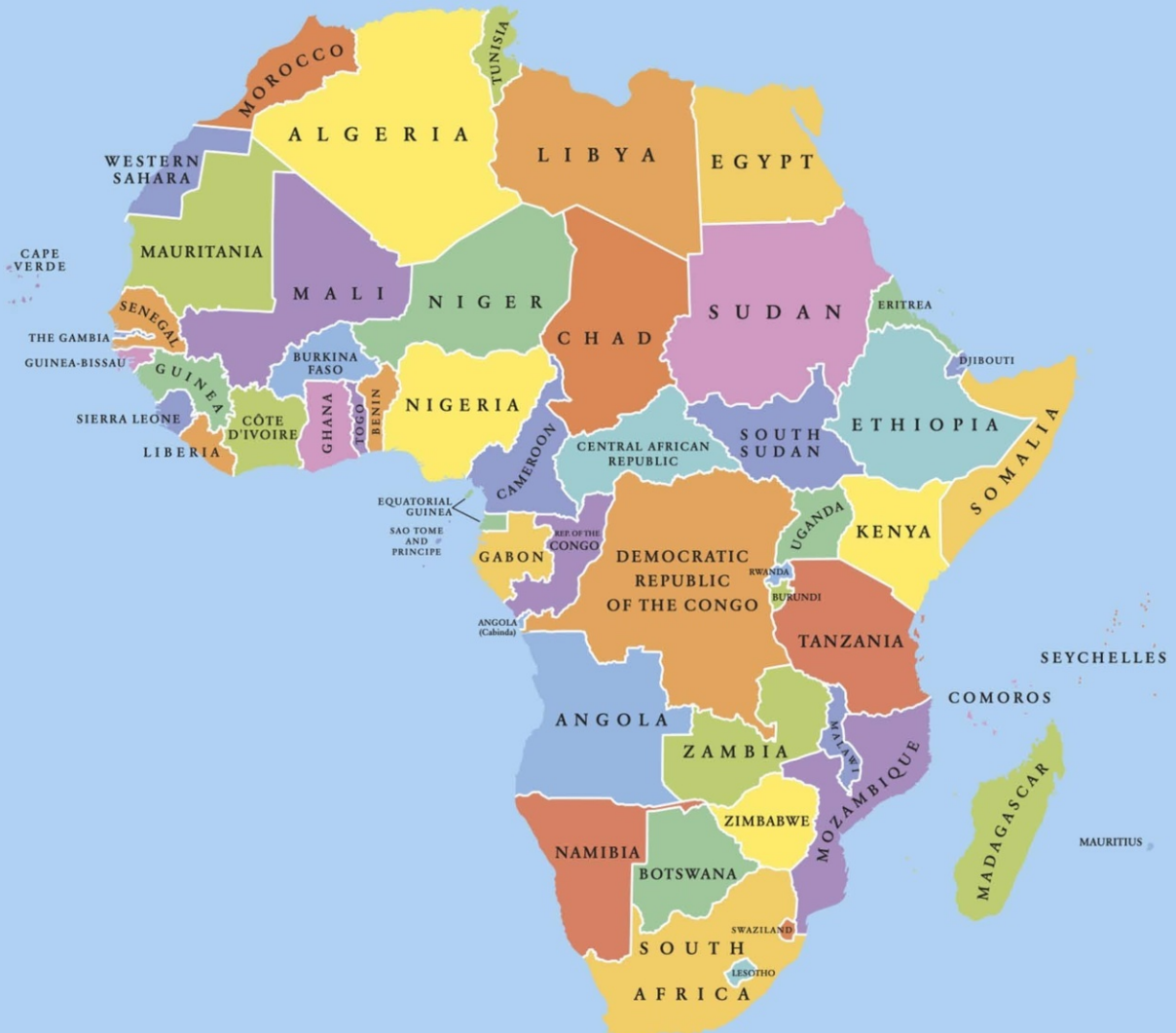
CULTURAL PERSPECTIVES IN SCIENCE EDUCATION

The World of Science Education

Handbook of Research in Science Education in Sub-Saharan Africa

Femi S. Otulaja and
Meshach B. Ogunniyi (Eds.)



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The World of Science Education

CULTURAL AND HISTORICAL PERPECTIVES ON SCIENCE EDUCATION: HANDBOOKS

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Each volume in the 7-volume series *The World of Science Education* reviews research in a key region of the world. These regions include North-America, South and Latin America, Asia, Australia and New Zealand, Europe and Israel, North Africa and the Middle East, and Sub-Saharan Africa.

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Handbook of Research in Science Education in Sub-Saharan Africa

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PREFACE

The central goal of this *Handbook of Research in Science Education in Sub-Saharan Africa* has been to determine the nature of science education and research in sub-Saharan Africa. On the look of things, the task first seemed straightforward and one that we thought every African science educator and researcher would be eager to make some contributions to. We were so optimistic when the work started in 2011. However, it did not take long before our enthusiasm was dampened as we began to realize how arduous the task we embarked upon would soon turn out to be. Among the various challenges we faced, the greatest perhaps, was the unwillingness or lack of enthusiasm of our colleagues, especially those in the former French-speaking colonies to contribute to the project. For instance, in the early stages of this project, we made spirited efforts to contact colleagues working across the former English- French- Portuguese- and Spanish-speaking colonies based on the information we gathered from their institutions' websites and other networks (including our previous contacts at conferences); but to our surprise, not much responses were forthcoming – even from majority of the English- and French-speaking countries. After a series of reminders, all to no avail, we refocused our attention on the few willing colleagues from the English-speaking countries. In view of this situation, we see this volume as only a first attempt which hopefully would spur more responses in later attempts to get a more robust picture of the nature of science education and research in this field in sub-Saharan Africa.

Furthermore, it is our hope that the submissions by the contributing authors, summarized in the nine chapters in this *Handbook*, would show that, with few exceptions, many of the challenges prevalent in many African countries four or five decades ago still persist, even today. These challenges include among others: paucity of qualified science teachers; poor infrastructural facilities; inadequacy in instructional materials; insensitivity of most teachers to the prevailing multi-cultural classrooms in which they teach; conflicting educational and curricular policies; large classes; examination-driven curricula and so on. It is not uncommon for science teachers to teach as much as 25 lessons or more in a week apart from the organization of practical activities in the absence of technical assistants; multiplicity of administrative commitments; poor administrative support for teachers who have been exposed to new instructional strategies; and so on. There is generally low morale among science teachers especially in some countries where teachers are poorly paid and the poor salaries are not often paid for several months, back-to-back, as a result of mismanagement of funds by government functionaries.

Despite the challenges facing science education and science teachers in sub-Saharan Africa, there have been great strides in science education research, curriculum and material development. Most countries now have curriculum and

curriculum evaluation centers where most of the personnel are Africans. However, there is still a wide chasm between curriculum policies and instructional practices. Likewise, very little use has been made of research findings – even those that have direct bearing on science teaching and learning processes. Till date, the teacher-centred and chalk-and-talk approaches are still the dominant methods of science teaching. In some cases, spurious efforts have been made to make science teaching and learning more culturally relevant to students' life-worlds but the haphazard and crash training approaches adopted have not allowed this effort to achieve the desired goals. As a result of poor and uninspiring instructional practices, the interest shown by primary school students towards school science, as exemplified in the various Trends in International Mathematics and Science Study (TIMMS), soon wanes as these primary school students progress into the high school level. But while it is not all gloom and doom, much still has to be done by all education stakeholders – teachers, teacher educators, science education researchers, school administrators, curriculum planners, policy makers and subject advisers – to improve the quality of science education in all sub-Sahara African countries.

Femi S. Otulaja and Meshach B. Ogunniyi
Johannesburg and Cape Town
June 2017

SERIES PREFACE

Science education, as science more generally, is premised on the ideology that scientific knowledge (about nature, cognition, method, methodology) is universal and that it can be taught equally well anywhere and in any context. Statistical methods in the social sciences generally and in science education more specifically are the epitome of this form of thought. However, for those who travel a lot to different countries around the world, especially when they speak several languages, it is immediately evident that not all forms of thinking are the same. In fact, one can detect cultural difference between the US and Canada even though most people living outside the North American continent often conflate the two. (Many Canadians and Americans can detect the other by the ways in which they speak and pronounce the English language.) Because of our experiences with science educators around the world, the differences in thinking, doing, and speaking science education has become quite salient to us. We therefore negotiated with Sense Publishers a series of handbooks that would take a regional focus. Such a series then would allow us to bring the regional differences into the light of day. 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 that the different regional volumes—each of which is spearheaded by a regional editor—will take.

After conferring with several potential regional editors, we decided to have seven volumes focusing on (a) North America, (b) Central and South America, (c) Europe, (d) Asia, (e) Australasia, (f) North Africa and the Middle East, and (g) sub-Saharan Africa. We imagined that each volume would consist of reviews of the key research foci that have characterized research in this geographical region of the world in the past 50 years or so. We therefore did not ask the editors to follow one scheme, as we expected the foci to differ according to the region. For example, there appears to be a substantive focus especially in the US on urban science education, whereas elsewhere a similar focus does either not exist or exists to a much more limited extent. It therefore makes sense to have a number of chapters focusing on urban science education in the North American volume but not in some other regions.

We envisioned that the focus could be on individual research programs and those that have most closely framed such a program. The reviews would then begin locally and situate what has been accomplished within a given field in a regional rather than international context. We envisioned that the purpose therefore would be to articulate and exhibit the regional networks and trends that led to specific forms of science education. For example, if a North American conceptual change researcher agreed to do a chapter on the topic, s/he would include the work of other scholars like Peter Hewson or John Clement, but would not include those who primarily work in a different region, for example, Reinders Duit (Germany) or David Treagust

(Australia). We knew there would not be an easy answer to the question of how to cut up the research, as there are numerous science educators who conduct research with colleagues in other parts of the world and therefore, with researchers whose work would be reviewed in a different regional volume. Thus, for example, Reinders Duit and David Treagust have a long-standing working relationship and have co-authored many papers. Would they be included in the Australasian or in the European regional volumes? We thought that such decisions could be made in a case-by-case manner. For example, the research that one of us (WMR) did in 1995 with Cam McRobbie researching physics teaching and learning in a high school in Brisbane, Queensland, would be part of the Australasian volume; however, research WMR conducted with Reinders Duit during the same year on learning physics in a German high school would be featured and reviewed in the European volume.

In the sense of getting key works included, we thought that a review would be inclusive of the most cited works and those that have shaped the field. The thrust would be on identifying the roots of research programs and sketching trajectories—focusing on the changing face of problems and solutions within regional contexts. A reader would be left with a sense of what has been accomplished and what is to be done next. We also should get a sense of the blossoming scholars within the regions of the world.

Wolff-Michael Roth and Kenneth Tobin
Victoria and New York
June 2017

FEMI S. OTULAJA AND MESHACH B. OGUNNIYI

1. INTRODUCTION AND OVERVIEW OF CHAPTER CONTENTS

Science Education Development and Research in Sub-Saharan Africa

INTRODUCTION

> For a long time, all kinds of myths and prejudices concealed the true history of Africa from the world at large. African societies were looked upon as societies that could have no history. In spite of important work done by such pioneers as Leo Frobenius, Maurice Delafosse and Artura Labriola, as early as the first decade of this century, a great many non-African experts could not rid themselves of certain preconception and argued that the lack of written records made it impossible to engage in any scientific study of such societies. (Amadou-Mathar, 1990, p. vii)

The completion of this handbook on the development of and research in science education in sub-Saharan Africa has taken much longer than expected or perhaps needed. This handbook is the second to the last in a series. The volume and series editors of the handbook series had sectioned the globe into seven regions, namely: (a) North America, (b) Central and South America, (c) Europe, (d) Asia, (e) Australasia, (f) North Africa and the Middle East, and (g) sub-Saharan Africa for the purpose of producing a handbook for/in each region. Editor(s) were appointed in each region to coordinate and collaborate with other authors from their region to produce a handbook that takes a rear-view look at the trajectory of science education over the last 5 decades in their region. While the other regions were quick to the chase, Africa took a little bit longer to get into the chase; even though late in getting there, she got there and provided her story and contributions to the development of science education in the respondent countries and how research in science education is shaping knowledge production in the field of science education within each respondent country.

In the sub-Saharan Africa region, concerted efforts were made by the editors of this handbook to obtain contributions from as many African countries below the Sahara as are possible. We sought for contributions from the Eastern, Central, Western and Southern Africa countries, from Anglophone, Francophone and Portuguese-speaking and Spanish-speaking countries, with limited successes. Most

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of the contributors to the chapters in this handbook are from English-speaking countries. We continue to make concerted efforts to obtain contributions from non-English sub-Sahara African countries so that this handbook can be "thickened".

As in many regions of the world, the knowledge of how to teach and learn science is still emerging and evolving in sub-Saharan Africa. Sub-Saharan Africa is making great strides in trying to catch up with new developments in this field. Efforts to overcome the hegemony of the Newtonian, Baconian and Cartesian science and the conflicts of mainstreaming Eurocentric science as the objectified truth over indigenous knowledge is still deeply engrained in the science being taught to African students in many sub-Sahara African countries, post-independence. Hence, this handbook reflects many of the tensions faced by education reformists, science education researchers, teachers, students and learners of science subjects in post colonial countries.

It is, therefore, our hope that this handbook provides some insights into the complex nature and diversities of development and trajectories in science education in the context of the various stages of pre-colonial, colonial and post-colonial sub-Saharan Africa. As you can see, there is no one-size fits all as sub-Saharan Africa is not a homogenous group of people or communities.

SYNOPSIS OF THE CHAPTERS

This handbook starts with the exploration of science education development in the Gambia in Chapter Two. Gambia is one of the smallest countries in sub-Saharan Africa. She is located in an area of land surrounding the Gambia River and is herself surrounded by the country of Senegal, except on the west coast where it is bordered by the Atlantic Ocean. In this chapter, Kabba Colley traced the development of education, science education inclusive, through three eras of sub-Saharan Africa's (Gambia's) development, namely: pre-colonial, colonial and post-colonial eras. He discussed the pre-colonial and colonial eras, and then provided a proposed model to fast-forward the progress of science education into the post-postcolonial era. The author leaned heavily on available official records and online databases, especially on the seminal works that van Sertima (1998) did in detailing the accomplishments of African people in areas of science (and concomitantly in science education as Africans must have taught or apprenticed each other) in this region before the advent of the Whiteman. "The Senegambia region of West Africa, which was part of the great empires of Ghana, Mali, Songhai and others, was a center of cultural, scientific and technological revolution before AD1000 and was heavily impacted by the two historical events and continues till today", cited the author.

This chapter also gave some details on the introduction of formal schooling led by Christian missionaries in Gambia during the colonial era after which the colonial government took over control and expanded schooling to all Gambians. "However", as the author indicated, "the science curriculum implemented in colonial schools could best be described as very rudimentary and teacher-centered. The teachers' and students' surroundings were the main source of scientific knowledge and experience".

The author posited that "[d]uring the colonial period, science teaching and learning focused mainly on subjects such as nature study, gardening and hygiene". The post-colonial period witnessed continued interests in educational reforms with specific mention of the need to improve teaching and learning of science and technology. In this endeavor, the author proposed a Project-Based Science Instruction (PBSI) model and he defended his choice for science education, delineating his assumptions and its possible limitations within the context of the Gambia.

Chapter Three is a very interesting chapter as Marissa Rollnick traced the history of the formation and development of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE), as a regional organization, and that of the South African Association of Science and Technology Educators (SAASTE), a national organization, in a climate of change following the demise of apartheid in South Africa and in the unfolding post-independence context. Organization of professional bodies that would represent subject teachers, in South Africa, started with the Association of Mathematics Educators of South Africa (AMESA) and later the South African Association of Science and Technology Educators (SAASTE), followed by the Southern African Association for Research in Mathematics and Science Education (SAARMSE); SAARMSE later became the SAARMSTE, in 2000. The author traced how the formation of the National Education Crisis Committee (NECC), in 1986, led to the formation of both the Science Commission (SC) and the Mathematics Commission (MC). While the SC did not last long, the MC was very active and soon began negotiating for unity with the former (up till 1978) all-White Mathematics Association of South Africa (MASA) in 1991. In July 1993, AMESA, a single mathematics teachers' organization, was formed.

The author informed that the science community in South Africa had organized itself into two professional, mostly White-dominated, communities, namely: the South African Association of Teachers of Physical Sciences (SAATPS) and the South African Association of Teachers of Biology (SAATOB), both of who focused on senior secondary sciences. She traced the evolution of SAASTE as an organization before embarking on that of SAARMSTE as the histories of MASA and SAASTE were interlinked. The author also gave detailed information on how various activities prepared the way forward culminating in the workshop held in the Drakensberg Mountains in January of 1992; that workshop gave birth to one collective organization (SAARMSTE). SAARMSTE is responsible for promoting mathematics, science and technology education and created room for participation, not only from South Africa, but also other southern African countries that had provided homes for those in exile during the apartheid days from where they have accumulated knowledge that can be shared with other academics.

Marissa went on to discuss the structure of SAARMSTE, the conferences and the various landmarks in the organization's development, including journal publications, capacity building through the yearly research schools. She ended the chapter by detailing the impact of SAARMSTE throughout the twenty-one years of her existence.

In Chapter Four, Oyelekan and Omiwale discussed the trends of science education in Nigeria within a global context. They traced the history and development of education in Nigeria, particularly in the western part from the days of the missionaries through many of the education reforms and curricular innovations and transformations. They discussed the Ashby Commission that pre-dated independence in 1960 and the various other post-independence efforts to reform education as the country attempted to sustain itself educationally, economically and politically. They delineated the reform projects and programs that formulated various science education curricular and material developments for use at the primary and secondary school levels including the recent Universal Basic Education (UBE) policy implementations. The authors took readers through the trends in science education research in Nigeria. They ended the chapter with tips on the future of science education in Nigeria.

Chapter Five by Tony Lelliott provides insights into how science is being communicated or disseminated (shared) in Africa and the possibilities and opportunities for informal science learning. Using Africa's participation in the biennial Public Communication of Science and Technology (PCST) conference as his unit of analysis, Tony placed emphasis on the importance of science communication with the goals of increasing/improving scientific literacy. To buttress this point, the author provided comparisons of sub-Sahara Africans' participation at conferences such as the African Science Communication Conferences (ASCC) and the PCST and he discussed the relevance of the topics presented by representatives from different African countries. He interrogated the contestation of what scientific literacy is as indicated in published literature by various non-Western authors who challenged the universality of scientific literacy. Linking scientific literacy to informal science learning, Tony contended that "there is little evidence of research into informal science learning in most of sub-Saharan Africa". He then went on to show that concerted efforts are being made, especially in South Africa, to study the use of museums and science cafés as opportunities for informal science learning.

In Chapter Six, Mhakure and Otulaja advocated for inclusion of indigenous knowledge systems (IKS) in science education as an opportunity to shift ontology and traditional ways of teaching to more culturally-responsive pedagogy. After comparing IKS to westernized science, the authors discussed the implications of integrating IKS and Western Science Knowledge (WSK) in the sub-Sahara African science classroom, especially in light of the South African National Curriculum that advocates for the teaching and learning of IKS and WSK in the classroom. Building on these, the authors discussed the use of argumentation as an instructional model for changing the methods of teaching and learning so as to catalyze integration of IKS and WSK. They then gave examples where such model has been engaged in teacher, research and academic development at a South African University.

Chapter Seven, authored by Mussa Mohamed and Simon Karuku, provides readers with historical perspectives on educational, hence science education, development in mainland Tanzania. The authors were quick to point out that whatever happens to education on the mainland is replicated on the three other Islands of Zanzibar, which

is the largest, Pembe and Mafia. As in most other chapters in this book, the authors traced the developments of education from before the country's independence to after independence with focus on post-independence educational and curricular reforms. They discussed the policies and politics of educational reforms, from indigenous education to the Arab incursion followed by those associated with the advent of missionaries who wanted to Christianized the Africans piggy-backed by hegemonic education under colonialism of the Germans and the British. Political independence, as they indicated, marked the end of the segregationist educational policies of the British and the beginning of various attempts and struggles by the independent nation to reform and indigenise her education system, including science education. The authors critiqued the current competency-based curriculum (CBC) which the government has been trying to implement and its implications in the classroom.

In Chapter Eight, Paul Webb provides readers with another angle on scientific literacy focusing on the issues of language in South Africa. He discussed the persistent tensions resulting from the dominance of the English Language as the language of teaching and learning, the language-in-education policy, parental preferences, additive bilingualism, multilingualism, code-switching, mother tongue, and the language of the discipline as they affect scientific literacy in the African context, particularly in South Africa. He also brought into account the consideration for including indigenous knowledge.

Chapter Nine, authored by Mukundu, Chineka and Madzudzo, provides insights into science education, training and research in Zimbabwe. The authors discussed the structure of colonial and post-colonial Zimbabwean education system. As indicated in other chapters in this handbook, these authors gave the reader a synopsis of the education system pre- and post-independence, focusing more on post-independence curricular and education reforms and policy changes. The authors alluded to the common dilemma of most African countries coming out of colonial rules, whereby the new government massively expand access to education, often declaring primary education as basic human right and making it free and compulsory, only to struggle with poor and inadequate infrastructures, learning material resources and inadequate supply of well-trained teachers. They took the reader through series of programmatic changes focusing on science education, science teacher preparation and professional development as fundamental to teaching and learning and sustainability in/of science. They discussed marginalization and gender issues in science education in Zimbabwe and the challenges of the language policy in education with the need to develop indigenous Africa science. The chapter ended with issues related to the current level of educational funding and the need to support research and development and their dissemination in Zimbabwe.

CONCLUSION

As alluded to earlier, it would have been good to have obtained a chapter each from each country in sub-Saharan Africa. This book would not have been so lean and we

would have needed to produce this book in more than one volume. We hope we can still do this as we continue to press for contributions from our French-speaking, Portuguese-speaking and Spanish-speaking countries, former Belgian colonies and other English-speaking countries that are not represented in this volume. Our hope is that your knowledge of science education development since the advent of Western invasion of African countries south of the Sahara will be enriched by the work that has been done in this volume.

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