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Colonial Antecedents Influencing the Current Training and Practice of STEM Educators in Sub-Saharan Africa

Moses, Olayemi; Jennifer DeBoer.
Purdue University
molayemi@purdue.edu

ABSTRACT

CONTEXT
Since the 1950s, a period known for the mass decolonization of Africa, thousands of policy documents, philosophy papers, and strategic plans have been published to map out a path for independent states' approaches to sustainable national development (Birmingham, 1996; Welz, 2021). The common narrative is that education goals and the training of educators need to be aligned to individual national priorities for sustainable development (Kivunja, 2017). This objective is perhaps best illustrated through the steps taken to capitalize on the affordances of technical and vocational education and training (TVET) and science, technology, engineering, and mathematics (STEM) education.
GOAL
The overarching goal of this paper is to use a postcolonial lens to identify antecedent factors influencing the current form of STEM teacher education in sub-Saharan Africa (SSA). Understanding these factors and the ways that they overtly or covertly influence current forms of teacher education and practice is crucial if sub-Saharan African countries are to succeed in their efforts to achieve their sustainable national goals. Specifically, in this work-in-progress paper, we ask "*what are the antecedent factors that influence the current approach to STEM teacher training and practice in sub-Saharan Africa?"*
METHODOLOGY
To answer our research question, we conducted an extensive review of the literature surrounding postcolonial education in sub-Saharan Africa. Over 60 documents were included in our review, spanning several disciplines including history, philosophy, psychology, social sciences, and engineering education. We performed a thematic analysis to identify factors that authors had identified in over 7 decades of postcolonial research. To report our findings, we employed a sociological framework that identified micro-, meso-, and macro-level factors using structural-functionalism, interactionism, and conflict theory.
OUTCOMES
The review is still a work-in-progress. However, the findings thus far have identified major colonial antecedents that still influence the training, certification, and teaching practices of STEM educators in SSA today. These include (1) using colonial language fluency as a measure of meritocracy, (2) reifying professional expectations that are colonially subservient, (3) normative deidentification of culture, (4) hegemonizing indigenous knowledge and culturally relevant teaching, (5) reclaiming student-centered teaching as a posited alternative to the religious history of teacher-centered pedagogy, and (6) deconstructing the notion that the scientific method is an irrefutable, universal, legitimate way of knowing.
CONCLUSIONS
We emphasize that a review of the pre-, and post-colonial forms of STEM education as it relates to teacher training and practice unearths exciting findings: cultural values that have a rich history, pedagogical techniques that were learner-centered, pedagogical tools that served as cultural mediators, and an African indigenous knowledge that predates the introduction of western scientific thoughts. This paper seeks to contribute scholarship that will enable stakeholders to rethink their ways of knowing, doing, practicing, and sustaining STEM education in SSA
KEYWORDS
Postcolonial, STEM teacher training, Sub-Saharan Africa

Introduction

"Those who do not know (their) history are bound to repeat it." (Santayana, 1905, p. 284) This paper is a contribution to a series of studies that argue that developing the teaching and research capabilities of educators in sub-Saharan Africa is one of the most effective ways of improving the state of education, and indirectly, the quality of life of Sub-Saharan African citizens (Johnson et al., 2000; Lan & Kisjes, 2014). In a previous literature review, the authors posited that effective teacher development requires an intricate understanding of the current state of science, technology, and engineering education, practice, and research in the subcontinent (Olayemi et al., 2021). Our previous study investigated the modalities and impacts of various programmatic interventions for developing the competency of STEM teachers in SSA. This study ushers the conversation forward by taking a step back to recognize the history behind current practices that are characteristic of the sub-Saharan STEM education landscape. We expand on the rationale for this study in the following sub-section.

Education in Sub-Saharan Africa

The history of education in SSA is a checkered one; glorious on one end with records of advances that assert that this was home to some of humanity's earliest known civilizations (Chu & Skinner, 1990), marred on the other with the realities of and consequences associated with western colonialization (Mosweunyane, 2013). We argue that the history of education has a significant role to play in the development of any civilization. Engineering and technology feats that shaped civilization and continue to do so today are tied very closely to the system of education of the time (Pacey & Bray, 2021). These connections have been extensively discussed in other studies. In this study, we are curious about the history of science and engineering education in SSA, particularly the ways that current forms of teacher development have their roots in colonial and neocolonial practices and objectives. There is perhaps no better space to investigate these antecedents than in STEM education. As the bulk of SSA moves gradually into the realm of self-directed and sustainable national development, we recognize the value of producing scholarship that enables stakeholders (policymakers, thinkers, teachers, students) to rethink their ways of knowing, doing, practicing, and sustaining STEM education in SSA.

The Postcolonial Lens

The connotation of postcolonialism is most frequently used to describe a period "beyond" the events of colonialism and imperialism (Ivison, 2020). Oftentimes, the goal of reviewing events, actions, and processes through a postcolonial lens is to illuminate the aftermath of colonialism. However, several studies have nuanced this definition as being misleadingly simplistic because it supposes that the legacy of colonialism has been surpassed (Huggan, 1993; Shohat, 1992). Shohat (1992), for example, problematizes the term along spatial and temporal dimensions, arguing that it fails to hold the same meaning across different contexts and cultures even within the same subcontinent (e.g., for Nigeria, South Africa, and Sudan). According to the author, while colonialism and the new forms of colonialism (neocolonialism) impose dichotomies, the term postcolonial is characterized by an ambivalence that posits simultaneously close and distant relations to the "colonial" (1992, p. 107). This structural ambivalence served as a helpful lens through which this study was conducted. We recognized in our review of articles centered around postcolonial education in Sub-Saharan Africa that there is no consensus about the definitions of pre-, post-, and neo-colonial practices. Thus, we defined pre-colonial as activities that preceded colonialization and postcolonial as the activities that happened during colonization and existed afterward.

Research Question

The research question motivating this literature review is as follows: what are the antecedent factors that influence the current approach to STEM teacher training and practice in sub-Saharan Africa?

Methods

Literature Search

We conducted a systematic search of four electronic databases – Education Source, ERIC (EBSCO interface), Professional Development Collection, and PsycINFO between December 2020 and March 2021.

Search String: (STEM education OR science OR technology OR engineering OR mathematics) AND (Sub Saharan Africa OR sub-Saharan Africa OR sub-Sahara OR sub-Sahara or SSA) AND (educators OR instructors OR teachers) AND (training OR education OR development OR learning) AND (postcolonial OR neocolonial OR colonial)

We also conducted a follow-up manual search using Google Scholar and ProQuest in April 2021 using keywords such as colonial education, sub-Saharan Africa, and STEM teachers.

Inclusion and Exclusion Strategy

Our strategy for including articles in this study started with an initial assessment of the title and abstracts of the articles. Articles that fit the scope of the study as agreed by author one were listed for discussion with author 2. The authors met early on to discuss the alignment of the articles with the research agenda. Articles that did not have clear abstracts and titles were marked for full-text screening. To meet the criteria for inclusion in this review, articles were required to: (1) have a subject matter of STEM and TVET education in a post-, neo-, or pre-colonial frame; (2) be published in English language; (3) be available in abstract form; (4) be accessible in full-text version. To fit within the scope of this paper, we added an additional criterion of papers that have a subject matter of African education in a post-, neo-, or pre-colonial frame. This literature review followed the procedural guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Moher et al., 2009).

Data Extraction

We created a template to report the data extracted from the articles. Each article had separate columns for authors' names, paper titles, research questions, and methodology. We also created additional columns to report the main ideas of each article, cross-references to other articles in this review/articles outside of this review, relevant quotations from the articles, and comments that we as a team of researchers made as we carried out our review.

Quality Appraisal

The heterogeneous nature of the articles included in this review presented a challenge of quality appraisal. In this article, we were most concerned with reducing as much as possible any bias related to selective outcome reporting (Borrego et al., 2014). The research team engaged in regular meetings to address the alignment of the findings we were drawing from the articles with the original authors' intentions. Being a work-in-progress paper, our future goal is to use the Scale for the Assessment of Narrative Review Articles (Baethge et al., 2019) to evaluate the quality of the articles included in this review. This scale assesses the quality of articles using the following criteria: justification of article's importance to readers, statement of concrete aims/formulated questions, description of literature search, referencing, empirical reasoning, and presentation of data.

Results

Literature Search

In total, our initial search strings yielded 889 records [Education Source (885), ERIC (4), Professional Development Collection (312), and PsycINFO (4)] between December 2020 and March 2021. We also conducted a follow-up manual search using Google Scholar and ProQuest in April 2021. Using manual search with more targeted key words, we added 5 records to the total number. The first stage of screening focused on identifying articles that fit the scope of the research (see 4 criteria above) based on titles and abstracts. This screening stage left the research team with 71 records. Using our inclusion and exclusion criteria, in particular relevance to STEM/TVET, we were able to scope down the list of articles to 48.

Findings

We reviewed the selected articles by referring to the research question shaping this literature review (Borrego et al., 2014). The review is still a work-in-progress. So far, we have identified major colonial antecedents that still influence the training and certification of STEM educators in SSA today. To report the findings of this literature review, we debated the merits and demerits of different sociological perspectives. No single framework seemed perfectly adequate. From a structural-functionalism perspective using a sociological framework (Kuh et al., 2006), it was helpful to categorize the findings based on the roles that social institutions like the respective national governments of SSAn countries, education systems, community structures, religions, and local economies played. However, using this macro-level lens involved trading off the sensitivity associated with demarcating between the manifest and latent functions of these social institutions as they vied for the control of local, economic, and human resources known to be extant (China in Africa: The New Colonialism?, 2018; Plange, 1984; Schmidt, 2013). Conversely, while we attempted to analyze and report our findings from a micro-level interactionist perspective, we noticed that social institutions and structural constraints which were so prominent in the first analytical frame became less so in the second. Exclusively focusing on the meso-level helped us identify how the competition for economic, political, and human resources shaped not only the interests of colonial powers but also those of the local actors who continue to negotiate conditions in a post- or neocolonial era. Rather than constrain the reporting of our findings to a particular perspective, we opted instead to report on all three, using micro-, meso-, and macro-level lenses, identifying “structures of relationships linking social actors” (Marsden 2004, p. 2727).

At the micro-level, we focused first on the actions of and interactions between “the African” and “the African”. Next, we focused on the interactions between “the African” and “the Other”. We operationalized “the other” as actors that were outside the African context. At the meso-level, we identified the interactions between “the African” and “the field”, the “field” being Science, Technology, Engineering, and Math disciplines. These interactions manifested specifically in terms of how STEM teachers were taught, trained, or led to reconceptualize what “professionalism” looks like in their field. From an interactionist perspective, the field is continually shaping the identities of STEM teachers, and they in turn shape the identity of the field. The narrative that follows considers both the interests of colonial powers and the local actors who continue to negotiate conditions in a post- or neocolonial era, between citizens and their educational systems or political governments. Finally, at the macro-level, we categorized the findings of this literature review as interactions between complex social systems and structural apparatuses like education systems, national interests as reflected in education policies, and STEM workforce globalization efforts.

To address the theme of this conference, “Engineering Education Research Capability Development”, and fit within the limited scope, we present our findings only on the second and third units of analyses (micro-level interactions between the “African” and the “other” and meso-level interactions between the “African” and the “field”).

Discussion

Micro-level Unit of Analysis: Interactions between the African and the Other

In this conference paper, first, we focus on the actions of and interactions between “the African” and “the Other”. Many authors described the advent of colonial rule and the events that followed with respect to the African’s interactions with others. This lens explores the nature of interaction between the African STEM teachers and their non-African peers. It explores the nature of the relationship between STEM teachers and their non-African trainers. It unveils the steps taken to develop autonomy, agency, and professional legitimacy in reference to others outside sub-Saharan African contexts. The main factors that surfaced from the literature review under the micro-level analysis of the interactions between “the African” and “the Other” are Scholarship, Content, Mentorship, and Professionalism (Table 1).

Table 1: Table of findings (factors in the colored cells are not discussed in this article)

Analysis level	Actors	Factors	Precolonial	Postcolonial	Discussion points
Interactions at the individual level (micro)	The African and The African	Philosophy	Community-based, values and respect	Individualistic, competitive	Cultural values & character as contents, social utility as objective, Western competitive individualism versus African cooperative communalism, Axiology versus epistemology.
		Structure	Gender-based	Gender-based	Differential treatment of boys and girls in both pre and post.
		Curriculum	Served the ethnic majority	Served the colonialists	Curriculum as a reflection of the needs of the dominant group, Language as a reifying form of epistemic and political power.
		Pedagogy	Student-centered	Teacher-centered	Mutual respect between teacher & student in pre-, student subjugation & corporal punishment evident in postcolonial education, Power differential between teacher and student in both.
		Metrics for merit & success	Intrinsic, character, practical (handwork)	Extrinsic, language fluency, rote memorization & recall, (bookwork)	Cognitive achievement as substandard to affective achievement? Revisiting neocolonial structures and practices like western-style high-stakes/standardized tests, Colonial language fluency as a measure of meritocracy, External indicators as rubrics of successful STEM teaching.
	The African and The Other	Scholarship	African indigenous knowledge	Western empirical thought	Western ways of knowing, western culture as examples, rote memorization & recall.
		Content	Contextually relevant	Misaligned with local context	Are indigenous knowledge and culturally relevant teaching being hegemonized? Did colonial education intentionally exclude critical thinking?
		Mentorship	Culturally-consonant apprenticeship	Racially incongruent mentorship	Recognizing implicit assumptions, beliefs, and biases about knowledge (double image), Racially incongruent mentorship as reimagining colonialism.
		Professionalism	Embedded in everyday life, recognized by the community	Distinct, demonstrated by an ability to “stand out”	Recognizing professional expectations that are colonially subservient, Deconstructing claims of the teaching profession being white normative.

Interactions at the disciplinary level (meso)	The African and the Field	Method of inquiry	Observation of natural environment	Scientific empiricism	Challenging the irrefutability, universality of the Scientific Method, African indigenous observation and understanding of natural environment predating the introduction of western scientific thought.
		Professional expectations	Culturally mediated, teachers as custodians of cultural knowledge	Approved by a separate board, demonstrated through colonially subservient expectations	Normative deidentification of culture, Hegemonizing indigenous knowledge and culturally relevant teaching, Recognizing professional expectations that are colonially subservient, Deconstructing claims of the teaching profession being white normative, External indicators as rubrics of success, STEM language fluency, and paper authorship as new metrics of professionalism
		Pedagogical structure	Active, situated learning, practical, Apprenticeship	Classroom-based, theoretical, memorize, recall	Reclaiming active learning as the mode of African education, Relocating the restrictions that learning only takes place in the classroom, Revisiting the dialectical debate of bookwork versus handwork
		Pedagogical tools	Cultural mediators	Western concepts	Codeswitching; Local metaphors as pedagogical tools for postcolonial STEM education (Probyn, 2006)
Interactions at the National level (macro)	Social Institutions	National development	Localized, community-based	Reliant on external aid	From forced migration to voluntary immigration); External aid as neocolonial structures that benefit expatriate STEM teacher trainers and western private companies

Several articles in this review discussed the difference between precolonial STEM education and western ways of knowing, how postcolonial STEM education became tied to western culture, and how “the African” responded to this new way of learning from “the other”. School content was differentiated for boys and girls in ways that served the economic goals of the colonialist. Postcolonial curriculum contents were based on examples that Africans could not resonate with (Dei Ofori-Attah, 2006). For example, a study designed around a first-year astronomy course in a South African university found that most black students in the course struggled to reconcile the content with their spiritual and epistemological backgrounds (Cameron, 2019). Through this action, indigenous knowledge was initially excluded, the justification being that there was a lack of scholarship (Anthony-Stevens & Matsaw Jr, 2020).

Meso-level Unit of Analysis: Interactions between the African and the Field

Some of the main factors that surfaced from the literature review under the meso-level analysis of the interactions between the African and the field are listed in the table below. Several articles included in this review posit that the African way of knowing, interacting with, and experiencing the world predated colonialism (Boaventura de Sousa Santos, 2014; Fomunyam, 2017; Woolman, 2001); we highlight this thematic finding in order to problematize it and illustrate potentially persistent colonial mindsets in engineering education scholarship Through the postcolonial lens, we also find a fundamental difference between the philosophies of education. This begins first by revisiting the notion that culture, values, and character were the contents of African education before colonialism (Assie-Lumumba, 2012). Epistemology in itself was valid as long as it fit into the axiological views of the community (Higgs, 2008). However, with the advent of colonialism, some authors described the differences as the intentional marginalization of African indigenous thought, the battle of western competitive individualism versus African cooperative communalism (Khalifa et al., 2014; Woolman, 2001), and challenging the notion that the scientific method is a universal, irrefutable way of knowing. Using our review, we trace the influence of colonialism, the introduction of western thought, and the postcolonial effects of negotiating identities as STEM teachers in SSA.

African indigenous observation was a critical way of interacting with and understanding the natural environment. Many authors argued that this way of knowing predated the introduction of western scientific thought (see Boaventura de Sousa Santos, 2014; Gates & Davis, 2001; Khumalo & Baloyi, 2017; Woolman, 2001). Their argument entertains historical evidence which shows that this was home to some of the world's earliest civilizations and the world's oldest university (Assie-Lumumba, 2012). The objective of education, however, was to serve a social utility function. The mode of education was by active learning, being immersed in the context, and being mentored by learned others who were often experienced in the culture, education, practices, and history of the community (Marom, 2019). In this guise, teachers were seen as custodians of cultural and traditional knowledge, and teaching was seen as a way of ensuring the continuity of culture and community (Assie-Lumumba, 2012). Furthermore, teaching was not restricted to the school environment. Because the community was so integrally connected to the means of education, a child could learn from any experienced elder.

Western ways of knowing brought distinctions between the actors of education (Woolman, 2001). The teacher had a specific role and a place in the classroom. That role was to serve as the creator, transmitter, and assessor of acquired knowledge. That place was in the front of the classroom. Primarily, empiricism served as the foundation for scientific thought. Rationality and logic were elevated above cultural values. Further, western competitive individualism began to hedge out African cooperative communalism (Khalifa et al., 2014). Progenitors of the colonial form of education argued that there were no literary texts to celebrate African STEM. Directly and indirectly, the field took shape as one that marginalized indigenous knowledge and culturally relevant teaching. Many papers that made it into this review argue that actors in STEM fields in postcolonial contexts need to challenge the notion that the scientific method is a universal irrefutable way of knowing (Anthony-Stevens & Matsaw Jr, 2020; Fataar, 2018; Ryan, 2008; Ziegler & Lehner, 2018). Learning in African contexts should be re-centered on the African but not to the complete exclusion of other ways of knowing.

Like every field, STEM has its language, one that oftentimes appears invisible for those who are deep in the field. Actors within the field demonstrate their mastery through their command of the language. This was the case when it came to training STEM teachers. Command of theory was considered superior to practice. Through these actions, successful teachers were judged as those who could demonstrate command of the STEM language. In a sense, bookwork was again considered superior to handwork. Slowly but surely, the demarcations became more apparent – external indicators came to be reckoned as the rubrics of successful STEM teaching (Khalifa et al., 2014). Teachers demonstrated their professionalism through the ways they spoke, dressed, and acted (Marom, 2019). By talking in the language and by acting more like the colonialists, the African could be distinguished

from their peer. Language was still a reifying form of epistemic power. And by changing the way teachers appeared in the class, there ensued a normative deidentification by appearance (Marom, 2019). It suggested to African STEM teachers that the teaching profession was white normative. In a way, not only was school a social and physical representation of the distinction between the weak student and the strong, the same could be said of trainee teachers who wanted to make it in the field as professional teachers (Domínguez, 2019; Johnson et al., 2000; Martin & Pirbhai-Illich, 2016). These professional expectations, we thematically surmised, were colonially subservient.

Many papers that made it into this review still problematized these historical antecedents to the current professional STEM teaching practice. STEM trainee teachers are still trained to master content that is not culturally relevant (Marom, 2019), conditioned to view their African peers as competition who stood in their way of getting coveted resources that come with job security and promotion (Tabulawa, 2013), and judged on their ability to memorize and transmit as much knowledge as they can (Williams & Grierson, 2016). Pedagogically speaking, teacher-centered class control is seen as evidence of classroom management (Mogari, 2017). The teacher is expected to demonstrate professionalism at all times, sometimes through their ability to remain objective, rational, and uninvolved in student affairs (Marom, 2019); at other times, through their command of English, Latin, and whatever language showed that they were scholars. Promotion is still based on external indicators which serve as the rubrics for successful teachers, such as high student scores in external examinations (Banya, 2005), and the ability to demonstrate command of western thinking by engaging in scientific thought and publishing findings in a language that their African peers do not understand but their academic peers in the field do (Brock-Utne, 2016; Mchombo, 2016).

Limitations

The limitations of this paper are intrinsically connected to the chosen methodology. This paper is not representative of the whole sub-Saharan African context, a complex tapestry of over 2000 different spoken languages and unique cultures just as diverse. A critical review will reveal that we did not report our findings by regions or by countries of historical colonial influence (e.g., British, French, German, Portuguese, Spanish, Italian). We remind readers of the fact that this paper fails to capture articles, documents, or policy papers that were published in languages other than English language, a limitation that continues to surface in our scholarship. Furthermore, as a work-in-progress paper, we do not report the results of quality assessment of the articles as prescribed in the SANRA process.

Conclusion

In this paper, our goal was not to merely criticize the influence of western education on the training and practice of STEM educators in SSA or provide a silver bullet solution that would serve as an alternative to current practices. Our goal was to identify colonial factors that have historically influenced the training and practice of STEM educators in the sub-Saharan African context and continue to do so today, sometimes unbeknown to the populace. We argue that understanding how current practices and approaches to STEM teacher education and practice came to be is crucial in the ongoing efforts to achieve sustainable self-directed indigenous education. Using a postcolonial lens, we reviewed over 60 articles in this study and categorized our findings by identifying micro, meso, and macro-level factors. While our review categorizes the overall findings on four levels, in this work-in-progress paper, we discussed only (micro-level interactions between “the African” and the “other” and meso-level interactions between “the African” and “the field”). We emphasize that a review of the pre-, and post-colonial forms of STEM education as it relates to teacher training and practice unearths exciting findings: cultural values that have a rich history, pedagogical techniques that were learner-centered, pedagogical tools that served as cultural mediators, and an African indigenous knowledge that predates the introduction of western scientific thoughts. This paper seeks to contribute scholarship that will enable stakeholders to rethink their ways of knowing, doing, practicing, and sustaining STEM education in SSA.

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