CURRICULUM STUDIES WORLDWIDE

SCIENCE EDUCATION AND CURRICULUM IN SOUTH AFRICA

Oscar Koopman

Curriculum Studies Worldwide

Series Editors

William F. Pinar
Department of Curriculum and Pedagogy
University of British Columbia
Vancouver, British Columbia, Canada

Janet L. Miller
Teachers College
New York, New York, USA

Aim of the series

This series supports the internationalization of curriculum studies worldwide. At this historical moment, curriculum inquiry occurs within national borders. Like the founders of the International Association for the Advancement of Curriculum Studies, we do not envision a worldwide field of curriculum studies mirroring the standardization the larger phenomenon of globalization threatens. In establishing this series, our commitment is to provide support for complicated conversation within and across national and regional borders regarding the content, context, and process of education, the organizational and intellectual center of which is the curriculum.

More information about this series at
http://www.springer.com/series/14948

Oscar Koopman

Science Education and Curriculum in South Africa

palgrave
macmillan

Oscar Koopman
Cape Peninsula University of Technology
Kuils River, South Africa

Curriculum Studies Worldwide
ISBN 978-3-319-40765-4 ISBN 978-3-319-40766-1 (eBook)
DOI 10.1007/978-3-319-40766-1

Library of Congress Control Number: 2016954262

Printed on acid-free paper

This Palgrave Macmillan imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

To my late father, Andreas Willem Koopman, who always believed in me.

Foreword

My first engagement with the author on a personal level was as a critical reader for his doctoral dissertation. I must admit that reading his dissertation then and this book now is not an easy task, as he always draws his ideas and knowledge frameworks for his work from the complex field of philosophy, psychology and subfields such as science education. Through many other personal discussions with the author, I came to know him as a critical scholar with a deep sense of purpose, which is to humanise the teaching and learning of science. This book endeavours to do just this and is a long-overdue guide for in-service science teachers, preservice teachers and teacher educators in South Africa.

Developments in Africa (and in South Africa) depend critically on the effectiveness of its mathematics, science and technology programmes. This is because these disciplines drive the technological and scientific innovations in the rest of the world and are central to a nation's economic growth. It is for this reason that major monetary investments are made in a country's education system. Despite initiatives to support the development of science through heavy monetary investments and research by entities such as the African Union and the World Bank, Africa contributes roughly 5% to the world's gross domestic product (GDP) compared to the USA's 17.1%, and it holds 0.1% of the world's patent rights compared to 23.6% of the USA. South Africa is the second largest economy on the continent and contributes 0.7% to the world's GDP and holds less than 0.01% of the world's patent rights. These statistics are directly related to the quality of the country's mathematics and science programmes.

This raises a very important question: How effective are South Africa's mathematics and science programmes?

This book is an attempt to answer this important question and gives an indication of what is happening in the teaching and learning of science in South African classrooms. It addresses critical elements such as the nature of the physical science curriculum over the last five decades (Chap. 2), the teachers' disposition towards curriculum change (Chap. 4) and the nature of teacher content knowledge (CK) and pedagogical content knowledge (PCK) (Chap. 5) and offers some interesting suggestions on how to improve the quality of teaching and learning of science in South Africa.

Steven Biko speaks in all his work about the importance of a 'critical consciousness of blacks' in order to reclaim the self as a subjective epistemological being in the racial malaise of the South African context. Chapter 3, in a dialogue between father and daughter, captures all the essential elements in this book. First, there is his nine-year-old daughter's disposition towards the content she is taught by her Grade-4 teacher and how she (the daughter) displays a critical stance towards the information. Second, the role of the teacher in the teaching process is discussed and the way that she (the teacher) decries change with respect to her practice and knowledge in post-apartheid South Africa. Although the latest Curriculum and Assessment Policy Statement dictates that teachers should act like catalysts to awaken the creativity and curiosity of learners with the aim of instilling a critical consciousness in them, the teacher is still stuck in an authoritative and instrumental paradigm that aims to produce—to borrow a term from the author—'robots'. This dialogue also captures the essence of the author's positionality in the data-construction process and his thinking in which he skilfully puts on his phenomenological cap to elicit further details from his daughter. This approach is also the predominant methodological and data-explication framework for the book to describe the state of science teaching and learning in South Africa.

In summary, in Chap. 1, the author develops an overarching framework for applied phenomenology for science teachers. This lays the foundation for the methodological and data-explication framework for almost all of the chapters. His aim is to humanise science teaching and learning, with a strong focus on the 'object pole' as opposed to the 'ego pole' by using experience both as the starting point and as the end point in researching the activities of science teachers.

Chapter 3 narrates the author's personal life journey from childhood to being a university student of science and the impact of the values instilled

in his consciousness on his later life as a teacher and teacher educator of physical science. Here he provides the reader with deep insight into the impact and significance of apartheid education as he elucidates the inner tensions he grappled with to overcome firmly held (unconscious) beliefs. This journey is central to his development of a critical consciousness, hence his critical scholarship with respect to science teaching and learning. This narrative articulates his becoming and exemplifies Steve Biko's notion of 'a critical awareness of the self'.

Through the eyes of Thobani, in Chap. 4, we get a sense of the lived experiences of many black physical science teachers in the new South Africa. It accentuates his life journey as a learner and as a science teacher and will resonate with so many physical science teachers in the country who were exposed to 'horrible science teaching' under apartheid. At the same time, the author cautions in-service teachers of the potential impact that a teacher can have on his learners and society by being what Thobani refers to as destroyers of dreams. This chapter also explains how black teachers grapple with the implementation process because of dialogical tensions that could arise with older colleagues and heads of departments who resist change and as such hinder curriculum change. The phenomenological methodological framework allowed me to understand to a certain extent what so many new graduates might be going through.

Chapter 5 addresses a critical question: *Do teachers also see what chemists see when they teach science?* This chapter unpacks the CK and PCK of 15 teachers that is essential for effective science teaching. As this book speaks to heart of the science teacher, another underlying question is: *Do learners also see what chemistry teachers see when they sit in their science lessons?* In order for this to happen, teachers of science should have strong CK as well as PCK. This will help teachers to make better didactical decisions with respect to their science teaching, all informed by a strong science content base.

In Chap. 6 the author looks to the outside world to see in what way a wine expert can contribute to the teaching of science. The author now observes and engages with a wine expert to see what lessons could be learnt for the teaching of science. These lessons are eloquently captured in his critical reflection of the wine expert's lived experiences to bring his approach to learning about the sensory properties of wine into the science classroom.

An important element of the teaching process is what is at play when decisions are made around the development of school curricula for school subjects. Chapter 2 speaks about the abuse of power. The author rightly

warns that government has an obtrusive role aimed at policing the curriculum process rather than working towards empowering learners for a science for life. The concluding chapter asks the question: *Can a phenomenological approach enhance learning in science in South Africa?* This question is critical for readers and especially science educators in the South African context. Dwindling numbers for the subject in the final three years of schooling for Grades 10–12 necessitate a new look at the teaching of science. This is the contribution the book makes to the field of science education; let us be bold in exploring this approach in all spheres of science education to follow a 'science for life' approach in which teachers harness the full use of the senses to empower our learners. This book touches a critical nerve for us all to take a conscious decision to contribute in this regard to reclaim the rightful academic space of science education in South Africa.

Wellinggton, South Africa Kalvin Whittles

Preface

To get some idea of the current state of science teaching in South Africa, I asked five physical science education specialists from different provinces to describe in one sentence what they think the main reason is for the poor performance of learners in the subject. Unsurprisingly, all blamed the teachers. Three of the five in agreement said, 'It is because teachers do not understand the content.' The other two said, 'Teachers do not understand the curriculum' and 'Teachers do not know how to teach the content effectively.'

These views raise serious issues, and this book brings all these concerns together—by design and by coincidence. First of all, the book explores the impact of the socio-historical, political and economic environment in South Africa on the physical science curriculum, which in turn impacts on the nature of science teaching. This is because both during and after apartheid South Africa school science took an interest in a specific kind of didactical approach and knowledge, which the book refers to as 'a science of government'. This 'science of government' approach leaves the learners with a blurred sense of the foundations of science that is disconnected from external nature and human nature and is presented as a series of abstract concepts and definitions. Six of the eight chapters investigate the dialectical tensions between the physical science curriculum and the teacher in his or her role as an active implementer of the curriculum as planned. By drawing on the work of various phenomenological scholars, such as Edmund Husserl, Martin Heidegger, Merleau-Ponty and Max van Manen, the book is an attempt to describe the lived experiences of the science teacher to unpack these tensions.

The following is the brief synopsis of the book. Chapter 1 introduces the reader to phenomenology as a potential methodology to research the lived experiences of science teachers as opposed to the dominant quantitative approach to research for the last two centuries. The author provides a succinct account of phenomenology with respect to its philosophy, data-construction methods and the data-explicitation process. Chapter 2 examines how the 'governmentality' of the apartheid and post-apartheid governments established the pedagogical and knowledge discourses that constrain the intellectual development of physical science learners in South Africa. Chapter 3 chronicles the lived experiences of the author under apartheid as a learner and university science student and then as a science teacher in post-apartheid South Africa. This chapter discusses the impact of the behaviourist core values instilled into his consciousness under apartheid at primary school, secondary school and as a university science student on his later life as a science teacher. The chapter also discusses his 'unbecoming' and how he had to unlearn deeply embedded values to repudiate most of his previously acquired formal learning *about* science. Chapter 4 recounts the lived experiences of a black physical science teacher and his struggle to implement a new curriculum. This chapter reveals how lack of support from the Department of Education and his head of department retarded the implementation process. It also highlights the difference between 'curriculum as planned' and 'curriculum as lived'. Chapter 5 investigates the content knowledge of 15 physical science teachers on selected topics in the science curriculum. The focus of this chapter is on investigating whether they include all three levels of representation in chemistry when they teach a topic: macroscopic, microscopic and submicroscopic levels. Chapter 6 explores the lived experiences of a wine expert and how he acquired his knowledge about wine. This chapter also discusses what science teachers can learn from the wine expert and offers the experience of a wine expert's approach as an analogy to learning science. Chapter 7 valorises the use of the senses in the science classroom and offers science teachers alternative teaching strategies, referred to as sense-experience approaches, to enhance the use of the senses in the science classroom to assist learners to codify, analyse and construct knowledge. The concluding chapter reports on an investigation into the question of whether a phenomenological approach can enhance the quality of learning in science. The study critically compared the rationale, approaches and outcomes of various other didactic approaches to teaching and learning in science education in South Africa.

This book carries with it an enormous debt of gratitude to many individuals, some of whom cannot even be named. I must begin by expressing my gratitude and appreciation to William Pinar, also grateful to Lesley Le Grange, who introduced me to William, which I see as where the book initially started.Chapter 4 is a revised version of the article I published with Lesley Le Grange and Karen de Mink in the journal *Education as Change*. Therefore, I would like to thank the journal for giving me permission to do so.
There are some persons to whom the successful completion of this book was directly related and to whom I am happy to express my gratitude here. For the critical but always helpful and insightful comments and suggestions, I want to thank Albert Harold and Edwin Hees for their outstanding editorial work. To my wife, Karen, who has been my Rock of Gibraltar. Finally, to my two daughters, Taffi and Phoebe, who inspire me always to give my best.

Kuils River, South Africa Oscar Koopman

Contents

List of Figures

List of Tables

CHAPTER 1

Phenomenology as a Method in Education Research

D'Agnese (2015), in a thought-provoking article entitled 'The inner [and unavoidable?] violence of reason: Re-reading Heidegger via education', alludes to the powerful influence of Western thought on modern-day discourses on knowledge production. He draws from Heidegger when he writes,

> Since Plato, Western thought has framed knowing as a procedure within 'some realm of what is' and a predetermined 'sphere of objects'. This method erases its own traces, presents this reduction as unavoidable, and establishes that 'human beings' 'stand-over-and-against' the world. (D'Agnese 2015, 435)

Today, this trend still persists, both nationally and internationally, in which science education researchers put too much emphasis on the mathematical nature of knowledge and consequently lose its roots in lived experience. In other words, knowledge is framed in some mathematical procedure that ignores the importance of human relationships and lived experience. Since these mathematical transformations of knowledge proved to be very successful for many centuries, researchers have become more and more obsessed with them (Dahlin et al. 2009). Consequently, this paradigm of 'knowing' dominates modern discourses, including human science research in which human behaviour is converted into mathematical formulas and lived experience loses its central epistemic position and described as mathematical models of truth. To this end, researchers reduce

O. Koopman, *Science Education and Curriculum in South Africa*,
DOI 10.1007/978-3-319-40766-1_1

their research participants to mere objects, and their findings are seen as more real than the concrete, lived experiences from which they have been abstracted. Husserl (1970, 59) calls this the 'technisation' of scientific knowledge. He avers that this technisation involves a gradual sedimentation of meaning in which lived experience is ignored (or forgotten) in favour of mathematical conceptualisations. He writes,

> … This problem of forgetfulness is exacerbated by the fact that with each new generation's inheritance of the new techniques—an inheritance that presupposes the processes of transformation without explicitly recognising them—another increment in the Selbstverständlichkeit [matter of course] of natural scientific achievement occurs as well (Husserl 1970, 59).

According to Dahlin et al. (2009), the 'sedimentation of meaning' relegates mathematical formulas to a higher level than lived experiences, and by doing so mathematics takes on a form of its own. When this happens, science replaces the concrete lifeworlds of individuals with abstract mathematical models and formulas that people find strange and difficult to understand. Landau (1997) explains how mathematics and science were reinforced and popularised in the seventeenth and eighteenth centuries in the West. He avers that in the course of these centuries, rationalism and the enlightenment's critical and sceptical spirit spread among comparatively large sections of the population and how Newtonian science was popularised for the uneducated. Although these long-standing traditions of discourse and practice have solidified and cannot be transformed in an instant, the development and establishment of alternative discourses are needed to gradually change things.

Dahlin et al. (2009) assert what is needed to change these dominating trends and traditions of knowledge and knowing is an ontological reversal in our approach to research. They point out that an ontological reversal occurs when experience-as-lived is elevated to a much higher level than mathematics. In other words, what is secondary ontologically becomes primary. This means a complete transformational shift from cognitive reductive abstraction to a more phenomenological description of reality and nature. If this shift takes place, the knowledge is justified by the approach adopted towards acquiring it.

This brings me to the aim of this chapter, which is to argue for a shift to a phenomenological approach to conducting research into the practices of science teachers. As a method, phenomenology brings together the

theory and practice of science teaching and reverses the order of priority of the ontological (being) and epistemological (knowing) aspects of human existence as revealed in the lived experience. I will argue that phenomenology is systematic and rigorous enough to research the lived experiences of science teachers with a high degree of accuracy. Drawing on the work of Husserl and Heidegger, this chapter highlights the value of phenomenology in revealing the natural attitudes of research participants as they emerge in the phenomenological reduction deeply embedded in the consciousness of individuals. A related aim is to guide novice researchers in how to use phenomenology in the data-construction process and also how to explicate phenomenological findings without contaminating the data with extraneous presuppositions, strongly held beliefs or preconceived ideas and notions based on the researcher's own worldview. I start by explaining my journey in discovering phenomenology as a potential research method in science education.

My Journey in Discovering Phenomenology

In a paper entitled 'Phenomenology as a potential research methodology for subjective knowing in science education research', I paint a picture of my research journey in search of an appropriate methodology to research the subjective lived experiences of science teachers in South Africa. In this article, I draw on the work of Husserl, Heidegger, Merleau-Ponty and van Manen, among others, to recount my personal engagement with how I discovered phenomenology as a research method to frame my doctoral study. I describe this search—to borrow from Pinar (2004)—'as the nightmare that is present' as I engaged with the work of these scholars and various other phenomenological scholars. Indeed, the difficulty of the text of these phenomenological scholars and my obligation to keep on looking, reading and tarrying in search of a rigorous methodology evoked feelings of confusion as well as misinterpretations and misreading. However, what motivated me to continue searching and reading this 'complex language' and 'terminology', as Cerbone (2009) puts it, was the rewarding insights the work of these scholars gave me. For example, phenomenology made explicit my own thoughts about life, human actions, behaviours of people and their intentions. It also helped me to become more thoughtful and tactful in my role as a science teacher (and later researcher) to be more 'caring' and 'sensitive' to the other. From this experience I could relate to Pinar and Reynolds' (1991, 2) claim when they describe their own

encounter with phenomenology when they write that instead of 'having found something' they 'have been found'. To them, Heidegger's and Husserl's work made their sky visible in its entirety in a metaphorical sense.

Each time the meaning of the writing of different phenomenological scholars distilled and eventually settled in my mind, I realised the value of phenomenology simply not as a research methodology but as a philosophy to understanding human lived experiences. This engagement with phenomenology liberated me from the constraints of positivistic thinking. To support this claim, I wrote, "Like a bird released from a cage, I experienced science anew and recognised the viability of phenomenology as a research methodology that would assist me in answering my research question…" (Koopman 2015, 4).

I learned that what separates phenomenology from other methods is that it does not offer the possibility of a theory with which researchers can explain the world of participants, but rather it offers the possibility of bringing the researcher into closer contact with the world of the participant (Van Manen 2007). In other words, phenomenology moves away from the researcher as an outsider in search of data in favour of the researcher as an active participant in generating knowledge. This means the phenomenologist brings sensitivity to the field of educational research, something which, according to van Manen (1990), has been long overdue. I also learned when entering the data-construction field, it is not about me but about the participant and that I have an ethical responsibility to report his or her experiences in their fullness, richness and greatest depth. To do so I had to be perceptive and avoid the dangers of being misled, sidetracked or enchanted by extraneous elements and had to avoid getting carried away by unreflective preconceptions and personal emotions. So instead of theorising about my participants, I had to bring out the significance of their voices as they describe their lived experiences as science teachers in contemporary South Africa. This brings me to the question: what is lived experience?

Epistemological Foundations of Lived Experience

Merleau-Ponty (1962) describes *lived experience* as an embodied act that manifests in time and space. This embodied act is centred on the thesis that an object is perceived in relation to the horizon within which it is embedded and from which it stands out. Horizon refers to those pure acts that are impressed on human consciousness. In other words, experience