challenges, including educational inequality and scientific literacy (Samaržija, 2023).

In South Africa, UCE is shaped by the country's historical and sociopolitical context, functioning both as a university function and as a constitutional imperative to redress past injustices and promote social transformation (Wabike, 2023). South African universities implement UCE through community-based research, participatory outreach, and integrated service-learning models to empower marginalised groups. For example, initiatives in rural STEM education link universities with under-resourced schools to improve learning outcomes through mobile laboratories and teacher training (Dube & Mojapelo, 2017). These engagements are conceptualised as transformative practices that reconnect universities with local realities while enhancing students' critical consciousness.

A critical comparison of these conceptualisations reveals important differences. European approaches tend to emphasise institutionalisation and policy frameworks, reflecting well-resourced higher education systems with established engagement infrastructure. South African approaches, by contrast, are more explicitly political and transformative, grounded in the redress of historical inequalities. Both contexts, however, share an emphasis on mutual benefit and knowledge co-creation, key principles that remain unevenly realised in many African contexts, where engagement often remains project-based and donor-dependent.

In Tanzania, UCE is formally recognised as one of the university's core functions, alongside teaching and research. At UDSM, it is institutionally referred to as "public service" or "outreach and consultancy services," coordinated through

various units, centres, and academic departments. This function reflects UDSM's strategic commitment to contributing to national development through knowledge exchange and community partnerships. UCE is operationalised through outreach programmes targeting schools and communities, including capacity-building workshops for teachers, mentorship programmes for students, provision of science kits, and curriculum support to enhance STEM education (UDSM, 2024). However, unlike European and South African contexts, where engagement is often embedded in formal curricula, UCE in Tanzania remains predominantly project-based and reliant on donor funding or institutional grants. This raises critical questions about institutionalisation, long-term impact, and sustainability, which the current study aims to address directly.

2.2 UCE and STEM Education in Africa

Across Africa, universities have increasingly embraced UCE as a means of addressing educational challenges, particularly in STEM fields. Research consistently demonstrates that UCE initiatives enhance academic outcomes, stimulate innovation, and promote socioeconomic empowerment. For instance, Dellelo (2024) highlights that outreach programmes involving mobile laboratories, science camps, and STEM fairs increase students' interest and competence in science subjects across Sub-Saharan Africa. Similarly, Mittal and Bansal (2024) argue that UCE promotes inclusive knowledge dissemination by encouraging collaborative problem-solving in real-world contexts. However, a critical synthesis of this literature reveals several patterns and gaps. First, while many studies document individual initiatives, few provide comparative analysis across different institutional contexts. Second, the literature tends to emphasise successes while underreporting challenges related to the institutionalisation and sustainability of UCE initiatives. Third, there is limited attention to how UCE initiatives address gender disparities in STEM, despite the persistent underrepresentation of girls and women in science disciplines across Africa (Wang & Degol, 2017; Matete, 2021).

In Tanzania, universities including UDSM, the University of Dodoma (UDOM), and Sokoine University of Agriculture (SUA) have implemented projects to equip secondary school teachers with pedagogical and practical skills in STEM disciplines. These initiatives strengthen the foundational pipeline for higher education and national development. However, as Nanyazi (2023) notes, the strengths of these initiatives in addressing STEM education challenges remain largely underexplored. This study addresses this gap by providing systematic empirical evidence on UDSM's UCE initiatives, their effectiveness, and the factors that enable or constrain their impact.

2.3 Linking UCE to School Outcomes

UCE directly influences educational outcomes in schools, particularly in under-resourced settings. By extending academic expertise, mentorship, and material support to schools, universities enhance students' performance, teacher competence, and curriculum relevance. Research indicates that schools involved in structured UCE initiatives demonstrate higher engagement in science-related subjects and improved examination results. Anderson et al. (2022) highlight how sustained university-school partnerships lead to increased teacher efficacy and improved instructional quality, particularly in STEM subjects.

Through collaborative teaching programmes, student mentorship, and research-informed interventions, UCE strengthens the academic ecosystem that supports student learning outcomes. Moreover, UCE fosters a culture of collaboration and shared responsibility for educational development. In Tanzania, where schools frequently experience shortages of teaching aids, laboratories, and experienced teachers, university-led outreach programmes help fill these gaps by providing laboratory equipment, facilitating interactions with university lecturers, and organising science camps. These efforts enhance learning, increase student motivation, and improve academic results (Mittal & Bansal, 2024).

Gender equity represents a critical dimension of UCE's potential contribution to STEM education. Gender disparities in STEM persist globally, with girls significantly underrepresented in science, technology, engineering, and mathematics disciplines (Wang & Degol, 2017). In Tanzania, cultural norms and systemic inequalities intensify these barriers (Matete, 2021). UCE can challenge these imbalances through targeted outreach programmes, mentorship schemes, and science camps that inspire and support girls to engage with STEM subjects. Lee (2021) highlights how gender-responsive pedagogy and community sensitisation efforts have contributed to increased female participation in STEM education in East Africa. This study examines how such gender-focused initiatives are considered.

2.4 The Quadruple Helix Model: Rationale and Adaptation

This study is guided by the Quadruple Helix Model (Carayannis & Campbell, 2009), which conceptualises innovation and knowledge production as emerging from interactions among four key actors: academia, industry, government, and civil society. The model builds on the traditional Triple Helix by adding civil society as a fourth player, recognising that sustainable development requires broader participation to address complex social problems (Leydesdorff & Etzkowitz, 2021; Carayannis & Grigoroudis, 2022).

The Quadruple Helix Model is particularly suitable for analysing UCE in Tanzanian STEM education for three reasons. First, it explicitly recognises civil society—including schools, communities, NGOs, and individuals—as active participants in knowledge production and innovation, rather than passive recipients of university outreach. This aligns with UCE's collaborative ethos and the study's focus on multi-stakeholder engagement. Second, the model draws attention to interactions among all four helices, enabling analysis of how government policies, industry partnerships, and community participation enable or constrain UCE effectiveness. Third, the model's emphasis on sustainability and innovation provides a framework for assessing not only the existence of UCE initiatives but also their long-term viability and impact.

In adapting the model to the Tanzanian context, this study recognises that helix development is often uneven. UDSM may be relatively strong, while government support, industry engagement, and civil society participation may be weaker or inconsistent. The model thus provides a diagnostic tool for identifying gaps and opportunities—examining which helices are active, how they interact, and what this means for UCE sustainability. As the findings will demonstrate, applying the Quadruple Helix Model reveals that while UDSM has developed multiple engagement initiatives, their long-term impact is constrained by weak government policy frameworks, limited industry involvement, and fragmented civil society collaboration.

3. Methods

3.1 Research Design and Approach

This study employed a qualitative research approach to explore participants' experiences, meanings, and practices in their real-life contexts, recognising the complex and socially embedded nature of UCE. A case study design was selected as most appropriate because it enables in-depth examination of a contemporary phenomenon within its real-world context (cf. Yin, 2018). The case of UDSM's UCE initiatives for promoting STEM education was bounded by the institution (UDSM), focused on STEM education, and considered the level of secondary schools (units). While a phenomenological research design could be appropriate for exploring participants' lived experiences, the case study design was deemed more appropriate because the research questions sought to examine not only participants' experiences but also institutional practices, programme implementation, and contextual factors, which are key elements that the case study design is specifically designed to address.

3.2 Sampling and Participant Selection

Participants were selected using purposive sampling, followed by snowball sampling for specific categories. Purposive sampling was initially employed to ensure inclusion of key informants with direct knowledge of UCE initiatives and STEM education in Tanzania. The sample comprised 27 participants: three district education officers (responsible for overseeing secondary education), three secondary school heads (Engaged with UDSM outreach), 12 science and mathematics teachers (direct beneficiaries of UCE initiatives), three school board members (representing community perspectives), and six university lecturers (directly involved in designing and implementing UCE initiatives).

Snowball sampling was subsequently used to identify university lecturers, as they were not easily identifiable. The initial two lecturers, identified by their heads of department as being involved in prior UCE initiatives in schools, were reached out to and later asked to recommend colleagues actively involved in UCE initiatives targeting STEM education. This approach was justified because UCE involvement cuts across departments and faculties, making comprehensive identification through purposive sampling alone impractical. Snowball sampling continued until data saturation was reached, the point at which additional recommendations yielded no new information and interviews no longer generated novel insights (cf. Guest et al., 2020). Thus, saturation was achieved after interviewing six lecturers, with the final three interviews confirming rather than extending emerging themes.

3.3 Data Collection Methods

Data were collected for three months through two primary methods: semi-structured interviews and documentary review. Semi-structured interviews, lasting 45-60 minutes each, were conducted with all 27 participants. The interview protocol was designed explicitly to address the study's two research questions, with more specific questions exploring: types of UCE initiatives participants were involved in or aware of; perceived effectiveness of those initiatives in addressing STEM challenges; factors enabling or constraining initiative success; and suggestions for strengthening UCE. Interviews were conducted in Kiswahili or English, depending on the participant's preference, audio-recorded with consent, and transcribed verbatim. Those conducted in Kiswahili were translated into English during transcription, with back-translation checks to ensure accuracy.

The documentary review complemented the interview data by providing contextual information and triangulating the findings. Documents were purposively selected based on their relevance to UCE and STEM education at

UDSM and nationally. Selection criteria included: official status (institutional or government documents); relevance to UCE or STEM education; coverage of the study period (2015-2024); and accessibility. Analysed documents included: *UDSM's Five-Year Rolling Strategic Action Plan 2020/2021–2024/2025 (Directorate of Research and Publication, 2020), UDSM Guidelines for Outreach Programmes (2024), UDSM Research Policy and Operational Procedures (2015), outreach programme brochures, STEM workshop lecturers' diaries, and relevant government policy documents including the Handbook for Standards and Guidelines for University Education in Tanzania (TCU, 2019), Tanzania Education and Training Policy (Ministry of Education and Vocational Training, 2014), and National Higher Education Policy (Ministry of Education, Science and Technology, 2016)*. Document analysis enhanced triangulation by corroborating interview data, providing historical context, and exposing gaps between policy rhetoric and implementation.

3.4 Data Analysis

Data were analysed using Braun and Clarke's (2006) six-phase inductive thematic analysis. Analysis began with familiarisation through repeated reading of transcripts and documents. Initial codes were generated inductively, capturing features of the data relevant to the research questions. Codes were then grouped into potential themes, which were reviewed and refined through an iterative process of moving between data, codes, and themes. This process was both inductive (themes emerging from the data) and theoretically informed (with attention to Quadruple Helix concepts during later analysis). The final phase involved defining and naming themes, six of which were used to structure the findings section. Rigour was enhanced as the themes were reviewed by the two researchers, one of whom was a senior qualitative research expert, and later shared with an outsider who assessed their coherence and grounding in the data.

3.5 Ethical Considerations

This study adhered to established ethical principles for research. All approvals and research permits were obtained from the University of Dar es Salaam (Reference: UDSM/REC/2024/017). In addition, all participants received detailed information about the study's purpose, procedures, and their rights, including the right to withdraw at any time without consequence. Written informed consent was obtained from all participants prior to data collection. To ensure anonymity, all identifying information was removed from transcripts, and pseudonyms are used in reporting findings. Participants are identified only by their professional roles (e.g., Science Teacher 3, Lecturer 2) to prevent identification while providing contextual information essential for interpretation.

4. Findings

This section presents findings organised around six major themes that emerged from thematic analysis. Each theme corresponds to a specific UCE initiative through which UDSM engages with secondary schools to promote STEM education. Consistent with the study's research questions, findings focus on both the nature of these initiatives and their perceived effectiveness in addressing STEM challenges. Quotations are presented as clearly identifiable, authenticated statements, followed by their respective interpretation.

4.1 Teacher Capacity-Building Through Improvisation Training

Analysis of interview data revealed that a significant barrier to effective STEM education in Tanzanian public secondary schools is the lack of functional science laboratories, which hinders practical instruction. In response, UDSM, through its outreach initiatives, conducts training programmes for science teachers focused on the improvisation and use of locally available materials for science experiments. Teachers who participated in these trainings expressed enthusiasm and noted marked improvements in classroom dynamics. One secondary school science teacher from school B explained:

> Before the training, practicals were a dream in my school. We just explained theories. However, now, I can confidently demonstrate combustion using a charcoal stove and simple materials in one of my Chemistry topics. The students are finally seeing what we have been talking about (Science teacher 2—Chemistry, Secondary school B).

Another teacher reported:

> I never imagined a plastic bottle could replace a test tube in a meaningful way. My chemistry students are more curious nowadays and ask deeper questions since we started using these locally available materials. They even bring materials from home, suggesting experiments we could try and work out (Science teacher 2—Chemistry, Secondary school A).

A third participant noted:

> What impressed me most was that science no longer feels distant, expensive or difficult. The training offered by UDSM science experts helped me realise that with creativity, I can bring science to life, even without a lab. This has transformed how I teach and how my students learn physics (Science teacher 1—Physics, Secondary school A).

Documentary analysis of training manuals and post-training reports confirmed that teachers were trained to use local materials, including plastic bottles, charcoal stoves, glass bottles as test tube substitutes, clay pots for heating, vinegar and baking soda for chemical reactions, and banana stems to demonstrate water absorption and osmosis. These materials are cost-effective and widely accessible in local communities.

The effectiveness of this initiative (teacher capacity-building through improvisation training) lies in its contextual responsiveness. Rather than assuming that only Western-style laboratories are essential for quality science education, the training builds on local resources and teachers' creativity. Students benefit from seeing abstract scientific principles demonstrated with familiar materials, enhancing comprehension and retention. However, as one lecturer noted, the initiative's reach remains limited:

> We train perhaps 50 teachers in secondary schools near the university, whom we reach out to each year, but there are thousands of schools. Without government support to scale this up, we are making a small difference in a very big problem (Lecturer 4, UDSM, outreach coordinator).

4.2 Training on Innovative Pedagogical Approaches

Beyond improvisation, UDSM has contributed to enhancing the quality of STEM education through workshops focused on innovative, learner-centred teaching methods. Teachers reported being introduced to inquiry-based learning, in which students engage with scientific concepts through guided experiments, investigations, and collaborative problem-solving rather than rote memorisation. One science teacher reflected:

> Before the training on innovative pedagogical approaches, my teaching was mostly textbook-based. Now, I use inquiry-based methods to guide my students in asking questions and exploring their ideas. I have seen them become more confident and curious. They don't just memorise formulas. They always want to understand why things work, hence, probing (Science teacher 3—Biology, secondary school C).

Another teacher explained:

> I used to think experiments were only for advanced schools with big labs. However, after learning inquiry-based methods, I realised I can create meaningful science experiences using simple materials and thoughtful questions. My students now design their own simple experiments (Science teacher 2—Chemistry, Secondary school C).

In addition to learning inquiry-based methods, the integration of Information and Communication Technology (ICT) emerged as a central theme in the training. Participants noted an emphasis on utilising digital tools, such as simulations, virtual labs, and online learning platforms, to enhance classroom delivery and address the limitations of conventional resources. One teacher shared:

> The virtual labs blew my mind. My students, too, were surprised and attracted. Even without real chemicals, my students could see reactions and interact with experiments on-screen during UDSM science events. It keeps students engaged, especially those who struggle with theory. Despite limited ICT resources in my school, nowadays I use my smartphone to facilitate some lessons (Science teacher 1—Physics, Secondary school B).

Another added:

> In overcrowded classrooms, ICT has helped me personalise instruction. Students can revisit lessons online or experiment digitally through YouTube on their smartphones. This is particularly helpful for slow learners who need more time. The only problem is when students are not allowed to possess phones (Mathematics teacher, Secondary school A).

A documentary analysis of workshop materials confirmed that the training sessions covered inquiry-based and problem-based learning, as well as the integration of open educational resources. Lecturers' diaries from outreach events noted that teachers consistently rated these sessions as highly valuable, with one diary entry observing: *"Teachers are hungry for these methods. They tell us their students become more engaged when they use what they've learned"*.

The effectiveness of this initiative lies in addressing the gap between traditional teacher-centred approaches and the demands of modern, skills-based STEM education. By equipping teachers with twenty-first-century teaching skills, UDSM contributes to modernising classroom practice. However, as with improvisation training, scale and sustainability remain challenges. Training reaches a fraction of teachers, and without follow-up support, newly acquired skills may not be sustained.

4.3 Mentorship Programmes for Secondary School Students

Mentorship emerged as a crucial UCE component, with UDSM facilitating connections among students, teachers, and experienced professionals to enhance learning, skill development, and career guidance. The mentorship programme involved UDSM lecturers, UDSM students, and alumni providing academic

and professional support to secondary students pursuing STEM careers. One physics teacher described:

> It was the first time I had someone from the university walk into my classroom, not to supervise but to teach with me and reflect on the lesson. The mentorship gave me new ways to explain complex ideas, such as energy transfer, using real-life examples (Science teacher 1—Physics, Secondary school A).

Another teacher highlighted the aspirational value:

> One of the UDSM alumni mentored my Form Five students. They were so inspired hearing from someone who came from a similar background and is now in engineering. It made university feel achievable for them (Mathematics teacher, Secondary school C).

A school head observed the broader impact of the mentorship programmes**:**

> Now I feel part of a bigger professional community. It's not just about teaching what is in the syllabus, but preparing learners for the future with confidence and guidance. The mentorship has changed how our teachers see themselves professionally (School Head 3).

Documentary analysis of outreach programme brochures confirmed that mentorship activities included career talks, subject-specific tutoring, laboratory demonstrations, and university visit days. These activities aimed to demystify university education and STEM careers, particularly for students from disadvantaged backgrounds. Despite these benefits, analysis indicates that mentorship programmes are not yet systematically integrated into UDSM's broader STEM education strategy. One lecturer acknowledged:

> We do mentorship when we have time, funding, or someone volunteers. It's not institutionalised. Some departments do a lot, others do nothing. The students who benefit are those whose teachers happen to know someone at UDSM (Lecturer 2, UDSM).

This lack of systematic integration leads to inconsistent access, uneven implementation across departments, and limited long-term impact, contrasting with structured mentorship frameworks in countries like South Africa and Ghana, where university-industry collaborations have demonstrated higher STEM retention and success rates (Albertyn, 2023; Skrzypek et al., 2022).

4.4 University Student-teacher Co-teaching Programme

The university student-teacher co-teaching programme enabled UDSM student-teachers to volunteer in nearby secondary schools facing critical shortages of qualified science teachers. Unlike structured field attachment programmes, this voluntary initiative allowed university students to offer their time and knowledge to support struggling schools. Organised by their university departments, student-teachers assisted in delivering lessons, providing subject-specific tutoring, and supporting extracurricular activities. Teachers in beneficiary secondary schools expressed deep appreciation for the programme. One mathematics teacher explained:

> When the UDSM students came, it felt like a burden had been lifted. We were only two staff members in the science department. Their help in teaching and running practical sessions changed everything. We could finally give students individual attention (Mathematics teacher, Secondary school A).

Another teacher added:

> The UDSM student-volunteers were well-prepared. They connected easily with our students and employed creative methods to explain complex topics such as algebra. You could see the students gaining confidence week after week. This has made our work easy (Mathematics teacher, Secondary school B).

One head of school elaborated on the broader impact of the university student-teacher co-teaching programme:

> They did not just come to teach. They organised science clubs, prepared extra classes before national exams, and even mentored some of our students about university life. Our students started staying after school to study together, though the programme did not last long (School Head 2).

A documentary analysis of outreach reports confirmed that the participating student-teachers were drawn from the College of Natural and Applied Sciences (CONAS). They received orientation before they went to the identified schools, but without formal compensation, though some schools provided transport and meals when it was within their financial capability. Through their voluntary efforts, university students helped improve the delivery of education while gaining valuable teaching experience, leadership skills, and a deeper understanding of the challenges facing secondary school education. One teacher summarised:

> It is a win-win situation. Our students learn, and the university students grow into passionate, experienced educators. Some of them have told me this experience confirmed their calling to teach (Science teacher 3—Biology, Secondary school A).

However, some challenges still threaten the programme's sustainability. One university lecturer involved in coordination noted:

> We rely entirely on student-teachers' goodwill. There is no budget, no formal recognition, no transport support. Many students cannot afford to volunteer regularly because they need to earn money. Some schools are too far for them to reach. We need institutional support to sustain this (Lecturer 1, UDSM).

Documentary analysis revealed that no formal policy framework governs the programme; it operates informally through individual lecturer-student networks. This lack of institutionalisation, combined with reliance on volunteer labour and absence of transport or stipend support, limits scalability and long-term viability.

4.5 Research Collaboration

Research collaboration between UDSM and schools emerged as another UCE dimension fostering knowledge co-creation to address educational challenges. UDSM lecturers collaborate with schools and teachers to conduct research identifying problems in quality education and proposing evidence-based solutions. Though few teachers were involved, on a few occasions, those collaborations contributed to improved curriculum implementation, teaching methodology, students' academic performance, and educational policy recommendations. Teachers expressed the value of being involved in such research activities. A school head shared:

> When UDSM experts involved us in data collection and discussions on how to implement the curriculum, it felt like our voices finally mattered. We helped shape the research by sharing our practical on-the-ground experience, and we also learned from it. Now, other teachers and I use those findings to adjust how we approach science lessons (School Head 1, also a Science teacher, School A).

Another teacher reflected:

> It was the first time I had been part of a research project. The university researchers did not just study us; they worked with us. That partnership gave us confidence and better knowledge for teaching. They shared the findings

> with us in simple language, and the improvement in our teaching is quite significant (Science teacher 3—Biology, Secondary school C).

One science teacher highlighted the practical orientation:

> Through collaboration with a researcher from UDMS, we were able to present real classroom issues, such as overcrowding and a lack of labs, and the researcher listened. It was a change from a top-down approach to understanding our realities, though no changes were seen (Science teacher 1—Physics, Secondary school B).

Documentary analysis of research policy documents confirmed that UDSM's strategic plan emphasises community-engaged research. However, lecturers noted that promotion and reward systems still prioritise traditional academic publications over engaged scholarship, while research funds for collaborative research were limited.

4.6 *Teaching and Learning* Resource Support to Schools

Teaching and learning resource support represents a related UCE initiative. Interviews revealed that UDSM provided textbooks, laboratory equipment, and science kits to secondary schools, particularly in underserved schools. A Biology teacher explained:

> Before the university stepped in to support us by providing lab kits, our students had never seen a proper lab kit. Now they perform Biology experiments themselves, not just read about them. The difference in their understanding is dramatic (Science teacher 3—Biology, Secondary school A).

Another teacher noted:

> The textbooks we received have made a huge difference. I used to teach Form Three chemistry, using photocopied notes and outdated ones. Now we have books that align with the syllabus (Science teacher 1—Physics, Secondary school A).

However, interview data from heads of schools and university lecturers revealed significant inequities in the distribution of teaching and learning resources. Urban schools, those with existing university connections, and those near the UDSM campus received substantially more support than peripheral schools.

A lecturer acknowledged this challenge:

> We try to reach schools, but the facilities are limited, and, of course, we mainly offer the resources we no longer need in our departments. So often,

> we work with schools where we already have contacts because it's easier. But this means the most disadvantaged may not benefit (Lecturer 6, UDSM).

This uneven distribution raises critical questions about equity and the university's mission to serve all communities, not only those already advantaged. It also highlights the need for stronger collaboration with government and civil society to ensure equitable resource distribution.

5. Discussion

This study examined UCE initiatives implemented by UDSM to promote STEM education in Tanzanian secondary schools. It assessed their effectiveness in addressing key challenges that could affect the quality of secondary education. Applying the Quadruple Helix Model as an analytical lens, this section interprets findings in relation to existing literature and draws out theoretical and practical implications:

5.1 Interpreting Findings Through the Quadruple Helix Model

The Quadruple Helix Model posits that sustainable innovation and knowledge production emerge from interactions among academia, industry, government, and civil society (Carayannis & Campbell, 2009). Applying this model to UDSM's UCE initiatives reveals important patterns about helix development and interaction. The academia (UDSM) emerged as the most active helix in engaging secondary schools within the larger community. The university initiated multiple engagement programmes, including teacher training, mentorship, co-teaching, research collaboration, and the provision of teaching and learning resources. All these demonstrate institutional commitment to community engagement as a core function. This aligns with UDSM's strategic documents, which formally recognise outreach as a university responsibility (UDSM, 2024). The university's role as a knowledge creator and disseminator is evident across all six themes, from training teachers in improvisation to conducting collaborative research with schools.

However, the other three helices are notably weaker and less engaged. Government involvement appears limited and inconsistent. While national policies articulate commitment to STEM education (Ministry of Education and Vocational Training, 2014; Ministry of Education, Science and Technology, 2016), they provide little specific guidance or funding for university-school partnerships. Teachers and lecturers repeatedly mentioned the lack of government support for scaling up successful initiatives, integrating them into national programmes, or providing sustainable funding. This policy-implementation gap constrained the reach and sustainability of the UCE initiatives.

Industry engagement is even more limited. No initiative described in the findings involved a substantive industry partnership. A teaching and learning resource support and scholarship programme for qualified STEM students could require corporate sponsorship, in collaboration with the university and donors. Mentorship programmes also did not systematically involve industry professionals. This absence is significant, as the industry could provide funding, equipment, expertise, and authentic career pathways for students. Thus, the Quadruple Helix Model's emphasis on industry-academia collaboration for innovation remains largely unrealised in this context.

Civil society, on the other hand, including schools, communities, and individuals, participated in UCE initiatives but primarily as beneficiaries rather than co-creators. Schools received training, resources, and mentorship, and individual teachers attend workshops. However, they were not systematically involved in the design, implementation, or evaluation of the initiatives. In this case, community knowledge/experiences and priorities do not consistently and adequately shape university programmes. This represents a missed opportunity, as research emphasises that sustainable engagement requires genuine partnership and mutual knowledge exchange (Mittal & Bansal, 2024; Wabike, 2023).

The model thus reveals uneven helix development: strong academia, weak government and industry, and passive civil society participation. This misalignment has important implications. First, it explains the sustainability challenges evident across all themes—initiatives dependent on a single helix (academia) are vulnerable to funding cuts, staff changes, and shifting institutional priorities. Second, it limits sustainability, as government policy support and industry resources are needed to expand successful programmes. Third, it constrains innovation, as diverse perspectives and resources across multiple helices typically yield more creative, contextually appropriate solutions.

5.2 UCE Effectiveness in Addressing STEM Challenges

Despite the revealed structural limitations, the findings demonstrate that UCE initiatives were quite effective in addressing key STEM challenges in several ways. First, UCE initiatives directly addressed the resource gap that constrained practical science teaching. Improvisation training enabled teachers to conduct experiments without fully equipped laboratories, while resource provision supplied textbooks, kits, and digital materials. These interventions address the material realities of Tanzanian schools, where traditional laboratory infrastructure is often absent or under-equipped. The effectiveness of improvisation training, in particular, lies in its contextual responsiveness, building on local resources rather than lamenting their absence. This finding extends research

on contextualised science education in resource-limited settings (cf. Dube & Mojapelo, 2017; Dellelo, 2024).

Second, UDSM UCE initiatives address the teaching quality gap by building capacity and introducing innovative pedagogies. Inquiry-based learning, ICT integration, and learner-centred approaches equipped teachers with twenty-first-century teaching skills that enhance student engagement and comprehension. The finding that teachers report increased student curiosity and confidence after applying these methods aligns with research demonstrating that pedagogical innovations tend to improve STEM outcomes (Anderson et al., 2022; Singh et al., 2024).

Third, UDSM UCE initiatives addressed the motivation and aspiration gap through mentorship and scholarships. Secondary school students exposed to university mentors and successful alumni developed a clearer understanding of STEM career pathways and increased motivation to pursue them. These findings align with other research findings on the aspirational effects of university-school partnerships (Sithole et al., 2017; Mwangi et al., 2024).

Overall, however, the effectiveness of the UCE initiatives in addressing key challenges in STEM education, including teaching quality, student outcomes, and resource availability, is uneven and conditional. Schools with existing university connections benefit disproportionately. Urban and nearby schools receive more resources, while students whose teachers happened to know UDSM staff accessed mentorship. This unevenness reflects the absence of systematic, policy-driven approaches to UCE right from the university level, and it raises equity concerns that the university's mission to serve all communities must address.

5.3 Reflection and Critical Analysis of the Emerged Contradictions

Several contradictions emerged from the findings, warranting researchers' reflection and critical analysis. First, there is a contradiction between institutional commitment and the reality of implementation. UDSM's strategic documents formally recognise outreach as a core function (UDSM, 2024), yet on the ground, initiatives operate informally, depend on individual lecturers, and lack sustainable funding. This gap between policy rhetoric and practice reflects broader patterns in African higher education, where engagement is often acknowledged but under-resourced (Mtawa & Wangenge-Ouma, 2022; Nanyazi, 2023).

Second, there is a contradiction between strong teacher feedback and weak

sustainability mechanisms. Teachers consistently report that UCE initiatives transform their practice and benefit their students. However, these same teachers describe initiatives as one-off events without follow-up, scaling, or institutionalisation. This suggests that while UCE generates genuine value, that value is not systematically built upon or sustained.

Third, there is a contradiction between equity rhetoric and uneven impact. UCE initiatives aim to serve underserved communities, yet resource distribution favours already-advantaged schools. This reflects what Mtawa and Wangenge-Ouma (2022) identify as *private good-driven* engagement, where outreach benefits those already connected to the university rather than those most in need.

All the aforementioned contradictions point to deeper structural issues. Dependence on university support, the absence of government policy frameworks for UCE or a clear implementation modality, limited industry engagement, and weak civil society partnerships all constrain effectiveness. Without addressing these structural constraints, even well-designed UCE initiatives will remain limited in reach and sustainability.

5.4 Theoretical Contributions

This study makes two theoretical contributions to the literature on UCE and STEM education.

First, it extends the *Quadruple Helix Model* by demonstrating its utility as a diagnostic framework for analysing UCE in resource-constrained contexts. The model is typically used to describe ideal-type innovation systems. This study shows that applying it critically to identify which helices are active, how they interact, and where gaps exist, reveals structural constraints that might otherwise remain invisible. The finding that uneven helix development (strong academia, weak government and industry, passive civil society) undermines sustainability and scalability provides a framework for understanding why UCE initiatives often fail to achieve long-term impact.

Second, the study contributes to the empirical literature on UCE in Africa by providing detailed, context-specific evidence of how one university operationalises community engagement for STEM education. While previous research had examined the UCE conceptually (Wabike, 2023) or critiqued its private-good dimensions (Mtawa & Wangenge-Ouma, 2022), few studies have documented specific initiatives, their perceived effectiveness, and the factors enabling or constraining them. This study addresses that gap, offering evidence that can inform both theory and practice.

6. Conclusion and Recommendations

This study examined UCE initiatives employed by UDSM to promote STEM education in Tanzanian secondary schools and assessed their effectiveness in addressing key challenges. The findings revealed that UDSM has developed multiple engagement initiatives, including teacher capacity-building, mentorship, co-teaching, research collaboration, and resource provision that demonstrably enhance teaching quality, motivate students, and improve resource access. These initiatives reflect the university's commitment to its third mission and generate genuine value for participating schools and teachers. However, applying the Quadruple Helix Model as an analytical lens revealed significant structural constraints. While academia (UDSM) was active, government engagement was limited and inconsistent, industry involvement was virtually absent, and civil society participation remained passive and beneficiary-oriented. This uneven helix development explains the sustainability challenges evident across all initiatives, including the absence of policy frameworks, limited scalability, and inequitable distribution of benefits. The study's empirical contribution is thus to provide detailed, context-specific evidence of UCE operationalisation in a Tanzanian university, evidence that can inform both institutional strategy and national policy.

Based on the findings, the following policy recommendations are addressed to specific stakeholders: For the UDSM leadership, a formal, institutionalised UCE policy framework that moves beyond ad hoc, project-based initiatives toward systematic, sustainable programmes with dedicated budgets, staffing, and monitoring mechanisms could be put in place. Furthermore, an equity-focused resource distribution plan that prioritises underserved schools and addresses the current pattern of urban and connected-school advantage could be developed. For the government, particularly the Ministry of Education, Science and Technology, a national policy framework for university-community engagement could be introduced that provides guidance, standards, and funding mechanisms specifically for UCE initiatives targeting STEM education at the secondary level. At the same time, establish matching grant programmes that incentivise universities to partner with industry and civil society in expanding successful UCE initiatives.

7. Limitations and Future Research

This study encountered several limitations that suggest directions for future research. First, as a single-case study of UDSM, findings may not be transferable to other Tanzanian or African universities with different institutional histories, resources, and engagement approaches. Comparative studies across multiple

universities would illuminate how institutional factors shape UCE effectiveness. Second, the study relied primarily on participant perceptions of effectiveness rather than direct measurement of student learning outcomes, examination performance, or STEM career progression. Future research employing longitudinal designs and outcome measures would strengthen evidence on UCE impact. Fourth, while the study identified gender as a relevant dimension, it did not systematically examine how UCE initiatives address gender disparities in STEM. Future research specifically focused on gender and UCE would address this gap. Despite these limitations, this study provides robust evidence that UCE initiatives can meaningfully contribute to STEM education in Tanzanian secondary schools, and that realising their full potential requires addressing structural constraints through systematic, multi-stakeholder collaboration of the kind the Quadruple Helix Model envisions.

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Mind the Gap: How Internal Beliefs Shape Gender Disparities in Nigerian Engineering Labs

Ayodeji Bolanle Balogun[1] & Olufunke Adewunmi Ayegbusi[2]
[1]Department of Electrical/Electronic Engineering, Federal Polytechnic Ilaro, Ogun State, Nigeria
[2]Department of Civil Engineering, Federal Polytechnic Ilaro, Ogun State, Nigeria
Corresponding Author[1]: ayodeji.balogun@fedederalpolyilaro.edu.ng
Email[2]: olufunke.ayegbusi@fedederalpolyilaro.edu.ng

Abstract

Gender equity in engineering education remains a global concern, with issues of self-efficacy and engagement often contributing to women's underrepresentation. However, limited evidence exists from African higher education contexts. This study explored gender disparities in engineering students' confidence and engagement with practical work in a Nigerian polytechnic. A cross-sectional survey of 338 students (274 male, 64 female) from four engineering departments was conducted using a validated 30-item scale (α = 0.931). Independent-samples t-tests and effect-size analyses revealed significant gender differences in self-efficacy and engagement. Female students reported lower confidence and reduced engagement with practical tasks. Statistical power (0.71) confirmed sufficient sensitivity to detect a medium effect. No significant gender differences emerged in perceptions of instructor quality, resource adequacy, or the learning environment, indicating that disparities are concentrated in personal efficacy beliefs rather than external conditions. These findings highlight a critical challenge in Nigerian engineering education: female students' lower self-confidence in practical learning. Addressing this gap through targeted interventions can help strengthen female participation and foster more inclusive laboratory environments.

Keywords: *gender equity, engineering education, self-efficacy, practical work, inclusive education, STEM participation*

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1. Introduction

Gender equity in engineering education is one of the most enduring issues in the global engineering community, whose effects extend beyond institutions of learning into workforce diversity and innovation (Yamani and Almazroa, 2024). Even with decades of intervention efforts, very few women are ever represented in the engineering sector worldwide. Recently released meta-analytic data

confirm that gender equality targets can be undone by feminist interventions in STEM education (Yu et al., 2024): the controlled results show a small but significant positive impact of such activities (Hedges g = 0.434). The Nigerian case study is a critical one in terms of formulating how gender functions within the African engineering education. Nigeria is the second-largest economy and most populous country in Africa, so its engineering education system must serve a wide population and address gender equity issues. The realisation of gender inequalities in this setting offers valuable insights into efforts to improve education in similar developing areas, as girls are quite underrepresented in STEM fields in sub-Saharan Africa, with an average participation rate as low as 21 per cent (Ntombela et al., 2025; Ojong and Kareem, 2025).

Self-efficacy theory provides an effective explanation of the relationship between beliefs about capability, motivation, behaviour, and achievement (Bandura, 1997). Through mastery experiences, vicarious experiences, verbal persuasion, and physiological states, Bandura's theory explains how self-efficacy beliefs affect the choice of activities, efforts, perseverance, and eventual accomplishment as they develop. Gender differences in self-efficacy beliefs have been substantial across many areas of life, with female students often showing less confidence than their male counterparts even when they achieve the same level of performance (Chan, 2022). The practical aspect of engineering education is a realm of study that can be considered one of the most crucial in addressing gender inequality. Experiences in laboratories allow the acquisition of theoretical expertise and technical skills, as well as the development of confidence (Hofstein & Lunetta, 2004). Nonetheless, such experiences can also contribute to gender inequality if they are not thoughtfully designed with inclusive practices (Yu et al., 2024).

The research will contribute to the literature by examining gender differences in self-efficacy and the capacity to engage in practical work among engineering students in the Nigerian context. The study bridges a substantial literature gap by providing empirical data on a highly underrepresented culture, thereby making a major contribution to the study of engineering education, where more inclusive experiences can be developed.

The specific objectives of this study are to:

i) Examine gender differences in engineering students' self-efficacy and engagement with practical work.
ii) Identify the areas in which gender disparities are most pronounced.
ii) Assess the practical significance of observed differences through comprehensive effect size analysis.

ii) Provide evidence-based recommendations for creating more inclusive laboratory learning environments in Nigerian engineering education.

2. Literature Review

A comprehensive analysis of global trends in gender inequality in higher education found that despite progress in some areas, significant disparities persist in STEM fields, with the gender gap estimated to take over 100 years to close at current rates (Valero-Ancco et al., 2025). Research specifically examining gender disparities in engineering courses has found consistent patterns across countries, with Brazil showing underrepresentation patterns similar to those observed globally (Camila Francisco De Castro et al., 2024). Gender inequalities in STEM education represent a global phenomenon with persistent patterns across cultural contexts. International data consistently demonstrates low levels of female participation in engineering fields, with UNESCO statistics showing that women comprise only 35% of STEM graduates globally (UNESCO, 2023). A comprehensive meta-analysis of interventions for gender equality in STEM education found an overall effect size of Hedges' $g = 0.434$, indicating that well-designed interventions can have meaningful positive impacts (Yu et al., 2024).

Recent research has identified multiple contributing factors to gender disparities, including stereotype threat, imposter syndrome, lack of female role models, and educational systems that inadvertently favour male students (Spencer et al., 2016). A systematic review of STEM education impact found that interventions have differential effects across academic levels, with high school students showing the most significant improvements in cognitive outcomes ($d = 0.58$) (Cao et al., 2025). Self-efficacy theory provides a robust theoretical framework for understanding gender disparities in engineering education. Bandura's social cognitive theory posits that self-efficacy beliefs are developed through four primary sources: mastery experiences, vicarious experiences, verbal persuasion, and physiological and emotional states (Bandura, 1997). These beliefs subsequently influence individuals' choice of activities, effort expenditure, persistence in the face of obstacles, and ultimate achievement levels (Power et al., 2024).

A meta-analysis of gender differences in academic self-efficacy reveals consistent patterns across diverse cultural contexts, with female students typically reporting lower self-efficacy beliefs even when their academic performance equals or exceeds that of male students (Huang, 2013). These patterns are also evident in STEM contexts, where female students tend to report higher levels of science anxiety and perceive tasks as more difficult

despite comparable performance (Rozgonjuk et al., 2024). In sub-Saharan Africa, girls remain significantly underrepresented in STEM fields, with participation rates averaging approximately 21% (Ojong & Kareem, 2025). This underrepresentation is linked to intersecting structural and socio-cultural constraints, including adverse cultural norms, poverty, child marriage, teenage pregnancy, institutional discrimination, and insufficiently gender-responsive curricula, which collectively limit sustained participation and achievement (Chan, 2022; Solomons, 2025).

Research on engineering self-efficacy further indicates that gendered differences are shaped by socialisation processes, including discriminatory experiences from teachers, peers, and family members (Wang & Yu, 2023). The underrepresentation of women in engineering thus creates a self-reinforcing cycle, as limited opportunities for vicarious learning stem from the shortage of female role models (Lübeck, 2023). Within this context, practical work and laboratory experiences play a central role in engineering education by developing technical skills, building confidence, and facilitating the application of theoretical knowledge (Agustian, 2025; Hofstein & Lunetta, 2004). Evidence from meta-analytic studies further shows that hands-on learning positively influences students' motivation and self-efficacy (Abdurakil et al., 2024). Studies on inclusive laboratory design emphasise the importance of collaborative learning, scaffolded instruction, structured reflection, and alignment of practical activities with real-world applications and career pathways (Lübeck, 2023; Hofstein & Lunetta, 2004). Such approaches are particularly beneficial for female students, who may experience isolation in male-dominated disciplines, as they foster participation, belonging, and sustained engagement (Freeman et al., 2014).

3. Methodology

3.1 Research Design

This study employed a cross-sectional quantitative design to investigate gender disparities in engineering students' self-efficacy and engagement with practical work within Nigerian higher education. The research was conducted at a representative Nigerian polytechnic institution, selected for its diverse student population and comprehensive engineering programs. Nigerian polytechnics play a crucial role in technical education, offering both National Diploma (ND) and Higher National Diploma (HND) programs that prepare students for engineering careers (National Board for Technical Education, 2025).

3.2 Sample Size Determination

The sample size was determined through convenience sampling of all available engineering students during the four-week data collection period in the 2023 academic session. While an a priori power analysis was not conducted, post-hoc power analysis using G*Power 3.1.9.7 (Kang, 2021) revealed that the final sample of 338 students provided adequate statistical power (0.710) to detect the medium effect size observed in the primary outcome (Self-Efficacy & Engagement, d = – 0.35, p = 0.045). However, power was limited (0.171-0.252) to detect small effect sizes for other factors, suggesting that non-significant findings should be interpreted with caution. For future research, we recommend an a priori power analysis targeting medium effect sizes (d = 0.35) with 0.80 power, which would require a minimum sample of approximately 210 participants per gender group.

Participants were recruited using convenience sampling from all available engineering students attending regular class periods during the four-week data collection period (July 3 – July 28, 2023). Research assistants visited scheduled lectures and laboratory sessions across the four engineering departments. All students present during the visited sessions were invited to participate. The extreme variation in departmental representation (Computer Engineering n=182, Electrical/Electronic Engineering n=152, Agricultural Bio-Environmental Engineering n=3, Civil Engineering n=1) reflects the actual distribution of students across departments at the institution, with Computer and Electrical Engineering programs enrolling substantially more students than the other two programmes, as shown in Table 1. The questionnaire was administered electronically using a Google Forms link. The survey link was shared with students during class sessions, and participants completed the questionnaire using their personal mobile devices. Participation was voluntary, and informed consent was obtained prior to completion of the instrument.

Student attitudes toward practical work were measured using a validated 30-item instrument developed specifically for engineering education contexts. The instrument demonstrated excellent psychometric properties, with an overall Cronbach's α of 0.931, indicating high internal consistency. The instrument comprises four factors: (1) Instructor Quality and Pedagogical Effectiveness (8 items, α = 0.96), (2) Resource Adequacy and Institutional Support (7 items, α = 0.89), (3) Learning Environment and Atmosphere (6 items, α = 0.82), and (4) Student Self-Efficacy and Engagement (9 items, α = 0.78).

Data collection was conducted over four weeks during the 2023 academic session. Prior to data collection, ethical approval was obtained from the institutional review board, and permission was secured from department heads and course

instructors. Surveys were administered during regular class periods to maximise response rates, with an overall response rate of approximately 78%.

Population and Sample Distribution by Department

Department	Total Enrolled	Sample Size	Response Rate	% of Total Sample
Computer Engineering	220	182	82.7%	53.8%
Electrical/Electronic Engineering	200	152	76.0%	45.0%
Agricultural Bio-Environmental Engineering	5	3	60.0%	0.9%
Civil Engineering	8	1	12.5%	0.3%
TOTAL	433	338	78%	100%

The statistical analysis plan was designed to provide a comprehensive examination of gender differences while meeting contemporary standards for quantitative research reporting (American Psychological Association, 2020). All analyses were conducted using Python with specialised statistical libraries. Primary analyses consisted of independent samples t-tests examining gender differences across all four attitude factors. Effect sizes were calculated using Cohen's d with 95% confidence intervals, providing information about both statistical significance and practical significance of observed differences. Statistical power analysis was conducted post-hoc to determine the study's ability to detect effects of various magnitudes.

4. Results

4.1 Sample Characteristics

Table 2 presents demographic characteristics by gender. Chi-square analyses revealed no significant associations between gender and department ($\chi 2 = 3.42$, $p = 0.331$) or class level ($\chi 2 = 0.18$, $p = 0.914$), indicating that these demographic variables do not confound gender differences in attitudes.

Table 2

Sample Characteristics of Engineering Students (N = 338)

Characteristic	Male (n=274)	Female (n=64)	Total (n=338)	χ^2/t	p-value
Department				3.42	0.331
Computer Engineering	142 (51.8%)	40 (62.5%)	182 (53.8%)		
Electrical/Electronic	128 (46.7%)	24 (37.5%)	152 (45.0%)		
Class Level				0.18	0.914

ND2 (200 level)	229 (83.6%)	54 (84.4%)	283 (83.7%)		
HND2 (400 level)	38 (13.9%)	9 (14.1%)	47 (13.9%)		
Age	25.8 (2.6)	25.4 (2.3)	25.7 (2.6)	0.89	0.374

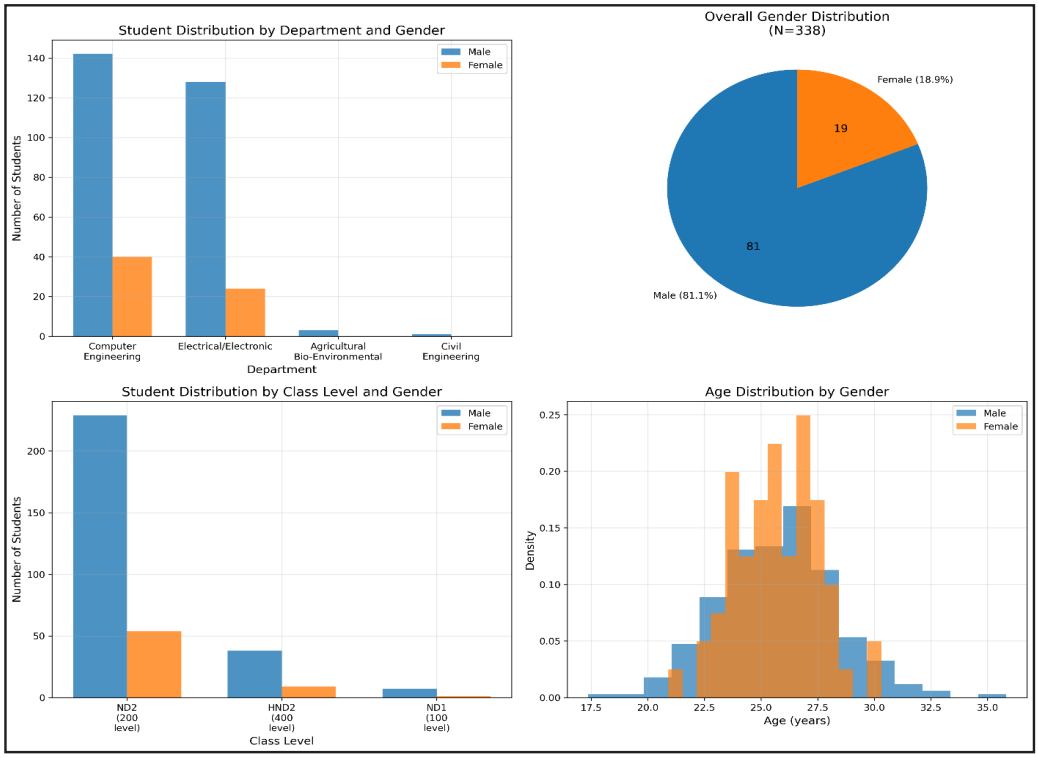


Figure 1: *Demographic Distribution Charts*

4.2 Primary Analysis: Gender Differences

Statistical assumptions were rigorously tested prior to primary analyses. Shapiro-Wilk tests indicated normal distributions for both gender groups (Male: $W = 0.983$, $p = 0.672$; Female: $W = 0.989$, $p = 0.840$), and Levene's test confirmed equal variances ($F = 1.067$, $p = 0.303$), supporting the use of parametric statistical procedures. Table 3 presents comprehensive descriptive statistics for all attitude factors by gender group. The analysis revealed a statistically significant gender difference only in Factor 4 (Self-Efficacy and Engagement), with female students reporting significantly lower levels ($t = -2.009$, $p = 0.045$). The effect size (Cohen's $d = -0.35$) represents a small to medium effect, indicating meaningful practical significance beyond statistical significance.

The absence of significant differences in instructor quality, resource adequacy, and learning environment suggests that gender disparities are concentrated

in personal efficacy beliefs rather than perceptions of external educational factors. This pattern indicates that female students recognise the quality and value of their educational experiences but experience lower confidence and engagement in practical work activities.

4.3 Gender Differences in Perceptions of Instructor Quality

Post-hoc power analysis was conducted to examine the study's ability to detect effects of different magnitudes. Results showed that the study had adequate statistical power (0.710) to detect the medium effect size found in Factor 4, giving confidence in the validity of this significant result.

Table 3

Gender Differences in Attitude Factors among Engineering Students

Factor	Male M(SD)	Female M(SD)	t	p	Cohen's d	95% CI for d
Instructor Quality	3.81 (0.80)	3.69 (0.89)	-1.234	0.218	-0.15	[-0.39, 0.09]
Resource Adequacy	3.24 (0.93)	3.11 (0.98)	-0.876	0.382	-0.14	[-0.38, 0.10]
Learning Environment	3.38 (0.74)	3.25 (0.82)	-1.456	0.146	-0.18	[-0.42, 0.06]
Self-Efficacy & Engagement	3.51 (0.87)	3.20 (0.94)	-2.009	0.045*	-0.35	[-0.68, – 0.02]

*Note: $p < 0.05$

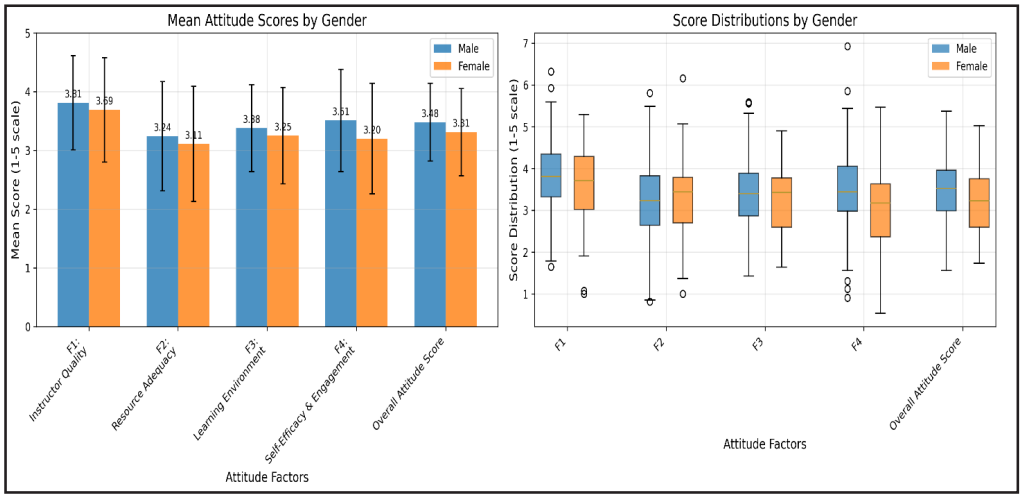


Figure 2: *Factor Comparison Analysis*

However, the power was low (0.171–0.252) for detecting the small effect sizes observed in other factors. This means the non-significant findings should be viewed with caution, as they do not necessarily indicate the absence of real differences. The effect size for self-efficacy and engagement (Cohen's d = – 0.35) suggests that female students scored about one-third of a standard deviation lower than male students.

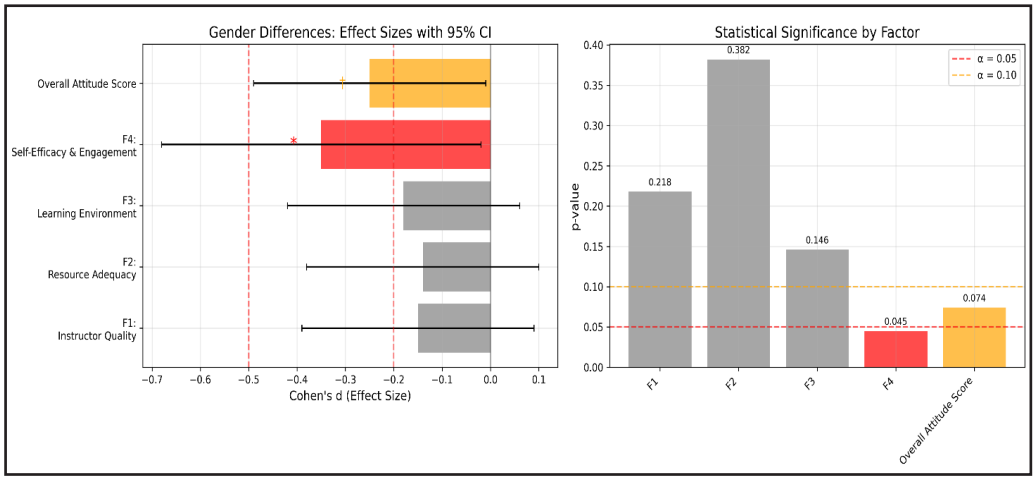


Figure 3: *Statistical Results Visualisation*

In practical terms, this represents a non-overlap of roughly 64% between the two distributions. Although this falls between a small and medium effect according to Cohen's guidelines, it reflects a meaningful difference that may influence female students' persistence, academic outcomes, and longer-term career paths in engineering.

4.4 Gender Differences in Self-Efficacy and Engagement

To understand specific aspects of self-efficacy and engagement that show gender differences, a detailed item-level analysis was conducted for Factor 4. Table 4 presents the results for individual items, revealing that gender differences are most pronounced in confidence-related and affective aspects. The largest differences were observed in confidence in practical abilities (d = – 0.37), interest in practical work (d = – 0.35), and enjoyment of practical work (d = 0.32). These findings suggest that interventions should focus particularly on building confidence and enhancing positive attitudes toward practical work among female students.

Table 4

Item-Level Gender Differences in Self-Efficacy and Engagement

Item	Male M(SD)	Female M(SD)	t	p	Cohen's d
Confidence in practical abilities	3.67 (0.92)	3.31 (1.05)	-2.45	0.015*	-0.37
Interest in practical work	3.58 (0.89)	3.25 (0.98)	-2.31	0.021*	-0.35
Practical work enjoyment	3.72 (0.85)	3.44 (0.91)	-2.12	0.035*	-0.32
Motivation for practical work	3.45 (0.94)	3.16 (1.02)	-1.98	0.048*	-0.30

*Note: $p < 0.05$

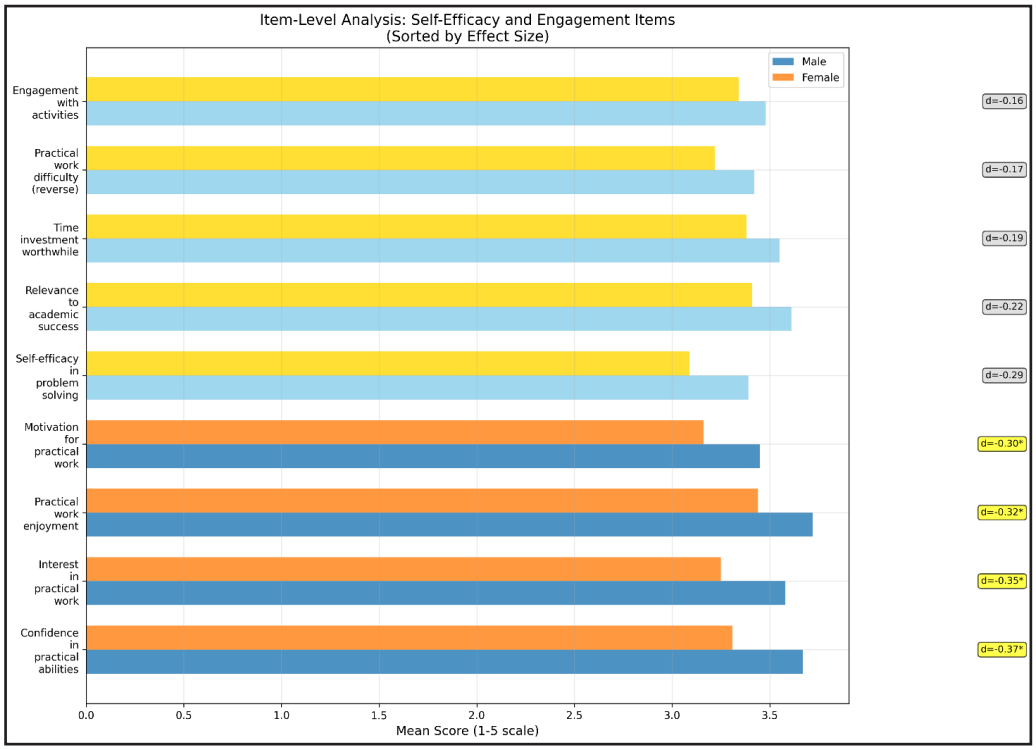


Figure 4. *Item-Level Analysis*

5. Discussion

5.1 Principal Findings and Theoretical Implications

This research offers strong evidence for a gender difference in engineering students' self-efficacy and outlook towards real-world work in Nigerian higher education. Although recruitment was carried out across four engineering departments as intended, the sample distribution was strongly skewed, with Computer Engineering (n=182, 53.8%) and Electrical/Electronic Engineering

(n=152, 45.0%) accounting for 98.8% of the research participants. The numbers of Agricultural Bio-Environmental Engineering (n=3, 0.9%) and Civil Engineering (n=1, 0.3%) were significantly underrepresented. This distribution shows the relative magnitude of these programmes at the institution, with Computer and Electrical Engineering admitting several students, significantly more than the others. In turn, the results can be regarded as representing students in these two larger programs. The imbalance in cell sizes was considered too strong to conduct departmental comparisons, which would have violated statistical testing assumptions. Future studies ought to either focus on departments with adequate enrolments to allow meaningful comparisons or use stratified sampling to ensure adequate representation of all departments of interest.

The main result-that female students also report experiencing considerably less self-efficacy and engagement ($d = – 0.35$, $p = 0.045$) and no differences in their views of external factors of education has both theoretical and practical implications on the comprehension and resolution of gender equity in engineering education. The fact that the gender differences in the self-efficacy and involvement are more concentrated than the gender differences in the perceptions of instructor quality, resource adequacy or learning environment, is a strong indication of how the social cognitive theory has been applied by Bandura as well as the contribution made by the internalised beliefs towards the continuation of the gender disparities (Bandura, 1997). This trend indicates that female learners in Nigerian engineering education are aware of the quality and value of the educational experiences but report lower confidence and practical work involvement, which is also consistent with the international studies that indicate that gender differences in self-efficacy tend to be preserved even in the case of equal educational opportunities and resources (Chan, 2022).

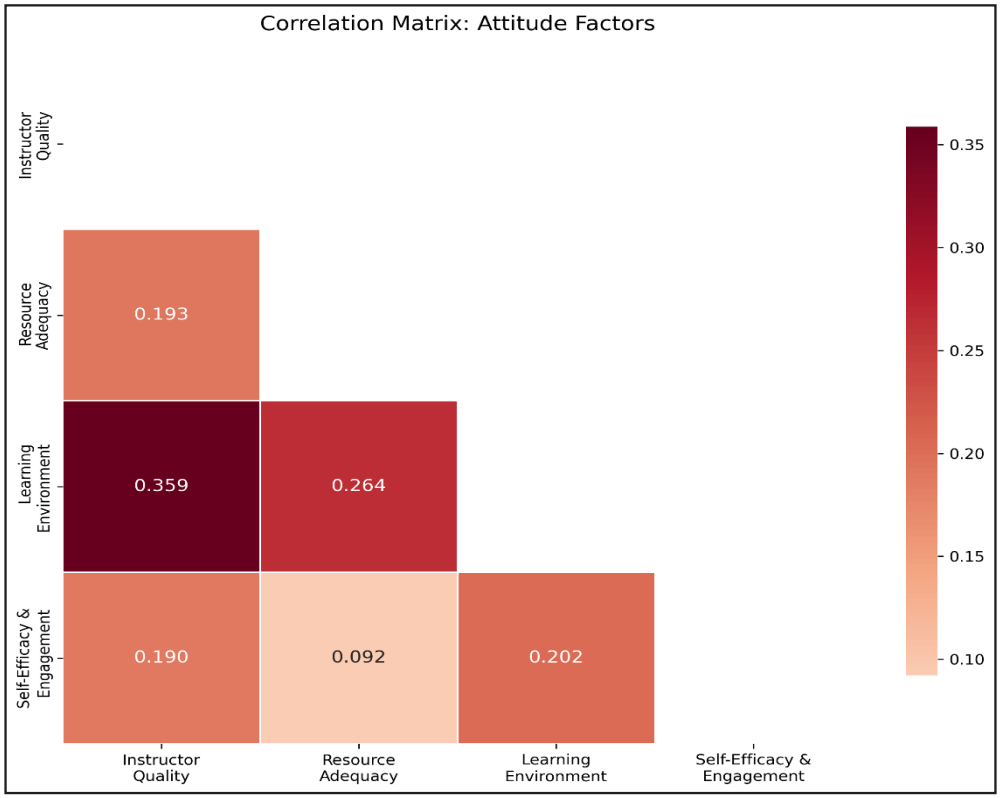


Figure 5: *Correlation Matrix Heatmaps*

5.2 Comparison with International Research

The observed effect size aligns closely with meta-analytic findings from international research. A comprehensive meta-analysis of gender differences in academic self-efficacy found similar effect sizes across diverse cultural contexts, suggesting that the patterns observed in Nigerian engineering education reflect broader global phenomena (Huang, 2013; Bero´ıza-Valenzuela and Salas-Guzma'n, 2025). However, the current study's finding that environmental factors show no gender differences may reflect positive aspects of Nigerian engineering education or cultural factors that influence how students evaluate educational experiences. The findings must be interpreted within the specific cultural and institutional context of Nigerian engineering education. The systematic review of STEM equity for girls in sub-Saharan Africa identified multiple barriers, including harmful cultural norms, poverty, and institutional neglect (Valero-Ancco et al., 2025; Ojong and Kareem, 2025). While the current study's participants have successfully enrolled in engineering programs, they may still experience the effects of these broader cultural factors through internalised beliefs and social expectations.

5.3 Practical Implications for Engineering Education

The findings have several important implications for improving engineering education practices in Nigeria and similar contexts. The concentration of gender differences in self-efficacy and engagement suggests that interventions should focus on building confidence and positive attitudes rather than improving external educational conditions. Specific recommendations include implementing confidence-building activities within laboratory courses, providing explicit instruction in self-efficacy development, and creating opportunities for female students to experience success in practical work activities (Lu¨beck et al., 2025).

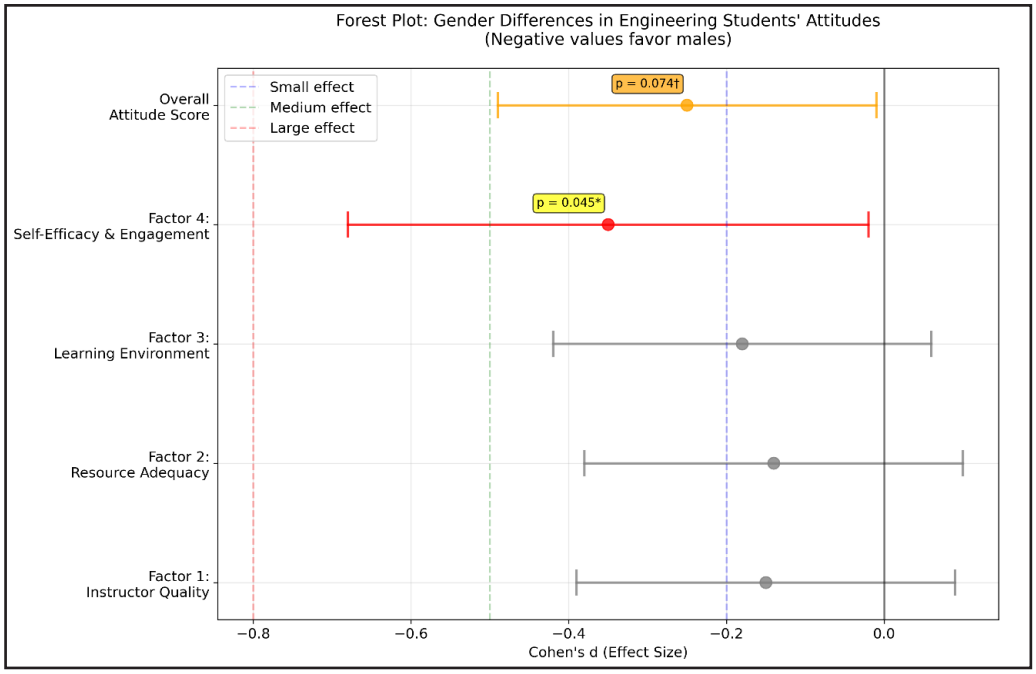


Figure 6: *Forest Plot of Effect Sizes*

Mentorship programmes pairing female students with successful female engineers could address the limited availability of role models while providing targeted support for confidence development. Such programs have shown effectiveness in other contexts and could be adapted to Nigerian cultural norms and institutional constraints (Packard, 2023). Instructor training programs could help faculty recognise and address subtle gender differences in laboratory interactions, providing equivalent encouragement and feedback to all students while creating inclusive laboratory environments.

5.4 Limitations and Future Research

These findings have several limitations that should be considered when interpreting and applying them. The study has a cross-sectional design, which

limits the ability to test causal hypotheses about the relationship between gender and attitude variables. This study was conducted at one polytechnic institution, using convenience sampling, which limits the generalisability of the results to other engineering education environments and academic institutions in Nigeria. Although the gender proportion (81.1% male, 18.9% female) was in line with the underrepresentation of women in Nigerian engineering, the departmental distribution was excessively skewed, with Computer and Electrical Engineering accounting for 98.8% of the sample. Hence, the results may be most applicable to these two larger engineering programs and might not apply to smaller programmes, such as Agricultural Bio-Environmental Engineering or Civil Engineering.

The argument that the demographic features are typical of engineering education in Nigeria must be viewed with scepticism, as this research reflects the distribution of programmes in one particular institution. Further studies that apply stratified sampling across various institutions would provide a stronger argument for representativeness. The current study should be advanced in the future by investigating the long-term effects of self-efficacy differences on academic perseverance, career selection, and professional achievement. Longitudinal research can be used to follow students from enrolment through graduation and into the first years of their careers, to examine how differences in confidence relate to educational and career outcomes. The effectiveness of different methods for developing self-efficacy and involvement among female engineering students could be tested through intervention research, with consideration of cultural suitability and institutional limitations.

6. Conclusion

This study highlights meaningful gender disparities in engineering students' self-efficacy and engagement with practical work in Nigerian higher education. Female students reported significantly lower confidence and engagement ($d = -0.35$, $p = 0.045$), while no gender differences were found in perceptions of instructor quality, resource adequacy, or the learning environment. This pattern indicates that disparities are rooted more in internal beliefs and attitudes than in external educational factors. The findings align with Bandura's social cognitive theory, showing that while formal equity in resources and instruction is important, it may not be sufficient to close gender gaps. Targeted interventions are needed to strengthen confidence and foster positive attitudes among female students, complementing structural improvements. This study adds to the limited body of research on gender equity in African engineering education, extending evidence from Western contexts. The similarity of effect

sizes across settings suggests that while cultural expressions of gender gaps differ, underlying mechanisms may be universal. For practice, the results point to the value of confidence-building initiatives, mentorship schemes, inclusive laboratory practices, and faculty training. Future research should track the long-term impact of self-efficacy gaps on persistence, career choice, and professional outcomes.

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Training Experiential Education Facilitators in Uganda: How Their Competences are Developed

Michael David Sumani[1], Willy Ngaka[2], Joseph Isabirye[3]
[1&2]Department of Adult, Community, and Lifelong Learning, Kyambogo University, P.O. Box 1, Kyambogo, Kampala, Uganda
[3]Department of Community and Disability Studies, Kyambogo University, P.O. Box 1, Kyambogo, Kampala, Uganda
Corresponding author[1]: msumani@kyu.ac.ug
Email[2]: willy.ngaka@kyu.ac.ug
Email[3]: isabiryejosephjb@gmail.com

Abstract

This paper analyses the development of experiential education competencies among Community Empowerment Group Facilitators (CEG-Fs) in Uganda's Integrated Community Learning for Wealth Creation (ICOLEW) programme. The study adopted a qualitative case study design, with data collected through interviews with CEG-Fs' trainers and focus group discussions with CEG-Fs from the four ICOLEW pilot districts: Iganga, Mpigi, Namayingo, and Nwoya. The findings reveal a recursive developmental cycle, initiated by readiness through reflective workshops, which successively link into planning and active application. This process culminates in a reflection phase that acts not as an endpoint but as a reconstructive link back to readiness, ensuring a continuous loop of competency development. The study concludes that facilitators' competency development is a recursive developmental cycle in which reflection serves as both an outcome and a catalyst for future development. The study underscores the need for sustained, reflective professional development to help teachers reconceptualise parental engagement beyond material and event-based approaches.

Keywords: *experiential education; experiential education competencies; experiential facilitator training; reflection loop, lifelong learning*

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1. Introduction

Professionalising adult educators has, of late, become a subject of concern among scholars and practitioners in Uganda and elsewhere. The lack of standardised adult education training for practitioners entering the field from diverse work backgrounds remains a critical concern. This systemic gap explains why recent studies, ranging from the USA (Ghimire et al., 2023) and Europe (Ezurike, 2025;

Zagir & Mandel, 2020) to Asia (Egetenmeyer, 2019) and Uganda (Nuwagaba et al., 2021), consistently advocate for the formal professionalisation of adult education and learning. The overriding justification across all the cited studies is that professionalisation is more essential for realising the learning outcomes of adult education programmes. However, DVV International (2021) highlights two other concerns: a shortage of qualified facilitators and a lack of institutions to train them. Thus, there is an urgent need to examine how educators in nonformal settings develop the competencies required to facilitate effective learning within their work contexts.

According to Vitello (2021), a professional's qualifications and knowledge base directly define the competencies required to perform their role effectively. This may equally apply to adult educators whose roles define them as facilitators. As described by Kolb and Kolb (2018), the facilitator's role from an experiential perspective is to help learners connect with their personal experience and reflect on it. Deltuva and Taylor (2010) argue that the facilitator's role and competencies are central to assessing the quality of adult education programmes. This implies that the management of any adult learning programmes must pay close attention to facilitators' competencies and, equally, to strategies for developing those who are found to have inadequacies. Community education programmes such as Uganda's ICOLEW adapt pedagogical frameworks noted by some scholars (DVV, 2020; Sumani et al., 2023) to be anchored on active, problem-based, and reflective learning. Scholars (Kranzow et al., 2018; Sanderson, 2020; Sumani et al., 2023) note that these action-oriented approaches require regular competency development for facilitators to deliver across the diverse participant contexts. Kolb et al. (2014) argue that the central role of the facilitator in experiential learning is to enable guided reflection: participants reflect on their actions and outcomes to gain deeper insights that reinforce learning. Therefore, unlike conventional pedagogical methods, experiential education centres on hands-on training activities and adopts approaches that facilitate reflection (Marshall et al., 2022).

Much of the research in experiential education (Bell & Bell, 2020; Deltuva & Taylor, 2010; Gencel et al., 2021; Kolb & Kolb, 2017; Kranzow et al., 2018) highlights the role of the trainer in the experiential learning process. Others focus on the experiential learner in terms of creating space for learning (Wright & Dean, 2019) or assessment criteria (Heinrich & Green, 2020there is a significant need for process learning theory with a practice-driven model. Scholars have only begun to explore the enhanced learning that often emerges from educative experiences designed with the fullness of experiential learning theory—designing with context, meaning-making, and assessment equal to the

learning. Purpose: Through the lens of scholar-practitioner reflective inquiry, we propose a remixed approach to designing experiential learning. By shifting approaches to experiential education (EE; Quesada et al., 2020; Voehl, 2018). While the cited studies provide valuable insights, there is a dearth of studies offering a structured, explicit, step-by-step framework for developing the competencies of experiential facilitators. The direct consequences of this are reflected in ethical concerns by scholars (Sanderson, 2020; Wright & Dean, 2019) who question the delivery of adult learning guided by experiential learning principles. These critics advocate a framework of minimum standards for developing the competencies of experiential educators, yet to date, none exists. This paper attempts to fill this empirical gap by describing the process of developing experiential education competencies among community empowerment group facilitators (CEG-Fs) in Uganda.

2. The Ugandan Context: Setting the Scene

The Ugandan Ministry of Gender, Labour and Social Development (MGLSD) piloted the Integrated Community Learning for Wealth Creation (ICOLEW) Programme in four districts of Iganga, Mpigi, Namayingo, and Nwoya in 2016, and two more, Mityana and Rukungiri, were added in 2020. ICOLEW is a successor to the Functional Adult Literacy (FAL) programme, implemented from the early 2000s to 2015. Unlike FAL, the ICOLEW programme offers community-based adult learning and education with the main aim of improving literacy, skills development, and wealth creation (MGLSD, 2020). As such, ICOLEW is built on five pillars: literacy and numeracy skills enhancement, village savings and loans association promotion, livelihood skills training, business skills training, and community development (MGLSD, 2020).

Community-level implementation of ICOLEW relies on volunteer CEG-Fs who must have a minimum qualification of a Uganda Certificate of Education (MGLSD, 2020). The CEG-Fs are recruited from communities and later given short-term training lasting between two and three weeks, before they are deployed to facilitate learning among adults in the communities (Nuwagaba et al., 2021). Justifiably, such facilitators ought to possess particular competencies, given the nature of their work. For example, the ICOLEW programme operational guides highlight experiential learning as a key principle for implementing learning at community learning centres (DVV, 2020; MGLSD, 2020). Given that ICOLEW leverages non-professional volunteers to deliver learning anchored on experiential learning principles, the efficacy of their preparatory training is of critical concern, as it directly affects their competencies in delivering learning that meets the complex demands of adult learners.

3. Literature Review

The literature reviewed here provides an exposition of experiential facilitator competences and their development. An overview of general adult education and experiential facilitator competencies is provided, followed by a review of the literature on the development of these competencies. The examination of general adult education professionals' competencies helps to enhance the understanding of experiential facilitator competencies, given the symbiotic link between adult education and experiential education (Kolb et al., 2014).

3.1. Competencies of Adult Educator Professionals

Competencies are unique to a particular profession because they define a blend of technical knowledge, role-specific attributes, and industry-driven standards tied to achieving the profession's high-value outcomes. Vitello et al. (2021, p.4) offer a broader definition of competence as 'the ability to integrate and apply contextually-appropriate knowledge, skills and psychosocial factors like beliefs, attitudes, values and motivations to consistently perform successfully within a specified domain'. Several frameworks exist to articulate the competencies of adult education and learning professionals. Buiskool et al. (2010) identify about twenty competencies segmented in seven generics (those that are relevant for carrying out all activities in the adult learning sector), seven specifics (on abilities possessed by the facilitator), and five that are supportive to the learning process, more linked to administrative and managerial functions.

Wahlgren (2016) group responses from scholars who have attempted to answer the question of the characteristics of professionals who can help adults learn from Europe and elsewhere. They depict the qualities of a qualified adult educator as one who can: i) communicate the subject content in an inspiring manner, ii) relate to the students' preconditions taken in a broad sense, iii) create a constructive learning environment, and iv) reflect on one's own experiences to improve performance constantly. Zagir and Mandel's (2020) study on five prominent European research projects conducted between 2004 and 2011, specifically on adult learning facilitators' competences, expands the list of competences. Their list aligns with the four thematic areas of competences outlined by Wahlgren (2016). Zagir and Mandel's study concludes that the common competencies highlighted in all the reviewed studies include:

> The teaching role and subject knowledge; knowledge and skills on teaching-learning methods; knowledge and skills on learning assessment and evaluation; planning and designing programmes; motivating adult learners; personal competence; professional

> development competence; communication and group management; needs analysis; and knowledge about adult development (Zagir & Mandel, 2020, p.170).

DVV International (2021) in the curriculum, globALE presents a basic competence framework for training adult educators worldwide, built on four generic principles: competency orientation, action orientation, learner orientation, and sustainability of learning and flexibility. As a result, DVV International presents five modules as core thematic and content areas with learning outcomes defined as competencies that all adult educators should possess, regardless of the geographical, institutional, or domain-specific context in which they work. The analytical synthesis of the literature reveals that the term 'competence' differs in content and meaning. The conceptualisation depends on the facilitator's working context. Given that all the cited studies offer a conceptual understanding of competencies from the European perspective, a contextual understanding from the African perspective is inevitable, as education and workforce skills ought to be relevant to the socioeconomic realities, cultural values, and specific learning challenges and contexts. The competences analysed in this paper relate to the demands, principles, and activities of the programme under implementation (ICOLEW), whose design and implementation, as noted earlier, are anchored on experiential learning principles.

3.2 Facilitators' Experiential Education Competencies

The concept of experiential facilitator is rooted in the experiential learning theory (Kolb & Kolb, 2014). Proponents of experiential learning theory contend that learning often follows unconventional, predetermined learning activities, thus creating an intricate role for the facilitator (Gencel et al., 2021; Kolb et al., 2014; Kolb & Kolb, 2018). Kolb and Kolb (2017) observe that the facilitator goes beyond merely preparing experiential learning activities that meet the learning outcomes to assessing practical conditions such as space, time, and technology to achieve the outcomes, while also considering the learning styles of the participants. Kolb and Kolb (2018) construe the facilitator's immense and extraordinary role as facilitator, coach, subject expert, and standard setter/evaluator. Such an educator is assumed to possess a developed competency in systematic reflection on their own practice, learning, and development, so that they are able integrate the findings of that reflection in their educational practices. In essence, the educator engages in dual-perspective reflection: viewing their practice as an immediate methodological activity and as their long-term role of community and sector development agents.

While several frameworks exist regarding facilitators' experiential competencies,

we find those models developed by Andrew (2025) and Gencel et al. (2021) most suitable. Their frameworks are more comprehensive and consistent with both existing broad adult educator competencies (Buiskool et al., 2010; DVV International, 2021) and the theoretical underpinning of this study. Gencel et al. (2021) developed a dual-component rubric for experiential educators, underscoring the inevitability of creating a supportive learning space characterised by learner-centred, reflective, and conversational learning as the first core competency. The second component outlines the educator's role as a facilitator, coach, subject expert, and evaluator/standard-setter. The rubric was found relevant because it provides comprehensive criteria for assessing each sub-component.

Andrew (2025) presents a seven-strategy framework construed as experiential learning competence domains. The first one is *engaging for impact,* focusing on developing individuals into influential communicators and connectors. The listed parameters for achieving this resonate with the experiential facilitator roles criteria highlighted by Gencel et al. (2021). The second is *navigating success,* which emphasises developing learners with a broad range of competencies to help them overcome challenges and adapt to changing circumstances. A critical look at the parameters for the foregoing competence suggests their consistency with the supportive learning competencies for adult educator professionals by Buiskool et al.(2010). The third is *wellness,* which Andrew (2025) describes as having parameters for measuring emotional, financial, and personal wellness. The fourth is *culture and value,* both aimed at developing not only compassionate but also culturally intelligent educators committed to building a harmonious society. The fifth is *sense-making,* aimed at equipping individuals with competencies for approaching problems analytically with critical thinking skills and the ability to synthesise information effectively. The sixth is *technology and digital literacy*, aimed at developing one's essential skills for navigating the digital landscape. Lastly, the *lifelong learning* competencies aim to enable learners to assume responsibility for self-directed learning in their professional and career development. Andrew's experiential competency framework was found relevant for interpreting and analysing findings on the process of developing experiential education competencies among community empowerment facilitators in Uganda. The framework is comprehensive, offering steps, strategies, and criteria to guide the development of facilitators' competencies across all seven competence areas.

The dominant narrative, running as a red thread through the two frameworks cited above, is that facilitators of learning programmes that espouse experiential

learning principles ought to have had sufficient prior preparation before instructing experiential learning activities. What is unclear, however, is how the facilitators develop the experiential education competencies needed to deliver effectively. In essence, the cited frameworks successfully conceptualise and describe the desired state (required competency/standard), but offer limited insights into the processes through which the competencies are developed. Nonetheless, the competency frameworks were relevant, for example, in interpreting findings on the essential competences of CEG-Fs.

3.3 Experiential Facilitator Training

The contribution of experiential learning to professional educator competency development is often noted for supporting learners' active engagement and for providing learners with an opportunity to experience the real-life application of a particular theory or skill in different contexts (Nakelet et al., 2017; Shore & Dinning, 2023). A literature review presents some experiential learning-based educator professional competency models. Among such studies, four with frameworks that directly connect educators' training phases to experiential learning are as follows.

Stocker et al. (2014) propose an ideal simulated training cycle: concrete experience scenario – reflective observation/abstract conceptualisation debriefing – active experimentation scenario. Matsuo et al. (2015) propose a framework highlighting five facilitators for developing experiential competency skills. They are sequenced as: challenging tasks, critical reflections, enjoyment, learning orientation, and development networks. Wang and Zorek (2016) present a four-stage, processual development cycle: analysis of strengths and weaknesses, active interprofessional experience (IPE), reflexive and peer synthesis, and collaborative recalibration. In essence, the recursive, individualised, experiential educator competency development process is initiated with an interprofessional experiential education (IEE) plan, which serves as a baseline analysis of the person's strengths and weaknesses. This is followed by active participation in an interprofessional education (IPE) experience, a form of clinical immersion in practice. Then the post-experience analytics with peers acts as a catalyst for iterative plan refinement. Although the four-stage processual development cycle originated from a systematic literature review, its structural framework provides a foundational template for developing experiential facilitator models within empirical study contexts.

While all the cited frameworks offer valuable insights, some (Stocker et al., 2014; Matsuo, 2015) are conceptual or theoretical rather than empirically validated models. Even those that are empirically validated (Wang & Zorek, 2016) were

based on formal learning contexts. The dearth of empirically validated models from nonformal learning contexts then becomes a major concern for studies on experiential learning. Indeed, Saikrishna (2025) acknowledges this concern, recommending that future scholars conduct qualitative, longitudinal empirical studies to validate some of the proposed frameworks in the existing literature.

4. Methodology

4.1 Study Design

The major assumption of the study was that ICOLEW CEG-Fs' preparations for the tasks ought to be informed by experiential learning principles, for which proper investigation required a case study design and a qualitative approach underpinned by an interpretive philosophy. Experiential learning aligns well with interpretivism because the outcomes of the learning process are varied and often unpredictable, and learners play a pivotal role in assessing their learning (Voehl, 2018). Understanding such a process requires an interpretivist philosophy to guide investigations (Denzin and Lincoln, 2018). The study purposively selected four districts: Iganga, Mpigi, Namayongo, and Nwoya, which have piloted the ICOLEW programme since its inception in 2016. The contextual heterogeneity across these different districts necessitated a qualitative case study design to facilitate a lucid exploration of the diverse socioeconomic factors influencing programme implementation. This multi-site approach offers a robust framework for analysing how the CEG-Fs' competencies are enhanced by trainers not only during content design but also during active immersion in practice.

4.2 Study Population and Sample

Data were collected from trainers and CEG-Fs from the four districts. Typical purposeful sampling techniques were used to reach the targeted participants. The typicality of the participants was determined by their extent of experience in working with CEG-Fs. MGLSD (2020) indicates that the staffing for the ICOLEW had 16 designated district trainers across the four districts, with a further eight trainers deployed across the pilot sub-counties. ICOLEW implementation guidelines (MGLSD, 2020) indicate that at the pilot stage, 10 CEG-Fs from each pilot sub-county were trained and deployed to manage at least 30 community empowerment groups in that sub-county. Considering the foregoing facts, the targeted population was summarised in Table 1.

Table 1

Total Population of Participants

Category	Number
District Trainers (4 per district)	16
Sub-county-based trainers	08
CEG Facilitators (20 per district)	80
Total	**104**

Due to institutional staffing constraints and high attrition rates within CEG-Fs, the realised sample size (n=81) fell short of the initial projection (n=104). The resulting distribution included 17 trainers and 64 CEG-Fs. Despite these limitations, exhaustive access was maintained for all the eligible participants, ensuring 100% participation rate among the targeted population.

4.3 Data Collection

Interviews were conducted with the 17 trainers, and eight focus group discussions (FGDs) were held for CEG-Fs. We conducted FGDs with eight participants per group at the ICOLEW learning centre in each sub-county within the pilot districts. The CEG-Fs in their respective FGDs shared how trainers prepare them for experiential education. Interviews for trainers focused on: i) process and strategies for developing experiential education competencies of the CEG-Fs, ii) the essential experiential competencies they consider before recruitment of CEG-Fs, and iii) the CEG-Fs' competency inadequacies. The aforementioned two methods were triangulated with document reviews. The documents reviewed included ICOLEW implementation guidelines, training materials from district trainers, reports from programme evaluation meetings organised at both district and sub-county levels, instructional materials developed by both trainers and facilitators, and trainees' notebooks.

4.4 Data Analysis

The analysis adopted the rigorous six-step procedure outlined by Naeem et al. (2024) for developing conceptual models in qualitative research. The analysis commenced with the verbatim transcription of the seventeen interviews and eight FGDs. Since all sessions were conducted in English, the first author conducted all transcriptions before sharing them with co-authors to foster collective familiarity with the data. Secondly, the first and second authors individually did the initial open coding before meeting as a research team to compare notes. A total of 142 keywords emerged from this process. The 142 keywords were later mapped into 16 codes related to the competence development process

and five related to essential competencies of an experiential educator. Thirdly, the codes were re-evaluated to arrive at broader and more specific themes. For instance, prospects, plans, and future-focused applications were merged into a single theme of reflective action. This was reflective coding, informed by key concepts from the literature on experiential learning and competency development. Fourthly, refining themes generated at the third stage was done to determine how coherent patterns were supported by data. Fifthly, the themes are defined. For instance, what reflective training workshops and collective content design mean. Their presentation is supplemented with direct quotes from the data to ensure the trustworthiness of the findings. Finally, a conceptual model was developed (see Fig. 4).

4.5 Ethical Protocols

As noted earlier, while setting the scene, this paper analyses findings from the larger research project, whose data were collected between September 2024 and January 2025. Before commencement, the proposal went through several ethical reviews by accredited research ethics committees. Besides, the presentation of findings with direct quotes has been coded, while referring to the respective participant interview excerpt.

5. Findings

Before presenting the findings, experiential education competency profiles of trainers are provided in Table 2. The findings are under two main themes: a framework for developing experiential education competencies among CEG-Fs and essential competencies of CEG-Fs.

5.1 Experiential Education Competence Profiles for the Trainers of CEG-Fs

As reflected in Table 2, the profiling considered two areas: (i) professional qualifications in adult education and learning, and (ii)work-based experience, in terms of the number of years in the field. Through professional development and work-based learning, individuals have opportunities not only to gain confidence but also to develop skills and a better understanding of the ethos that guides practices in that field.

Table 2

Experiential Education Competence Profiles for the Trainers

Aspects	Frequency	Percentage
Professional Competency in Adult education and learning		
Degree or diploma in Adult Education	02	11.8
Certificate in Adult Education and Learning	02	11.8
Short – Competence-based Training in Adult education and learning	07	41.2
None of the above	06	35.2
Work-based Experience in Education Provisions in Years		
Below 5 years	03	17.6
6-10 years	07	41.2
11 years and above	07	41.2

Findings in Table 2 indicate that six (35.2%) of the 17 trainers did not hold any professional qualifications in adult education and learning. Although the focus of the current study was not on the trainers' competencies, these findings suggest that these trainers may be operating with limited knowledge of integrating experiential learning principles into training for adult learners' facilitators, a key component for adults to connect theory to practice.

5.2 A Framework for Developing Experiential Education Competencies Among CEG-Fs

The thematic analysis of findings revealed a five-stage process of experiential competency development for CEG-Fs. These were reflective training workshops, collaborative learning and content design, active experimentation, a supportive environment, and practical reflection.

5.2.1 Reflective Training Workshop

The findings depicted reflective training workshops as readiness activities. It is evident from document review and interviews that these activities involved convening recruited CEG-Fs at a central location within the pilot district to receive either initial or intervention-based training. The initial training was for newly recruited facilitators, and the intervention-based training was for those practising. The findings reveal that initial training was concerned with roles of the facilitator and skills of conducting situation analysis as demonstrated by the interview, where one of the trainers noted that, 'the training contents are developed from the needs assessment training needs, so by the time we train, we have had thorough discussions with colleagues during the planning stage'.

On the other hand, the intervention-based reflective workshops are organised quarterly, and learning units are generated from the support monitoring mechanisms, as demonstrated with Trainer TNW1 interview transcript:

> Refresher training usually follows identification of a training need, especially during our regular monitoring and visits to their community empowerment groups, where much of the learning takes place. For example, if the issue is not following adult learning principles while facilitating learning, then we would conduct practical sessions on that. We can give one a topic and ask them to train us. Here, we monitor how the person upholds the principles of adult learning when instructing. We remind them not to mind us being their trainers, because if we don't debrief, they may feel timid and think we are too experienced to be trained by them.

Analysis of the findings from reflective training workshops reveals a four-stage reflective action loop that bridges the gap between prior understanding and action, as illustrated in Figure 1.

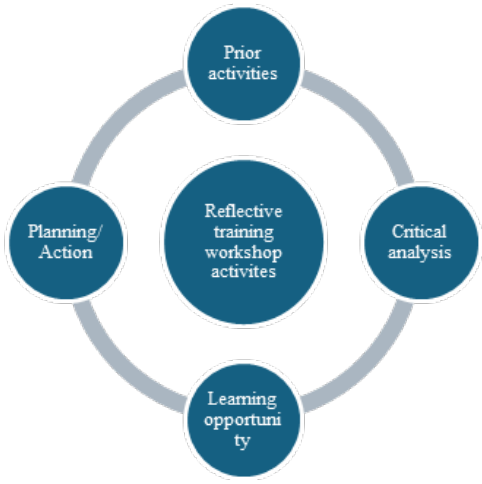


Figure 1: *The Reflective Action Loop for Training Workshops*

*Source***:** Research Raw Data

Initially, training workshops immerse participants in their current experience, where they discuss their daily tasks (understanding their experience). Participants then link theory and practice, critically evaluating their prior experience against existing knowledge (critical analysis). This then presents them with a learning opportunity where participants discuss how they can translate new knowledge into their specific roles. The process culminates in the development of action

plans for future, evidence-based improvements.

5.2.2 Collaborative Learning and Content Designing

Findings from the interviews and focus group discussions revealed a proactive approach to content design, frequently referred to by participants as learning units. The reason for adopting such an approach was primarily to achieve participatory learning for action. The interview excerpt from trainer TNA3, anonymised, is illustrative of the narrative repeatedly provided by others from all four districts on the issue.

> The materials development process brings the facilitators on board. The subject matter specialists and facilitators work together to design the materials that are then used to train them. During development, their involvement is to enhance their experiences. Remember, the materials are again generated from the situational analysis reports that the facilitators generated and brought to the district coordinator. The involvement is a crucial strategic attempt to immerse the CEG-Fs in the content they will use to train the community members.

Findings from the focus group discussions were consistent with those from the interviews. It was, for example, observed by FGD2IG participants that:

> We keep telling the trainers our challenges, and they come in to help. They trained us in conducting a situational analysis. We then went out to do it, and our reports had issues. They used our materials to identify issues, helping us understand what to do next. There was a situation where we were taken to peers, and we learn to develop the materials together. This has helped in doing the tasks effectively.

Consistently, the findings from content reviews demonstrate that the trainers adopt a participatory approach in building the facilitators' competency. It is noticed that CEG-Fs were part of the data collection, needs assessment, analysis, prioritisation, and action, which informed the thematisation of learning units. The process starts with CEG-Fs conducting meetings to identify the issue or community-prioritised problem, such as low crop yield, as demonstrated in Figure 2, captured during document reviews.

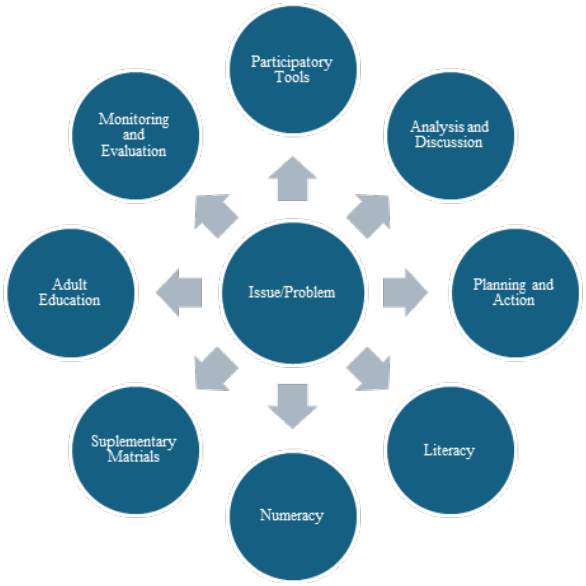


Figure 2: *ICOLEW learning cycle adopted from (MGLSD, 2020, p.36)*

The findings indicate that the generation of learning units signals a shift towards participatory co-design of learning content. By adopting such a model, the training process guarantees that the training materials are rooted in the lived realities of the trainees. In essence, the model may achieve two goals: validating the situation analysis data and offering an opportunity for facilitators to immerse themselves in an environment that sharpens facilitators' preparation for complexities in future implementation of the learning activities – community-learning-centre-based action.

5.2.3 Creating a Supportive Environment

Findings from the interviews revealed a seemingly dominant strategy of support monitoring, a post-training activity. The trainers used these avenues for co-facilitation and to build the confidence of the CEG-Fs. Trainer TNW1 interview transcript that may be illustrative of many others with a similar approach was as follows:

> We regularly visit them in classes and instantly correct them. We don't confront them, but after the sessions, we have a one-on-one discussion. Sometimes, we prepare the facilitators and participants to expect our input. In that way, when a facilitator makes a mistake, and I come in, the participants don't easily see it as a corrective measure but rather think we are co-facilitating their learning.

The above quote also highlights the importance of feedback and co-facilitation in developing facilitators' experiential education competencies. Moreover, the feedback approach signals a shift from conventional support supervision to a collaborative mentorship model. For instance, the new model supports supervision that embeds real-time corrective measures while preserving the psychological safety of trainees. Other instances of creating a supportive environment while building facilitators' competencies included incentivising the ICOLEW activities. This included integrating ICOLEW learning activities with other government development programmes, with small facilitation provided to CEG-Fs. This was done as a motivation strategy for CEG-Fs, as demonstrated in the interview with Trainer TNA1, who noted that:

> We have encouraged the formation of associations for all CEG-Fs in each ICOLEW sub-county. This has helped in linking them to development programmes. For example, we have ensured they are lead facilitators in PDM, CDD, the youth livelihood fund, and even the women's fund. These have created more learning opportunities for them in executing their duties. The little allowances they receive motivate them to integrate learning and also promote the knowledge sharing bout ICOLEW programme activities. For instance, the SACCOS under ICOLEW promote PDM SACCOS. The learning activities under the savings groups focus on the activities community members are engaged in, thereby building the capacity of the CEG-Fs.

In essence, placing the CEG-Fs in a lead role in other community development programmes may not only be an incentive but also an opportunity for experiential learning. The practical implication is that avenues for continuous competency building are enhanced because the roles place facilitators in immediate application of skills, as was lucidly indicated in the management of SACCO activities. The findings also show a creative way to promote post-learning activities that are life-changing for participants, offering intrinsic motivation for learning through the CEG-Fs.

5.2.4 Reflective Practices

These are practice-based evaluations of the competence developed. These practices were guided by maintaining reflection journals for both CEG-Fs and trainers. Document reviews revealed that this was a form of assessment of learning. As an example, the reflection journal included the following question: What key point*s were taught during this session? What didn't I know before the session? What did I discover after the session? What do I need further clarification/guidance on? How do I apply what I have learned today?* The

reflection journal was corroborated by interviews and focus group discussions. During interviews, for instance, Trainer TNA5 noted:

> Some lessons are conducted at the community learning centre here. I participate to see how teaching and learning take place. After that, we sit with the CEG-F to reflect on the process, including what we learned. How can we take it to another level? It is a good and interesting process. Almost every activity is a learning opportunity for us.

The trainers' cited experience was corroborated by the focus group discussion anonymised as *FDG2NW,* where excerpts of the discussions were as follows:

> We always have good learning scenarios with our trainers. In case studies, for example, we share our testimonies from the projects we work on with our learners, and they listen. They often appreciate what we do. One day, our CDO said, "I am lucky to learn from you guys." You have done more than I. In our next month's meeting, I request that you use this scenario to let your colleagues know that this approach works.

The synthesis of the findings reveals a continuous, sequential pattern of learn-reflect-apply, illustrated in Figure 3. It starts with strategic hindsight, using past experiences to set expectations and reduce future difficulties. It progresses through the post-experience re-conceptualisation and culminates in future-focused application. In essence, the prior experiences are catalysts for professional competency development.

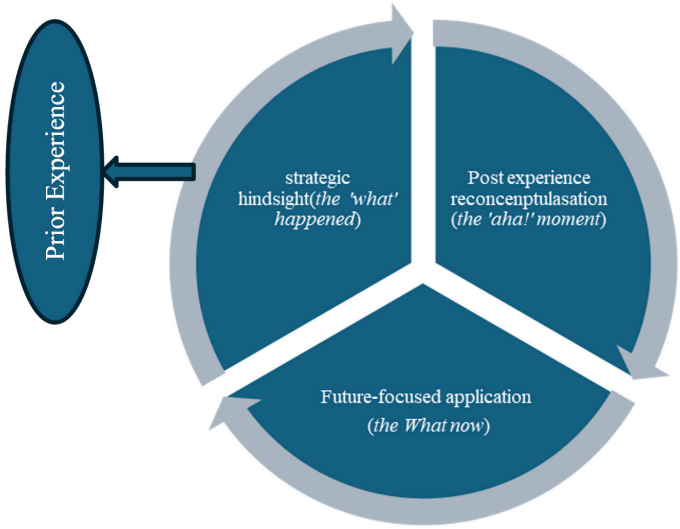


Figure 3: *The CEG-F Reflective Competence Development Cycle*
*Source***:** Research Raw Data

5.3 Essential Competencies of CEG-Fs

The analysis of the findings on the essential competences used a focused thematic analysis strategy, aligning emerging categories with the concepts in the literature and the experiential learning competence framework. As a result, three main themes emerged, namely interpersonal effectiveness, communication, and prior experience with adult education and learning.

5.3.1 Interpersonal Effectiveness

It was repeatedly noted from the interviews and focus group discussions that the recruitment process would involve the community members and their leaders. It was corroborated with the ICOLEW implementation guidelines noted during the document review. The process starts with the district team sharing the qualities of the desired CEG-F, and the community members then forward three names for consideration. The qualities mentioned during interviews and FGDs, as well as those stipulated in the implementation guidelines, resonated with the interpersonal effectiveness competencies listed in the experiential learning competence framework. For instance, participants repeatedly mentioned one's residence in the area as a qualification for recruitment into CEG-F. Trainer TNW1, for instance, observed that 'we give opportunities to residents of that area who understand the community members, what they do, what they want, and so on, which always forms the basis of their training activities they organise later'. Consistently, trainer TNA1 also noted that 'we want an active member of the community, with some already existing projects that can make others learn from'.

Based on the findings, interpersonal effectiveness was understood to include aspects that demonstrated a good relationship with others. Moreover, for community residence, it requires the contribution one makes to encouraging lifelong learning. Other reasons for preferring the residents related to their ability to easily understand the learning needs, the learning contexts, and how their fellows prefer to learn, as illustrated in an interview with Trainer TNA5, who said:

> We recruit someone with good discipline and who relates well with other community members, since they have to offer opportunities for others to learn. We task community members with assessing their interaction style, commitment to work, what they do for a living, and their willingness to support others voluntarily.

The interview findings were corroborated by focus group discussion sentiment, as reflected in the excerpt from FGD1IG: 'the community is seeing value in

us as we now give back to the community that educated us'. It can be noted that interpersonal effectiveness emphasises discipline and wellness in the community member who would be appointed as a facilitator, and perhaps who was initially working with communities and appreciates adult learning as a process that requires patience.

5.3.2 Communication

Three key aspects of communication competencies emerged from interviews, focus group discussions, and document reviews. The first one was the consideration of the basic formal education achievements of the desired CEG-F. A minimum qualification of Ordinary Level, certified by the Uganda National Certificate of Education, was essential. Based on the findings, this was done on the assumption that one with such an educational qualification would be competent in reading and writing in English and the local language. Although instruction is in the local language, reporting would be in English. Thus, the emphasis is on communication competencies in both languages. For example, one of the participants stated that 'the facilitator should be at senior four, and for this, we believe this person has developed better reading and writing skills to be used in contextualising the training and learning activities of the learners at the community level'.

5.3.3 Prior Experience with Adult Learning and Education

Findings from interviews and FGDs revealed that consideration of previous experience in facilitating other adult learning programmes was key to recruiting CEG-Fs. Such experience was expected to have been acquired, for example, if a person was a functional adult literacy (FAL) instructor, a village health trainer, and/ or participated in any known community mobilisation endeavours. The reasons for considering prior experience were primarily two: the ability to deliver following adult learning principles and a volunteerism spirit, as demonstrated in the interview with Trainer TNA4, who noted that:

> Being a former FAL instructor was an added advantage. We believe such a person already has experience with how adults learn. They have patience, since the programme outcomes may not be instant. They also value volunteerism. So, they are known for not exerting much pressure on stakeholders regarding remuneration demands, but rather for valuing the services rendered.

Prior experience is not only recognised as a starting point for learning but also a crucial component of the learning process itself. The opportunity it offers in facilitators' competence development is in connecting what they already

know to the likely outcomes of the learning process they actively lead, which is a key facilitator of reflective practices.

6. Discussion of Findings

This paper aimed to examine the process of developing experiential competences of the CEG-Fs of Uganda's ICOLEW programme. The findings revealed that the process involves a phased yet continuous series of activities for readiness, planning, learning, applying, and reflecting, as illustrated in Figure 4. To succeed in this, some competencies are regarded as essential, including interpersonal effectiveness, communication, and cultural and value engagement. The discussion takes a critical reflection on the foregoing issues. Based on the findings, the process was perceived to start with the reflective training workshops as preparatory activities. The learning activities followed a four-stage process (prior experience, critical analysis, learning, action for improvement) that CEG-Fs go through to develop their competencies. This process does not seem to be unique to Ugandan CEG-F. However, it is consistent with Schön's notion of the three-phase reflective practice: reflection-in-action, reflection-on-action, and Tan's (2020) *Daoist* interpretation of creating new understanding/knowledge. This process also resonates with the four stages of continuous learning under the experiential learning cycle (Kolb & Kolb, 2018).

Although the findings are consistent with established frameworks by Kolb and Kolb (2018), critics such as Heinrich and Green (2020) and Tan (2020) argue that these frameworks primarily focus on individual cognition and ignore the social and collaborative perspectives of learning. Indeed, as can be seen in the professional training of CEG-Fs in Uganda, their learning and development of experiential education competencies seems to be a distributed process that occurs within communities of practice rather than in isolated reflection. Despite the criticism, the practical implications of the findings suggest the potential of reflective training workshops to foster continuous learning and skills development among CEG-Fs, thereby developing their lifelong learning competencies outlined in the experiential learning competence framework (Andrew, 2025). The findings, therefore, illuminate the relevance of reflective-practice-based training in facilitating the development of lifelong learning competencies recognised as personal competencies for adult education and learning professionals (Buiskool et al., 2010; Zagir & Mandel, 2020) and for competent experiential facilitators (Andrew, 2025).

The findings repeatedly highlight the reflective practices throughout the different phases of training the experiential facilitators. Moreover, the practice is for both trainers and trainees, thus demonstrating the importance of providing

space for reflective practices in competence building for both personal and team professional development. The findings are consistent with Marshall et al. (2022, p.484), who argue that "reflective practice is an inherently personal and relational process, occurring privately within people, and publicly, between people". They are also consistent with the first set of competences in Gencel et al. (2021), as outlined in the rubric for measuring experiential education training, especially regarding what they term a conversational learning space. On the contrary, emphasising the recurrent use and importance of reflective practices for both trainers and trainees may raise practical and institutional limitations. Practically, reflective practices are inherently internal and personal (Marshall et al., 2022). In essence, they may lead to self-confirmation bias rather than competence-building. Institutionally, issues of power dynamics may arise. For instance, there may be unclear role boundaries between the trainer and trainees regarding who has the final say on content, especially if the trainees also serve as assessors of the trainer. Despite the limitations, the study specifically elucidates practical scenarios for enriching the conversational learning space between teams, that is, peers, the more experienced, and novices..

The findings on collaborative content design revealed that the starting point is an issue or community problem, and that the planning of learning follows a problem-based learning process. This not only demonstrates a participatory approach to building the facilitators' competency but also validates previous studies (Association for Experiential Education, 2025; Sumani et al., 2023) that underscore problem-based learning as a methodology of experiential education. The point of divergence between the current study and the previous one is the emphasis on how problem-based learning through collaborative content design builds the experiential competencies of the CEG-Fs. At the application phase of the competence development, the findings emphasise the importance of a supportive environment. This is not new but rather a regular catechism by scholars of experiential learning. Proponents (Kolb & Kolb, 2017) and advocates (Gencel et al., 2021) of experiential learning underscore the importance of a conducive learning space or a constructive learning environment (Wahlgren, 2016). This study, therefore, introduces a novel dimension to pedagogical practice: the systematic integration of participatory, respect-based feedback processes. This dimension is noted to prioritise learner motivation and mutual respect as primary mechanisms for nurturing a supportive learning environment, as corroborated by the participants' testimonies.

The findings on perceived essential competencies for recruiting CEG-Fs have a limited scope, focusing on the experiential education competencies of the

facilitator. Out of the seven competency areas suggested by Andrew (2025), only three: interpersonal effectiveness, communication, and cultural and values engagement, are considered essential in the recruitment and development of competent community empowerment facilitators. This, as noted further in the findings, perhaps had a bearing on competence inadequacies in sense-making, technology, and digital literacy, as well as communication competencies. The supposition is that if there were no deliberate efforts to build digital literacy and sense-making competencies, it would not be surprising if participants expressed inadequacies in these areas.

7. Emerging Framework on Competency Development Process

The five-phased, cyclic, and continuous stages of CEG-F competence development present an emerging model, as illustrated in Figure 4.

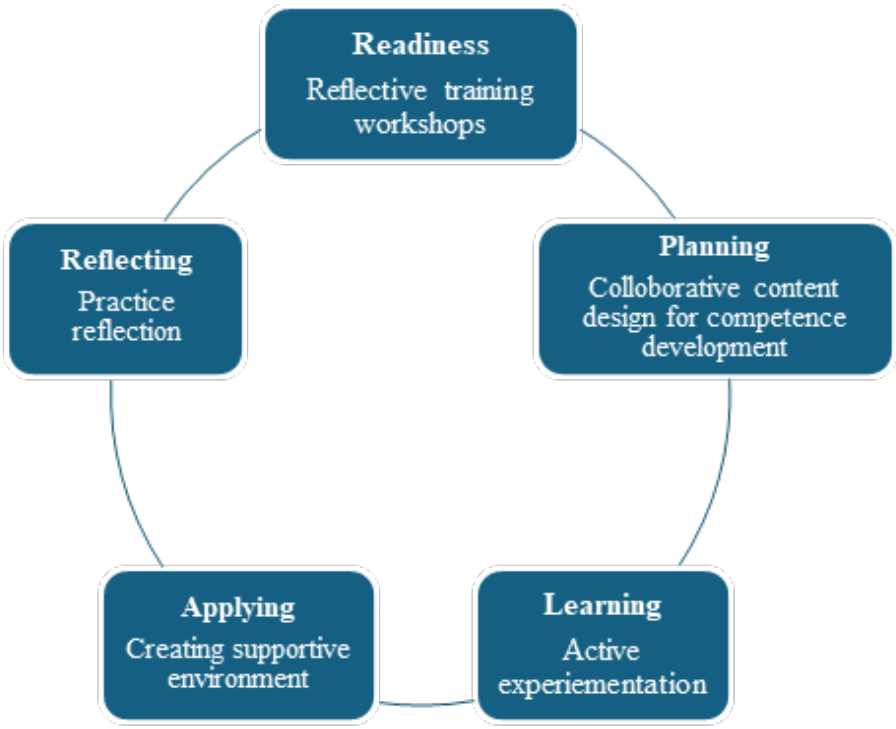


Figure 4: *Process of Experiential Education Competences Development*

Based on the findings (illustrated in Figure 4), it can be deduced that competence is a product while competence development is a process. Findings also suggest the existence of external actors who offer support, such as access to resources and ideas, for competency development. It can be noted that, whereas the competence development process follows a certain pattern, each stage

provides new experiences for the facilitators and opportunities for planning future actions. Moreover, an environment where both trainers and facilitators (trainees) engage in mutual reflection (a conversational learning space) is a catalyst for the development of experiential education competencies at the individual and team levels.

8. Conclusions and Recommendations

The fundamental question raised at the beginning of this paper was: *How are the competent experiential facilitators prepared?* Based on the findings and the suggested implications, the following conclusions are drawn. Firstly, reflective training workshops are essential preparatory activities that foster the development of facilitators' experiential education competency. They trigger a learning loop that moves from prior experience to critical analysis, creating an opportunity for learning and action. Thus, validating Kolb's experiential learning cycle. This implies that, although the experiential learning framework is a learning model, it may also apply to competency development. Moreover, its individualistic approach to developing competencies may not make it obsolete, but rather should be extended to integrate social learning perspectives, which align with the communities-of-practice model of experiential education educator competencies, as evidenced by participants' testimonies of their competency development process. Based on this observation, we recommend that reflective training workshops be conducted more regularly and organised over a reasonable period. At all stages, the findings underscore the importance of reflective practice as a cornerstone for experiential competency development for both facilitators and trainers. For practice purposes, it further highlights the importance of a conversational learning space in professional development. This leads to the recommendation that institutions that train facilitators should formally integrate conversational learning spaces into such programmes.

Secondly, the training only considers three competency areas of interpersonal effectiveness, communication, and cultural and values engagement as most essential in the recruitment of CEG-Fs. Yet CEG-Fs demonstrated competency gaps in sense-making, technology, and digital literacy, in addition to communication competencies. The study recommends that trainers and planners familiarise themselves with various competence frameworks and deliberately integrate them into the design of training content to develop competent professional community empowerment facilitators. Thirdly, as previously stated, there was a gap in the literature and practice related to the lack of a structured model for developing experiential facilitators' competencies. The findings of this study now offer a framework (Fig. 4) with the potential to fill this knowledge

gap. The model adds to the current knowledge of the role of the experiential facilitator in delivering experiential learning effectively. Despite its Western research origins and a formal adult learning focus, the experiential learning framework appears effective in developing competencies among educators in non-formal adult education programmes. This suggests that the crossing cuts across intercultural and interprofessional diversity in the learning theory.

However, a notable limitation of this study is the exclusion of items for data collection specifically addressing the competencies in assessing experiential learning. Future studies may consider this, given the novelty and complexity of approaches to assessing experiential learning.

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Tanzanian Teachers' Knowledge of Parental Engagement in Students' Participation and Learning in Physical Education

John Siayi Irafay
Department of Physical Education and Sport Sciences, School of Education, University of Dar es Salaam, Dar es Salaam, Tanzania
Email: john.siayi@udsm.ac.tz

Abstract

This study explored teachers' knowledge of parental engagement in supporting students' participation and learning in physical education (PE) in secondary schools. Eight PE teachers, each with at least two years of teaching experience, participated in interviews, and data were analysed using thematic analysis. The findings indicate that PE teachers have a limited understanding of parental engagement. Although teachers recognise its motivational value, they primarily view parents' roles in material terms, including providing resources, supporting facility rehabilitation, and participating in school-organised sports activities. The study further reveals that, despite greater material support, higher-income families often lack motivation to foster students' interest in PE. Overall, teachers hold a narrow, largely material-oriented view of parental engagement, while both low – and high-income families face distinct barriers to supporting students' participation and learning in PE. The study recommends that PE teachers reconceptualise parental engagement beyond material and event-based approaches through professional development that emphasises collaborative and communicative forms of involvement.

Keywords: *socioeconomic status, parent engagement, support strategies, student participation, teachers' knowledge*

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1. Introduction

Parental engagement in education has increasingly been recognised as a critical factor influencing students' participation and learning across different subject areas, including physical education (PE). Globally, research consistently demonstrates that parental engagement is positively associated with students' academic achievement, motivation, and overall educational outcomes (Kelley, 2022; Otani, 2020). However, contemporary scholarship moves beyond viewing parental engagement merely as attendance at school events or homework support, instead conceptualising it as a multidimensional construct

that encompasses home-based involvement, school-based participation, and academic socialisation (Anastasiou & Papagianni, 2020; Otani, 2020). These dimensions highlight that meaningful engagement is relational, communicative, and embedded within broader socio-cultural contexts. A key mechanism through which parental engagement influences student outcomes is communication. Evidence suggests that open and sustained communication strengthens parental involvement and aligns home–school relationships, thereby enhancing student engagement (Anna et al., 2022; Schmid & Garrels, 2021). At the same time, parental roles extend beyond communication to include modelling behaviours, providing encouragement, and supporting access to learning resources, all of which shape students' participation in learning activities (Keech et al., 2018; Atunde et al., 2023; Lilian, 2021).

Despite this broad recognition, parental engagement is uneven in practice and often shaped by contextual constraints, such as limited knowledge of school programmes, competing work demands, and restricted access to school activities. In some contexts, even when parents recognise the importance of education or specific subjects, this awareness does not necessarily translate into active engagement (Earley & Fleet, 2021). This suggests that parental engagement is not only a matter of awareness but also of opportunity, access, and alignment between school practices and family realities. Socioeconomic status further complicates patterns of parental engagement by shaping both its forms and intensity. In higher socioeconomic contexts, parents may be less directly involved due to reliance on external educational support and demanding professional commitments (Poncelet et al., 2023). In contrast, lower socioeconomic contexts often experience constrained engagement due to limited resources and lower levels of educational attainment (Kapinga, 2014). These contrasting patterns indicate that parental engagement is structured by broader social and economic conditions, rather than being solely a matter of individual choice.

Within the domain of physical education, these challenges are particularly pronounced. Although parental encouragement has been shown to positively influence students' participation in physical activity (Olivares et al., 2015), PE remains a marginal subject in many education systems. It is often perceived as less academically valuable compared to core subjects, leading to lower prioritisation by both schools and families (Earley & Fleet, 2021). As a result, students may receive limited encouragement and support for participation and learning in PE, despite its recognised contribution to holistic development. In Tanzania, parental engagement is formally embedded within education policy and curriculum frameworks, which emphasise parents' roles in supporting

students' learning and teachers' responsibility to involve parents in the educational process (MoEC, 2005; Ministry of Education, Science and Technology, 2023). However, implementing these expectations occurs within a context marked by structural and institutional constraints. The expansion of PE provision in secondary schools, from a small number of institutions in 2008 to a broader national presence by 2024 (NECTA, 2024), reflects growing recognition of the subject. Nevertheless, this expansion has not been matched by adequate human and material resources, particularly the availability of qualified PE teachers.

In many schools, one teacher is responsible for multiple classes, limiting opportunities for both effective instruction and meaningful engagement with parents. Empirical evidence also indicates that parental engagement in Tanzania remains limited in both scope and form. Communication between parents and teachers is often minimal, participation in school activities is low, and involvement in students' learning processes is inconsistent (Seni & Onyango, 2021; Vicent, 2018). Where engagement exists, it tends to be narrowly oriented towards examination performance, reflecting dominant educational priorities that privilege examinable subjects over broader learning domains (Mwakililo & Mgaya, 2021; Marwa, 2015; Kazungu, 2016). This emphasis contributes to the marginalisation of physical education, which is frequently perceived as recreational and non-essential within the formal curriculum (Kazungu, 2016). Longstanding societal perceptions of PE in Tanzania reinforce these dynamics. Historically viewed as a non-examinable, recreational subject, PE has received limited attention from both schools and families, which has shaped patterns of low participation and support (Kazungu, 2016). Consequently, students often experience limited encouragement from home, which affects both their engagement and performance in the subject. This situation underscores the importance of examining how parental engagement is understood and enacted specifically within the context of physical education.

Despite the growing recognition of parental engagement in education, existing research in Tanzania has largely focused on its relationship with academic achievement, particularly examination outcomes, with limited attention to subject-specific contexts such as physical education (Marwa, 2015; Kazungu, 2016). Moreover, little is known about how teachers conceptualise parental engagement in PE, or how this understanding shapes their strategies for involving parents in supporting students' participation and learning. Against this backdrop, a critical gap exists in understanding teachers' knowledge of parental engagement in physical education and how this knowledge informs practice. This study, therefore, examines how secondary school PE teachers in Tanzania perceive the role of parental engagement, the strategies they use

to involve parents, and how their understanding of socioeconomic differences shapes their instructional practices.

Specifically, the study addresses the following questions:

i) How do secondary PE teachers perceive the role of parental engagement in supporting students' participation and learning in PE?

ii) What strategies do PE teachers use to engage parents in physical education?

iii) How does teachers' knowledge of parents' socioeconomic status shape their instructional practices in PE?

2. Conceptual Framework

The study was guided by a conceptual framework developed by the researcher, based on concepts drawn from the literature. The conceptual framework outlines how schools and teachers implement structured activities and communication channels to involve parents in the educational process. School serves as a vital bridge connecting teachers, parents, and students in the learning process. It opens access to sports facilities and equipment and organises workshops and meetings to foster collaboration and support students' participation and learning in PE. On the other hand, teachers play a key role in communicating the importance of PE to parents and encouraging their involvement in PE programs and home-based activities. Once actively engaged, parents motivate their children, model an active lifestyle, and participate in school Physical Education activities. Parents engage in two main ways: through home-based activities and school-based activities. This dual approach enables parents to play an active role in both their children's academic and personal growth, creating a more supportive and holistic learning environment for PE. Generally, this conceptual Framework highlighted teachers and school roles in facilitating parents' engagement in supporting students' participation and learning in PE. The central focus of this framework was to explore the teacher's theorisation of parent engagement, the role of the school in empowering parents' engagement, and the contribution of parents' socioeconomic status to their engagement in supporting students' participation and learning in PE, as shown in Figure 1.

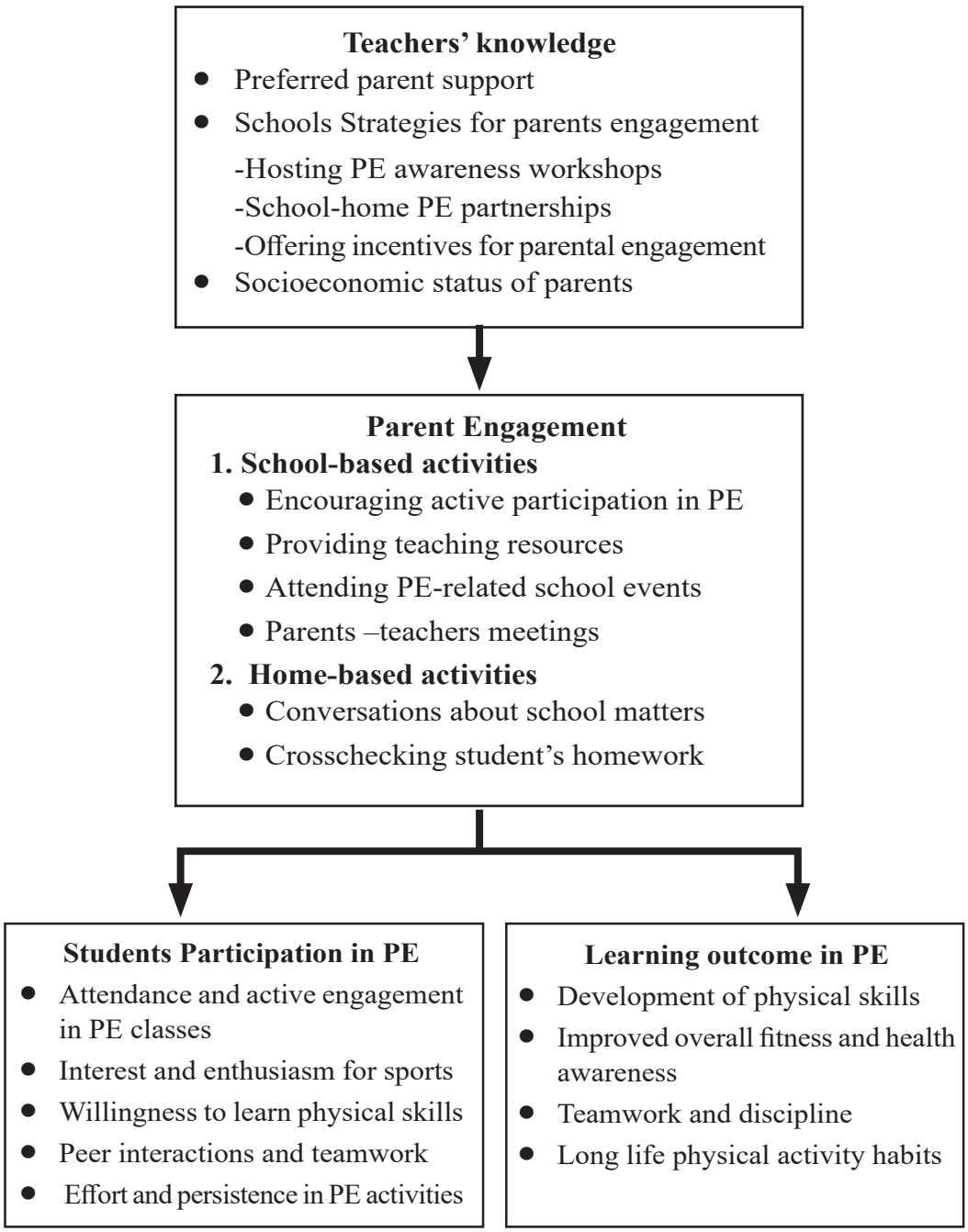


Figure 1: *Conceptual Framework Regarding Parent Engagement*

As shown in Figure 1, teachers' knowledge influences learning outcomes by first shaping how parents engage, which in turn shapes students' participation and ultimately their physical education outcomes. This sequential pathway heightens students' participation and learning in Physical Education.

3. Research Methodology

The social constructivist philosophical paradigm guided the study. The paradigm recognises the importance of human subjective creation of the meaning without rejecting some outright notion of objectivity. Moreover, the paradigm assumes the social construction of knowledge through interaction between researcher and participants via dialogue, questions, and other related methods (Kivunja & Kuyini, 2017). Furthermore, the paradigm assumes the social construction of multiple realities developed through personal experiences. Based on these assumptions, teachers' knowledge of parents' engagement was socially constructed through dialogue between the researcher and teachers. Multiple realities regarding parents' engagement were socially constructed through teachers' experiences in teaching PE, and meanings from those realities were developed through theme development. In addition, the paradigm informs the researcher to employ a qualitative research approach.

The study employed a qualitative research approach. The approach was useful for exploring views and opinions on teachers' knowledge of parents' engagement in supporting students' participation and learning in PE. Creswell (2018) highlights that the qualitative approach was useful when exploring why and how people think and behave about the phenomenon. This approach thus emphasises understanding teachers' perspectives and the meaning they attach to their practical experiences. By using this approach, the study was able to access rich information that illuminated the meaning and motivation behind teachers' actions in secondary schools. Moreover, the study employed an explorative case study design to examine teachers' knowledge of parents' engagement in students' participation and learning in physical education. According to Yin (2017), an exploratory case design was effective for addressing "what" and "how" questions and for generating rich, in-depth descriptions of complex social phenomena. It highlights how an event happens in the surrounding area. This design enabled researchers to develop detailed insights into how teachers view parents' engagement in supporting students' participation and learning in PE.

Furthermore, the researcher conducted a study in the Arusha region, located in northern Tanzania, which was well known for producing high-performing athletes in track and field. A few secondary schools in the region actively offer physical education (NECTA, 2024). Diverse populations live in the Arusha Region, with many residents engaged predominantly in livestock rearing and farming. These residences' economic backgrounds offer a unique context for understanding parents' engagement in supporting students' participation and learning in physical education.

The study employed a purposive sampling technique to select schools and PE teachers. The researcher selected schools purposively based on offering PE for more than 3 years. The researcher purposively selected teachers based on their qualifications as certified teachers, each with at least 2 years of teaching PE. Based on experiences, eight PE teachers were involved.

The researcher collected data from eight PE teachers at secondary schools. All teachers provided verbal consent after understanding the study's purpose. The researcher collected data through semi-structured interviews with PE teachers from four secondary schools in the Arusha region. Thirteen preset questions were designed to capture information on teachers' knowledge of parents' engagement, the strategies used to engage parents, and the impact of parents' socioeconomic status on the teaching and learning process in PE. Nevertheless, the probing questions facilitated further clarification from the respondents.

The interviews provided data on teachers' knowledge and perceptions of parents' engagement in supporting students' participation and learning in PE. The interviews helped researchers capture data on teachers' knowledge and perceptions of parents' engagement in supporting students' participation and learning. Each interview session lasted 40 minutes. Each conversation was audio-recorded, and notes were recorded in a diary. To minimise the limitations of non-verbal cues, probing questions were used to assess participants' understanding and encourage detailed responses.

Data from interviews were analysed thematically. This analysis method suited the context, as the researcher had limited prior knowledge about the data content gathered. The audio-recoded data were transcribed, after which the transcripts were carefully read and revised to ensure accuracy. The researcher manually coded the transcribed text. The key terms, phrases, and statements were inductively coded. Forty codes emerged, which were organised into twenty categories of related codes. From these groups, 15 initial themes were generated. The researcher then refined and merged these themes based on similarity and relevance, ultimately producing three major themes that captured the core ideas. The generated themes include (a) understanding of parent engagement, (b) schools' role and strategies in empowering parent engagement, and (c) knowledge of parents' socioeconomic status. To enhance credibility, members are rechecking employed to cross-check the accuracy of the themes. However, the pseudonyms such as Balodina, Qaymo, Felix, Francis, Kelvin, Marko, Zoro, and Karo were used in reporting the data to conceal their identity and privacy. After generating themes, the researcher developed a detailed findings report.

4 Findings

Teachers' knowledge of parents' engagement in students' activities was crucial for enhancing their participation and learning in PE. This study explored teachers' knowledge of parents' roles, the strategies they use, and the socioeconomic factors that enhance parent engagement in PE matters. However, the following are the detailed findings.

4.1 Teachers' Understanding of Parents' Engagement in Physical Education

Teachers' knowledge of parent engagement in PE activities enhances students' participation and learning within and beyond school contexts. When exploring teachers' understanding of the role of parents in supporting students' participation and learning in PE, teachers were asked to explain what parents' engagement means as used in PE. The majority of the teachers responded that parents' engagement encompasses involvement in school events such as sports and Bonanza, as well as the provision of basic items to facilitate students' learning. Teacher Qaymo, in elaborating on what parent engagement means in the PE context, had this to say:

> Mmh, from my experience, parents' engagement means parents' participation in the school Sport Bonanza. It may occasionally include providing basic resources to facilitate students' participation in PE. Schools, through teachers, often acknowledge the importance of parents' participation in their children's learning.

Teacher Zoro also had this to say:

> Parent engagement is about their awareness of the subject itself. Most of them, as is their tradition, believe that physical education contributes to students' failure. I think what matters is engaging them (parents) to raise their awareness of sports. However, PE helps students shine academically and physically in school, so long as they arrive at school earlier and clean the classroom.

The quotes above indicate that teachers equate parents' engagement with attendance at visible, structured school events, such as sports day. Although this type of engagement was essential, it was limited in scope. Some parents provide teaching materials, such as sports equipment and attire, indicating their support for PE when it involves tangible needs. Teachers' definitions reflect a somewhat limited perspective on parental engagement, focusing primarily on support for students' participation and learning in physical education while neglecting broader aspects such as ongoing communication and involvement in decision-making. Teachers may have mentioned Sport Bonanza as an opportunity

for parents to attend meetings where teachers interact with them and discuss matters related to physical education. To explore further teachers' understanding of parents' engagement in physical education, they were asked to describe the role of parents in supporting students' participation and learning in PE. The majority of the teachers responded that parents' role was to supply material support, such as equipment and sports attire. Teacher Karo, in elaborating on the role of parent engagement in supporting student participation in physical education, said the following.

> In general, parent engagement in physical education is similar to that in other subjects such as biology, physics, and Kiswahili. When parents are aware that their child is studying physical education and are asked to contribute items such as equipment and sports attire, some respond positively and purchase them. However, it was important to acknowledge that not all parents respond in this manner, as various factors, including socioeconomic background, cultural perspectives, and individual circumstances, can influence their level of engagement and support. For example, parents of third-year students at our school, whose children take physical education as an optional subject, often question their children's future career prospects. Some of these parents refuse to support their child's participation in physical education.

The above quotes reveal that the roles mentioned by teachers primarily involve providing material support. Parents facilitate the availability of sports equipment used in physical education lessons. However, this support largely depends on their level of awareness of the importance of physical education for their children's future careers. From the teachers' responses, it can be inferred that parents generally had limited awareness of the potential role of physical education in their children's career development.

To better understand parents' engagement, teachers were asked to specify the types of support they expected from parents. It was revealed that teachers expect material support, including assistance with facility maintenance. Teacher Karo, in elaborating the support that teachers expect from parents, shared the following insight:

> Personally, the type of support I would like to receive from parents regarding students' participation in physical education, for example, in those sports that need playgrounds, is the improvement of the playgrounds. Parents could also have been involved in purchasing equipment, such as a racket and balls. This kind of parental support could have been attractive for facilitating my students' participation and learning in PE.

In contrast, teacher Kelvin, in elaborating on the type of parents' support that teachers expect, has the following to say:

> .... It is good for parents to support the development of school playgrounds. For sure, we lack adequate playgrounds for games like soccer and netball at our school. If parents took an active role in improving the playgrounds, students would benefit significantly, as it would enhance their learning experiences and add value to their participation in physical education lessons.

As depicted in the quotes above, teachers confined parents' engagement to material facilitation. Moreover, the teachers expressed a desire for parents to contribute to maintaining school playgrounds and to provide sports equipment and attire. The emphasis was on facility improvement and equipment provision as the primary types of support expected from parents.

Moreover, teachers were asked to explain the importance of parents' engagement in supporting students' participation and learning in PE. Findings from the teachers' interview revealed that parent engagement motivates students' participation in PE. Students, through their parents' encouragement, develop a participatory attitude toward the PE lessons. Teacher Kelvin provides the following insight concerning the importance of parents' engagement in PE activities.

> Yes, for the overall development of the subject, parents' engagement is very important because it motivates students. If parents support a subject, it reinforces the perception that the subject holds value. Conversely, if parents disapprove of the subject, students may perceive it as unimportant and irrelevant to their lives. You know, others study PE because it's on the school timetable, without knowing its history or anything about it, until convinced by teachers.

As the quote above indicates, parent engagement is an important factor in encouraging students' participation and learning in physical education lessons. Students seem to conclude that physical education is important based on their parents' recommendations.

4.2 The School's Role and Strategies for Empowering Parent Engagement

Teachers' understandings of the school's role in empowering parent engagement are essential for promoting students' participation in physical education lessons. When interviewed about the school's role in fostering parent engagement, many teachers emphasised that organising sports competitions and establishing

playgrounds are among the school's key roles in fostering parent engagement. Teacher Balodina, in elaborating on how school can foster parent engagement, provided the following insight.

> I believe school can enhance parent engagement through organising various sports competitions at the school level. For instance, holding such events twice a year would be ideal for bringing parents closer to the school. Prioritising the upgrading of schools' playgrounds is also essential. Moreover, introducing a dedicated Parents' Sport Day could significantly enhance parents' involvement in PE-related activities. This day should be a true celebration of sports, with active participation from parents, students, teachers, and support from the school as a whole.

Similarly, teacher Qaymo, in elaborating the role of school in empowering parent engagement, had this to say.

> I think schools have an obligation to provide mechanisms to encourage parental engagement in their children's education. The head of school should plan to encourage teachers to put in place mechanisms to involve parents in students' education. To promote collaboration with parents, teachers should plan events and send invitations to parents. I think this is what school is supposed to do.

As the above quotes show, schools need to create an environment conducive to parents' engagement by organising sports competitions and sports days, and ensuring playground availability. Teachers highlighted that sports competitions and sports days serve as a bridge, bringing parents and students together in a shared sporting arena within the school compound.

Furthermore, when teachers were asked to identify the strategies commonly used to promote parent engagement in supporting students' participation and learning in PE, the majority highlighted parents' meetings. In elaborating the strategies for parent engagement in PE lessons in school, teacher Felix shared the following insight:

> Eeh, often we use parents' meetings. It is in such meetings that we inform parents about the presence of physical education, sport teachers, playgrounds, and related matters. At our school, we do not have any other strategies to facilitate parent engagement.

Teacher Zoro also had this to say:

> In my school, we use two ways to engage parents: individual and mass involvement. I prepared the plan by either contacting parents in person

> or by phone. I follow primary school students who are good at sports; after they graduate, I consult their parents to convince them to send their children to our school. The second method is through parents' meetings in schools, where the head of school reports to parents, including evidence of students' participation in national and East African secondary school competitions and their academic achievements.

The quote above underscores that parent-teacher meetings and physical visits are the primary strategies schools use to connect both parents and teachers. Key discussion points in those meetings often include the availability of PE teachers and the inclusion of academic and sports achievements in physical education within the school curriculum.

When teachers were asked to specify further the methods they use to communicate with parents regarding students' progress in PE, the majority emphasised parent-teacher meetings as the primary mode of communication within schools. Teacher Felix elaborated on this approach, stating that 'we communicate with parents through parents meetings during school closing season'. We reach out to them through invitations to these meetings. This statement highlights that parents' meetings, typically held at the end of a term or year, are the primary opportunity for informing parents about their children's progress. However, relying solely on such end-of-term or end-of-year meetings may provide limited insight into students' ongoing progress in physical education.

4.3 Teachers' Knowledge of Parents' Socioeconomic Status

Teachers' knowledge of parents' socioeconomic status was vital for fostering parents' engagement in students' participation and learning in PE. To elicit teachers' knowledge of parents' socioeconomic status, teachers were asked to describe the socioeconomic backgrounds of parents whose children are studying PE in secondary schools. Findings indicate that most parents are at a low income level and engage in animal farming. Teacher Felix says this while narrating the parents' socioeconomic status.

> Most of the parents, though not all, living near our school are pastoralists, with few working as government employees. A significant number of these parents are primarily engaged in livestock herding, which limits the time they can devote to their children's education. They earn little income, just enough to feed their families and, occasionally, cover school expenses when requested by the school.

As the above quote highlights, teachers recognised that most parents had low incomes, making it difficult for them to meet their families' basic needs. It was

also revealed that parents had limited time to engage in education-related matters, including their children's physical education.

When asked whether they had ever observed differences in parents' engagement based on socioeconomic background, many teachers responded that parents' socioeconomic status influences their mindset and decision-making. Teachers Francis elaborated on the difference in parents' socioeconomic status and its impact on supporting students' participation and learning in PE, by offering the following insight:

> Students from some low-income families sometimes come to school late, with an empty stomach or feeling weak when in class. I am sure these students are breadwinners in some families. They spent some time doing activities to earn money for themselves and their families. Interestingly, despite these challenges, such students often perform well in class.

Teacher Kelvin added:

> Although students from low-income families struggle in PE lessons due to limited resources, students from high-income families often undervalue PE. Even though they have enough sports attire and other essential equipment, PE is a last priority for them.

As highlighted in the quotes above, there was a relationship between family socioeconomic status and students' participation and learning in PE. Students from low-socioeconomic backgrounds face shortages of necessities, which negatively affect their engagement in PE. Conversely, students from high-income families experience different challenges often related to parents' expectations and preferences. This finding suggests that differences in parents' socioeconomic status influence students' motivation to participate in physical education.

When teachers were asked to explain how parents' socioeconomic status shapes PE lessons and instructional practices, the majority responded that parents' background affects students' decision to participate in physical education. Teacher Marko explained how parents' socioeconomic status influences PE lessons and instructional practices, offering the following insight.

> You know, this is a significant challenge to teachers. The majority of parents in this community are pastoralists with low incomes. Although the government mandates that students participate in physical education, not all parents are aware of its importance. For those who understand

> the value of PE, their children respond positively. Yet, for parents with limited awareness of PE, we must invest significant effort in educating them. It takes time for them to recognise the potential of a PE career for their children. This delay in understanding often results in delayed parental support for students and, subsequently, affects students' decisions to join physical education classes on time.

As noted in the quote above, parents' socioeconomic background affects teachers' decision-making ability to facilitate student learning in physical education. Students from low-income families often delay joining physical education classes because their parents are unable to provide adequate support, which, in turn, affects teachers' efforts to engage students in the learning process.

5. Discussion

This study examined teachers' knowledge of parental engagement in supporting students' participation and learning in physical education (PE). The findings reveal a predominantly narrow, material-oriented understanding of parental engagement, shaped by contextual constraints, institutional practices, and socioeconomic factors. Three key themes emerge: (i) the conceptualisation of parental engagement, (ii) strategies for engagement and communication, and (iii) the influence of socioeconomic status on engagement and learning.

First, teachers largely conceptualise parental engagement in terms of visible, event-based, and material support rather than as a multidimensional and relational process. Engagement is primarily associated with participation in school sports events, provision of equipment, and support for school-based activities. This contrasts with broader conceptualisations that emphasise home-based involvement, academic socialisation, and sustained interaction between parents, teachers, and students (Otani, 2020; Anastasiou & Papagianni, 2020; Tan et al., 2020). By privileging observable and resource-driven forms of involvement, teachers overlook less visible yet equally significant dimensions, such as parental expectations, communication, and support for learning at home. This limited framing constrains the development of comprehensive engagement strategies and reflects a tendency to align parental roles with immediate institutional needs rather than long-term learning processes. Relatedly, teachers equate parental engagement with resource mobilisation, particularly the provision of sports equipment and support for infrastructural development. While material support can facilitate participation, it does not, on its own, constitute meaningful engagement in learning. Evidence suggests that parental encouragement, role modelling, and involvement in children's physical activity are critical in shaping participation and motivation (Hosokawa et al., 2023;

Anastasiou & Papagianni, 2020). The emphasis on material support observed in this study may reflect structural realities, including shortages of facilities and equipment in schools, which position parents as supplementary resource providers. However, this orientation risks reducing parental engagement to a compensatory function and limits teachers' ability to mobilise parents as active partners in students' learning.

Second, the findings indicate that strategies for engaging parents are limited in scope and largely confined to formal and periodic interactions, particularly school meetings. While such meetings serve as important platforms for information sharing, they do not support continuous dialogue or collaborative engagement. This contrasts with broader approaches that emphasise partnership, cooperation, and formalised structures for parental involvement (Sharabi & Cohen-Ynon, 2022; Okeke, 2014). The reliance on end-of-term meetings suggests that communication between teachers and parents is episodic rather than sustained, thereby limiting opportunities for feedback, joint problem-solving, and active participation in students' learning. Communication channels such as telephone or written correspondence also appear underutilised and are often reserved for disciplinary issues, further limiting constructive engagement. In addition, schools frame parental engagement within logistical and performance-oriented domains, such as organising sports events and improving facilities. While these activities are important, they provide a narrow basis for assessing and fostering engagement. More transformative approaches emphasise the creation of inclusive and collaborative school environments that align parental expectations with educational goals and actively involve parents in learning processes (Tan et al., 2020; Sianturi et al., 2022). The limited scope of the school-led engagement strategies identified in this study suggests a need to reconceptualise schools' role from organisers of events to facilitators of sustained partnerships.

Third, teachers recognise that socioeconomic status shapes parental engagement, but they interpret this understanding primarily through a resource-based lens. Students from low socioeconomic backgrounds are perceived to face constraints related to unmet basic needs, which affect their participation and learning in PE. This aligns with broader evidence linking socioeconomic disadvantage to reduced parental involvement and educational challenges (Şengönü, 2022; Kapinga, 2014). Conversely, parents from higher socioeconomic backgrounds are often seen as capable of providing material support and influencing educational decisions, although their direct involvement may be limited due to professional commitments (Poncelet et al., 2023; Naite, 2021). However, the findings also reveal a more complex dynamic. While students from higher

socioeconomic backgrounds benefit from access to resources, they do not necessarily demonstrate greater engagement in PE, partly because parental emphasis on the subject is limited and there are few relevant role models. This contrasts with assumptions that higher socioeconomic status uniformly enhances educational engagement (Wardere et al., 2020; Sujarwo et al., 2021). These patterns suggest that socioeconomic status influences not only the capacity to engage but also the value attached to specific subjects, with implications for students' participation and motivation. Furthermore, teachers appear to adapt their instructional practices based on their perceptions of students' socioeconomic backgrounds, particularly regarding resource availability and participation levels. While such adaptations may be responsive to contextual realities, they also reflect an implicit normalisation of inequality, in which parental engagement is primarily understood in terms of financial contributions rather than broader forms of involvement. This reinforces a limited understanding of engagement and may inadvertently constrain efforts to promote inclusive participation.

Overall, the findings indicate that teachers' knowledge of parental engagement is shaped by institutional constraints, dominant educational priorities, and socioeconomic realities, leading to a predominantly material, event-based orientation. This narrow conceptualisation limits the potential of parental engagement as a relational and pedagogical resource for supporting students' participation and learning in physical education. Finally, it is important to acknowledge the study's limitations. The small sample size and focus on a limited number of schools restrict the generalisability of the findings. In addition, the use of purposive sampling limits the extent to which the results can be transferred to other contexts. Future research could expand the sample and incorporate multiple stakeholder perspectives to provide a more comprehensive understanding of parental engagement in physical education.

6. Conclusion and Recommendations

Parental engagement in PE plays an important role in shaping students' participation and learning. This study shows that secondary school PE teachers largely perceive parental engagement in narrow, event-based and material terms, focusing on participation in school sports activities and the provision of resources rather than on sustained, relational forms of involvement. This limited conceptualisation constrains the potential of parental engagement as a pedagogical resource for supporting students' learning. In terms of engagement strategies, teachers rely primarily on school–parent meetings as the main mechanism for interaction. Although these meetings provide a platform for communication, they remain episodic and insufficient for fostering continuous

dialogue and meaningful collaboration. As a result, opportunities to engage parents as active partners in students' learning processes are underutilised. The findings further demonstrate that teachers recognise the influence of parents' socioeconomic status on students' participation and learning in PE. However, this influence is interpreted largely through a resource-based lens, where parental support is associated with material provision rather than broader forms of involvement. Consequently, teachers' instructional practices and expectations are shaped by assumptions about students' home backgrounds, which may reinforce inequalities in participation and engagement. Overall, the study highlights the need to reconceptualise parental engagement in PE beyond material and event-based approaches, and to promote more inclusive, communicative, and collaborative forms of involvement that support students' holistic learning.

Based on the study's findings, it was recommended that physical education teachers should reconceptualise parent engagement beyond event-based and material contributions by participating in a professional development program that emphasises collaborative and communicative forms of involvement. Moreover, schools should strengthen and diversify their communication channels, including meetings, workshops, and digital platforms, to foster continuous, meaningful interaction with parents. Schools should further integrate parents into a more holistic support system by involving them in school-based and home-based activities to enrich students' learning experiences. However, future studies shall focus on the feasibility of implementing parent involvement strategies to support students' participation and learning in physical education.

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An Inquiry into the Relationship Between the Probability Language Skills and Achievement

Muhagachi Peter Chacha[1] & Joseph Njiku[2]
[1&2]Dar es Salaam University College of Education, Dar es Salaam, Tanzania
Corresponding author[2]: *leunati@gmail.com*

Abstract

The cognitive processes underlying mathematical thinking are intrinsically tied to language, underscoring the interdependence of linguistic capabilities and mathematical proficiency. This study employed a correlational research design to examine the probability language skills of secondary school students and to explore how these skills correlate with their probability achievement. A sample of N = 49 students participated in probability language assessments alongside classroom probability achievement tests. Results revealed that while students demonstrated strong probability-related linguistic abilities, their comprehension and interpretation of probability concepts were notably low. Furthermore, a significant positive correlation [r (49) = 0.532, p < .01] was observed between students' probability language skills and their performance in the achievement tests. These findings underscore the potential role of mathematical language in the cognitive assimilation of mathematical concepts.

Keywords: *mathematical language, mathematics symbols, mathematical syntax, mathematics vocabulary, probability*

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1. Introduction

Imagine a teacher guiding students to draw a table and explaining that it must have 5 columns and 5 rows. Some learners begin wondering how a column used in buildings is used to draw a table, let alone having rows and not legs. To add to the confusion, there are signs such as +, – , and = that are commonly used in mathematics and other disciplines. Whenever such words and symbols are used, they may communicate a mathematical process or concept (Makonye, 2019), especially in a mathematical expression or statement. Many other signs are used in mathematics and may vary depending on the topic. To grasp the meaning of what is communicated in mathematical texts, symbols, or diagrams, one needs to understand the meanings of the symbols and expressions (Njiku, 2024), since mathematics is analytical in nature. Understanding mathematical symbols and vocabulary has been an area of research interest (Jourdain & Sharma, 2016;

Sepeng & Madzorera, 2014). Learners have been found to misinterpret the meanings communicated mathematically using various symbols, vocabulary, and diagrams (Chin et al., 2022; Sepeng & Madzorera, 2014). For example, Thompson and Chappell (2007) show that even simple operations such as + and – may be problematic. For instance, when simplifying the expression 12 – 4 + 5, students incorrectly wrote 12 – 4 = 8 + 5 = 13, implying that 12 – 4 = 13. Mathematical language has its semiotics. For example, Chin et al. (2022) show that the wording of the expression 2 + 2 x 3, when read left to right, confuses learners, because the operation 2 x 3 must be performed first, whereas 2 + appears first. These difficulties explain the need to draw attention to learners' difficulties and give more attention to mathematical language in general for effective learning.

Njiku (2024) explains that mathematics language is a foreign language to many, which is learnt and spoken at school. It is only at school that students have an opportunity to communicate mathematically, including speaking, writing, reading, and listening to mathematics language (Thompson & Chappell, 2007). However, at home, it may involve naming small numbers and informal expressions, but it also points out that such uses do not directly or correctly map onto the mathematical syntax. When learners discuss mathematics concepts, they tend to use peer-appropriate everyday language, which may inhibit the development of their understanding of the required mathematical register (Kotsopoulos, 2007). Nevertheless, in everyday conversations, learners' discussions may reveal complex mathematical structures, though not in a formal way, requiring teachers to bridge the gap between everyday and formal mathematical language (Simpson & Cole, 2015). Multiple representations may be used to effectively communicate mathematical meaning (Arias de Sanchez, 2022), and articulation involves verbal embodiment of mathematical symbolism, expressions, or equations (Chin et al., 2022). This communication involves, for example, semantically representing an algebraic expression graphically or syntactically, whereby mixed fractions may be presented as improper fractions. This paper examines whether competences in mathematical language relate to performance in probability.

In probability, a common topic in school curricula, language problems have been observed (Groth et al., 2016). Whereas probability as a topic shares much with everyday language, its formal mathematical meaning may still pose difficulties for learning probability. In everyday language, probability is used in discussions of weather forecasts, the possibility of a traffic jam, and political debates about which candidate is favoured. Everyday discussions about probabilities may

involve informal vocabulary different from formal probability language but useful for learning (Findley et al., 2021). Students have been reported to struggle with simple words such as likely, unlikely, average, and random (Groth et al., 2016), especially because of their imprecise use in everyday communication (Findley et al., 2021). These difficulties may influence students' performance in probability, and this study examines students' competencies in probability language and their relationship with performance.

2. Theoretical Framework

Language is not only a way by which people communicate, but it also aids thinking. This notion is found in classical work by Vygotsky (1986), and other scholars such as John Dewey and Paulo Freire have adopted this view of the importance of language as a socio-cultural element informing learning to a democratic notion of learning and critical approaches to education, respectively (Aubrey & Riley, 2022). Language influences thought, and since mathematics is a thought-based discipline, this renders the topic necessary, especially for mathematics instruction. Language is context-based (Arias de Sanchez, 2022; Vygotsky, 1986), and this context may influence how it accommodates mathematical aspects. Kotsopoulos (2007), for example, shows that everyday language influences students' approaches to mathematics, since mathematics is language-dependent. The interaction between the mathematical language on which mathematics depends and everyday language creates difficulties in learning the subject. Mathematical language possesses a register whose meaning is shared by the social group of mathematicians or those who do mathematics. Although Vygotsky's theory argues that language comprehension does not necessarily require understanding specific vocabulary, mathematics is more analytical than common language, whose vocabulary may require more attention. Appropriate conceptions of probability or statistical terms are important and should be reinforced, especially when students are required to construct and articulate viable arguments and conjectures (Simpson & Cole, 2015). For instance, Nabbout-Cheiban (2017) found that students misinterpreted the concept of independent events as a property of a pair of events; instead, they considered them as one-way, as in the case of one person who may depend on another, where the latter is independent of the former. The use of the words 'dependent' and 'independent' in daily life made the concept of independent events complex (Nabbout-Cheiban, 2017). The view that understanding the concepts communicated is the pivot upon which mathematics depends (Bhuvaneswari & Umamaheswari, 2020; Quinnell, 2019) underscores the importance of language in mathematics. For these reasons, studies of mathematical language may serve to understand mathematics and inform mathematics instruction.

3. Literature Review

3.1 Mathematics as Language

Mathematical language involves specific symbols, numerals, words, and their combinations in diagrams, graphs, and numerical expressions. Mathematical language may include words (Hornburg et al., 2018) such as more, less, take away, and most in numeracy; odd, even, and prime in numbers; mean, mode, and median in statistics; log and ln in logarithms; product, sum, difference, quotient, and remainder in operations; perimeter, area, radius, diameter, and chord in geometry; and sine, cosine, tangent, hypotenuse in trigonometry. Some of these words are used in general language and may therefore have different meanings in mathematical language. Thus, they must be relearned within the mathematical register. Their meanings may also differ across topics in mathematics, such as the median, which is used in statistics but not in geometry (Thompson & Chappell, 2007). When these words, phrases, symbols, and their syntax are used to communicate mathematics concepts, they are referred to as the language of mathematics.

The arrangement of these mathematical symbols, numerals, and words forms a special syntax that carries specific meanings. The meanings may be represented in multiple ways, such as graphs, diagrams, word problems, or algebraic expressions. This may sometimes be done pedagogically to aid learning. For example, diagrams and multiple representations are generally considered positive influences on learning (Batanero & Álvarez-Arroyo, 2024). From a syntactic point of view, for example, learners need to know that $3(x + 5) = y$ remains correct when written as $x + 5 = y/3$ (Leibowitz, 2016). Also, numerals such as 1 and 2 are values in terms of quantity that differentiate them (Schmitt et al., 2019). Thus, learning mathematics involves learning the language of mathematics, which is often specific to mathematics and, even more so, topic-specific (Hager, 2018). Through communication, such as writing and explaining, teachers can identify students' difficulties with the content (Sepeng & Madzorera, 2014). Experience shows that teachers tend to help learners understand the meaning of the mathematical language before focusing on mathematics itself. Also, Arias de Sanchez (2022) points out that learning the language of mathematics is part of learning mathematics. This suggests there may be a relationship between mastery of the content and the ability to communicate it. Various studies (Makonye, 2019; Sepeng & Madzorera, 2014) have examined English or mathematics language competence in relation to mathematics performance. The general conclusion is that there is a relationship between the ability to express oneself in English or in mathematical language and performance in mathematics (Jourdain & Sharma, 2016).

The literature suggests a close relationship between what happens in the common language and the formal mathematical language, requiring special attention to register that construes specific mathematical meanings (Jourdain & Sharma, 2016; Makonye, 2019). This view suggests that some registers carry special meaning in different contexts, and learners who come to the class with prior knowledge from a different context may be confused when their use is not clarified in a new context (Yanik, 2011). This assertion follows from the view that some words used in a common language may have precise meanings in other contexts, such as in normative mathematical conceptualisation (Yanik, 2011). However, mathematical language becomes more foreign when symbols are used to convey actions or expressions that act as complete sentences or when everyday words like table, factor, round, and eliminate are used in mathematics classrooms.

This study is situated in Tanzania, where subject-specific language is under-researched. In Tanzania, performance in mathematics has not only remained low (Kyaruzi et al., 2019; Kisakali & Kuznetsov, 2015), but has also affected boys and girls differently (Njiku, 2019). Boys and girls have been recorded to perform differently in mathematics, leading to gender gaps attributed to cultural factors (Mazana et al., 2020) and limited inclusive language. Previous research has shown that boys perform better than girls in mathematics (Mazana et al., 2020). These studies did not discuss gender differences in mathematical language. This study intends to examine this topic further by comparing the performance of boys and girls, including their mathematical language skills, especially in probability.

3.2 Mathematical Language Skills and Performance

The ability to express oneself in mathematics goes beyond the register of any common language, such as the English language. It can be done with minimal understanding of such a common language. Communication in mathematics involves mathematics-specialised language. Mathematical language is used to communicate mathematically and carries conceptual knowledge in mathematics. The language of mathematics is, in fact, concept-based, and without it, mathematics cannot be communicated. This area has received little attention in the literature. For example, Njiku (2024) points out that, despite some attention to vocabulary, little has been done to address ambiguities, double or multiple meanings, and word problems in mathematics. Consequently, the current study examines the level of mathematical language students possess and whether it relates to their mathematics performance.

With a focus on the relationship between ordinary and mathematical language,

Jourdain and Sharma (2016) argue that, for success in mathematics, students must learn the ordinary-language register and its specific meanings in mathematics. Thompson and Chappell (2007) add that discussing mathematical concepts with colleagues leads to a deeper understanding than merely solving mathematical problems. However, the language in use may have different influences on the difficulties. Njiku (2024) provides an example that the number 12 is called twelve, a name that seems to have no relationship with other numbers, as may be the case in Chinese, where 12 is ten and two. This is the case in some languages like Kiswahili, the native language of most participants in this study. Although it may be accepted that mathematics learning occurs in a cultural space (Makonye, 2019), 12, for example, communicates the quantity it represents to people regardless of their language. For example, the place values of 1 and 2 are known, and when performing operations, these values must be treated consistently irrespective of the language in use. This mathematical syntax does not change meaning or quantity, regardless of the form or nature of the language (Leibowitz, 2016). The 12 is a numerical representation of a quantity, and its meaning is consistently conveyed across cultures. Moreover, the positions of the numerals communicate yet another thing – the value. And mathematical syntax does not change across cultures.

When mathematical language is viewed from a non-symbolic perspective, it may suggest a yet different debate. For example, working on numeracy with young children, Fuchs et al. (2010) and Hornburg et al. (2018) conclude that mathematical language, including vocabulary suggested by Purpura and Logan (2015), such as more, less, take away, fewest, most, near, and far have no relationship with formal addition (such as in 1 + 2). Evidence from this line of thinking shows that learners can confidently perform addition with relevant mathematical expressions, such as 1 + 2. However, they are unable to succeed in solving story problems bearing the same concept (Mayer & Hegarty, 1996). On the contrary, it is also viewed that mathematical language can significantly predict the execution of mathematical problems (Schmitt et al., 2019). Given these divergent views, in this paper, we consider numerals such as 1, 2, and 3 and signs such as +, – , and = as a mathematical language register. Hence, they carry a specific meaning. When performing operations, one must know what 1 or 2 represents in terms of quantities and be able to interpret the expression 1 + 2 mathematically, appropriately use the sign =, and correctly communicate the answer 3 in a numerical form. Language use can potentially affect the learning of the subject matter (Yanik, 2011). This paper investigates how specific mathematical language influences students' performance, as the literature (Hornburg et al., 2018; Mayer & Hegarty, 1996)

indicates that some difficulties stem from an inability to comprehend problems rather than from carrying out procedures.

At the early stages of elementary education, students' mathematical language skills are naïve and primarily related to everyday, familiar experiences (Simpson & Cole, 2015). Students aged 7-8 may use probability language accurately, especially when explaining the likelihood of chance events, but find it hard to explain impossibility and certainty, even by 11-12-year-old students (Groth et al., 2020; Kazak & Leavy, 2018). Students whose home language is not English tend to have limited skills in interpreting mathematical problems compared to native English speakers (Christiansen & Aungamuthu, 2012). Teachers are recommended to bridge these gaps between everyday language and formal mathematical language to avoid confusion. Studies examining probability language have focused solely on vocabulary (Findley et al., 2021; Groth et al., 2016). In this study, we extend the discussion to other elements of probability language, including symbols (writing given sentences/phrases in symbols), wording (writing given symbols in words), and interpretation (explaining what a mathematical statement means).

3.3 Probability Language

In probability, the focus of this paper, multiple studies (Nabbout-Cheiban, 2017; Sharma, 2014; Teigen et al., 2014; Wagner et al., 2015) have been conducted. Teigen et al. (2014) show that probability language is common, as in explanations of the possibility of rain tomorrow or of whether people's interest in a political wing will increase. In such cases, percentages may be used. Words such as certain, possible, most likely, random, mutually exclusive, and chance carry probability meaning. Gal (2005) identifies other terms such as randomness, chance, independence, predictability, and certainty. It follows that probability is part of everyday life and influences individual and collective decisions (Gal, 2005; Sharma, 2014). Probability language is a combination of words, symbols, and their syntax used to communicate concepts in probability topics. In the secondary school curriculum, a combination of symbols such as P(A) and P(A'), words like complement and union, and interpreting statements like the probability of an event is 1 carries this specific language of definite concepts in probability. Language is considered a window to understanding probability (Wagner et al., 2015). Knowledge of probability is essential for interpreting and critically evaluating data-based information (Sharma, 2014).

Probability literacy includes, among other domains, the language of probability. Probability language includes understanding words and phrases, as well as various ways to represent and communicate about the occurrence of events

(Kazak & Leavy, 2018). Whereas many studies on probability language are limited to vocabulary (Findley et al., 2021; Groth et al., 2020; Groth et al., 2016), mathematical language contains multiple elements, including written and oral language, symbols, and visual representations (Simpson & Cole, 2015). These elements are essential for the appropriate interpretation of mathematical problems. Although understanding probability is seen as crucial, and mathematical language influences performance, little is known about the relationship between these two: probability performance and probability language skills. In this paper, we examine students' probability language skills and their influence on students' performance on the topic. To do this, we assess three four elements, vocabulary, wording, symbols and interpretations to address the following questions:

i) What mathematical language skills do students possess in probability?

ii) Do students' probability language skills differ by gender?

iii) What is the relationship between students' mathematical language skills and performance in probability?

4. Methodology

4.1 Study Design and Participants

Situated in the classroom where one of the authors was teaching, the study was designed to examine the relationship between students' mathematical language skills and their performance in mathematics. Specifically, the study employed a quantitative approach and adopted a correlational research design to examine the relationship between probability language skills and performance in probability. The study uses data about students' gender, mathematical language skills, and achievement in probability. The study involved 49 secondary school students (18 females and 31 males). In the context of the study, these were fourth-year secondary students whose syllabus covered probability. Their age range was 14-18 years ($M = 16.49$, $SD = 0.74$). Because the study assessed knowledge of probability and its language, the students selected for the study had completed the curriculum topic on probability. To reduce potential biases, data analysis was conducted by the other author. Additionally, participants were assured of anonymity, and consent was obtained before their participation.

4.2 Instruments and Data Analysis

The researchers developed the data collection tools. The development was especially necessary for the language part since no existing tools from the Tanzanian context assessed the language of mathematics. To assess students'

probability language skills, we used items distributed across four dimensions: symbols: 3 items (for example, write in symbols: Probability of A intersection B is equal to two out of five), wording: 2 items (for example, write in words: P(A')), interpretations: 2 items (for example, What does it mean by saying that the probability of an event is 1?), and vocabulary: 2 items (for example, What it means by impossible event?). We also used five items to assess students' achievement in probability. Content validity was ensured by designing items on the topic under investigation (Ary et al., 2010) – probability – and testing them only with students who had learned the topic. Two experts with experience in teaching the topic reviewed the items for relevance. The split-half reliability by the Spearman-Brown formula was used to calculate the coefficient where:

= estimated reliability of the test

= person r correlation between the two halves of the test.

The language test had the reliability of r_{xx} = .673, and the achievement test had the reliability of r_{xx} = .722. Although the coefficients were low and acceptable rather than good, we proceeded with the study because this might have been partly due to the test length (Ary et al., 2010), given that the study was classroom-based. Although the number of achievement test items was five, they were considered sufficient because a single mathematical problem may be solved through several stages that require knowledge from multiple concepts and adequate time.

Research questions guided the data analysis. Descriptive statistics (mean for central tendency and standard deviation for dispersion) were used to address the first research question on students' mathematical language skills. The second research question was addressed using descriptive statistics (mean and standard deviation) and the *t*-test. The Pearson correlation was used to examine the relationships among mathematical language skills and achievement. The study did not use effect sizes to complement the *p*-values for the *t*-test since non-significant differences were observed.

5. Findings

5.1 Students' Level of Probability Language Skills

To address the first research question, descriptive statistics were used to analyse students' performance in the language skills test. Findings are presented in Table 1, by specific language dimension and overall, using means and standard deviations. Each dimension was scored out of 100 for consistency.

Table 1
Students' Performance on Probability Language Skill Test

	Mean	Standard Deviation
Symbols	80.44	6.33
Wording	76.36	7.23
Interpretation	41.84	4.67
Vocabulary	83.67	6.45
Overall language	70.58	18.13

Figure 1: *Students' Scores in Probability Language Skills*

Overall performance in the probability language test was 70.6%. Similarly, data show that students performed highly in the dimensions of symbols, wording, and vocabulary, with scores of 80.4%, 76.4%, and 83.7%, respectively. However, the score on students' ability to interpret probability concepts was only 41.8%. Figure 1 shows language scores ranging from 21 to 88, with the majority (31) of students scoring above the average of 70.58. This suggests that students who scored below the mean, although few (18), greatly affected the overall mean. The median score was 75, the minimum score was 21, and the maximum was 87.5.

5.2 Probability Language Skills by Gender

Further analysis examined how students' performance levels in probability language skills were distributed based on gender. This comparison used both descriptive and inferential statistics. In this analysis, achievement test scores (out of 100) were also included. Table 2 below summarises the findings using mean scores and standard deviation.

Table 2
Students' Performance by Gender

Gender	Symbols	Wording	Interpretation	Vocabulary	Language	Achievement
Female	78.75(2.63)	79(3.01)	43.58(2.05)	85.5(3.17)	71.71(7.31)	42.56(7.82)
Male	83.33(3.69)	71.75(4.19)	38.92(2.57)	80.58(3.01)	68.65(10.87)	40.00(10.63)

Note: Language scores are the average scores of symbols, wording, interpretation, and vocabulary.

Findings show that females outperformed males in the achievement test, the overall probability language skill test, and three of the four dimensions of the probability language skill test. These differences were further investigated using

an independent samples *t*-test. The findings from this analysis are summarised in Table 3.

Table 3

t-test Results for Probability Language and Achievement Tests Between Female and Male Students

	t-statistic	*p*-value
Symbols	-0.605	0.548
Wording	0.775	0.445
Interpretation	0.840	0.405
Vocabulary	0.641	0.525
Language	0.512	0.613
Achievement	0.390	0.699

From Table 3, it may be observed that none of the *p*-values was less than 0.5. This suggests that none were statistically significant, despite differences in mean scores between females and males.

5.3 Relationship Between Probability Language Skills and Performance in Probability

The bivariate Pearson correlation coefficient was used to address the third research question, which examined the relationship between language skills and performance. Students' scores in the probability language skill test and the achievement test were correlated, and the findings are summarised in Table 4.

Table 4

Correlation Between Probability Language Skills and Achievement Test Scores

	Symbols	**Wording**	**Interpretation**	**Vocabulary**	**Language**	**Achievement**
Symbols	1.000					
Wording	.304*	1.000				
Interpretation	.610**	.407**	1.000			
Vocabulary	.298*	.240	.583**	1.000		
Language	.733**	.695**	.840**	.705**	1.000	
Achievement	.504**	.244	.486**	.376**	.532**	1.000

Note. $^{**}p < .01$, $^{*}p < .05$

The findings from correlation analysis show that scores from the probability language skills test correlated positively with performance in the probability achievement test, r (49) = 0.532, $p < .01$. This means that the coefficient of determination $r^2 = .283$, indicating that about 28.3% of the variability in

the achievement test may be explained by the probability language skills. The relationship between the specific probability language dimensions and achievement test performance was positive and significant except for wording. This suggests that the ability to turn probability symbolism into words did not relate to performance in probability.

6. Discussion

The study assessed secondary school students' probability language skills. Language skills enable students to understand and communicate mathematically. Limited ability to communicate mathematically may consequently affect their learning of the topic and performance (Nacarato and Grando, 2014), although such an analysis was not conducted in the study. Findings show that students scored high in language skills in general. It is worth noting that the inquiry into the relationship between language and thought is historical and is evident in Vygotsky's (1986) classical work, Thought and Language. However, when specific language dimensions were examined, students scored high in symbols, wording, and vocabulary but low in interpreting mathematical meanings. Similar findings are reported by Kotsopoulos (2007), who argues that interpretation requires an understanding of mathematical register and the context in which it is used, and that learners find it challenging to associate everyday register with mathematical register. Unlike the current study, in which vocabulary was scored highly, Nacarato and Grando (2014) report challenges with vocabulary; their findings align with this study's findings regarding how such vocabulary is used in real contexts, as shown in the interpretations students provided, which differed from the appropriate mathematical registers. In this study, for example, students were told to explain the meaning of "the probability of an event is zero" and "the probability of an event is one". Students might have needed to use words such as 'impossible' or 'sure event' to provide such explanations. However, as Lesser et al. (2016) noted, this would be difficult for learners whose language of instruction is not their first language. Furthermore, the limited ability to interpret mathematical meanings suggests the need to integrate mathematical language in instruction since, as Arias de Sanchez (2022) argues, language does not exist in isolation.

Females and males may have different language abilities, which may also result from classroom or out-of-class interaction. Gender differences in relation to mathematical language have received little attention in the literature. For example, although Bhuvaneswari and Umamaheswari (2020) collected data about participants' gender, their analysis lacks this variable. Kotsopoulos (2007) shows that interaction between students leads to register interference, which may

include peer-appropriate language but differs from appropriate mathematical registers. No differences are expected between females and males when such interaction is not gender-based. The findings show no significant difference between females and males in probability language skills. Nevertheless, the descriptive statistics showed that females performed better than males, except in one dimension.

Although the descriptive statistics showed that females generally had better language skills and outperformed males on the achievement test, the difference was not statistically significant. In previous studies, males have usually been reported to do better in mathematics than females (Njiku, 2019). Sampling and sample size are likely contributing factors to these findings. Unlike in this study, when such differences become significant, teachers may need to facilitate mathematical discussions and conversations during learning sessions to bridge gaps that may exist between females and males. Teachers may need to do so to facilitate mathematical discussions and conversations during learning sessions. The findings show that language skills and achievement are positively correlated. Limited studies have examined the topic in relation to performance. For example, focusing on English rather than mathematical language, Tanko et al. (2022) examined its relationship with mathematics performance and found a positive, significant relationship.

However, various studies have framed their arguments around the relationship between mathematical language and learning or difficulties in learning. For example, Nacarato and Grando (2014) argue that students' familiarity with probabilistic language provides them with a linguistic repertoire that they may use to justify their mathematical solutions. Similarly, Quinnell (2019) associates understanding mathematical language with understanding mathematical concepts. However, in this study, one dimension – wording – had no significant correlation. These results were surprising, as the wording seems to be deeper than simple vocabulary, involving articulation in writing (Chin et al., 2022). This is probably because turning symbols into words requires them to use mathematical registers that they unfortunately use in everyday life, but in a different context (Nacarato & Grando, 2014). A similar observation is made by Nabbout-Cheiban (2017), who found that students encountered difficulties understanding the concept of independent events, and the author argues that this was probably due to the meaning of the word 'independent' as used in daily life language. Also, similar difficulties in probability are reported among teachers and are also partly associated with language (Molnar, 2016).

7. Limitations of the Study

Since the study was contextualised in the classroom, the context may differ from other schools. Thus, it is difficult to generalise; where needed, it should be done cautiously. Also, since the study adopted a quantitative approach, it did not provide qualitative perspectives. Further investigations are recommended to adopt mixed-methods approaches to provide a more comprehensive picture of the nature of the language students use in mathematics. Furthermore, the study used a correlational design with a small sample size, which does not establish causal claims. Further investigations may address the limitations of the design by adopting designs that establish a causal relationship between probability language skills and achievement in probability. Furthermore, the achievement test consisted of only five mathematical problems. The assessment tool for probability achievement can be improved by increasing the number of items that span various concepts of the topic, while accounting for other factors such as time, item difficulty, and the problem-solving demands of the items.

8. Conclusion

The study found a relationship between probability language skills and achievement, where students demonstrated fairly good language competencies. The relationship may suggest that as students become familiar with mathematical registers and their use in mathematical contexts, they also develop the ability to understand and solve mathematical problems. Although the relationship examined in this study is not causal, a positive association was observed, which warrants further causal and qualitative investigation. To this end, teachers may need to dedicate more time, through action research, to exploring how mathematical language can be appropriately adopted in the classroom. This may also include practising dialogue in mathematics classrooms in order to develop subject-specific language competencies. To do this, we argue that teachers must clearly understand students' needs in mathematical language and actively engage students in articulating the elements of mathematical language that may be used across various mathematical problems.

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Socio-Demographic Differences in Physical Access to Digital Technologies among Secondary School Students in Tanzania

Jacqueline Nkwamah[1], Albert Tarmo[2] & Wadrine Maro[3]
School of Education, University of Dar es Salaam, Dar es Salaam, Tanzania
Corresponding author[1]: jacqseba2017@gmail.com
Email[2]: paulo.albert@yahoo.com
Email[3]: marowadrine2016@gmail.com

Abstract

This study examined secondary school students' physical access to digital technologies and the influence of selected socio-demographic characteristics on access. The study employed a cross-sectional survey design with 1,997 students from 39 secondary schools, selected using stratified and systematic sampling. Data were collected using a structured questionnaire guided by Jan Van Dijk's Resources and Appropriation Theory. Descriptive statistics were used to determine levels of physical access to digital technologies, while independent-samples t-tests and one-way ANOVA examined differences across students' socio-demographic characteristics. The findings indicate that 57.2% of students reported moderate physical access to digital technologies, and 23.5% reported high physical access. Access varied significantly across several socio-demographic factors, including school type, gender, age, students' education level, parental education, and parental employment status, though the effect sizes were relatively small (η^2 = 0.46%–3.64%). Interestingly, female and younger students reported slightly higher levels of physical access than their counterparts. Overall, the results show that students' access to digital technologies is generally greater at home than at school. The study concludes that many secondary school students still experience limited access to digital technologies, particularly within school environments.

Keywords: *digital divide, physical access, material access, secondary school students, digital technologies, Tanzania*

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1. Introduction

AAccess to digital technologies is a critical enabler of sustainable development at the individual, community, and national levels (ITU, 2024; Sharp, 2024; UNDP, 2022). Without equitable digital access, social and economic disparities are likely to deepen, undermining efforts toward achieving the Sustainable

Development Goals (SDGs) (Van Dijk, 2013; UNDP, 2022). The digital divide is linked to the growth and development of countries and regions, where highly developed countries also have greater access to digital technologies, specifically the internet. On the contrary, the marginalised regions have the lowest access (ITU, 2024). It is a global agenda to promote access to digital technologies for sustainable development. Physical access to digital technologies remains an area of interest in bridging the digital divide in education. While some studies suggest that the first-level digital divide, based on motivation and physical access gaps, is closing, material access, especially in developing countries, remains uncertain (Van Deursen & Van Dijk, 2019).

Earlier research often focused solely on device availability, overlooking the need for a sustainable supply of hardware, software, electricity, and internet connectivity. Without these, the first-level digital divide persists and underscores the need for ongoing research on physical access gaps. Digital technologies are important in education for preparing students for a rapidly evolving world (Oreku, 2022). Unlike traditional classroom teaching, digital learning provides an immediate learning environment, faster assessment, and greater engagement, enabling students to play a more productive role and be at the centre of the learning process (Dancsa, 2023). Ensuring equality in physical access is therefore crucial to enabling all students to develop the digital skills required for a digital age and to enhance their learning experiences with technology.

This paper examines whether secondary school students of varied demographic characteristics in Tanzania have reliable physical access to digital technologies for learning. The paper forms part of a broader study that investigates predictors of students' use of digital technologies for learning. While the broader study examines multiple factors influencing digital technology usage, the focus of the present paper is specifically on the first-level digital divide, that is, students' physical access to digital technologies. Accordingly, this paper reports descriptive statistics on levels of access and examines differences across key socio-demographic characteristics. The analysis, therefore, emphasises group comparisons rather than predictive modelling.

2. Literature Review

2.1. Physical Access

The most common meaning of access to digital technologies is physical access, referring to devices such as desktop computers, laptops, smartphones, and tablets (Van Deursen & Van Dijk, 2019). However, physical access involves not only purchasing a particular technology but a continual process of getting

access to new versions of hardware and software, peripheral equipment, and subscriptions (Resta et al., 2018; Van Dijk, 2013). Research suggests that simply supplying computers, smartphones, or other digital tools does not ensure physical access to technologies; societies, schools and individual families have to ensure a continual supply of necessary infrastructure like electricity supply, internet, hardware and software to enable digital learning (Resta et al., 2018; Wallet & Kimenyi, 2019).

2.2. Digital Technology Infrastructure in Tanzania

Tanzania has experienced significant digital transformation, driven by mobile technology due to its affordability and convenience (GSMA, 2019; Ministry of Works, Transport and Communication (MoWTC), 2016). Investments in fibre infrastructure, including the National ICT Broadband Backbone (NICTBB) and the Fibre Consortium, have expanded connectivity across major cities and regions (GSMA, 2019). By 2023, Tanzania had 70.3 million mobile subscriptions (111% penetration) and 35.9 million internet users (58% penetration), with internet adoption growing at 9.8% annually since 2019 (Tanzania Communications Regulatory Authority(TCRA), 2024). Given that Tanzania has two-thirds of its population under the age of 25, digital access is crucial for education and future workforce readiness (Nieminen, 2020). The Tanzanian government has prioritised digital education through policies like Tanzania National ICT Policy of 2024, the Education and Training Policy 2014 version 2023, National Digital Education strategy 2024/25-2029/30(draft), Tanzania Digital Economy framework 2024-2035, and the ICT policy for basic education of 2007 (MICT, 2024; MOEST, 2024; MOWTC, 2016; MoEVT, 2007). These initiatives are aligned with improved budgets allocated to education, focusing on promoting access to technologies covered by internal and external funds (Daily News, 2024, 2025; UNESCO, 2025). Nonetheless, the gap between policies and the actual integration of digital technologies in education has persisted, which implies a need for continuous research to close it.

It is reported that ICT integration in education remains uneven, primarily benefiting urban and private institutions (Jordan et al., 2021). While initiatives from telecommunication services such as Vodafone's "smart classrooms" and Tigo's school internet connectivity project have improved access, many public schools still lack sufficient ICT infrastructure and electricity (GSMA, 2019). The average student-to-device ratio in government schools is 1:129, compared to 1:11 in private schools, with regions like Geita having the highest disparity at 1:184 (MoEST, 2021). Despite government and donor-driven efforts, access to digital learning remains inequitable (Jordan et al., 2021). Alternative

solutions, such as e-learning platforms like Shule Direct, Halostudy, and the TIE e-library, have expanded educational access, especially during COVID-19 school closures (TIE, 2022; Mtebe & Kondoro, 2019). Nevertheless, disparities persist, influenced by factors such as socioeconomic status and school conditions. Understanding these challenges is essential to ensuring equitable access to digital technologies in Tanzania's education sector.

2.3 Secondary School Students' Physical Access to Digital Technologies

Studies in developed countries suggest that students have greater access to digital technologies at home than at school, often due to school-level restrictions on device use (Nowell, 2014). In the U.S., nearly all students taking the ACT in 2017 reported having internet access and at least one device at home, with smartphone ownership being the most common (Moore & Vitale, 2018). Access to devices also varied by family income and racial or ethnic background. Students perceived their home internet as more reliable than school connections. Similarly, findings from ICILS 2018 in countries such as Germany, Denmark, Finland, France, and South Korea showed that students in developed nations are generally better equipped with digital technologies at home than at school (Fraillon et al., 2020). In contrast, access in many African contexts remains limited. While over half of Rwandan schools reportedly have ICT infrastructure, issues such as power shortages in remote areas and high internet costs hinder effective technology use (Wallet & Kimenyi, 2019). Moreover, Muinde and Mbataru (2019) reported that teachers' ICT capacity and the availability of facilities significantly affected the implementation of the OLPC project in Kenya. Across Africa, limited access to mobile phones, network coverage, and electricity significantly contributes to the digital divide (Kronke, 2020).

In Tanzania, several studies report insufficient and faulty ICT infrastructure in schools, leading to high device-to-student ratios (Ndume et al., 2020; Ngeze, 2017). Students are often restricted from using personal devices at school (Daudi & Nzilano, 2019), but still engage with digital tools outside school, especially through mobile phones (Mtebe & Raphael, 2018; Kafyulilo et al., 2015). Mwakisole et al. (2018) found that over half of the students had access to mobile phones at home and used them to access the Internet. However, internet availability at school remained limited. Almasi et al. (2017) reported that while very few students accessed the Internet on school or personal computers, most did so via smartphones or internet cafes. The reviewed literature related to students' physical access to digital technologies has mostly been conducted in developed countries. Although some reviewed studies were conducted in Tanzania, they are limited in their ability to explain the factors

associated with physical access. It was not clear from these studies whether students have equal physical access to digital technologies regardless of the schools they attend, their families' socioeconomic status, theirs' and their parents' educational levels, or their age. Moreover, some studies are based in a single region, district, or purposively selected school, and the findings cannot be generalised. This study builds on prior Tanzanian studies but adds a multi-region scope and socio-demographic analysis.

The paper addressed two objectives, which are:

i) To assess students' physical access to digital technologies
ii) To examine the differences in students' physical access to digital technologies, considering their demographic characteristics.

3. Methods

3.1 Design and Participants

This article draws on data from a broader study that examined predictors of access to usage using hierarchical multiple regression and multilevel modelling. However, the present study focuses exclusively on describing levels of physical access to digital technologies and examining variations across socio-demographic characteristics. The study used a cross-sectional survey design within a quantitative approach, conducted in five regions of Tanzania with high connectivity to the National Grid and low device-student ratios. Two districts from each region (one urban and one semi-urban/rural) and four schools per district (two government and two non-government) are included. The targeted population was 3,077,355 secondary school students, of whom 90.2% were enrolled in Government schools in 2023. Using Yamane's sample size formula, around 400 questionnaires were distributed per region to ensure representation across various strata.

A multistage sampling procedure was employed, with stratified sampling used to first group the districts in the selected regions into urban (the city centre) and rural (council and Municipal councils). City councils manage large, densely populated urban centres with extensive infrastructure. District councils oversee wider, less populated rural areas and smaller towns within a district. Municipal councils govern medium-sized urban areas that are more developed than rural areas but smaller than cities. All city centres were selected because there was only one in each region. Then, one district from the list of rural/ semi-urban districts was selected using the random number method under the simple random sampling technique. The district councils represented different settlement contexts, including six urban councils (Mbeya City, Dar es Salaam

City, Temeke Municipal, Dodoma City, Mwanza City, and Arusha City), two semi-urban councils (Ilemela and Meru), and two rural councils (Rungwe and Kongwa). This distribution was intended to capture variation in students' access to digital technologies across diverse geographical and socioeconomic settings.

Likewise, in each district council, stratified sampling was used to group schools into government and non-government secondary schools, and from each group, two schools were randomly selected, resulting in 4 schools per district and 8 schools per region. In each school, stratified sampling was used to first group the students based on their level of education (Form 1-VI), and then, for each level, stratified sampling was used to group the students into boys and girls. Students were chosen systematically based on their sitting position in the classroom, with specific numbers selected per class stream: three boys and three girls from two-stream classes, and five boys and five girls from one-stream classes, aiming for about 10 students per education level per school. Due to tight school timetables and examination preparations, adjustments were made in the sample selection to accommodate levels that could not participate. For example, in some schools, Form II students could not participate due to examination schedules. To maintain the sample size, additional students were selected from other levels (e.g., Form I or III) in the same school or from Form II in other sampled schools within the district. A total of 2200 questionnaires were distributed; 1997 valid responses were retained after excluding incomplete submissions. No systematic response pattern suggesting non-response bias was observed. Table 1 presents the distribution of respondents by demographic characteristics.

Table 1

Students' Demographic Characteristics based on Field Data Collected in 2023

Characteristic	Category	n	%
Gender	Male	981	49.4
	Female	1006	50.6
Age Group	10-15 years	737	37.1
	16-20 years	1250	62.9
Student's education level	Form I	350	17.6
	Form II	365	18.4
	Form III	403	20.3
	Form IV	418	21.1
	Form V	104	5.2
	Form VI	345	17.4
Father's Education	STD VII and below	393	23.1
	Form IV	369	21.7
	Form VI, Certificate & Diploma	348	20.5
	Degree and above	590	34.7
Mother's Education	STD VII and below	515	30
	Form IV	383	22.3
	Form VI, Certificate & Diploma	380	22.2
	Degree and above	436	25.4
Father's Employment	Employed	675	34.4
	Self-Employed/Entrepreneur	1169	59.6
Mother's Employment	Employed	455	23.3
	Self-Employed/Entrepreneur	1296	66.4
School Location	Urban	19	48.7
	Semi-urban/Rural	20	51.3
School Type	Government	20	51.3
	Non-Government	19	48.7

Number of Students' Access to Digital Devices at Various Places

Device	*Home*	*School*	*Other*
Smartphone	1623	63	434
Desktop PC	351	687	237
Laptop	768	210	313
Tablet	534	189	267
TV	1454	272	309
Radio	1227	98	256

Students' Ownership of Digital Devices Accessed at Home

Device	*personal*	*Parents'*	*Siblings'*	*shared*
Smartphone	879	882	244	246
Desktop PC	102	298	146	257
Laptop	266	393	236	246
Tablet	190	302	170	212
TV	218	744	121	737
Radio	323	553	103	514

Status of Internet connection at home, school and other places

	Home		*School*		Other	
	N	%	N	%	N	%
No access	206	10.7	419	31.4	200	16.1
Very bad	88	4.6	116	8.7	53	4.3
Bad	127	6.6	164	12.3	114	9.2
Good	849	44.2	424	31.7	521	41.8
Very good	652	33.9	213	15.9	357	28.7
Total	**1922**	**100**	**1336**	**100**	**1245**	**100.0**

Students' Internet costs at home

	N	%
I don't access the internet	125	6.4
I don't know	535	27.6
Less than 1000 Tsh	174	9.0
Between 1000 and 2000 Tsh	369	19.0
Between 2000 and 3000 Tsh	308	15.9
More than 3000 Tsh	428	22.1
Total	**1939**	**100.0**

3.2 Instrument Development and Validation

A questionnaire was appropriate, given the large number of students involved. It consisted of closed-ended questions on demographic information and students' physical access at home and at school. The items measuring students' physical access were adapted from other studies, including Van Deursen and Van Dijk (2019) and Moore and Vitale (2018), and modified based on the reviewed literature, peer-checked, and expert-reviewed to ensure content validity. The items captured different aspects of access, including availability

of ICT equipment, access to digital learning resources, internet connectivity, and financial or institutional support for ICT use.

The items include "my school does not have enough ICT equipment (e.g., computers)", "my school does not have access to digital learning resources", "my school does not have internet connection", "my school has limited connectivity (e.g., slow or unstable speed) to the internet", "the computer equipment in our school is out of date "there is no sufficient provision for me to develop expertise in ICT at school", "I don't have sufficient access to ICT equipment (e.g., computer, smartphone) at home", "I do not have access to digital learning resources at home", "I do not have access to the internet at home", "I have limited connectivity (e.g., slow or unstable speed) to the internet at home", "the computer equipment at home is out of date", "there is no sufficient provision for me to develop expertise in ICT at home", and "there is no sufficient financial support to maintain ICT resources at home".

Respondents rated each item on a 5-point Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree). Since the statements were phrased as barriers to access, the responses were reverse-coded so that higher scores indicated greater physical access to digital technologies. Composite scores were averaged, and access levels were categorised into low, moderate, and high using Likert-scale interpretations by Hussain (2022). Given that composite scores ranged from 1 to 5, the range (5) was divided into 3 equal-width categories, yielding intervals of 1.33. This ensured mutually exclusive and exhaustive classification categories (1-2.33 (Low), 2.34-3.37 (Moderate), 3.38-5 (High)). The average score approach was preferred because it preserves the original 1-5 metric, facilitating interpretation and comparisons. The instrument was piloted in May 2023 to ensure its validity and reliability and data collection occurred from July to August 2023. The reliability coefficient (Cronbach's alpha) for the physical access scale was 0.834 during the pilot study and 0.839 in the final dataset, indicating acceptable internal consistency.

3.3 Data Analysis

Data collected from student questionnaires were analysed using SPSS version 25. Descriptive statistics reported levels of students' physical access to digital technologies. An independent-samples t-test compared mean physical access scores across gender, school type, location, age group, and parental employment status. At the same time, a one-way ANOVA analysed the effects of students' and parents' education on students' mean physical scores.

3.4 Ethical Considerations

The University of Dar es Salaam provided ethical clearance, and the local administrative and educational authorities provided permission to access schools. All participants, comprising 1,997 respondents in the main analysis, were provided with clear, accessible information about the study's purpose, procedures, and benefits. Each questionnaire was preceded by a consent form in clear language that participants could understand. Moreover, before administering the questionnaires, the researcher reminded respondents of their right to withdraw from the study at any time without consequences. The data was anonymised to protect identities. Ethical considerations were adhered to in this study (Creswell & Creswell, 2018; Gay et al., 2012).

3.5 Limitations

This paper reports findings on one objective within a broader research project examining students' use of digital technology for learning. Consequently, the analysis focuses on descriptive patterns of access and group comparisons rather than predictive modelling. Moreover, the regions were selected based on relatively higher connectivity to the national electricity grid and internet infrastructure, which may limit the generalisability of findings to less connected regions. However, the selection of districts included 2 rural councils. Among the 39 schools involved in the study, 8 schools (about 20%) are situated in rural councils.

4. Results

4.1 Students' Physical Access to Digital Technologies

Table 2 illustrates the frequencies and percentages of students' responses.

Table 2

Frequencies and Percentages of Students' Responses Regarding their Physical Access to Digital Technologies

PHYSICAL ACCESS	SD		D		NS		A		SA		
	n	%	n	%	n	%	n	%	n	%	N
My school does not have enough ICT equipment (e.g., computers).	458	23.4	291	14.8	294	15	415	21.2	503	25.7	1961
My school does not have access to digital learning resources.	371	19.2	378	19.5	384	20	433	22.4	370	19.1	1936

PHYSICAL ACCESS	SD		D		NS		A		SA		
	n	%	n	%	n	%	n	%	n	%	N
My school does not have an internet connection	445	23	373	19.3	458	24	330	17.1	326	16.9	1932
My school has limited connectivity (e.g., slow or unstable speed) to the internet	316	16.4	257	13.3	623	32	403	20.9	329	17.1	1928
The computer equipment in our school is out of date	366	18.9	272	14	635	33	325	16.8	339	17.4	1937
There is no sufficient provision for me to develop expertise in ICT at school	344	17.8	269	13.9	420	22	404	20.9	495	25.6	1932
I don't have sufficient access to ICT equipment (e.g., a computer or smartphone) at home.	569	29.2	444	22.8	168	9	412	21.1	358	18.3	1951
I do not have access to digital learning resources at home.	486	25.1	520	26.8	228	12	415	21.4	291	15	1940
I do not have access to the internet at home	523	27.2	517	26.8	254	13	353	18.3	279	14.5	1926
I have limited internet connectivity (e.g., slow or unstable speeds) at home.	388	20.1	396	20.5	367	19	477	24.7	304	15.7	1932
The computer equipment at home is outdated.	467	24.2	396	20.5	449	23	323	16.7	296	15.3	1931
There is no sufficient provision for me to develop expertise in ICT at home.	396	20.5	385	19.9	336	17	470	24.3	345	17.9	1932
There is no sufficient financial support to maintain ICT resources at home.	375	19.3	354	18.3	367	19	440	22.7	403	20.8	1939

Further analysis, as presented in Figure 1, shows that, generally, the majority (51%) of students have moderate physical access, followed by 20.9% with high access and 17.2% with low access. 32% of students have high access at home, compared to 20.8% at school. This means more students are highly accessing digital technologies at home than at school. Nevertheless, the majority of

students only moderately access digital technologies at school (43.6%) and at home (37.2%). Considerable numbers of students have equally low access at home (23.7%) and school (23.6%).

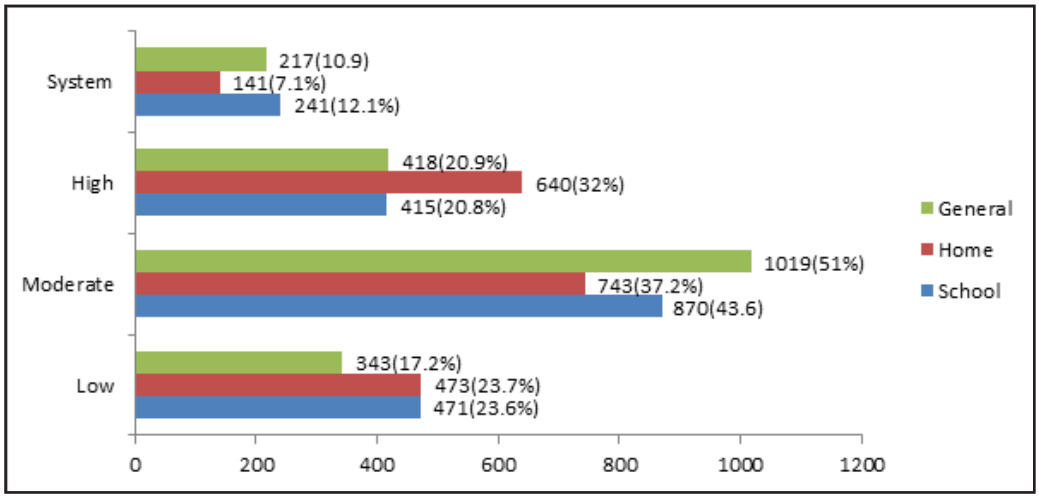


Figure 1: *Students' Physical Access to Digital Technologies at School, Home, and General (Both Home and School)*

Based on the data presented in Table 1 on access and ownership of digital devices, the majority of students reported having access to a variety of devices at home; however, findings revealed that they use them only moderately. The reason could be that most of them do not own the devices, so they perceive they have only moderate physical access to digital technologies. For example, among the 1623 students who indicated having access to smartphones at home, only 879 (44%) own them. The majority (882 students) access their parents' smartphones. Others access their siblings', and others share smartphones. In addition, only 266 (13.3%), 190 (0.1%), and 102 (0.05%) students own laptops, tablets, and desktop PCs, respectively. Apart from device ownership, another hindering factor for students' limited physical access to digital technologies is internet costs. The majority (75.1%) of the students indicated that the internet connection at home was good or very good; however, 21.4% indicated that it costs them more than 3000 per week, 15.4% between 2000 and 3000, and 18.5% between 1000 and 2000. The students who have more physical access to digital technologies at home are also the ones incurring more than 3000 Tsh per week on the internet.

4.2 Effects of Socio-Demographic Characteristics on Students' Physical Access to Digital Technologies

This sub-section reports findings on the effects of socio-demographic characteristics on students' physical access to digital technologies. Table 3 summarises the independent t-test results for students' physical access scores.

Table 3

Independent t-Test Results on Students' Physical Access Mean Scores

Variables	Category	*N*	*M*	*SD*	*t*	*p*	η^2
Gender	Male	883	3.01	0.86	-2.846	.004	0.005
	Female	896	3.12	0.79			
School	Public	1004	2.97	0.82	-5.489	< .001	0.017
	Private	776	3.19	0.83			
location	City council	849	3.10	0.87	1.698	.09	0.002
	Municipal/council	931	3.03	0.79			
age	10-15	636	3.18	0.78	4.32	< .001	0.010
	16-20+	1141	3.00	0.85			
Fathers' Employment	Employed	601	3.16	0.83	3.462	.001	0.007
	Self employed	1054	3.02	0.82			
Mothers' Employment	Employed	397	3.20	0.87	3.841	< .001	0.009
	Self Employed	1183	3.02	0.81			

Eta squared (**η^2**)

Data in Table 3 show that girls have slightly higher physical access to digital technologies than boys. Moreover, private school students have slightly greater physical access to digital technologies for learning than public school students; however, there is no significant difference in mean physical access scores between students' schools located in city councils and those in Municipalities/ councils. Interestingly, students aged 10-15 have slightly greater physical access to digital technologies than students aged 16-20+. Moreover, students whose parents/guardians are employed have slightly higher physical access to digital

technologies than those whose fathers/male guardians are self-employed or entrepreneurs. Nonetheless, the magnitude of the differences in the means, as indicated by eta-squared values, is small.

The effects of students' and parents' education on students' mean physical access scores were assessed using a one-way ANOVA. Table 4 summarises the results.

Table 4

One-Way ANOVA Test Results on the Students' Mean Physical Access Scores

Attribute		***SS***	***df***	***MS***	***F***	***p***	**η²**
Students' education	Between Groups	27.841	4	6.96	10.266	< .001	0.023
	Within Groups	1200.728	1771	0.678			
	Total	1228.569	1775				
Father's education	Between Groups	38.305	3	12.768	19.117	< .001	0.036
	Within Groups	1013.866	1518	0.668			
	Total	1052.171	1521				
Mothers' education	Between Groups	33.911	3	11.304	16.906	< .001	0.032
	Within Groups	1025.671	1534	0.669			
	Total	1059.582	1537				

Based on ANOVA results in Table 4 and robust tests of equality of means (Welch and Brown-Forsythe), there is a significant difference in students' physical access to digital technologies by education level ($F(4, 1771) = 10.266$, $p < .001$). However, the effect size is small (eta squared = 0.023, which equals to 2.3%). Moreover, as illustrated in Tables 5 and 6, there is a significant difference in students' physical access to digital technologies between A-level students and Form I ($p < .001$) and between A-level students and Form IV ($p = 0.004$). However, there are no significant differences between A-level students and Form II and Form III students in their physical access to digital technologies. Interestingly, Form I students have the highest physical access to digital technologies, followed closely by Form IV, but access varies significantly with Form II and Form III students, who differ slightly and insignificantly, and last is A-level students, who vary significantly with Form I in physical access to digital technologies.

Table 5

Mean Physical Access Scores by Student's Education Level

Education	*N*	*M*	*SD*	*SE*	95% CI
Form 1	308	3.29	0.85	0.048	[3.19, 3.38]
Form II	309	3.02	0.74	0.042	[2.94, 3.11]
Form III	354	3.03	0.78	0.042	[2.95, 3.11]
Form IV	389	3.12	0.83	0.042	[3.04, 3.21]
A Level	416	2.91	0.89	0.043	[2.82, 2.99]
Total	1776	3.29	0.85	0.048	[3.19, 3.38]

Table 6

Mean Physical Access Scores by Students' Education Level: Games-Howell Post Hoc Results

Education	Education	*MD*	*SE*	*p*	95% CI
Form 1	Form II	0.265*	0.064	<.001	[0.09, 0.44]
	Form III	0.261*	0.064	<.001	[0.09, 0.43]
	Form IV	0.166	0.064	.074	[–0.01, 0.34]
	ALevel	0.380*	0.065	<.001	[0.20, 0.56]
Form II	Form 1	-0.265*	0.064	<.001	[–0.44, –0.09]
	Form III	-0.005	0.059	1.000	[–0.17, 0.16]
	Form IV	-0.099	0.060	.458	[–0.26, 0.06]
	ALevel	0.115	0.061	.322	[–0.05, 0.28]
Form III	Form 1	-0.261*	0.064	<.001	[–0.43, –0.09]
	Form II	0.005	0.059	1.000	[–0.16, 0.17]
	Form IV	-0.095	0.059	.501	[–0.26, 0.07]
	ALevel	0.119	0.060	.276	[–0.05, 0.28]
Form IV	Form 1	-0.166	0.064	.074	[–0.34, 0.01]
	Form II	0.099	0.060	.458	[–0.06, 0.26]
	Form III	0.095	0.059	.501	[–0.07, 0.26]
	ALevel	0.214*	0.061	.004	[0.05, 0.38]
A Level	Form 1	-0.380*	0.065	<.001	[–0.56, –0.20]
	Form II	-0.115	0.061	.322	[–0.28, 0.05]
	Form III	-0.119	0.060	.276	[–0.28, 0.05]
	Form IV	-0.214*	0.061	.004	[–0.38, –0.05]

4.3 Students' Parents' Education Level

Levene's statistic indicate that the test of homogeneity of variances has been violated hence the use of robust tests of equality of means (Welch and Brown-Forsythe) which shows significant difference in students' physical access to digital technologies based on the education of their father/male guardian ($F(3, 1518) = 19.117$, $p < .001$) (Table 4). In addition, descriptive statistics presented in table 7 and post hoc results in table 8 show that there is significant difference in students' physical access to digital technologies between students with education of their father/male guardian at degree level and above and STD VII with $p < 0.001$; and Form IV with $p < 0.001$; and Form VI, Certificate and Diploma at 0.002. Students whose fathers/male guardians have a degree or higher level of education have greater physical access to digital technologies than those whose fathers/male guardians have a Form VI or equivalent certificate/diploma. However, there is no significant difference in students' physical access with fathers'/male guardians' education STD VII and below, Form IV and Form VI, Certificate and Diploma.

Table 7

Descriptive Statistics on Students' Mean Physical Access Scores by Father's Education Level

Father's Education	***N***	***M***	***SD***	***SE***	**95% CI**
STD VII and below	355	2.88	0.88	0.046	[2.79, 2.97]
Form IV	332	2.93	0.74	0.040	[2.85, 3.01]
Form VI, C & D	301	3.05	0.81	0.047	[2.96, 3.14]
Degree+	534	3.26	0.83	0.036	[3.19, 3.33]
Total	1522	3.06	0.83	0.021	[3.02, 3.10]

Table 8

Games-Howell Post Hoc Results on Students' Mean Physical Access Scores by Father's Education Level:

Father education	**Father education**	***MD***	***SE***	***p***	**95% CI**
STD VII and below	Form IV	-0.051	0.062	.838	[–0.21, 0.11]
	Form VI, C & D	-0.165	0.066	.059	[–0.33, 0.00]
	Degree+	-0.380*	0.059	<.001	[–0.53, –0.23]

Father education	Father education	*MD*	*SE*	*p*	95% CI
Form IV	STD VII and below	0.051	0.062	.838	[–0.11, 0.21]
	Form VI, C & D	-0.114	0.062	.252	[–0.27, 0.04]
	Degree+	-0.328*	0.054	<.001	[–0.47, –0.19]
Form VI, C & D	STD VII and below	0.165	0.066	.059	[0.00, 0.33]
	Form IV	0.114	0.062	.252	[–0.04, 0.27]
	Degree+	-0.214*	0.059	.002	[–0.37, –0.06]
Degree+	STD VII and below	0.380*	0.059	<.001	[0.23, 0.53]
	Form IV	0.328*	0.054	<.001	[0.19, 0.47]
	Form VI, C & D	0.214*	0.059	.002	[0.06, 0.37]

*. The mean difference is significant at the 0.05 level.

Moreover, data in Table 4 show that there is a significant difference in students' physical access to digital technologies based on mothers'/female guardians' education ($F(3, 1534) = 16.906$, $p < .001$); however, the effect size is small. In addition, Table 10 shows Tukey HSD post hoc results indicating a significant difference in students' physical access to digital technologies by their mother's/female guardian's education. Students whose mothers/female guardians have a degree and higher level of education have greater physical access than those whose mothers/female guardians have Form IV and below. However, there is no significant difference in physical access between students whose mothers'/female guardians' education is a degree or higher and those whose mothers'/female guardians' education is Form VI or an equivalent certificate/diploma. Also, there is no significant difference between students' physical access to students whose mothers/female guardians' education is STD VII and below and students whose mothers/female guardians' education is form IV.

Table 9

Students' Mean Physical Access Scores by Mother's Education Level

Mother's education	*N*	*M*	*SD*	*SE*	95% CI
STD VII and below	469	2.91	0.82	0.038	[2.83, 2.98]
Form IV	345	2.98	0.78	0.042	[2.89, 3.06]
Form VI, C, D	332	3.15	0.80	0.044	[3.06, 3.23]
Degree+	392	3.28	0.87	0.044	[3.19, 3.36]
Total	1538	3.07	0.83	0.021	[3.03, 3.11]

Table 10

Students' Mean Physical Access Scores by Mother's Education Level: Tukey HSD Post Hoc Test Results

Dependent Variable: Physical access					
Tukey HSD					
Mother's education	**Mother's education**	***MD***	***SE***	***p***	**95% CI**
STD VII and below	Form IV	-0.068	0.058	.648	[–0.22, 0.08]
	Form VI, C & D	-0.237*	0.059	<.001	[–0.39, –0.09]
	Degree+	-0.368*	0.056	<.001	[–0.51, –0.22]
Form IV	STD VII and below	0.068	0.058	.648	[–0.08, 0.22]
	Form VI, C & D	-0.169*	0.063	.036	[–0.33, –0.01]
	Degree+	-0.301*	0.060	<.001	[–0.46, –0.15]
Form VI, C & D	STD VII and below	0.237*	0.059	<.001	[0.09, 0.39]
	Form IV	0.169*	0.063	.036	[0.01, 0.33]
	Degree+	-0.131	0.061	.138	[–0.29, 0.03]
Degree+	STD VII and below	0.368*	0.056	<.001	[0.22, 0.51]
	Form IV	0.301*	0.060	<.001	[0.15, 0.46]
	Form VI, C & D	0.131	0.061	.138	[–0.03, 0.29]

*. The mean difference is significant at the 0.05 level.

5. Discussion

This study examined secondary school students' physical access to digital technologies and differences across socio-demographic characteristics. Overall, the findings indicate that many students have moderate levels of access, but access remains uneven across home and school environments. Consistent with the concept of the first-level digital divide, access to devices and internet connectivity continues to shape students' opportunities to engage with digital learning resources. The findings reveal that students rely more on digital technologies at home than at school. Smartphones are the most commonly owned devices, reflecting their affordability and multi-functionality compared with laptops or desktop computers. However, many students depend on shared devices provided by family members, which may restrict their learning time. Limited access to digital devices in schools further intensifies this challenge, particularly for students from low-income households who rely on schools as their primary opportunity to engage with digital technologies.

These patterns support Jan van Dijk's Resources and Appropriation Theory, which argues that inequalities in material and social resources lead to differences in digital access and participation. Students with greater economic resources, supportive family environments, and access to devices are more likely to engage with digital learning opportunities. Restricting smartphone use in schools may hinder learning opportunities; instead, schools should promote guided use to ensure all students develop digital skills equally. Without equitable access, students continue to use devices outside school without supervision, leading to deepening existing divides. The present study aligns with previous studies that reported that the majority of secondary school students in Tanzania are accessing digital devices outside the school environment (Mtebe & Raphael, 2018; Mwakisole et al., 2018schools have been investing heavily on information and\ncommunications technology (ICT; Almasi et al., 2017; Kafyulilo et al., 2015). Similarly, other studies have reported on insufficient ICT infrastructure in some of Tanzanian schools (Ndume et al., 2020; Ngeze, 2017; Tarimo & Kavishe, 2017)and teachers in terms of knowledge, skills and possession of ICT devices. Data were collected from 202 teachers selected from 32 Secondary Schools from all the Educational Zones in Tanzania. The study revealed that most schools do not have ICT infrastructure in place. In schools where ICT infrastructure is present, student to computer ratio is very high. On the other hand, teachers are ready to use ICT in their teaching and learning activities if and only if they have the skills and knowledge to do so. The findings revealed that most of the secondary school teachers (77.0%. In contrast, Moore and Vitale (2018) found that nearly all high school students who sat for the American College Testing (ACT) tests in 2017 had access to home internet and at least one electronic device for home use.

Socio-demographic factors significantly influence students' physical access to digital technologies. However, the effect sizes are small, ranging from 0.46% (gender) to 3.64% (father's education), as indicated by eta-squared values. Although the observed differences are small, female students reported slightly higher levels of physical access than male students. This finding contrasts with some earlier studies that reported male advantages in access to digital technology. These findings align with Van Dijk's (2013) theory of resources and appropriation, which links digital access to disparities in material and social resources. The results may indicate growing efforts to promote girls' participation in STEM through STEM programs, educational policies, and school practices aimed at reducing gender gaps. Additionally, female students may be more engaged with, or have more structured access to, digital tools at school, possibly due to behavioural differences or institutional support.

Likewise, programmes and interventions that support the empowerment of women and girls must include men and boys as well (Moraa, 2018; Philemon, 2024). In contrast, it is still observed elsewhere that male students are more likely than female students to access digital devices. Mendoza-Lozano et al. (2021)the digital divide evolution over time and its determinants are analyzed using a probabilistic model and the calculation of georeferenced concentration indexes. The topic is relevant as previous studies have shown a positive relationship between access to ICTs (Information and Communication Technologies in Colombia found that male students have a slight advantage in access to a computer at home compared to female students. Perhaps this alerts regions to focus more on the data specific to their area, as the theory suggests that there will be variations across regions.

Parental education and employment were also associated with students' access to digital technologies. Students from households with higher educational attainment or stable employment reported greater access to devices and home internet connectivity. These findings support previous research indicating that socioeconomic resources influence students' opportunities to engage with digital technologies for learning. These findings support Van Dijk's (2013) theory, which highlights the importance of material resources in shaping digital access. Families with higher parental education are better positioned to provide their children with devices and reliable technology. This study aligns with that of Mendoza-Lozano et al. (2021), who found that parents' education is positively associated with access to ICTs at home. As argued by Riyan Rizaldi et al. (2021), parental support is important whether parents can use technology or not; they can guide students' learning at home, including the time spent on digital devices for learning. However, it is observed that parents who use technology appreciate it more and are likely to provide or share technological devices with their children (Goodall, 2016; Katz et al., 2019).

Parents' employment status significantly affects students' physical access at home, with children of employed parents having greater access than those of self-employed parents. This may be due to the financial stability of salaried employment, which allows for better investment in devices and internet connectivity. These findings support Van Dijk's (2013) theory that differences in material resources, like stable income, lead to access gaps. However, no significant differences were found at school, suggesting that school environments may help level the differences through shared resources and infrastructure. Despite this, gender disparities persist, with girls having greater access, possibly due to STEM-focused initiatives or educators' efforts to promote gender equity

in technology use. This study aligns with other scholars including Gobena (2018) who conducted a similar study in Ethiopia and Treviño et al. (2021) who based the study in 19 countries during COVID-19 pandemic, both agree that physical access influences how much learners can engage with digital learning environments, with employed parents having better financial means to support their children's access to computers, internet, and other technological resources at home than their counterparts. Moreover, employed parents, who may have higher educational backgrounds, are more likely to emphasise digital literacy and provide the necessary resources to ensure their children have better access to learning tools (Yang et al., 2023).

Younger students reported slightly greater levels of physical access than older students. Although the differences are small, this pattern may reflect changing technology adoption trends among younger cohorts, who often encounter digital devices earlier in their educational experience. This unexpected trend can be partly explained by Van Dijk's theory, which suggests that younger generations tend to have greater access to newer technologies. Older students may also face stricter rules due to concerns about distractions during exam years. At school, younger students might benefit from more flexible schedules and curricula that integrate digital tools, while older students face academic pressures that limit their time with technology. Overall, this trend indicates a systemic imbalance where technology is more embedded in the lives of younger students, potentially disadvantaging older students in developing essential digital skills for higher education and future careers. Equitable access across all grade levels is, therefore, necessary. Moreover, it should not be ignored that, without proper guidance, younger and lower students are at a higher risk of misusing devices. In contrast, according to Mendoza-Lozano et al. (2021), a low-level student in Colombia experiences less access to the internet at home than their counterpart. Nonetheless, it is argued that every stage of education, from pre-primary to higher education, must prioritise digital equity and inclusion (Gottschalk & Weise, 2023).

School location did not significantly affect overall physical access at school. However, students in urban areas reported slightly greater access at home. This may reflect stronger internet infrastructure and higher household incomes in urban settings. It is also important to note that the study included relatively few schools from remote rural areas, which may limit the generalisability of this finding. The lack of significant differences in physical access at school may also be a positive sign that educational systems are mitigating geographic disparities; nonetheless, equity in schools should be extended to older and male students. Similarly, school location is typically associated with facilities in urban

areas, including access to electricity and a good internet connection, and with proximity to technology hubs (Gobena, 2018; Treviño et al., 2021). However, all visited schools, whether in urban, semi-urban, or rural areas, had electricity.

School type was another factor associated with access. Students attending private schools reported greater access both at home and at school, which may reflect differences in institutional resources, infrastructure, and family socioeconomic backgrounds. Private schools generally have more financial resources, better infrastructure, trained staff, and specialised programs that support technology use. These advantages align with Van Dijk's theory, which links access to material and social resources. Additionally, private school students often come from higher-income families with employed or educated parents who can afford devices and a stable internet connection. In contrast, public schools attended mostly by students from lower-income households rely on limited government or donor support for technology. Agreeing with Mendoza-Lozano et al. (2021), who found that students who belong to public secondary educational establishments in Colombia are less likely to access ICTs, compared to their peers who study in private establishments.

6. Conclusion and Recommendations

This study examined secondary school students' physical access to digital technologies in Tanzania and differences across socio-demographic groups. The findings suggest that although many students have some access to digital technologies, access remains uneven, particularly within school environments. Smartphones represent the most widely used devices at home, highlighting the potential for mobile-supported learning initiatives. Efforts to improve digital learning opportunities should prioritise expanding school ICT infrastructure while supporting equitable access among students from diverse socioeconomic backgrounds. Schools should be supported with sustainable technology infrastructure, while families and communities should aim to provide at least one device for digital learning. Efforts to close the gender gap must ensure both boys and girls benefit equally; giving girls more access will have boys left behind, creating further gender divides. Future research should include a broader range of rural schools and explore how differences in physical access influence students' actual use of digital technologies for learning.

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Fifty Years of *Papers in Education and Development*: Reflecting on Current Realities, Emerging Challenges, and Future Directions

Joseph C. Pesambili
School of Education, University of Dar es Salaam, Tanzania
Email: pesambili@udsm.ac.tz
ORCID No: 0000-0001-8734-7266

Abstract

This paper examines the current realities, emerging challenges, and future trajectory of Papers in Education and Development (PED) as it marks 50 years of scholarly contribution. It situates the Journal as an increasingly international platform that shapes educational debates, informs policy, and advances research across Tanzania and the wider African context. Drawing on editorial experience and recent submission and review trends, the paper first examines the current realities shaping PED before analysing key challenges in scholarly publishing, including the peer-review crisis, reviewer responsiveness, unethical author practices, digital transitions, the implications of artificial intelligence, and tensions within open-access and hybrid publishing models. It further outlines strategic directions for strengthening PED's internationalisation, editorial rigour, indexation, and contribution to knowledge sovereignty. The paper concludes by positioning PED as a living, future-oriented platform capable of shaping educational research, policy, and practice in Africa and beyond.

Keywords: *educational research, editorial practice, peer review, scholarly publishing, African journals*

DOI: *https://dx.doi.org/10.56279/ped.v43.special.i3.10*

1 Introduction: PED at 50 as an Intellectual and Editorial Milestone

As Freire (1970) reminds us, education is never neutral; it is always implicated in broader struggles over knowledge, power, and social transformation. Scholarly journals, as sites of knowledge production and validation, are not merely repositories of research but active participants in shaping intellectual and policy agendas. In this context, *Papers in Education and Development* (PED), as it marks 50 years (1975-2025) of scholarly contribution, stands as both a significant intellectual platform and a mirror of educational transformation in Tanzania, across Africa, and beyond. Over time, PED has evolved from a predominantly national outlet into an increasingly international journal, attracting contributions from across sub-Saharan Africa and the wider global context. This shift is evident not only in the geographic spread of authorship but also in the Journal's growing selectivity.

Recent editorial data show a rejection rate of approximately 80.6% between July 2025 and mid-March 2026, with 67 manuscripts receiving editorial decisions: 13 (19.4%) were accepted, and 54 (80.6%) were rejected. These patterns signal rising visibility, heightened competition, and an increasing demand for rigorous, objective, and high-quality scholarship.

Beyond its role as a publication outlet, PED has consistently served as a platform through which key debates in education are articulated, contested, and refined. Its contributions have engaged enduring concerns such as policy reform, curriculum transformation, teacher development, access, and equity, while also responding to shifting educational priorities. In this sense, the Journal has not only documented change but has contributed to shaping the intellectual and policy discourse surrounding education in Tanzania and the wider African context. Its trajectory reflects broader transformations in educational thought, from post-independence expansion and state-led reform to contemporary concerns with globalisation, digitalisation, and knowledge production. Similarly, increasing pressures to publish, demands for faster editorial processes, and the expansion of digital technologies are reshaping how knowledge is produced, disseminated, and evaluated (Tennant et al., 2016). Within this environment, journals based in the Global South face a dual challenge: maintaining rigorous academic standards while navigating structural inequalities in global knowledge systems. Issues of visibility, indexation, and global recognition remain particularly salient for journals seeking to position themselves within dominant scholarly networks.

For PED, these dynamics are further complicated by the need to balance its historical role as a national and regional journal with its emerging international orientation. The increasing diversity of submissions and rising rejection rates reflect a shift towards greater selectivity and quality assurance. However, this transition also raises critical questions regarding editorial capacity, peer review sustainability, and reliance on voluntary academic labour (Chan & Costa, 2005). At the same time, issues such as authorship ethics, reviewer engagement, and the growing influence of artificial intelligence are becoming central to the Journal's operational and intellectual environment. In this context, the 50-year milestone represents more than a commemorative moment; it is a critical point for reflection and repositioning. While Ishumi's account has documented the historical evolution of PED, there remains a need to interrogate its contemporary role and future trajectory within a rapidly changing scholarly landscape. This involves examining the challenges shaping its editorial practices, the opportunities to strengthen its institutional and intellectual positioning, and the strategic pathways to enhance its relevance and impact.

Against this backdrop, this paper reflects on PED's current positioning as both a scholarly and an editorial platform, analyses the key challenges shaping its operations

and contributions, and outlines strategic directions for its future development. In doing so, it positions PED not merely as a repository of knowledge but as an active agent in shaping the future of educational research, policy, and practice in Tanzania, Africa, and the global scholarly community.

2 PED Today: Positioning, Reach, and Scholarly Contribution

As the Journal continues to expand its reach and influence, its role is no longer confined to that of a national outlet but extends to a broader regional and global scholarly arena. This shift reflects both internal editorial developments and wider transformations in academic publishing, including digital dissemination, competitive selectivity, and changing expectations of scholarly impact. Figure 1 presents a snapshot of the current realities shaping PED, illustrating its evolving positioning at the intersection of expanding global reach, strengthening quality assurance mechanisms, and sustained scholarly and policy relevance.

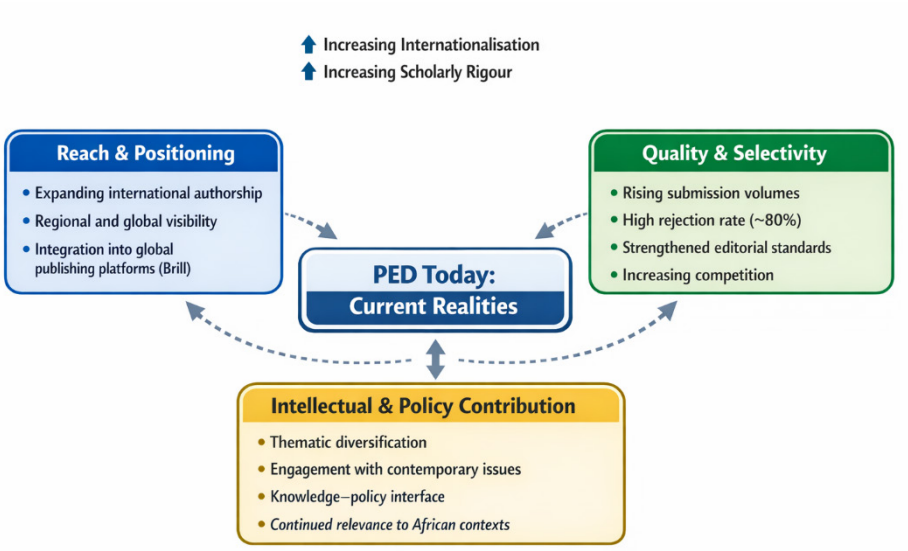


Figure 1: *Current Realities Shaping PED's Contemporary Positioning*

The subsections that follow unpack the key dimensions of PED's contemporary positioning, as synthesised in Figure 1.

2.1 From National Outlet to International Platform

Over the past five decades, PED has evolved from a predominantly institutional and national journal into an increasingly international scholarly platform. While its intellectual foundations remain rooted in the School of Education at the University of Dar es Salaam, its contemporary reach now extends across Africa and into wider

global academic networks. In addition to receiving submissions from authors across academic institutions in Tanzania, PED currently attracts contributions from across the African continent, including, but not limited to, Nigeria, Ghana, Côte d'Ivoire, Uganda, Rwanda, Kenya, South Africa, Benin, The Gambia, Zimbabwe, Malawi, Lesotho, and Morocco. Its reach has also expanded beyond Africa, with submissions now coming from countries such as the United States, Brazil, the United Kingdom, Germany, and the Czech Republic. This shift reflects broader transformations in scholarly communication, where visibility and influence are increasingly shaped by digital dissemination, international collaboration, and the capacity to attract diverse, high-quality contributions. A key milestone in this trajectory has been the Journal's strengthened international positioning since 2022, culminating in its publication partnership with De Gruyter Brill from June 2025. This development has enhanced accessibility, professionalised editorial and production processes, enhanced author services and analytics, and more firmly integrated PED into global scholarly circulation. The expanding geographic spread of submissions signals growing recognition beyond the Journal's original institutional and national constituency. PED now operates not merely as an institutional and national outlet, but as a regional and increasingly international forum for educational scholarship—one that remains grounded in African contexts while actively engaging with global academic debates.

2.2 PED as a Knowledge and Policy Interface

Beyond its publication profile, PED functions as a critical interface between knowledge production and policy engagement. Across its history, the Journal has hosted debates on educational policy, curriculum reform, pedagogy, teacher education, access, and equity. In doing so, it has served not only as a repository of research but as a space where ideas are interrogated, contested, and translated into wider conversations about educational transformation. This role is particularly significant in contexts where the relationship between research and policy remains uneven. As argued by Gibbons et al. (1994), the growing emphasis on socially distributed and application-oriented knowledge underscores the need for research to engage with real-world contexts. PED has contributed to this agenda by publishing work that speaks to both conceptual debates and practical concerns. Equally, the gap between research production and policy uptake persists. The Journal's continued relevance depends not only on what it publishes, but on how effectively it mediates between scholarship, policy, and practice in ways that are both critical and constructive.

2.3 Thematic Evolution of Scholarship

The contemporary profile of PED is also reflected in the evolution of its thematic scope. Earlier scholarship associated with the Journal was largely centred on foundational concerns such as educational philosophy, *Education for Self-Reliance*, language policy, adult and community education, curriculum development, and the

broader role of schooling in national development (See Ishumi's note in this issue). These early contributions were closely aligned with post-independence nation-building priorities and the imperative to situate education within the broader project of social and economic transformation. While these concerns remain important, subsequent scholarship expanded to engage issues of educational planning, assessment systems, research methodologies, and the structural legacies of colonial education. This marked a gradual shift towards more critical and system-oriented analyses of education in relation to development.

More recent work reflects a further widening of focus in response to changing educational realities. Contemporary scholarship increasingly engages questions of decolonisation and epistemic justice, language and identity, STEM education, gender disparities, digital inequality, teacher professional development, educational governance, and community engagement. This aligns with the Journal's broader commitment to examining the interrelationship between education and development in Africa and its responsiveness to emerging global and regional challenges. This thematic diversification is significant as it demonstrates the Journal's responsiveness to both persistent and emerging concerns in education and development. It shows that PED is not confined to inherited debates but is actively engaging with contemporary challenges, including technological change, shifting labour markets, global knowledge hierarchies, and demands for inclusion and social justice. In doing so, the Journal reflects broader transformations in educational discourse, where questions of relevance, equity, and knowledge production remain central.

Overall, these developments mark PED as a journal in transition—anchored in a strong national and institutional legacy yet increasingly international in outlook; committed to rigorous scholarship yet engaged with policy and practice; historically grounded yet responsive to emerging intellectual and social challenges. This contemporary positioning provides an important basis for reflecting on both the contributions of the present anniversary issue and the broader challenges and future directions that follow. The thematic evolution of scholarship in PED can be conceptualised as a layered process of intellectual expansion, as illustrated in Figure 2.



Figure 2: *Thematic Evolution of Scholarship in PED*

As shown in Figure 2, PED's thematic trajectory reflects a layered evolution—from foundational post-independence concerns, through system-oriented and critical expansion, to contemporary and emerging themes shaped by global, regional, and epistemic shifts in education and development.

3 Contemporary Challenges in Scholarly Publishing and Editorial Practice

The current landscape of scholarly publishing presents a complex set of operational, ethical, and epistemic challenges that shape the functioning and sustainability of journals such as PED. While many of these challenges are global in nature, their implications are often more pronounced within journals based in the Global South, where institutional capacity, resource constraints, and evolving publishing infrastructures intersect. Figure 3 synthesises these interconnected challenges, illustrating how operational, ethical, and epistemic pressures converge within a structurally unequal global knowledge system to shape PED's editorial and publishing environment.

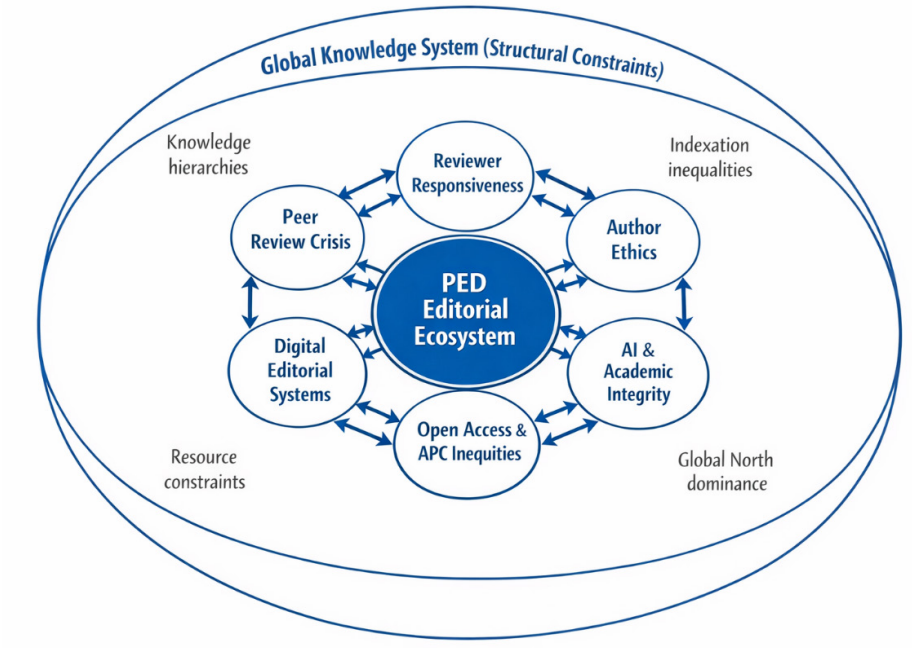


Figure 3: *Interconnected Editorial and Publishing Challenges Affecting PED Within a Structurally Unequal Global Knowledge System*

The following discussion highlights key challenges emerging from PED's experience and situates them within broader debates in academic publishing.

3.1 The Peer Review Crisis: Recruitment and Changing Expectations

One of the clearest pressures on contemporary journals is the growing difficulty of securing qualified peer reviewers. This problem is widely recognised in scholarly publishing and is closely linked to rising submission volumes, increased academic workloads, and what is often described as "reviewer fatigue" (Beecher & Wang, 2025; Phuljhele, 2024). Large-scale reviewer surveys have identified reviewer availability as a major source of inefficiency in peer review (Publons, 2018). Within this broader crisis, PED has also encountered a more troubling shift: some reviewers now condition their participation on financial remuneration. This signals movement away from the traditional norm of peer review as collegial scholarly service towards a more transactional logic. PED has maintained the position that peer review should remain voluntary, consistent with longstanding editorial norms and COPE's broader ethics framework for journal practice (Committee on Publication Ethics [COPE], 2023b). The issue is not merely procedural. Once review is normalised as a paid service, questions arise about equity, bias, and the uneven ability of journals to secure reviewers on comparable terms.

3.2 Reviewer Responsiveness and Editorial Delays

Recruitment is only one part of the problem; responsiveness is another. Even after reviewers agree to assess a manuscript, late or non-returned reports can significantly slow editorial decisions. The result is not only delayed feedback to authors but also repeated follow-ups, reviewer replacements, and disruptions to the editorial workflow (Felisi et al., 2026). Such delays are often treated as individual lapses. Nevertheless, they are better understood as systemic symptoms of an overstretched review culture in which reviewing remains weakly recognised despite being central to the legitimacy of academic publishing (Publons, 2018; COPE, 2023b). For PED, this challenge raises an important editorial question: how can journals preserve rigour and fairness while reducing avoidable delays? The answer is unlikely to lie in reminders alone. Rather, it calls for stronger reviewer engagement systems, clearer expectations, and the deliberate cultivation of reliable, voluntary, and sustainable reviewer communities. Increasingly, some journals and publishers worldwide are also experimenting with incentive mechanisms, such as time-limited access to publisher content, formal recognition through platforms linked to ORCID profiles, and review-credit systems, to enhance reviewer motivation and visibility (Publons, 2018; COPE, 2023b).

3.3 Unethical Author Practices

Reviewer-related pressures are compounded by unethical author practices that weaken trust in the publication process. Among the most disruptive are simultaneous submissions to multiple journals and the failure to return revised manuscripts after extensive peer review (Emanuele, 2025). These practices waste reviewer labour, distort editorial planning, and slow down the handling of other manuscripts. More importantly, they undermine the norms of transparency and responsibility on which scholarly publishing depends (COPE Council, 2024). COPE's guidance remains clear that redundant or overlapping submission is a serious ethical concern, not a minor procedural inconvenience (COPE, 2017a, 2017b; COPE Council, 2024). At the same time, such practices may partly reflect authors' responses to protracted editorial delays—often up to a year or more without feedback. This delay underscores the need for greater accountability on the part of journals and editors to ensure timely, transparent communication. For PED, this means that editorial strengthening must go beyond gatekeeping. It must also involve continued author education on publication ethics, clearer communication of journal policies, addressing protracted delays in the review process, and consistent enforcement of submission standards.

3.4 Artificial Intelligence and the Transformation of Scholarly Communication

Artificial intelligence, especially generative AI, is rapidly reshaping scholarly communication. Its potential benefits are real: AI tools can assist with language editing, improve readability, and lower some barriers for authors writing in English as an additional language (Zaim et al., 2025). Yet these advantages are inseparable from new ethical risks (Aladsani et al., 2026). COPE has already documented growing concern over undisclosed AI use in manuscripts, AI-generated peer reviews, and uncertainty about the limits of acceptable editorial and authorial use (COPE, 2023a). These developments challenge established assumptions about authorship, originality, confidentiality, and accountability. For PED, the issue is not whether AI should be embraced or rejected. The more urgent question is how it should be ethically used and governed. Clear editorial policies are needed to distinguish assistive from generative use, require disclosure where appropriate, and preserve meaningful human accountability in both authorship and review.

3.5 Digital Transition and Editorial Systems

The shift from email-based editorial handling to digital manuscript management systems has improved traceability, workflow management, and transparency. At PED, the adoption of De Gruyter Brill Editorial Manager represents an important step towards professionalised publishing. Yet the digital transition is not frictionless. Some reviewers and contributors, particularly those long accustomed to email-based systems, experience difficulties accessing manuscripts, navigating submission platforms, or uploading reports. What appears to be a technical issue is, in fact, partly a capacity issue: digital infrastructure only improves editorial efficiency when users can engage with it confidently. This suggests that digital upgrading must be accompanied by training and support, particularly to local reviewers. Without such investment, new systems may inadvertently exclude willing participants or introduce fresh bottlenecks into the review process.

3.6 Open Access, Hybrid Publishing, and Persistent Inequities

The shift towards open access has often been framed as a democratising move in scholarly communication. Yet the growth of hybrid models, where subscription access coexists with Article Processing Charges (APCs), has exposed a deeper tension between accessibility and equity. While such models can widen dissemination, they can also reproduce structural inequalities, especially for authors working in resource-constrained institutions and countries (Naim et al., 2021). Evidence from the wider publishing landscape increasingly warns that APC-based systems risk creating a two-tier order in which research may be more open to read, but not equally open to publish (Ross-Hellauer, 2022). For PED, this tension is especially important. The Journal's transition from a fully open-access model to a hybrid arrangement reflects broader shifts in global publishing. Open access increases visibility, but

APCs can create real financial barriers for authors without institutional or external support. The challenge is not simply technical or financial; it is normative. A journal committed to educational scholarship from Africa must continually assess whether its publishing model expands participation or quietly narrows it, while proactively enabling access through institutional support, alternative funding, and initiatives such as Research4Life. Sustaining access, visibility, and financial viability without reproducing exclusion will remain one of PED's most difficult editorial balancing acts.

4 Structural and Systemic Constraints in Global Knowledge Production

Beyond immediate editorial and operational concerns, PED operates within a broader global knowledge system characterised by persistent structural inequalities and asymmetries. Journals based in the Global South continue to face challenges of limited visibility, underrepresentation in major indexing databases, and constrained participation in global scholarly networks. These conditions often marginalise locally grounded scholarship, even when it addresses issues of high contextual and societal relevance (Chan & Costa, 2005). Knowledge hierarchies further shape what is recognised as legitimate or high-impact research, frequently privileging theoretical frameworks, methodologies, and publication venues rooted in the Global North. As Boaventura de Sousa Santos (2014) argues, global knowledge production remains marked by "epistemic injustice", where certain forms of knowledge are systematically excluded or devalued. Within this landscape, journals such as PED must navigate a persistent tension between maintaining contextual relevance and achieving global recognition. The dominance of English intensifies this tension: while it facilitates international visibility, it may simultaneously constrain the inclusion of diverse linguistic and epistemic traditions (Chan & Costa, 2005; Phillipson, 1992).

Resource constraints compound these structural challenges. Limited funding, reliance on voluntary editorial labour, and infrastructural limitations affect not only the efficiency of journal operations but also their long-term sustainability and impact. These constraints are not merely logistical; they shape the pace, reach, and authority of knowledge production itself. As Raewyn Connell (2007) notes, global academic systems continue to reproduce uneven patterns of knowledge production and circulation that disadvantage institutions in the Global South. Addressing these challenges requires more than internal editorial adjustments. It calls for broader systemic shifts in how academic knowledge is produced, validated, and disseminated, alongside sustained institutional commitment to strengthening scholarly ecosystems in the Global South.

5 Future Directions: Repositioning PED for the Next 50 Years

The future of *PED* will undoubtedly depend on its ability to respond strategically to both internal operational demands and broader transformations in scholarly publishing. The next phase requires not only consolidating recent gains but also deliberate repositioning to strengthen intellectual influence, editorial rigour, and global visibility. Figure 3 illustrates the strategic pathways for repositioning PED over the next 50 years, conceptualising its future as an interconnected ecosystem balancing quality assurance, global visibility, and epistemic responsibility.

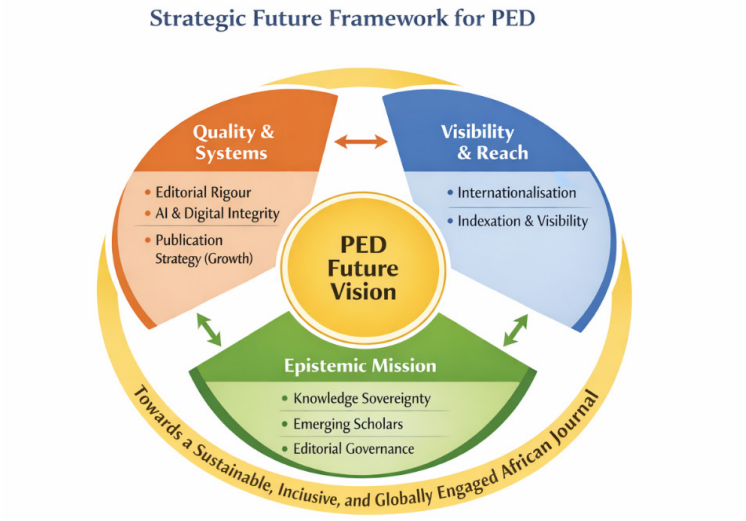


Figure 4: *Strategic Pathways for Repositioning PED For the Next 50 Years*

Building on the framework presented in Figure 4, the following discussion offers a detailed and systematic elaboration of the proposed strategic pathways.

5.1 Sustaining and Deepening Internationalisation

A central priority is to sustain and deepen PED's trajectory towards internationalisation. While the Journal has expanded its reach beyond Tanzania, maintaining this momentum calls for deliberate editorial strategies. In particular, there is a need to avoid re-localisation, in which publications become overly concentrated within a single national and/or institutional context. That said, continued strengthening of geographic and institutional diversity among authors, reviewers, and editorial board members will be essential. Internationalisation should not be reduced to visibility alone; it requires cultivating a genuinely diverse and inclusive scholarly community.

5.2 Safeguarding rigour in the Digital and AI Era

The growing integration of digital technologies and artificial intelligence in scholarly communication calls for renewed attention to academic rigour. PED should continue

strengthening peer review processes to ensure consistency, transparency, and accountability. Clear policies on AI use in manuscript preparation and review are also needed, with emphasis on disclosure, originality, and intellectual responsibility. For *PED*, such frameworks are essential for sustaining trust in published research within an evolving technological landscape.

5.3 Enhancing Quality, Objectivity, and Editorial Standards

Improving editorial quality and consistency remains critical. This includes strengthening reviewer guidelines to promote timely, constructive, and analytically rigorous feedback, as well as ensuring fairness, objectivity, and coherence in editorial decision-making. Reinforcing ethical publishing practices among authors and reviewers alike will further enhance PED's credibility as a journal committed to high-quality, principled scholarship.

5.4 Indexation and Global Visibility

Expanding indexation remains a strategic priority for PED. While the Journal is currently indexed in African Journals Online (AJOL) and Google Scholar, inclusion in major international databases such as Scopus, Web of Science, ERIC, DOAJ, and EBSCO would significantly enhance its visibility, credibility, and citation impact. To this end, several initiatives have already been implemented to strengthen PED's eligibility for inclusion in major indexing systems. These include the assignment of Digital Object Identifiers (DOIs) to all published articles since December 2023, the strengthening of author guidelines, and, more recently, the introduction of manuscript processing dates (received and online publication dates) by the current publisher. Indexation is not merely a technical milestone; it represents recognition within global scholarly ecosystems. Continued progress in this area will depend on sustained improvements in editorial transparency, publication quality, and international engagement. That said, PED's editorial leadership, in collaboration with the publisher, must prioritise inclusion in major indexing databases as an immediate and short-term strategic objective.

5.5 Managing Growth and Publication Strategy

Submission trends indicate rapid growth in both volume and diversity. Submissions increased from 44 in 2023 to 63 in 2024, reaching 105 by the end of 2025, with contributions from across Africa and beyond. While this expansion reflects rising visibility and scholarly relevance, it also places increasing pressure on editorial and peer review systems. This trajectory requires a careful reassessment of publication strategy, including issue frequency and acceptance thresholds. Expanding output, for example, increasing to three or four issues per year, may be desirable in the short to medium term to accommodate rising submissions. However, such expansion must not come at the expense of quality, objectivity, or the Journal's rigorous standards. Thus, strategic growth decisions should prioritise scholarly integrity

over numerical expansion, ensuring that increased output is matched by sustained editorial capacity and a robust peer review process.

5.6 Strengthening Editorial Leadership and Governance

Sustaining PED's growth and quality will require strengthened editorial leadership and governance structures. This includes expanding the editorial team—ideally to at least three editors, rather than the current two—enhancing the diversity and capacity of the editorial board, and reinforcing reviewer networks at both regional and international levels. Greater representation from across sub-Saharan Africa should be a key priority in the composition of future editorial boards, as this will reinforce the Journal's regional identity, visibility, and scholarly impact. Equally important is the need for sustained and visible institutional support, including dedicated funding mechanisms, to ensure efficient, professional, and resilient editorial operations. Such support is critical not only for managing increasing submission volumes but also for maintaining the integrity, timeliness, and long-term sustainability of the Journal.

5.7 Advancing Knowledge Sovereignty and Decolonial Scholarship

PED is well positioned to advance knowledge sovereignty and decolonial scholarship in the coming decades. This entails promoting research grounded in African epistemologies, Indigenous knowledge systems, and contextually relevant methodologies. It also requires ongoing critical reflection on editorial practices to ensure that diverse forms of knowledge are recognised, valued, and meaningfully integrated into scholarly discourse. Such a direction warrants sustained and deliberate attention as PED moves into its next fifty years. Positioning the Journal as a platform for "home-grown" scholarship will not only reinforce its intellectual identity but also enhance its distinctiveness within the global academic landscape.

5.8 Fostering Emerging Scholars and Scholarly Communities

The long-term vitality of PED will depend significantly on its ability to support emerging scholars, including postgraduate students and early-career academics. Despite its growing influence as a reputable international journal, PED has continued to uphold a developmental editorial approach that reflects its original vision. As noted by Ishumi, the inaugural issue in 1975 included contributions from postgraduate students, signalling an early commitment to nurturing new voices in academic scholarship. In recent years, this commitment has been sustained through iterative review processes and editorial guidance aimed at supporting less experienced authors to refine and publish their work. Strengthening this trajectory will require more structured mentorship pathways, including developmental peer-review models and dedicated spaces for early-career researchers. Such initiatives would not only enhance publication readiness but also contribute to building a more inclusive and supportive scholarly community. For PED, supporting emerging

scholars is not merely a continuation of tradition but a strategic priority and a long-term investment in the future of educational research in Africa.

6 PED in the Next 50 Years: A Forward-Looking Vision

Looking ahead, *PED* is well-positioned to evolve into a leading African epistemic hub that not only reflects educational realities but also actively shapes scholarly, policy, and practice-oriented conversations. Its future trajectory lies in consolidating its identity as a globally recognised journal while remaining grounded in African contexts, priorities, and knowledge systems. This dual positioning—locally rooted and globally engaged—will be central to sustaining its relevance and influence. As an African epistemic platform, PED can advance forms of knowledge production that are contextually grounded, methodologically diverse, and intellectually independent. This includes creating space for scholarship that interrogates dominant paradigms, foregrounds indigenous knowledge systems, and contributes to ongoing debates on decolonisation and knowledge sovereignty. Strengthening global recognition, in turn, will depend on sustained commitment to high editorial standards, international collaboration, and broader indexation, enabling the Journal to participate more visibly in global academic discourse.

PED's role as a policy-informing platform remains equally important. By publishing research that engages directly with educational challenges and reform processes, the Journal can continue to bridge the gap between scholarship and practice. Strengthening this interface will require not only rigorous research but also greater attention to accessibility, relevance, and dissemination beyond academic audiences. Emerging global and regional challenges also call for stronger interdisciplinary engagement. *PED* is well positioned to promote scholarship that connects education with fields such as artificial intelligence, climate change, public health, and the future of work—areas that are increasingly reshaping educational systems. Similarly, there is a need to prioritise community-engaged research that links academic inquiry with lived realities, ensuring that knowledge production remains socially responsive and practically meaningful.

The next 50 years of PED will depend on its ability to remain intellectually vibrant, institutionally resilient, and strategically adaptive. By strengthening its position as an African-centred yet globally connected journal, PED can continue to advance educational research, inform policy, and contribute to broader processes of social transformation.

7 Conclusion: Consolidating Legacy, Confronting Challenges, and Shaping the Future

As *PED* marks its 50-year milestone, it stands as a testament to sustained scholarly commitment and intellectual engagement within Tanzania, across Africa, and beyond. Over time, the Journal has evolved from a nationally anchored publication into an increasingly recognised regional and international platform. This trajectory reflects both continuity in purpose and transformation in scope, reach, and ambition, underscoring PED's enduring relevance as a site for critical engagement with educational questions across shifting historical and social contexts. This paper has shown that the Journal's present moment is defined not only by achievement but also by tension. Pressures on peer review, shifting expectations around scholarly labour, unethical authorship practices, the disruptive implications of artificial intelligence, and persistent structural inequalities in global publishing all shape the conditions under which PED operates. These challenges are not peripheral; they go to the core of how knowledge is produced, validated, and circulated. Addressing them demands more than procedural adjustment. It requires sustained critical reflection on the norms, values, and responsibilities that underpin scholarly communication.

The future of PED will depend on a shared commitment across its scholarly community. Editors must safeguard rigour while providing strategic direction; reviewers must uphold the ethos of scholarly service; authors must engage responsibly and ethically; and institutional leadership must invest in the Journal's long-term sustainability. The strength of PED lies in this collective ecosystem, and its continued vitality will depend on how effectively these roles are sustained and aligned. PED's significance, however, extends beyond institutional continuity. Its future rests on its ability to remain intellectually assertive, contextually grounded, and globally engaged. As it navigates new pressures, the Journal must not only document educational change but also actively shape the terms through which education is understood, debated, and transformed. In this sense, PED is not simply a record of past scholarship; it is a living intellectual project with a continuing responsibility to shape the future of educational thought, policy, and practice in Africa and beyond.

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