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Knowledge Systems and the Colonial Legacies in African Science Education

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Abstract This review surveys Femi Otulaja and Meshach Ogunniyi's (2015) *Handbook of Research in Science Education in Sub-Saharan Africa*, noting the significance of the theoretically rich content and how this book contributes to the field of education as well as to the humanities more broadly. The volume usefully outlines the ways in which science education and scholarship in sub-Saharan Africa continue to be impacted by the region's colonial history. Several of the chapters also enumerate proposals for teaching and learning science and strengthening academic exchange. Concerns that recur across many of the chapters include inadequate implementation of reforms; a lack of resources, such as for classroom materials and teacher training; and the continued and detrimental linguistic, financial, and ideological domination of African science education by the West. After a brief overview of the work and its central issues, this review closely examines two salient chapters that focus on scholarly communications and culturally responsive pedagogy. The scholarly communication section addresses the ways in which African science education research may in fact be too closely mirroring Western knowledge constructions without fully integrating indigenous knowledge systems in the research process. The chapter on pedagogy makes a similar argument for integrating Western and indigenous knowledge systems into teaching approaches.

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This review addresses issues raised in: Review of Handbook of research in science education in sub-Saharan Africa.

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The series in which editors Femi Otulaja and Meshach Ogunniyi's (2015) *Handbook of Research in Science Education in Sub-Saharan Africa* appears is predicated upon challenging the ideological assumption that scientific knowledge systems are unproblematically universal. Their volume specifically surveys trends in postcolonial science education development within a representative selection of sub-Saharan African countries, with the aim of revealing the contours of and generating insight into the tensions inherent in this development and its ongoing struggle to overcome the dominance of entrenched Eurocentrism. The detailed descriptions and discussions of the achievements and difficulties in this process provide a sense of the power of polyphony in science education, as when the series preface notes that "the purpose of the series is not to explicitly work out the differences but to allow the differences to become salient in the side-by-side" (Otulaja and Ogunniyi 2015, p. 2). Such differences, whether within or among nations or between indigenous and Western knowledge systems, are unambiguously rooted in the sociohistorical complexities within which they occur. For example, Marissa Rollnick's (2015) refined account of the formation of two key science education organizations within the crucible of post-apartheid local politics in South Africa lives alongside Kabba E. Colley's (2015) enthusiastic description of the advances of Gambian science education models since independence from colonial rule. Taken as a whole, the nine chapters of the *Handbook of Research in Science Education in Sub-Saharan Africa* embody distinctive perspectives about the state of science education in this region, with broader implications for educators in general, as well as for scholars of postcolonialism.

While the perspectives and foci of the chapters are distinct, their accounts also contain, perhaps unsurprisingly, numerous echoes of one another. The three chapters that follow the

introduction by Otulaja and Ogunniyi (2015) are generally informational in nature. In the second chapter, Colley (2015) details the evolution of the teaching and learning of science in Gambia, including in precolonial and colonial times, and concludes with a four-point proposal for student-centered, project-based learning moving forward. Rollnick follows with a history of the Southern African Association for Research in Mathematics, Science and Technology and the South African Association of Science and Technology Educators. In the fourth chapter, Oloyede S. Oyelekan and Julius B. Omiwale (2015) turn their attention to the history and current state of science education in Nigeria. All three of these chapters describe the difficulties in moving beyond the legacies of colonialism; the inadequacies of infrastructure, resources, and reforms; and the indirect colonialism of, for example, Western funding. Chapter 7, in which Mussa Mohamed and Simon Karuku (2015) examine the implementation of a competency-based science curriculum in Tanzania, similarly points to conditional Western aid as a form of recolonization and argues for both a reform of the examination system to meet the needs of diverse learners and the importance of integrating indigenous knowledge systems (IKS) into science instruction rather than allowing them to remain in conflict. Paul Webb's (2015) subsequent chapter, focused on South Africa, highlights the dominance of English in teaching, learning, and scholarly publication, despite it being a second language for many teachers and students; he too argues for ameliorating the conflicts between Western and indigenous worldviews, which can alienate students, as well as for increasing support for code-switching and multilingual instructional materials. The dominance of English appears in Cecilia Kuziwa Mukundu, Raviro Chineka, and Anselem Madzudzo's (2015) chapter on science education in Zimbabwe. This chapter, the ninth, bears witness to the same types of training, resource, and reform shortfalls as many of the other chapters, as well as the effects of class and gender

divisions and a failure to permit IKS to play a role in instruction or indigenous languages in publication.

The book's nine chapters each make clear scholarly contributions and merit individual examination. Having touched on seven of them, the remainder of this review focuses on two of the most argument-centered chapters, whose themes revolve around the future of science education in a way that is both regionally specific and applicable to any educators teaching culturally diverse populations. Anthony Lelliott's (2015) chapter, the fifth, addresses science communication and the need for greater incorporation of informal learning and the hybridization of African and Western worldviews in these areas. Duncan Mhakure and Femi S. Otulaja's chapter, the sixth, appeals for a culturally responsive pedagogy whose foundation is argumentation and that, again, integrates indigenous and Western knowledge systems. The interrelatedness of scholarly communication and pedagogy may, in no small way, determine the advance of science education in sub-Saharan Africa. Therefore, we specifically consider these two chapters for their implications related to the circulation of scientific and pedagogical knowledge and scholarship among what Lelliott reminds us are actually multiple publics. Lastly, while discussing these chapters, we briefly consider the ways in which methodological science education research frameworks are not fully explored in the *Handbook of Research in Science Education in Sub-Saharan Africa* and how more detailed methodological considerations may usefully play a role in future work in these areas.

Scholarly and science communication

Lelliott's (2015) ambitious chapter, "Sharing Science in Africa: The State of Research Into Science Communication and Informal Learning," broadly covers the recent history of science communication in Africa, its relationship to IKS, and the case for increasing informal science

learning. Lelliott notes that all of these areas are understudied; he takes a step toward remedying this lack by examining pertinent examples of conferences, scholarly publications, and lay media. He links current problems with their sociohistorical context, such as the aftereffects of apartheid in the case of South Africa, and he presents a short case study on media representations of genetically modified organisms in several African countries and their impact on perceptions of science and technology. As part of his argument for enhancing public scientific literacy, he proposes expanding the involvement and investment of learners through informal means, such as school trips to science centers, museums, and sites such as water treatment plants, where scientific principles may be observed in application. At the same time, he acknowledges that the histories of exclusion and colonialism associated with some of these places can still interfere with learning. On the whole, this expansive chapter covers its array of topics with an impressive depth, given its limited length.

Lelliott's (2015) title suggests a narrow focus on science communication, yet the work may be more precisely categorized as engaging both science and scholarly communication. The difference is not a simple exercise in semantics. Research with broader implications for science education is more likely to be disseminated via scholarly communications, through which science education researchers share their work with peers. In fact, although Lelliott adeptly addresses concerns about science communication, a substantial portion of the chapter details salient issues of scholarly communications. For example, his skillful examination of the topic distribution of conference presentations and the question of whether, in relation to published articles, the idea of universal scientific literacy is a culturally exclusive Western construction, speaks to broader trends in African science education. This question in turn raises further questions about the extent to which the hegemony of Western science and science education

produces a sort of closed system of approaches, objectives, and ways of knowing that merely and continuously replicates itself. Attempts to counter such homogeneity must be mindful, however, to create true exchange and flexibility of response to local contexts and not simply to replace one universalism with another—to substitute for Western dominance, for instance, the regional dominance of South Africa noted by Lelliott. A further problem is the lack of access to the methods of disseminating knowledge caused by the insufficient infrastructure, funds, and other resources described in multiple chapters in this volume.

Lelliott's (2015) chapter is of keen interest because it surveys the region's scholarly production and knowledge dissemination. He importantly notes, much like Rollnick's (2015) work in this volume, how science communication may disenfranchise those whom it is intended to serve, and his analysis incisively exposes the ways in which the Western model may not be able to meet evolving needs in Africa. Moreover, Lelliott indirectly speaks to the limits of science communication, and for that matter scholarly communication, when the supporting research paradigms and epistemologies cohere too strongly. For example, Angela Barton (2001) adapted a critical ethnographic approach for catalytic research framework nearly two decades ago in order to engage with questions of identity and representation in teaching and learning science, and her concerns remain pressingly relevant. However, current science education dissertations and even recent publications are building on the same type of understanding initially framed by Barton. Similarly, it could be argued that ethnographic research practice in science education has not substantially advanced since the work of Wolf-Michael Roth (2005). Lelliott's point is thus all the more salient: If African authors and researchers are primarily or exclusively using the same type of investigative techniques that are used in the West, they may be underserving or even hindering both indigenous communities and knowledge production. His insightful critique of the

cultural forces at play in the complex process of knowledge production works in concert with one of the purposes of this handbook as a whole: expanding African scholarly communications. As seen in this volume, sub-Saharan Africa has extensive scholarship to communicate to the science education community, and this handbook itself may ameliorate some of Lelliott's concerns.

Culturally responsive pedagogy

In their chapter, "Culturally-Responsive Pedagogy in Science Education: Narrowing the Divide Between Indigenous and Scientific Knowledge," Mhakure and Otulaja (2015) address the thorny integration of African IKS with Western science knowledge (WSK) and the ways that they align as well as frequently collide. Well-crafted and theoretically rich, this work will likely give many science education scholars reason to consider the outer reaches of both IKS and WSK, as well as what they can tell us about the interaction of different worldviews and self-identities in other educational contexts.

The ongoing tension between IKS and WSK is unlikely to diminish in the near future. One reason for the continued disjunction stems from their respective epistemological claims and knowledge propositions. Mhakure and Otulaja (2015) skillfully address the intricate histories and intuitive pedagogies related to both IKS and WSK; adding a layer of complexity to a demanding concern, they acknowledge both the heterogeneity of IKS itself and the difficulty of separating the debate centering on knowledge claims from the damaging aftermath of colonization and the failure of Western aid models. In addressing these issues, they engage in a comprehensive discussion of this challenging situation, which is sufficient material for an entire book. However, Mhakure and Otulaja recommend several interventions for deploying culturally responsive pedagogy. They suggest an array of practices, including localized teacher training, communities

of practice, reflective practices, and the development of argumentation as a classroom base practice to navigate the seeming divide between IKS and WSK and place them into conversation with one another.

In examining Mhakure and Otulaja's (2015) work, the reader is reminded of ongoing concerns that have populated the science education literature over the last decade. One such concern has been addressing the degree to which IKS can help a student develop canonical science standards, which privilege WSK and downplay or entirely exclude ISK. Deploying a hermeneutical framework, Paul C. Mocombe (2016) indirectly addressed Mhakure and Otulaja's concern about how underrepresented groups remain marginalized. Numerous U.S.-based science education researchers have produced a plenitude of detailed and erudite ethnographic work that has importantly informed the field. However, this literature may not be advising the field significantly enough. To date, in spite of this work, the placement of underrepresented students into science career preparation programs and science-related careers is still remarkably low (Mocombe 2016). One cause for this continued underrepresentation is doubtless the same failure by science education that Mhakure and Otulaja identify in "promoting and enhancing" the "self-identities" and worldviews of marginalized students (p. 98).

While Mhakure and Otulaja (2015) address classrooms in sub-Saharan Africa, their call for culturally responsive pedagogy and legitimating IKS is not far afield from the scholarship of Edmund S. Adjapong and Christopher Emdin (2015). Mhakure and Otulaja perceptively engage a vital topic when they note, "Within the African context, success in learning science in schools will largely depend on how students effectively move from IKS to WSK—this is akin to making a culture border-crossing between two worldviews" (p. 103). Thus, like the literature referenced above, Mhakure and Otulaja's work is situated in their own type of border crossing by

addressing concerns pertinent both to Africans and members of the African diaspora. Their chapter engages in a noteworthy conceptualization of the complex relationship between IKS and WSK that should continue to garner interest. One point that would benefit from further exploration, however, regards cognitive dissonance. Where IKS is incompatible with WSK, as Mhakure and Otulaja highlight, students experience cognitive dissonance. However, the authors may not be fully acknowledging that cognitive dissonance is part of the WSK mental model as well, something that Webb (2015) actually tackles in the eighth chapter. Nonetheless, Mhakure and Otulaja engage the reader in an important and nuanced discussion with contentions that are seemingly relevant to every science classroom.

To summarize, Otulaja and Ogunniyi's (2015) *Handbook of Research in Science Education in Sub-Saharan Africa* is an important book in a field with much potential for growth in future editions. This collection addresses a complementary selection of key regional concerns in science education with their specific social and historical circumstances. Yet, at the risk of the same kind of universalizing that the handbook critiques, we see this also as addressing crucial concerns—pedagogy, teaching conditions, historical legacy, and scholarly endeavors—that make it an important work for science educators from far beyond the nations on which it focuses. Lastly, and perhaps more significantly, this volume may provide a foundation for further scholarship. One potential direction for such scholarship is the hybridization of cultural theory and data-analytic approaches, a methodological synthesis that will take us further toward answering the call by Kenneth Tobin (2012) to develop new theory and the appeal by Eileen Carlton Parsons, James Cooper, and Jamila Smith Simpson (2012) for educators to tailor science education to the needs of specific groups in order to provide more universal access to science.

Future research for new handbooks

Tobin (2012), while surveying his extensive work of the previous decade, noted that one possible purpose for future research is to develop new theory. The development of new theory is critical to advancing science education research, yet new theoretical frameworks often require new methods and methodologies, and invariably require new epistemologies. In our review of *Handbook of Research in Science Education in Sub-Saharan Africa*, it should be noted that likely not enough attention has been paid to development of new forms of inquiry. Rob Kitchin (2014) underscored that data has a complex epistemology, and he explored the ways in which new data infrastructures and data-intensive analytic approaches can change how and what researchers can investigate. Kitchin may not be considered a sociocultural researcher; however, he is no cryptopositivist either (Kincheloe and Tobin 2009). Kitchin highlighted the complexity of new big-data methodological frameworks and the ways in which they align with sociocultural theory. Joe L. Kincheloe and Kenneth Tobin (2009) noted that cryptopositivism will likely continue; yet there are possibilities for new science education research frameworks that can quantify and visualize data as an exploratory means to findings without being solely rooted in the binary positivism that has been so completely critiqued over the last two decades. This would allow researchers to quantify some of the qualitative elements of education research and to produce analysis-rich pictures of how teachers and students in Africa and the African diaspora currently and can better work together in science education.

For example, Gillian Bayne (2012) astutely built on the frameworks of Kwame Anthony Appiah (2010) by underscoring the ways in which interstitial culture can be developed in a biology classroom. Yet, aligning with Kitchin's (2014) notion of exhaust data gathered via Blackboard, formative assessment or any other learning management system can look closely at

students' engagement in the curriculum and quantify notions of interstitial culture. Interstitial culture does not need to be an arcanelly argued concept embodied solely in sociocultural theory; rather, it can be viewed via an active and dynamic visualization of real-time data.

Kitchin (2014) cited Marc Prensky's conceptualization of a fourth paradigm of research methods that moves beyond "educated guesses, construct[s] hypotheses and models, and test[s] them with data-based experiments and examples" (p. 4). Kitchin noted that a data revolution is coming to the social sciences in ways that do not need to align with outmoded notions of a traditional scientific method or with the philosophical underpinnings that manipulated or manually gathered data unnecessarily. Moreover, Kitchin proposed that big data sets provide the opportunity to organically view the data, affording the opportunity to eliminate possible presuppositions that may too rigidly adhere to the zeitgeist.

Too few researchers are attempting to frame their theoretically informed work with applicable quantitative data. Often, it is in the research design stage that scholars have the opportunity to position data sets and knowledge claims alongside axiological, epistemological and ontological suppositions. Recently, Kenneth Tobin, Donna King, Senka Henderson, Alberto Bellocchi, and Stephen M. Ritchie (2016) provided an example of how sophisticated, theoretically rich work may cohere with a complex, quantitative data set. Tobin et al. aligns, in many ways, with Kitchin's (2014) notions of epistemology of data. In divergent and paradoxically cohesive ways, both Tobin et al. and Kitchin echoed Norman K. Denzin and Yvonna S. Lincoln's (2011) position of nonintrusive naturalistic inquiry.

This proposal returns us once again to the necessity stressed throughout the *Handbook of* examining the assumptions, often culturally, socially, and historically shaped and inflected, that underpin the way that knowledge is produced and disseminated—including, crucially, research

design. The collection and analysis of quantitative data is no more divorced from the epistemological, ontological, and axiological stances of the researchers than is qualitative study. Here too must we be aware of and account for the suppositions of, for instance, Western knowledge systems.

In sum, it is important to highlight that although rich theoretical work is being done, some work likely needs to be revisited and new directions pursued. A central part of such reappraisal and of future work must be sensitivity to context. The *Handbook of Research in Science Education in Sub-Saharan Africa* offers not only a varied examination of the past and future of African science education but also a reminder to all educators and researchers of the vital importance of acknowledging and addressing social, cultural, and historical specificities in our pedagogy, research, and scholarly communication.

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