Proposing a Culturally Sustaining Pedagogy Research Framework in Sub-Saharan Africa STEM Education: A Paradigm Shift from Deficit to Asset Based Perspectives

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Abstract

Research shows that teaching practices that are more contextual and inclusive of students' cultural backgrounds and experiences enhance students' learning. Culturally sustaining pedagogy (CSP) is one such example of an asset-based approach to teaching. The CSP framework has been used extensively in K-12 STEM education in the United States. In contrast, the STEM education literature in Sub-Saharan Africa (SSA) adopts a deficit-based approach to research that focuses on pedagogical challenges. This theory study, therefore, serves as preliminary work to ease the transition from a deficit-based to an asset-based approach to STEM education in SSA.
To achieve the purpose of this study, firstly, a research synthesis was conducted to investigate how prior research work has used the CSP framework. Secondly, a framework for the use of CSP in praxis and research within the SSA context is proposed drawing on Onwuegbuzie et al.'s (2012) methodology literature analysis. Findings present an adapted CSP framework for SSA, comprising 11 tenets for asset-based research. They highlight CSP's adaptability across contexts, underscoring its importance in SSA STEM education.

Keywords: culturally sustaining pedagogy, asset-based education, exemplary teaching, inclusion, transferability, Sub-Saharan Africa

Background

Research shows that teaching practices that are more contextual and inclusive of students' cultural backgrounds and experiences enhance students' learning [1]. It is this awareness of improved learning outcomes that paved the way for the conceptualization of asset-based approaches in education by researchers in the fields of education, anthropology, multicultural education, etc. [2]. Asset-based approaches are driven by the need to foster an inclusive learning environment for historically underserved students [3], [4], [5], [6], [7]. Resultantly, concepts like *culturally- appropriate, congruent, relevant, sustaining,* and *responsive* are now noted both in research and practice, centering the influence of culture on classroom practices [4]. The term *culture,* as operationalized in this study, refers to either a student or teacher's values, use of language, experiences, and the lens through which they see the world that ultimately affects their learning methods and teaching practices respectively in the classroom [8]. Due to this extensive influence of culture on the student and teacher, renowned researcher and educator, Dr. Geneva Gay [8] argued that a classroom's climate cannot be "culturally neutral" (p. 8). This paper, therefore, contends that ensuring an inclusive approach to research, with an asset-based perspective involves centering and amplifying the culturally grounded classroom practices of STEM teachers in resource-constrained settings.

Asset-based approaches require that teachers hold a positive perspective regarding students' cultural and background experiences, viewing students' background and experiences as a wealth of assets that can be used to facilitate learning [9]. The underlying idea of asset-based pedagogies is that teachers transition from their traditional roles as *sage on the stage* to *guide by the sides*, thereby switching students' roles from mere *objects* on whom learning is being performed, to *subjects*, leading their own learning [10], [11]. Though the underlying philosophical underpinnings of asset-based pedagogies were drawn from different fields, they have a common goal to ensure a paradigm shift from a teacher-centered to a student-centered classroom environment [11].

Culturally sustaining pedagogy (CSP) is one such example of an asset-based approach to teaching. This framework was conceptualized by Dr. Django Paris, a multicultural education researcher, by drawing on ideas from other asset-based pedagogies like culturally relevant pedagogy and culturally responsive pedagogy, among others [11]. While CSP shares conceptual commonalities with other asset-based pedagogies, its focus on cultural pluralism introduces a nuanced approach compared to others [12]. Building on the definition of culture drawn from [8], cultural pluralism entails the multiplicity or diversity of student's values, background experiences, languages, and lenses that can create different learning experiences within the classroom. The CSP paradigm leverages the diversity of the background experiences and cultural orientations students bring to the classroom to democratize learning [13]. In line with the underlying philosophy of CSP, Paris, and Alim [14] argue that schools should promote multicultural practices that are not used to transmit knowledge but also are considered "as good unto themselves" (p. 263) because "sustain what we love" (p. 269). To this end, Paris and Alim [14] stated that a culturally sustaining pedagogical practice should empower students who can critique conventional notions of academic knowledge.

Depending on the cultural context, CSP can take on different forms [15]. As a result, this theoretical study proposes a CSP framework adapted for the Sub-Saharan African context. Sub-Saharan Africa geographically is the region of the African continent that lies South of the Sahara Desert, including Central Africa, East Africa, Southern Africa, and West Africa regions [16]. The SSA region, though a resource-constrained region, has a massive human capital predicated upon its significant youthful population [17], [18]. Thus, leveraging the potential of STEM education could position the region for global competitiveness due to the untapped resources of this young population [19]. Given that SSA is a highly multicultural region [20], a typical classroom in the region has a wealth of cultural assets that a teacher can take advantage of to ensure students make meaning of what they are learning. That said, we argue in this paper that researchers of secondary STEM education in SSA should focus more on how SSA teachers are drawing on the principles of culturally sustaining pedagogy to ensure inclusive education. Aligning with the African Union's Agenda 2063, which represents a comprehensive 50-year blueprint aimed at reshaping the African continent. The agenda envisions future African citizens who would be well-educated and skilled by leveraging science, technology, and innovation. To achieve the goals of this agenda, there is a need to study the roles of African teachers. This need is underscored by the Agenda 2063 document, which positions these teachers at the frontline, highlighting the key roles they play in achieving the stated goal. Currently, however, the

knowledge base for this work, the STEM education literature in SSA, is fraught with the deficit-based approach to research that focuses on the pedagogical challenges of teachers within the region [24], [25]. This contrasts with how the CSP framework has been used in US K-12 research on classroom practices, where scholars explore how teachers can and are drawing on the multicultural assets of the students [21], [22], [23]. To overcome this current focus of the literature in SSA that could undermine the vision of achieving "the Africa that we want", we are proposing a guiding CSP framework. This framework facilitates the transition from a deficit-based to an asset-based approach to STEM education in SSA by amplifying the exemplary classroom practices of teachers.

Integration of Assets-Based Approaches in STEM Education in SSA

While there has been a massive campaign and many initiatives over the last few decades seeking to ensure quality education in SSA, research shows that the learning challenges facing education within the region persist [27]. These challenges negatively impact the skillset required for fostering development within the region [1]. To allay these challenges within SSA, scholars, and practitioners from within and outside of the region have advocated for indigenous knowledge systems that take into cognizance the culture, ways of knowing, values, and beliefs of African students [28], [18], [29],[1], [26], [27], [30]. Research shows that students' learning is enhanced when their education foregrounds their culture and background experiences [31], [32], [33].

Drawing a connection between the cultural assets students bring to the classroom and what they are learning could help address the wrong notions about education held by these students in resource-constrained settings. Integrating students' indigenous knowledge has been shown to facilitate learning, helping them see relevance, thereby mitigating the *school is a scam* narrative prevalent in some SSA nations [28], [1]. Also, teachers often *codeswitch* between the language of instruction and the students' indigenous languages in a bid to ensure a stronger learning experience for the students [18]. Consequently, in understanding the roles STEM teachers are playing in achieving the Agenda 2063 goals, we argue that researchers should employ culturally oriented lenses that could help unpack classroom practices unique to the SSA people.

Current State of Assets-Based Approaches in Sub-Saharan Africa

Even with all the potential benefits of these approaches, there are challenges with the implementation of asset-based pedagogical techniques by African educators. There appears to be a disconnect between the *will* to incorporate asset-based approaches in policy and the *way* to transform these policies into classroom practices. In Ethiopia for example, asset-based pedagogies are enshrined within policy documents, but research shows a substantial gap between policy and practice [35]. Similarly, in SSA nations, while the need for student-centered pedagogy that centers the assets of the students is advocated for in policy, classroom practices are still largely grounded in teacher-centered practices [10], [18], [36], [37], [38], [39], [40], [41]. In fact, change in seating arrangements (i.e., mixing students of different ability range) is one of few pieces of evidence some teachers within SSA point to when asked how they are implementing asset-based approaches to learning [42].

The inability of teachers to navigate the “murky waters” of asset-based approaches has constituted a barrier to implementation. Specifically, STEM teachers in SSA find it difficult to relate science concepts to the real world of their students [43]. This challenge becomes heightened against the backdrop of the fact that STEM concepts are notorious for being misconstrued by students [44], [33], making a STEM teacher’s task arduous yet transformative. By “arduous” we are of the opinion that the teachers would have to painstakingly master how to make STEM concepts relatable for the students. By “transformative,” we argue that the process creates a *transformative* learning experience for the teachers themselves. This challenge, thus, aligns with research findings that suggest educators need to transform into learners first to enact student-centered teaching strategies [38]. Similarly, the inability of some teachers to *codeswitch* between the language of instruction and the student's language is another challenge that impedes the enactment of student-centered teaching approaches in SSA [45]. Therefore, teachers find the enactment of asset-based techniques challenging, underscoring the need for professional development. However, for those teachers with the knowledge of the “how” of asset-based pedagogies, knowing “when” to apply “what” in the classroom can also be challenging for them [46].

Currently, research in STEM education within SSA is conducted mostly from a deficit-based perspective. We, however, argue that this mounting evidence of pedagogical challenges by SSA teachers is entrenched in a deficit-framing of research that entails “staring at the thorns” (i.e., pedagogical challenges of SSA teachers) while being “oblivious to the rose” (i.e., the exemplary classroom practices) [66]. In this point-of-departure paper, therefore, we propose a guiding CSP framework contextualized for the SSA region, helping to ease the transition from a deficit-framing to an asset-based framing of research. Also, while factors like race, ethnicity, gender, and language have served as impediments to quality education, in resource-constrained settings like SSA, the same factors, when viewed from an asset-based perspective, could serve as building blocks for quality education [47]. To this end, we argue that the challenges that confront the asset-based framing in SSA can provide the basis to ensure quality STEM education research.

Culturally Sustaining Pedagogy

Building on previous culturally grounded frameworks, Paris in [12] conceptualized culturally sustaining pedagogy as an approach to education that acknowledges, validates, and leverages the cultural frames of reference of students to foster learning for them. Some of these cultural frames of reference include the students’ languages, values, and background experiences. The framework aims to uphold cultural diversity in a classroom, ensuring an inclusive and equitable environment where each student feels respected and valued. CSP as an educational paradigm uses multicultural practices in the classroom to connect students' learning experiences and their background experiences. The multicultural orientation of the CSP framework makes it a very suitable lens for studying educational issues within the culturally diverse context of the SSA context.

Methods

The *between-study* framework conceptualized in Onwuegbuzie et al. [48] for the rigorous analysis and interpretation of literature is employed as a qualitative methodological approach to address the following research question.

How might STEM teachers in Sub-Saharan Africa be leveraging the asset-based ideology of culturally sustaining pedagogy to foster an inclusive classroom environment?

The *between-study* framework entails the rigorous analysis and interpretation of literature. The framework was conceptualized to facilitate the literature synthesis process (see Table 1 for components of the framework). Comparison and contrasting information from two or more literature sources are two core elements of the framework. The framework serves not only as a tool for identifying research gaps but also aligns with the insights suggested by Onwuegbuzie et al. [48], who considered literature synthesis as a "methodological process in its own right." (p. 2). It is to the end of leveraging the *between-study* framework as a methodological stance that it was chosen for this study.

Concepts	**Definition**
Between-study	A methodological approach for the rigorous analysis of literature on a particular concept to have an in-depth understanding of the concept than would have been gotten from just a study.
Representation	Refers to how information concerning the concept under consideration compares across multiple literature sources to have a nuanced understanding. In this study, *representation* was done in four different passes of analysis of literature.
Development	This refers to how data from one literature source can help inform data from another source.
Expansion	Refers to the expansion of the frontiers of information gleaned from a literature source by information from another literature source.
Triangulation	Refers to seeking convergence of information from multiple literature sources.
Complementarity	Refers to seeking clarification of information from one literature source with information from another source.
Legitimization	Refers to the trustworthiness measure employed towards the quality of the literature synthesis.
Between-source triangulation	Assessing the level of corroboration of information from different literature sources.
Between-source initiation	This refers to the exploration of contradictions in information across literature sources that leads to a renewed understanding of phenomena.

Table 1: Definitions of methodological terms adapted from Onwuegbuzie et al. [48]

Leveraging the *between-study*, we employed the representation and legitimization methods of the framework as methodological standards for the study (see Figure 1). Representation involves the comparison of information from multiple literature sources to ensure an adequate understanding of the phenomenon under consideration. Using multiple literature sources helps generate more meaning from the available copious data, enhancing the synthesis's quality in the process. To this end, we searched various academic databases using the study title as keywords. Consequently, the following keywords were used as search terms, "culturally sustaining pedagogy," "STEM education," and "Sub-Saharan Africa." We limited the search to different combinations of these keywords across titles, abstracts, summaries, and full text of articles. Our search was guided by inclusion/exclusion criteria of *sources* of the articles and *language*. Articles presented in a scholarly/ peer-reviewed study and published in academic journals or conferences were selected. Also, only articles that were published in the English language were considered. Consequently, 19 articles were extensively reviewed for this study.

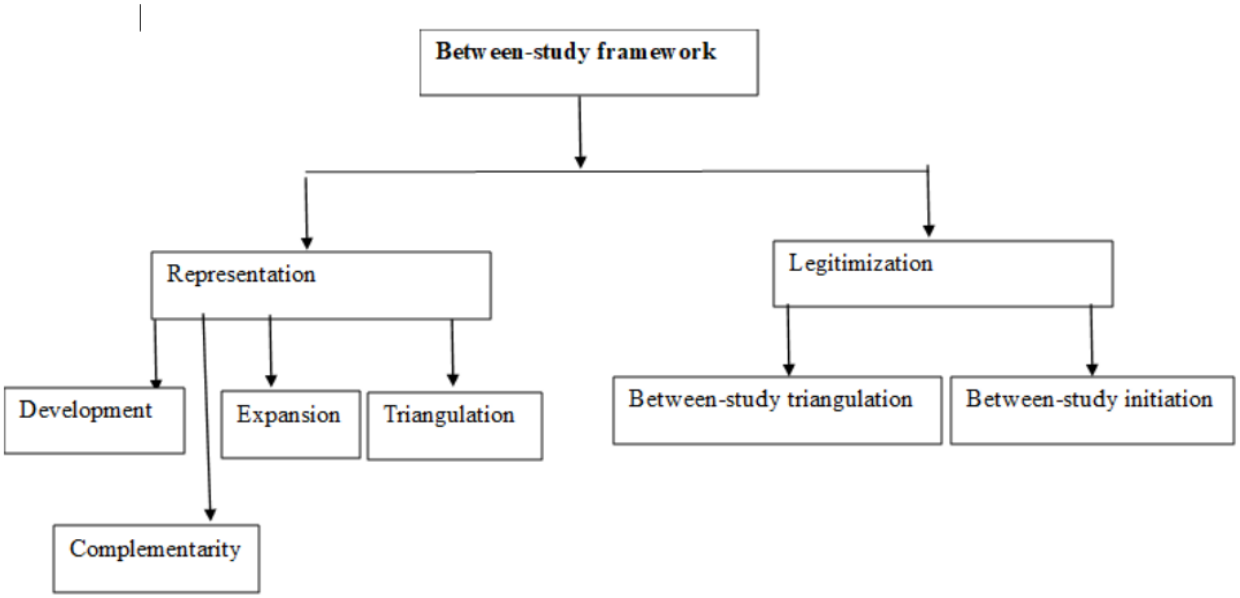

Figure 1: The methodological process for this study adapted from Onwuegbuzie et al. [48]

Using *representation,* an extensive analysis of the 19 articles was conducted. In the first pass of analysis, we assessed the abstracts of the articles to have an overview of each study. In the second pass, an in-depth analysis of the articles was done to have a nuanced understanding of the concept of culturally sustaining pedagogy across the articles. At this point, the in-depth analysis of the phenomenon under consideration generated an understanding of the underlying philosophy, rationale, and components of the CSP framework. During our review, no single paper was fully able to answer the research question above. In the third pass, we sought out common themes that were emerging from our understanding of the CSP framework across the various articles. To this end, 11 themes that capture the essence and philosophy of CSP were generated.

As subcomponents of the *representation* method, we employed the *development* and *expansion* methods in the fourth pass to draw connections between the 11 themes and STEM education in Sub-Saharan Africa. In this regard, we drew a connection between the generated themes and the SSA context by highlighting how each of these 11 themes is grounded in the multicultural practices of the Sub-Saharan African people and by extension to classroom practices within the region. For example, the "*encourages students to demonstrate learning through multiple ways*" theme points to the multiple ways students are encouraged to demonstrate their learning in a CSP-inclined classroom. We made a connection of this theme with the SSA context by showing that African cultures assume reality can be known through multiple means other than through the reason that Western education supports. Hence, students in an African classroom should be encouraged to showcase their learning through the multiple ways of knowing consistent with African cultures. To this end, several research articles were reviewed extensively to seek a deep and nuanced understanding of the concept of culturally sustaining pedagogy. The tenets generated were informed by the themes that connected to the SSA context.

As measures to ensure research quality, *representation* in this study was done through *triangulation* and *complementarity*. The *triangulation* and *complementarity* methods of analysis provided a nuanced understanding of CSP by seeking convergence of CSP information gleaned from multiple sources to ensure information obtained from one literature is in congruence with information from other sources. The *complementarity* method was employed to elaborate, clarify, and illustrate information from multiple sources. While triangulation was used to seek convergence of information from multiple literature sources. The final codebook was based on three thematic areas and multiple iterations of coding and engaging in critical reviews of the codes by peer debriefer.

Given the need to ensure the trustworthiness of the synthesis, the *legitimation* method was used. *Legitimation* for this theoretical *s*tudy was done in two steps i.e., *between-source triangulation* and *between-source initiation.* Guiding the synthesis, *between-source triangulation* was useful in assessing that the underlying philosophy of the CSP framework is obtained when one source converges and corroborates with the ones from other sources. Leveraging the *between-source initiation* trustworthiness approach, we ensured there were no inconsistencies or contradictions in the outlined principles of CSP across the various sources reviewed. Scholars in engineering education, international education policy, and K-12 education were involved in the critical reviews of the themes.

Results

The results comprise the 11 tenets of the CSP framework drawn largely from Paris and colleagues' seminal literature on CSP, Ladson-Billings inquiry into the framework and other researchers who have worked extensively on the CSP framework. The proposed framework in this study contextualizes the CSP framework by providing a connection to SSA, ensuring its applicability both in research and praxis within the region.

This section discusses the 11 tenets, the grounding of the tenets in literature and their connection to the Sub-Saharan African context.

1. Draws on the Ubuntu Philosophy by Encouraging Collaboration

Cultural sustaining pedagogy according to [13] recognizes and acknowledges the indigenous knowledge systems and ways of knowing that students bring to the classroom. These frames of reference provide a lens through which these students interact with their world. Further, the literature on CSP [11]-[15] centers cultural pluralism, necessitating students from diverse backgrounds work together to make meaning of their learning by leveraging the assets (i.e., background experiences, cultures, ideas) they bring to the classroom.

The underlying collaborative philosophy of the CSP framework has its place in the African culture. Africans have been known to live communally, extolling the Ubuntu philosophy, grounded in the belief that humans are interconnected and the wellbeing of one hinge on the well-being of others [49]. To this end, enacting CSP within SSA will ensure classroom practices are grounded in ubuntu values by promoting students' participation and ensuring a class environment where the cultural assets each student brings to the classroom are valued. It is within this communal type of classroom where cooperative learning is advanced that students' learning is enhanced, while fostering mutual respect among them.

2. Leverages Cultural Capital of Student to Scaffold Teaching

One of the core philosophical underpinnings of the CSP framework is its multicultural stance, i.e., acknowledging and incorporating diverse cultural backgrounds into academic content and teaching practices [12]. CSP's multicultural stance in comparison to the monocultural orientation advanced by traditional education provides a nuanced approach to teaching [11], [13]. The need to ensure that education is designed from the standpoint of the cultural pluralism prevalent in today's classroom was one motivating factor for the advancement of CSP. Consequently, a CSP ensures classroom practices leverage the diverse cultural capital to scaffold academic concepts. Given the pluralistic cultures within SSA, rather than ignoring these capitals, STEM education in SSA should leverage them as building blocks to deepen learning, providing a footing for the realization of "the Africa we want" [18]. In Nigeria, for instance, while there is a general misconception of monoculturalism especially by folks in the US, there are over 500 different languages, each providing different cultural nuances. Hence, researchers must acknowledge this cultural heterogeneity in capturing the lived realities of the SSA people.

3. Incorporates Multiple Perspectives in the Teaching Process

A fallout of the multicultural stance of culturally sustaining pedagogy is the acknowledgment that students learn in diverse ways [13]. Hence, the classroom should be an inclusive learning environment, where multiple perspectives are incorporated, accommodating the different worldviews and background experiences of the students. STEM education in SSA, more than what obtains in any other region globally, should incorporate multiple perspectives due to the region being the most culturally diverse globally [50]. The importance of advancing multiple perspectives is heightened against the backdrop of evidence that shows that the legacy of colonial education is still evident long after African nations gained independence [43]. Hence, STEM education in SSA is not designed to address the local needs, nor does it consider indigenous knowledge and perspectives. As such, there is the need to ground African STEM education in indigenous cultures to ensure African development, by Africans, using African

knowledge systems. Using classroom examples that center the diverse lived experiences of the students is one of the ways to incorporate diverse perspectives within the classroom.

4. Centers and Honors Students' Ideas in the Classroom

Culturally sustaining pedagogy, as an educational framework, advocates for a student-centered classroom environment [14]. Student-centered teaching techniques put the students actively at the center of the learning process while the teacher facilitates knowledge construction by building on the students' prior knowledge [51]. Putting the students actively at the center of the learning process requires teachers to value students' cultures, ideas, and lived experiences, [15]. The African youth population has been referred to as the continent's greatest resource considering the global knowledge economy where an educated human capital is the "trading currency" [67, p. 225]. Moreover, within the field of anthropology, there is a proliferation of research on the contributions African youth population could play in the development of the continent [68]. As such, centering, and honoring students' ideas and their cultural orientations could ensure the retention of Africa's critical mass within STEM education, as students in SSA often drop out of STEM classes due to the lack of value accorded to their culture in the classroom [18]. To this end, we advocate for an increased emphasis on STEM education research studies to explore how the growing youth demographic in SSA can harness the human development capabilities of STEM education for the continent's advancement.

5. Encourages Students to Demonstrate Learning through Multiple Ways

The CSP framework, according to Paris [15], can take on different forms depending on the cultural context, and it acknowledges different *ways of knowing*. Hence, a CSP oriented classroom should encourage learning demonstration through multiple ways that may be consistent with the *ways of knowing* of the students. Within the Sub-Saharan African context, reality can be known through imagination, intuition, and personal feelings and not just the logical analysis mode of knowing advanced by Western education [52]. Challenging the universality of the Western scientific method and promoting African ways of knowing, while ensuring inclusiveness in the process. Taken together, designing education from the standpoint of CSP in SSA should promote the diverse ways students can demonstrate their learning.

6. Incorporates Digital Media to Enhance Learning for Digital Natives

Educator and researcher, Ladson-Billings [53] argues that the CSP framework incorporates the intersectional identities and cultures that shape "today's youth culture" (p. 82). Hence, the education of today's youth should consider the global identities emerging in arts, sports, music etc. because of the effects of globalization on youth's identity [54]. In the 21st century, digital platforms have enabled cultural exchange and transmission for the youth population [55], making these platforms a medium of acculturation for this digital-native generation. Given that SSA has the highest number of youth population globally [56], STEM teachers in this region should leverage digital media to assist the substantial number of digital natives in making meaning of their learning. Also, we believe that incorporating digital media could be a way to democratize education, addressing the perennial concern of access to quality education for the youthful population in SSA.

7. Draws on Authentically Meaningful Examples

Teachers help students activate their prior knowledge when they make connections between what the students already know and what they are learning [13]. This cascaded mode of teaching takes the students on a journey from the known to the unknown, their cultural frames of reference serving as signposts, illuminating their understanding in the process. Such *transformative* learning is helpful in the formation of a science identity for students [57], especially for SSA students, who often see STEM subjects as exempting them [18]. Furthermore, "development for Africa" is often inundated with a "multiplicity of Western-generated ideas, models and research paradigms" according to Nyamnjoh [58, p. 182]. To this end, Ngara [59] asserted that since development does not occur in "cultural vacuum," African educators should prioritize using their students' culture as a conduit to transmit learning (p. 9). Also, we posit that grounding SSA STEM education only in Western-generated ideas could potentially create the *dangers of a single story* [69]. This approach could limit the opportunities to give examples that are more authentic to African cultures, fostering the creation of a Western-centric stereotype around the examples in STEM, who gets to be part of STEM, and the applications of STEM.

8. Encourages Teachers to Code switch to Support Student Learning

Learning STEM subjects can be linguistically challenging especially in Africa where the language of instruction is often different from the students' indigenous language [18]. To allay this challenge, the CSP framework encourages teachers to *codeswitch* between the language of instruction (often English or French) and the every-day language of the students [11]. In doing this, CSP fosters and sustains the linguistic capital of students, underscoring its importance in enhancing students' learning experience [14]. Taken together, the CSP framework provides the opportunity to capture in research how and when SSA STEM teachers are codeswitching and the implications of this for their professional development.

9. Leverages on Students' Social Capital for Instructional Design

Central to the CSP framework is the acknowledgment of the role family plays in enhancing students' learning experiences [15]. In line with this objective, teachers who enact culturally sustaining classroom practices leverage students' lived experiences by incorporating inputs from families and the communities where the students live [13]. Engaging students' social capital has been described as an educational approach that could help unpack the learning needs of SSA students, addressing these needs and empowering them to contribute meaningfully to society [60].

10. Observes to Learn About Students

Owing its philosophical paradigms to anthropology, culturally relevant pedagogy [the seminal work upon which CSP was based] is predicated on how a teacher's observation of students in the natural setting of their out-of-school environment could influence classroom practices [62]. CSP, drawing on the philosophical underpinning of culturally relevant pedagogy, also ensures teachers know their students by gaining useful insights into their lived experiences [13]. Insightful knowledge of who the students are could inform classroom practices for teachers [63]. Traditionally, observation has been described as a *way of knowing* by which Africans interact

and seek understanding of their environment [10]. This approach to knowing is done through direct sensory experience. For example, in African culture, the stretching of the hands through a window on a cold morning is used to gauge the weather condition. African educators who want to enact CSP should consider observations of their students of paramount importance. This emphasis is rooted in cultural (i.e., African) perspectives and aligns with the paradigmatic approach of CSP, promoting observation as a *way of knowing*.

11. Reflects on Teaching Practices

The ability of teachers to self-reflect on teaching practices is an essential component of the CSP framework [13]. By reflecting on their instructional practices, teachers examine their actions within the classroom and the underlying philosophies and beliefs that power their decisions and actions. This critical reflection can then improve teaching practices and foster teachers' personal development and growth [64]. Therefore, teachers within the Sub-Saharan African context ought to engage in similar reflective practices [65]. This rationale is predicated on the fact that teachers within resource-constrained settings like SSA need to reflect on their practices, and what works, unpacking novel methods of teaching and handling learning challenges peculiar to the context.

Discussion and Implications for Researchers

In this theoretical study, a culturally sustaining pedagogical framework was proposed that emphasized the shift from a deficit to an asset-based framing in STEM education research within Sub-Saharan Africa. The reason for undertaking this research endeavor is the need to provide an asset-based theoretical lens suitable to the SSA context. While there are many asset-based frameworks that could be used to frame education research in SSA, the choice of CSP hinges on its multicultural stance to education. In this regard, CSP provides an appropriate guiding lens for the cultural pluralistic setting of Sub-Saharan Africa. This allowed for the contextualization of the CSP framework to the SSA context, Hence, underscoring the transferability of the framework.

Researchers within STEM education in SSA could leverage this proposed framework as a guiding lens to unpack teaching practices that are grounded in the students' cultural frames of reference. Also, by emphasizing an asset-based approach to research, the proposed framework is an attempt at providing a research tool that could contribute to the realization of the *Africa that we want* as outlined in the Agenda 2063 document. While the framework was developed with researchers in mind, other stakeholders like teachers and policymakers could find it useful in the design and redesign of an inclusive STEM education within SSA.

Though the CSP framework has been adapted to the SSA context in this study, its ability to take on different forms across different contexts highlights its universality, lending itself to contextualization in non- US and non-SSA contexts. As a result, researchers in other non-US contexts could adapt the method used in this research to contextualize the CSP framework.

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Reference

[1] G. Bethel, “Mathematics Education in Sub-Saharan Africa,” *Pap.*, 2019, Accessed: Aug. 24, 2023. [Online]. Available: https://elibrary.worldbank.org/doi/epdf/10.1596/25289

[2] M. Vavrus, *Culturally responsive teaching. 21st century education: A reference handbook, 2, 49–57*. Thousand Oaks, CA: Sage Publishing, 2008.

[3] Aceves, Terese and Orosco, Michael, “Culturally Responsive Teaching,” 2014, [Online]. Available: https://ceedar.education.ufl.edu/innovation-configurations/

[4] B. Aronson and J. Laughter, “The theory and practice of culturally relevant education: A synthesis of research across content areas,” *Rev. Educ. Res.*, vol. 86, no. 1, pp. 163–206, 2016.

[5] V. L. Bond, “Culturally Responsive Education in Music Education: A Literature Review,” *Contrib. Music Educ.*, vol. 42, pp. 153–180, 2017.

[6] G. Gay, “Politics of Multicultural Teacher Education,” *J. Teach. Educ.*, vol. 56, no. 3, pp. 221–228, May 2005, doi: 10.1177/0022487105275913.

[7] C. M. Rhodes, “A Validation Study of the Culturally Responsive Teaching Survey,” *Univers. J. Educ. Res.*, vol. 5, no. 1, pp. 45–53, Jan. 2017, doi: 10.13189/ujer.2017.050106.

[8] G. Gay, *Culturally responsive teaching: Theory, research, and practice*. teachers college press, 2018.

[9] K. Holmes, E. Mackenzie, N. Berger, and M. Walker, “Linking K-12 STEM Pedagogy to Local Contexts: A Scoping Review of Benefits and Limitations,” *Front. Educ.*, vol. 6, 2021, Accessed: Jan. 16, 2024. [Online]. Available: https://www.frontiersin.org/articles/10.3389/feduc.2021.693808

[10] Olayemi, Moses and DeBoer, Jennifer, “Colonial antecedents influencing the current training and practice of STEM educators in Sub-Saharan Africa | REES AAEE 2021 conference: Engineering Education Research Capability Development.” Accessed: Jan. 16, 2024. [Online]. Available: https://search.informit.org/doi/abs/10.3316/informit.354598408451122

[11] F. M. Mensah and K. Larson, “A summary of inclusive pedagogies for science education,” *Natl. Acad. Sci. Eng. Med.*, 2017.

[12] D. Paris, “Culturally Sustaining Pedagogy: A Needed Change in Stance, Terminology, and Practice,” *Educ. Res.*, vol. 41, no. 3, pp. 93–97, Apr. 2012, doi: 10.3102/0013189X12441244.

[13] M. K. Ramzan, “How Can Principles of Culturally Sustaining Pedagogy Inform the Design of a Junior High Curriculum to Enhance Science Learning in a Meaningful Way?” Antioch University, 2023.

[14] Paris, Django and Alim, Samy, “What Are We Seeking to Sustain Through Culturally Sustaining Pedagogy? A Loving Critique Forward | Harvard Educational Review.” Accessed: Jan. 16, 2024. [Online]. Available: https://meridian.allenpress.com/her/article-abstract/84/1/85/32145/What-Are-We-Seeking-to-Sustain-Through-Culturally

[15] Paris, Django, “Culturally Sustaining Pedagogies and Our Futures.” Accessed: Jan. 16, 2024. [Online]. Available: https://www.tandfonline.com/doi/full/10.1080/00131725.2021.1957634?casa_token=y-hIhretrXMAAAAA%3AeN92WjOd3PWUpjzLb-GUB6wtcRvO_nBDEWQvmzWxP70ZnEar6qldPIMgpX6-dpjE3Fakjw7g4DoD

[16] H. P. Linder, H. M. de Klerk, J. Born, N. D. Burgess, J. Fjeldså, and C. Rahbek, “The partitioning of Africa: Statistically defined biogeographical regions in sub-Saharan Africa,” *J. Biogeogr.*, vol. 39, no. 7, pp. 1189–1205, 2012.

[17] Kagia, “STEM education in Africa: Risk and opportunity.” Accessed: Sep. 04, 2023. [Online]. Available: https://www.brookings.edu/articles/stem-education-in-africa-risk-and-opportunity/

[18] L. Tikly, M. Joubert, A. M. Barrett, D. Bainton, L. Cameron, and H. Doyle, “Supporting secondary school STEM education for sustainable development in Africa,” *Univ. Bristol Bristol Work. Pap. Educ. Ser. Retrieved August*, vol. 30, p. 2020, 2018.

[19] Z. Ismail, “Benefits of STEM Education,” 2018.

[20] F. Muchenje, “Cultural Pluralism and the Quest for Nation Building in Africa: The rationale for Multicultural Education,” 2012.

[21] M. K. Montero, “Creating Cultural Sustenance in the Classroom: A Review of Culturally Sustaining Pedagogies: Teaching and Learning for Justice in a Changing World,” *J. Adolesc. Adult Lit.*, vol. 62, no. 6, pp. 698–701, 2019.

[22] J. Mistry, J. Segovia, L. W. Li, C. McWayne, B. Zan, and D. Greenfield, “‘I woke up to science’: Teacher narratives of growth in a culturally sustaining preschool STEM program,” *J. Appl. Dev. Psychol.*, vol. 83, p. 101456, 2022.

[23] N. A. Ortiz and D. Ruwe, “Black English and mathematics education: A critical look at culturally sustaining pedagogy,” *Teach. Coll. Rec.*, vol. 123, no. 10, pp. 185–212, 2021.

[24] O. Badmus and E. Omosewo, “Improving Science Education in Nigeria: The Role of Key Stakeholders,” *Eur. J. Health Biol. Educ.*, vol. 7, no. 1, Apr. 2018, doi: 10.29333/ejhbe/87086.

[25] Nsengimana, Théophile, Mugabo, Leon, Hiroaki, Ozawa, and Nkundabakura, Pheneas, “Reflection on science competence-based curriculum implementation in Sub-Saharan African countries.” Accessed: Jan. 16, 2024. [Online]. Available: https://www.tandfonline.com/doi/full/10.1080/21548455.2020.1778210?casa_token=TvMxa0FsN0AAAAAA%3AjZ4vc7gLMqz3opaRnSWIEphcex-iGtTPOjSfa05IkBYu2UYRekoOcILrGdxrPKhVaRfiijrHJEN5

[26] African Union Commission, “Agenda 2063: The Africa we want.” Accessed: Aug. 12, 2023. [Online]. Available: https://documents1.worldbank.org/curated/en/237371468204551128/pdf/910160WP0P126900disclose09026020140.pdf

[27] A. Breidlid, “Beyond the Western paradigm: Indigenization of education systems, the Sustainable Development Goals and state building in sub-Saharan Africa,” in *Indigenous knowledges and the sustainable development agenda*, Routledge, 2020, pp. 12–32.

[28] M. Seehawer and A. Breidlid, “Dialogue between epistemologies as quality education. Integrating knowledges in Sub-Saharan African classrooms to foster sustainability learning and contextually relevant education,” *Soc. Sci. Humanit. Open*, vol. 4, no. 1, p. 100200, Jan. 2021, doi: 10.1016/j.ssaho.2021.100200.

[29] Nigeria Federal Ministry of Education, “FEDERAL MINISTRY OF EDUCATION.” Accessed: Jan. 17, 2024. [Online]. Available: https://education.gov.ng/

[30] H. K. Altinyelken, “Pedagogical renewal in sub-Saharan Africa: the case of Uganda,” *Comp. Educ.*, vol. 46, no. 2, pp. 151–171, 2010.

[31] A. Asabere-Ameyaw, G. J. S. Dei, and K. Raheem, “The question of indigenous science and science education: A look at the current literature,” in *Contemporary issues in African sciences and science education*, Brill, 2012, pp. 15–28.

[32] E. Shizha, “Rethinking contemporary sub-Saharan African school knowledge: Restoring the indigenous African cultures,” *Int. J. Cross-Discip. Subj. Educ.*, vol. 4, no. 1, pp. 1870–1878, 2014.

[33] P. F. Ukata, N. Wechie, and E. L. Nmehielle, “Instructional strategies and teaching of business education in higher institutions in Rivers State,” *Int. J. Educ. Eval.*, vol. 3, no. 9, pp. 20–36, 2017.

[34] Y. Elkana, “A Programmatic Attempt at an Anthropology of Knowledge,” in *Sciences and Cultures*, vol. 5, E. Mendelsohn and Y. Elkana, Eds., in Sociology of the Sciences a Yearbook, vol. 5, Dordrecht: Springer Netherlands, 1981, pp. 1–76. doi: 10.1007/978-94-009-8429-5_1.

[35] D. D. Serbessa, “Tension between traditional and modern teaching-learning approaches in Ethiopian primary schools,” *J. Int. Coop. Educ.*, vol. 9, no. 1, pp. 123–140, 2006.

[36] C. Kaluyu and J. M. Ndiku, “Pedagogy and Information Technology Integration, As Strategies for Improving Academic Performance in Stem Subjects: A Critical Literature Review,” *J. Educ. Pract.*, vol. 11, no. 21, 2020.

[37] J. M. Ndiku and V. Kaluyu, “Learner perspective of pedagogy for improved performance in stem subjects: a literature review,” *IOSR J. Res. Method Educ.*, vol. 10, no. 4, pp. 15–27, 2020.

[38] M. El Nagdi, F. Leammukda, and G. Roehrig, “Developing identities of STEM teachers at emerging STEM schools,” *Int. J. STEM Educ.*, vol. 5, no. 1, pp. 1–13, 2018.

[39] B. Hassler, S. Hennessy, and R. Hofmann, “Sustaining and scaling pedagogic innovation in Sub-Saharan Africa: Grounded insights for teacher professional development,” *J. Learn. Dev.*, vol. 5, no. 1, 2018.

[40] K. M. O-saki and A. O. Agu, “A study of classroom interaction in primary schools in the United Republic of Tanzania,” *Prospects*, vol. 32, no. 1, pp. 103–116, 2002.

[41] M. O’Sullivan, “The reconceptualisation of learner-centred approaches: A Namibian case study,” *Int. J. Educ. Dev.*, vol. 24, no. 6, pp. 585–602, 2004.

[42] B. Nykiel-Herbert, “Mis-Constructing Knowledge: The Case of Learner-Centred Pedagogy in South Africa.,” *Prospects Q. Rev. Comp. Educ.*, vol. 34, no. 3, pp. 249–265, 2004.

[43] L. M. Semali and K. Mehta, “Science education in Tanzania: Challenges and policy responses,” *Int. J. Educ. Res.*, vol. 53, pp. 225–239, Jan. 2012, doi: 10.1016/j.ijer.2012.03.012.

[44] W. Ottevanger, J. J. H. Van den Akker, and L. De Feiter, *Developing science, mathematics, and ICT education in sub-Saharan Africa: Patterns and promising practices*. World Bank Publications, 2007.

[45] M. Probyn, “Language and learning science in South Africa,” *Lang. Educ.*, vol. 20, no. 5, pp. 391–414, 2006.

[46] T. G. Olatunde-Aiyedun and N. J. Ogunode, “School administration and effective teaching methods in science education in north central nigeria,” *Olatunde-Aiyedun TG Ogunode NJ 2021 Sch. Adm. Eff. Teach. Methods Sci. Educ. Niger. Int. J. Integr. Educ.*, vol. 4, no. 2, pp. 145–161, 2020.

[47] K. L. Biraimah, “Moving beyond a destructive past to a decolonised and inclusive future: The role of ubuntu-style education in providing culturally relevant pedagogy for Namibia,” *Int. Rev. Educ.*, vol. 62, pp. 45–62, 2016.

[48] A. J. Onwuegbuzie, N. L. Leech, and K. M. Collins, “Qualitative analysis techniques for the review of the literature.,” *Qual. Rep.*, vol. 17, p. 56, 2012.

[49] M. C. Maphalala, “Embracing Ubuntu in managing effective classrooms,” *Gend. Behav.*, vol. 15, no. 4, pp. 10237–10249, 2017.

[50] J. S. Ojo and J. Clarke, “Multiculturalism and policymaking in Africa,” in *Routledge Handbook of Public Policy in Africa*, Routledge, 2021, pp. 247–258.

[51] O. A. Filatova, “Cultural attributes of students to make student-centered approach successful,” *Int. J. Lang. Lit. Linguist.*, vol. 1, no. 1, pp. 20–24, 2015.

[52] D. Millar, S. B. Kendie, A. A. Apusigah, and B. Haverkort, *African knowledges and sciences: Understanding and supporting the ways of knowing in Sub-Saharan Africa*. Leusden, Netherlands: COMPAS, 2006.

[53] G. Ladson-Billings, “Culturally relevant pedagogy 2.0: aka the remix,” *Harv. Educ. Rev.*, vol. 84, no. 1, pp. 74–84, 2014.

[54] C. Heaven and M. Tubridy, “Global youth culture and youth identity,” *Highly Affect. Rarely Consid. Int. Youth Parliam. Comm. Rep. Impacts Glob. Young People*, pp. 149–60, 2003.

[55] D. Piper *et al.*, “Sharing culture in a tech world: Grandparent–grandchild cultural exchanges over video chat.,” *Transl. Issues Psychol. Sci.*, 2023.

[56] K. A. Omenugha, C. E. Uzuegbunam, and I. S. Ndolo, “Celebrity culture, media and the Nigerian youth: negotiating cultural identities in a globalised world,” *Crit. Arts*, vol. 30, no. 2, pp. 200–216, 2016.

[57] K. Nicola-Richmond, G. Pépin, H. Larkin, and C. Taylor, “Threshold concepts in higher education: A synthesis of the literature relating to measurement of threshold crossing,” *High. Educ. Res. Dev.*, vol. 37, no. 1, pp. 101–114, 2018.

[58] F. B. Nyamnjoh, “A relevant education for African development-Some epistemological considerations,” *Afr. Dev.-SENEGAL-*, vol. 29, no. 1, pp. 161–184, 2004.

[59] C. Ngara, “African ways of knowing and pedagogy revisited,” *J. Contemp. Issues Educ.*, vol. 2, no. 2, 2007.

[60] D. Bainton, A. M. Barrett, and L. Tikly, “Improving Secondary School Teacher Quality in Sub-Saharan Africa,” 2016.

[61] D. J. Carter Andrews, “Preparing teachers to be culturally multidimensional: Designing and implementing teacher preparation programs for pedagogical relevance, responsiveness, and sustenance,” in *The Educational Forum*, Taylor & Francis, 2021, pp. 416–428.

[62] G. Ladson-Billings, “Toward a Theory of Culturally Relevant Pedagogy,” *Am. Educ. Res. J.*, vol. 32, no. 3, pp. 465–491, Sep. 1995, doi: 10.3102/00028312032003465.

[63] W. C. Savenye and R. S. Robinson, “Using qualitative research methods in higher education,” *J. Comput. High. Educ.*, vol. 16, pp. 65–95, 2005.

[64] B. Gün, “Quality self-reflection through reflection training,” *ELT J.*, vol. 65, no. 2, pp. 126–135, 2011.

[65] T. Hyacinth and S. Mann, “Reflective Practice in Nigeria: Teachers’ Voices and Experiences.,” *Tesl-Ej*, vol. 18, no. 3, p. n3, 2014.

[66] M. J. C. Forgeard and M. E. P. Seligman, “Seeing the glass half full: A review of the causes and consequences of optimism,” *Prat. Psychol.*, vol. 18, no. 2, pp. 107–120, 2012.

[67] M. Makiwane and S. Kwizera, “Youth and well-being: a South African case study,” *Soc. Indic. Res.*, vol. 91, pp. 223–242, 2009.

[68] J. Philipps,” J. Youth Stud., vol. 17, no. 10, pp. 1362–1377, 2014.

[69] C. N. Adichie, The danger of a single story. TED Talk, 2009.