In Search of Meaning and Coherence
A Life in Research

Wolff-Michael Roth
In Search of Meaning and Coherence
CULTURAL PERSPECTIVES IN SCIENCE EDUCATION:
DISTINGUISHED CONTRIBUTORS
Volume 1

Series Editors

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Scope

Cultural Perspectives in Science Education: Distinguished Contributors features a profile of scholarly products selected from across the career of an outstanding science education researcher. Although there are several variants in regards to what is included in the volumes of the series the most basic form consists of republication of 8-10 of the scholar’s most significant publications along with a critical review and commentary of these pieces in terms of the field at the time of doing the work, the theories underpinning the research and the methods employed, and the extent to which the work made an impact in science education and beyond. Another genre of Key Works republishes the most influential research in a selected area of interest to science educators. Examples of the areas we will feature include science teacher education, science teaching, language in science, equity, the social nature of scientific knowledge, and conceptions and conceptual change. Collections of articles are placed in an historical context and the rationale for changing perspectives is provided and analyzed in relation to advances and changing priorities in science education. Each volume shows how individuals shaped and were shaped by the cultural context of science education, including its historical unfolding.
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## CONTENTS

Preface vii

Foreword xiii

INTRODUCTION: Roles of Individuals and Collective in the Making of a discipline 1

1 THE END OF A PARADIGM
   The Development of Reasoning on the Balance Beam 13

2 DAWN OF AN ERA: SOCIAL CONSTRUCTIVISM
   The Social Construction of Scientific Concepts or The Concept Map as Conscription Device and Tool for Social Thinking in High School Science 33

3 TALKING SCIENCE AND EPISTEMOLOGY
   The Interaction of Students’ Scientific and Religious Discourses: Two Case Studies 65

4 SITUATED COGNITION
   Art and Artifact of Children’s Designing: A Situated Cognition Perspective 97

5 PHENOMENOLOGY: PERCEPTION AND THE LEARNING FROM EXPERIENCE
   The Local Production of Order in Traditional Science Laboratories: A Phenomenological Analysis 135

6 THE POSTMODERN CONDITION: ALTERNATIVE WAYS OF WRITING
   Lifeworlds and the ‘Writ(gh)ting’ of Classroom Research 171

7 LINGUISTICS AND GESTURE STUDIES
   From Gesture to Scientific Language 199

8 COTEACHING AND COGENERATIVE DIALOGUING
   Lessons on/from the Dihybrid Cross: An Activity Theoretical Study of Learning in Coteaching 235
CONTENTS

9 MATHEMATICS AND WORKPLACE STUDIES
   Competent Workplace Mathematics: How Signs Become Transparent in Use 271

10 SOCIAL STUDIES OF SCIENCE

11 SCIENTIFIC LITERACY
   Scientific Literacy as an Emergent Feature of Collective Human Praxis 347

EPILOGUE: A Life in Research, Research in a Life 369

References 375

Index 395

About the Author 403
Over the past two decades, I have been an integral part of science education research. What I have done as research projects and written up in the form of articles, chapters, and books cannot be understood apart from the reigning culture of science education, even in those cases where what I offered was pushing the boundaries. Pushing the boundaries inherently means pushing the boundaries of a field, so that advances made by individuals always also are advances in the possibilities of the collective. In fact, to advance means putting one’s own research in the context of the research community and therefore, subordinating it to the collective. To understand the changes science education research has undergone, therefore the contributions of individuals need to be taken into account and seen in relation to the collective. The relationship between the two, the cultural conditions and individual actions, is not a simple one. Rather, the two are irreducible moments of the same phenomenon. By moments I mean to say that we can identify and talk about culture as if it were thinkable and subject to theorization independently of the individuals that constitute it in and through their membership; and we can talk about individuals as if they were thinkable and theorizable independently of culture. In such an approach—thinking the two moments independently—the best we can get in terms of relation is an interaction, which makes thematic exchanges of two independent entities, who have entered into a relation. Here I want to think culture and individual differently: as irreducible moments that mutually constitute each other. The relation therefore is one of transaction, a form of exchanges where the two entities cannot be thought independently of one another because each is part of the definition of the other. It is therefore impossible to think culture on its own, because its definition depends on the individuals that constitute it; and it is impossible to think the individual on its own, because its definition depends on the culture.

The upshot of such an approach to individual and culture is that cultural advances, innovations, are not reducible to individuals, even if some of us receive awards for the papers, articles, and career-long contributions they make to the cultural field. Here, too, culture and individuals are bound up with each other. First, for an individual to get an award, the culture generally had to be receptive. A Best Paper Award, for example, such as given annually by the National Association for Research in Science Teaching, arises from the transaction of a text and the award committee. The text already had been produced not by the individual for the individual; rather, it had been produced in a culture for other members. The language a paper uses is the language of the other and for the other. A paper, therefore, realizes cultural possibilities in a concrete form, whereby an author uses a language that has come to him or her from the Other to communicate something to and for this Other. For, if a paper were not to be a possibility, for example, if it had been
written or spoken in tongues (monoglossia), then it would lie outside culture and could not receive an award; it could not be understood by others and therefore be non-intelligible. Similar forms of thinking can be used to assess other contributions: by individuals to culture and to other individuals.

This book is part of a series that takes up the increasing interest science educators have developed for understanding their own history and the history of the ideas that have shaped the field. As a (social) science, science education is a rather new endeavor, though there have been science educators prior to the coming of research journals such as the Journal of Research in Science Teaching, which celebrated its 40th anniversary only recently. Other journals, including Science Education and School Science and Mathematics have been around for nearly a century. But the strong research focus that has emerged with the Journal of Research only emerged more recently. It is not surprising, then, that now, after about five decades of a strong research agenda, science educators begin to be interested on a broader front in the history of the field and the accomplishments of individuals. Thus, earlier this year, Ken Tobin and I published The Culture of Science Education: Its History in Person, where we built a narrative around 22 auto/biographical texts that science educators from various “age classes” contributed, including ourselves. Similarly, Great Ideas in Science Education (Liu, 2007) takes a look at key articles that eight science educators produced in the course of their research careers.

This book is part of a new series, Key Works in Science Education, that Ken Tobin and I edit and that we brought to life together with Michel Lokhorst and Peter de Liefde of SensePublishers. Our aim for the series has been to identify science educators known for their contributions to the field and to republish a series of articles that shaped their thinking and therefore the way science education culture developed. The articles would be accompanied by a commentary and critical review that focuses on the theories and methods used and on the way in which the work made an impact. The collection of articles were to be placed in a historical context from which they emerged and which they in part defined—following the logic of the dialectical relation of individual and culture that I sketched in the previous paragraphs. Each work therefore shows how a particular individual shaped, and was shaped by, the cultural context of the day in the course of his or her career and therefore also, in the course of the historical unfolding field of science education.

Such an endeavor cannot be understood unless the authors and editors of a book take a cultural-historical perspective, which properly locates the contributions of individuals and culture in transactional relations, from which the two emerge as identifiable entities. Individuals concretely realize and thereby presuppose cultural possibilities; but cultural possibilities do not exist independently of the individuals who produce culture and therefore the possibilities it offers to its members. I therefore understand my career as something made possible by the field as a whole while at the same time being enabled by a certain spirit and concrete singular life that I personally brought to my work and research.

Others may call it dedication, or excess, but throughout my career I have been interested in understanding. I was not satisfied knowing that there existed different
theoretical frames but rather I wanted to know these different frames and in which ways they differed or were similar. *In Search of Meaning and Coherence* therefore characterizes very much what my research career has been about, which itself was not the outcome of something I had envisioned and designed but something that has evolved from my work as a classroom teacher. Some of my early studies featured in this book derived precisely from my classroom work, where I had begun to question standard tasks and exercises that teachers regularly ask their students to do, including concept mapping exercises or open, student-designed laboratory inquiry. I had begun to question whether students actually learn what these tasks and exercises were designed for, but that never had been properly researched. In part, my work has been the evolution of methods for researching student engagement, participation, and learning in classroom situations, methods that went beyond using questionnaires and pre-post assessments of learning. My career is associated with the evolution of careful ethnographic observation, the use of video, and the evolution of methods for learning about learning and development by doing linguistic (discourse, conversation) analyses of the minute-by-minute unfolding conversations that one can find in science classrooms. In this sense, my career involves as much innovations as it involves realizations of collective possibilities at the brink of becoming standard ways of doing things. Because I was one of those people realizing these methods for the first time, I ended up with the label of pushing the boundaries, where in fact it was the community itself that made the pushing of its boundaries possible.

This book therefore constitutes a particular form of cultural history, a history in person and a history as realized in the work of an individual. This book therefore is not about me, at least not just about me; this book and its content is about us, science education researchers, who constitute a culture that is irreducible to our individual contributions. But these individual contributions are irreducible to the culture. This is the fundamental tenor of the present book, an articulation of cultural history through the works that I contributed, but which I could only contribute because they were already within the realm of cultural possibilities and therefore acceptable to and by other cultural members. At the same time, some of these contributions were “ahead of their times,” and, though accepted in other fields (such as discourse analysis in discursive psychology and sociology), still take a singular position in science education, dominated as it is by the conceptual change paradigm.

This book does not constitute a mere reprinting (reproduction) of some of the articles that I have produced in the past. This reprinting occurs in a different cultural context and therefore leads to the paper being different, in the same way that human beings can never step into the same river twice as the millenary saying goes. I therefore understand this book to be a document in its own right, which could have occurred only at this stage in our field and in my career. It is as much a cultural-historical as it is an individual document, being enabled both by the cultural (general) possibilities of researching and writing and by the individual (personal, singular) ways in which these possibilities were concrete realized in and through my personal endeavors. Also, the articles, originally published as they
were written, now are embedded in a continuing narrative that makes this book a historical document, because it reflexively elaborates the contexts, conditions, and mediating influences that have allowed a particular study or article to have emerged.

In the reproduction of the texts, I made slight changes to achieve a greater level of consistency. For example, in my early years, I used the Canadian form “which” for introducing a clause whereas in later years I consistently have used the APA recommendation for using “that.” In earlier years, I used the passive voice much more frequently than I use it today; and I used the Canadian comma conventions rather than the one that APA recommends. For the purposes of this book, I edited the texts to make them more consistent stylistically. I replaced all “in press” references, now citing the actual year and page numbers; and I changed the numbering of the figures to include the chapter number (e.g., rather than Figure 1 I use Figure 3.1 for the first figure in chapter 3). In some chapters, the figure numbers changed because I decided to use one or more figures in the introduction to the feature article, requiring the numbering of the immediately following article to change.

* * *

Endeavors such as writing this book are not possible without the indirect and direct mediations of others. Ken Tobin seeded the idea about such a book when I was still resisting, but which became increasingly salient as valuable contributions while he and I were working on The Culture of Science Education. It was during that time that Xiufeng Liu proposed editing a book featuring eight science educators and their work. Furthermore, I also became familiar with efforts in the National Association of Research in Science Teaching of working toward a history of the field and of editing a volume featuring key works. It became clear to me in the process that the time is right to contribute a reflexive component to our scholarship by publishing works that take a look back and establish a body of historical and auto/biographical writings that articulate how our field has unfolded.

Another key person in my life is my spouse, partner, lover, and beloved Sylvie Boutonné who has been supporting me throughout my career ever since I met her. In fact, some of the early studies conducted during my university career involved her, as she worked as a research assistant videotaping and transcribing, analyzing data sources, doing other aspects of research, and evening co-authoring some of the texts despite the fact that she had not been trained as an academic (the work reported in chapters 4–7). In part because of her deep involvement in all aspects of research, she has a keen understanding of what a research career is like. I am indebted to her, because without such an understanding partner, a career in research such as mine would not be possible. There are others as well, teachers, students, and people from many other walks of life who were participants in my studies and who thereby enabled my career in the way it unfolded. And, of course, there is the field of science education and its culture, constituted as it is by all its members collectively. Without this culture, my life as science educator would have been different, even impossible. My thanks therefore go to all those who often remain unacknowledged in science education research. In the end, what we do cannot be thought independently of society as a whole. For my life as a professor generally
cannot be understood independent of a complex society, where someone can pursue research in exchange for a series of services he (or she) provides, for example, by teaching or by contributing to the production of knowledge. I am fully aware that what I do is possible only because of the highly organized cultural-historically evolved division of labor that allows me to make a living doing research without having to hunt or gather or farm or fish to survive. I am grateful to have the possibilities society as a whole provides so that I can fully engage in the pursuit of a mundane activity—science education research—that others may see, from the outside, as somewhat esoteric.

My special thanks go to the journal publishers, whose generous copyright arrangements make it possible for an author to republish articles in books that he or she authors. Chapters 1 and 8 initially appeared in the *Journal of Research in Science Teaching* published, as *Science Education* that initially published the article featured in chapter 2, by John Wiley. Taylor and Francis publishes the *International Journal of Science Education*, where the article in chapter 3 was published, and the *Journal of Curriculum Studies*, which had featured the articles that are part of chapters 6 and 11; and it now produces the *Journal of the Learning Sciences*, formerly owned by Lawrence Erlbaum Associates. The article appearing as part of chapter 5 was first printed in *Learning and Instruction*, which, as the *Journal of Pragmatics* that first featured the main body of the text in chapter 7, is published by Elsevier. My thanks also go to Sage, which publishes *Social Studies of Science* that initially featured the text making the body of chapter 10 and to Kluwer/Springer-Verlag, a company that publishes the *International Journal for Computers in Mathematical Learning*, the venue in which the article from chapter 9 first appeared.

My thanks also go to the co-authors of some of the articles reproduced here. Anita Roychoudhury co-authored the study on the social construction of scientific concepts (chapter 2), and my former high school student Todd Alexander co-authored the article on the scientific and religious discourses (chapter 3). Cam McRobbie, Keith Lucas, and Sylvie Boutonné co-authored the article on the local production of order in traditional school science laboratories (chapter 5), and Cam also co-authored the article on the writing of classroom research. Finally, my thanks go to Ken Tobin, Andrea Zimmermann, Natasia Bryant, and Charles Davis who co-researched and co-authored the “Lessons on/from the Dihybrid Cross” (chapter 8). Finally, my thanks go to Chris Siry and Preeti Gupta, who carefully read and reviewed the manuscript.

Victoria, Canada
July 2007
FOREWORD

A LIFE IN RESEARCH:
PERSPECTIVES FROM COLLABORATORS

For the preparation of this foreword, I invited present and former graduate students, postdoctoral fellows, and colleagues to write brief commentaries or appreciations. My idea was to have their personal perspectives on working with me, addressing whichever aspect they find most salient. The individuals who contributed include the following:

– R. Todd Alexander, University of Alberta, who some 15 years ago must have been one of the first high school students participating in a research study and contributing as a legitimate author to a scientific publication;
– Lilian Pozzer-Ardenghi, who is only weeks from completing her PhD with me, after coming from Brazil to my laboratory in 2001 to do an MA and with whom I share an interest in gestures and other nonverbal forms of communication;
– Yew Jin Lee, National Institute of Education, Singapore, a former doctoral student, who arrived in my laboratory as a “quantitative” social researcher and who left as a specialist in the domains that we shared a love for, including activity theory, ethnography of the workplace, discursive psychology, and discourse analysis;
– SungWon Hwang, University of Victoria, with whom I share an interest in the role of the body in cognition and identity, who currently spends a third year as a postdoctoral fellow in my laboratory after having arrived in 2003 from Korea, initially completed a first and second year and then returned in 2007;
– Leanna Boyer, University of Victoria, who began as a research assistant right after graduating with a double major in biology and, after several years of work, decided to complete an interdisciplinary MA under my direction and with whom I share an interest in environmental issues and a love for gardening;
– Stuart H. Lee, Environment Canada, who pursued his PhD under my direction after leaving a position as a laboratory instructor, with whom I shared a love for bodies, networks, and connections and who, subsequent to his doctoral studies that focused on environmentalism, became a policy advisor;
– Michiel van Eijck, University of Victoria, who, after having arrived from the Netherlands, is near the end of completing a two-year postdoctoral fellowship in the Pacific Center for Scientific Literacy—of which I am the principal investigator and the director—and with whom I share a dedication to research and writing;
– Reinders Duit, with whom I spent three months during 1995 (at the Institute for Science Education [IPN], Kiel) to conduct a study on the learning of chaos theoretic concepts in a German tenth-grade classroom and who has been a role model for steadiness during a professional career; and
FOREWORD

— Kathryn Scantlebury, University of Delaware, whose career trajectory intersected with mine many times, especially because of our mutual friendship with Kenneth Tobin, and with whom I share a love for good wines and good food.

I am grateful to all these individuals for their contributions to the foreword to this volume, which constitutes a look back at 20 years of research both inside the field of science education and beyond. As long as health permits, I intend to spend at least another 20 years contributing to the field.

MANY YEARS THENCE

It is now more than fifteen years since we collected the data for our manuscript “The Interaction of Students’ Science and Religious Discourses: Two Case Studies” (Roth & Alexander, 1997). For me this work highlights many contemporary issues that I have been facing and will continue to face in my career. Since writing this paper I have completed medical training and am currently practicing medicine as a pediatric nephrologist. I have also completed scientific training in cell biology. I am fortunate in that a large majority of my time is spent doing laboratory research on the diseases that affect my patients. As such I am both a clinician and a scientist.

My clinical experiences emphasize our need to work within the framework of both religion and science. To provide my patients with the best advice and therapy for their disease I have to be able to correctly diagnose their ailment and then, through an understanding of the pathophysiology of their disease, provide the best treatment modern science has to offer. Unfortunately modern science cannot cure all known diseases and all too often I am faced with end-of-life decisions for my patients. There is no scientific approach that I have discovered that enables one to assist a family through such a terrible and difficult process as dealing with the death of a child. Without exception, spiritual or religious invocations are adopted to mediate these processes. As a physician I may flip between the realms of religion and science more frequently than most, but everyone deals with some aspects of both not infrequently.

As a scientist I am embedded in the process of describing “new knowledge.” I work on the regulation of renal proteins that control the absorption of salt from the kidney. Abnormalities in their function result in high blood pressure and alterations in blood pH. We cannot directly visualize these proteins and as such I must infer from various experimental procedures how these proteins function and are regulated. My epistemological view of science remains similar. I am in fact creating knowledge, which I hope approximates the truth (although I remain dubious as to whether I can know the “truth”). The theories I propose remain valid as long as their predictions remain consistent with the experimental evidence. Whilst this remains an interesting philosophical debate, I have begun to judge my and others’ theories on the basis of whether these can be applied clinically to help the lives of those affected by the disease states that we are studying. As such I feel that I have become more of a functional scientist. Whilst knowledge is useful in and of itself,
tax dollars need to be spent in the attempt to better the lives of members of our society afflicted with the ailments we have chosen to study.

The debate over whether schools should teach creationism/intelligent design or evolution rages on, as highlighted by a recent Pennsylvania court ruling. Regardless of the outcome of this case such examples serve to illustrate how we continue as a society to miss the point. Science and religion permeate our culture, they have done so for millennia and will continue to. Whether there are formal curricula espousing either point of view is irrelevant, as children and young adults will encounter both paradigms in their daily living and will have to deal with both. Our study serves to highlight the potential conflicts that a student can encounter when learning science. What we as a society need to do is not ban the teaching of specific ideas but engage students in conversations about these conflicts and attempt to facilitate their resolution.

Finally, I would be remiss if I did not thank my old high school physics teacher, mentor, and collaborator Dr. Wolf Michael Roth, affectionately referred to as “Doc” by his students of the time. We were privileged to have a teacher, himself a scientist, who clearly cared about us and our acquisition of critical thought. I continue to remember most fondly, not the formal classroom setting but our informal conversation at night in the lab or dorm about philosophy, religion, art and science. Doc provided an example of someone who clearly loved learning and enquiry, upon which I have been able to model myself and achieve the limited results that I have today.

R. Todd Alexander
Faculty of Medicine
University of Alberta

LIKE GOOD PARENTING

I remember clearly the 19th of April of 2001, the day I arrived in Victoria, BC, coming from Brazil to do a MA with Dr. Wolff-Michael Roth. He went to the airport to pick me up. We did not know each other; we had only exchanged emails for almost a year in preparation for this day. I came to study with Dr. Michael because of his work in science education, which I had read and used in my undergraduate research. I knew he was an accomplished and internationally recognized scholar, but I had no idea how eminent he was within the science education community. This I discovered during my first NARST (National Association for Research in Science Teaching) conference in New Orleans, Louisiana, exactly one year after my first face-to-face encounter with Dr. Michael. The ballroom poster session at NARST Conference takes place during the first evening of the event and draws all the conference attendants, as it is the only event scheduled for the evening (and, of course, there are food and drinks available). During this session Dr. Michael “walked me around the room” introducing me to all the “big names of science education.” I was tantalized. Other professors were also introducing their graduate students to prominent scholars, and Dr. Michael was one of the most sought after that night. I remember calling my (now) husband in Brazil and telling him about
Dr. Michael’s celebrity status. Perhaps I was unsuspecting of his distinguished
position within the scholarly community because of how approachable he has al-
ways been. He accepts students into his research group from all parts of the world,
most of us ESL students whom he has patiently taught not only how to do research,
write articles and get published, but also in many cases—including my own—how
to speak and write in English. Dr. Michael is one of the rare people who live by
example; everything he does is congruent with the theories that underlie his work.
In this book, Dr. Michael talks about communities of practice, and how he helps
his graduate students to become researchers through apprenticeship, by doing re-
search with him. And that is indeed what he does. I remember him seating beside
me in our lab prodding me to articulate in English what I was “seeing” in the Bra-
zilian high school textbooks that I was analyzing for my MA research. Later, when
I started writing articles, he would find a way of encouraging me to continuing
writing while pushing my boundaries to the limit and returning my drafts with
barely a paragraph of undeleted text. It was hard to see so much red in the page,
but in this manner he taught me how to write research articles, so much so that
today we exchange drafts only once. Dr. Michael is an avid reader (and writer) and
every Friday afternoon during our group meetings, Masters and PhD students and
postdoctoral fellows alike listen in awe to Dr. Michael’s divagations on various
theories, concentrating hard to keep up with him and hoping we will remember at
least one of those perfect sentences that make so much sense once you have finally
understood them. Every conversation with Dr. Michael, and every exchange of
textual material as well, is a “teachable” moment he carefully and patiently con-
structs to help us learn and become more, bigger, wiser. That is why, for me, Dr.
Michael’s patient, methodical, and persistent guidance as a supervisor looks a lot
like good parenting.

Lilian Pozzer-Ardenghi
University of Victoria

WORK | LIFE | PLAY

For a person whose publication volume has approached that of entire university
departments, it has been my unusual experience as a former doctoral student of
Michael Roth that he does not generally revel in telling “war stories” about his life
in research. If I recall correctly, whatever snippets of information I could glean
from him was directly solicited during our many long driving trips to our salmon
hatchery fieldsite, which often began at 5 A.M. during the Fall and Winter. Despite
the blurry eyes and very reluctant feelings I had to leave my heated room, I was
always more than compensated on these journeys for I could uncover yet a little
more about the career of my supervisor. Readers of this book are thus fortunate, for
they need not endure any such deprivations in order to enjoy similar insights. We
can begin to understand what drives this man, what makes him tick, and what
surely is at the tip of every tongue, “What is the secret of his prodigious output?”
Part of the answer to these questions we are told lies in the fact that the author was
as much a product of the reigning culture as he was trying hard to push the bounda-
ries of what was allowable or favored within the research community. In other
words, he did and does not consider himself to be inherently special but rather a
person that was there at the right place and the right time. If this cultural-historical
embedding of a life in science holds water, we can now appreciate Michael’s diffi-
dence towards retelling stories from what surely must have been a plentiful stock.
We also learn in this book how Michael’s trajectory in becoming the scholar that
he is today was a long and periodically difficult one marked by various hardships.
Through elbow grease as well as the hands of friendship extended by others, his
portfolio of significant and oftentimes trend-setting publications slowly grew. I
dare say that these 13 chapters detailing reflective accounts of praxis—a “natural
history” if you may—of one of the most recognized science educators today will
both enlighten and inspire readers.

We are now privileged to peek into the Latourian blackbox of research-in-the-
-making that is so valuable, if not more so, than the finished products themselves. I
do not guarantee that anyone will experience similar forms of success for these
publication milestones are located at the intersections of many contingent historical
factors as the text has made abundantly clear. However, it is amusing to note that
even Michael was not above emulating the mature writings of other scholars when
he was just starting out in his career, which perhaps offers some encouragement for
us. Reading these excerpts of his life woven with the articles that span a number of
disciplines and shifts in foci, we ultimately come to realize that Michael does not
separate his life from his work. It is an inseparable trialectic of work, life, and play,
which I believe he would not dispute. Whether one calls it self-actualization or a
personal attempt at fulfilling societal and personal needs at the same time, this is
something few can claim without hesitation. At the end of the day, this challenge
surely must be the most important one for us as educators that compels repeated
self-interrogation. I want to conclude by reiterating how envious I am of readers
who now are spared from hearing tantalizing allusions to bits and pieces of past
research work overheard in Michael’s jalopy: Savor it well!

Yew Jin Lee
National Institute of Education
Singapore

ON THE SHOULDERS OF THE GIANT

Having an opportunity to learn about the history of the discipline through the voice
of the person who has been at the forefront of pushing the boundaries over his life,
I feel as if I first came to know that starlight travels a long distance until I see it in
the sky and therefore the shining sky is a history of the universe. Here I would like
to share my learning experience that I luckily have had as his student (postdoc) and
wish to show a glimpse of the impact that his lifelong work has made on the field
and people of science education.

My research life over the past five years has been strongly affected by the phil-
osophical endeavor, as thoroughly described in the entire book, which grounds
theories of knowing and learning science in people’s real lives and experiences that
include those of researchers as well. The articles presented in this book have been influential on my learning to do research in this regard, because they have opened a new horizon to a junior researcher who just moved from Korea and newly stepped into an academic community in Canada. I was struck that there were new possibilities for talking about a wide range of interdisciplinary issues in science education. Theories that were articulated through conscientious data analyses intrigued me. More so, those pieces guided me to learn that understanding learning and articulating theories require the reflexive labor also directed toward the researchers themselves. To be self-consistent, therefore, theories must describe researchers’ own learning, which those conducting research in determinant (psychological, sociological) factors surely won’t accept for themselves. By the experience of participating in research projects and collaborating with others, I learned that the Other that I encounter in research praxis is the other side of my Self and therefore that I do not understand the Other unless I abandon my Self to the Self that is other than itself.

My time in Michael’s laboratory has allowed me to engage in a process of learning to do research, on the one hand, and learning to understand the Self, on the other hand.

I am currently participating in a research project focused on the topic of identity in a world characterized by globalization. Our present day societal lives are expansively globalizing and learners are likely to experience themselves differently than the ways that many existing educational discourse have presupposed—the recent tragedy at Virginia Tech—where an intruder on the campus shot more than 30 individuals—comes to my mind as a major instance of grief in this regard. As a migrating researcher and learner, I have experienced the significance of understanding the Self (as the Other) in learning science, which becomes particularly crucial in meeting heterogeneous cultures and languages. The awareness that the Self is a hybrid that is coextensive with the Other leads me to recognize the significance of social spaces that allow heterogeneous possibilities to contribute to opening a new relation of the Self to itself and thereby bringing forth the hybridization of identity. Because the Self accepts the Other at the heart of itself, this space is the space of solidarity. Thanks to Michael, I was able to experience and learn about this form of solidarity in the physical space of his laboratory where I have spent so much time. Therefore, I uphold the ongoing philosophical project that suggests difference, heterogeneity, and hybridity as key concepts for improving science education.

SungWon Hwang
University of Victoria

BECOMING A RESEARCHER

This book is written as both a personal narrative and as a concrete example of cultural possibilities that an individual scholar produces and reproduces. Interweaving papers published over several years with reflections on how they are situated within a cultural-historical milieu, it speaks to the readers’ own experiences thus making it accessible to a broad readership. The author encourages a reflective stance, as individuals, on our relationships to the broader culture of not only sci-
ence education but also other interrelated fields such as social studies of science. He cautions us to remember that what we know and write about is not ours alone, but is embedded in a cultural patchwork of colleagues, graduate students, editors, readers and personal life (selves).

When Michael asked me to write part of this foreword, he suggested writing about my own experience of learning to do research. So here is the short version. I stumbled upon post-secondary academic culture by happenstance. I had just completed a science degree, majoring in biology and anthropology, and was working part time at the University of Victoria as a teaching assistant in anthropology. I knew then that I was not interested in doing research in biology. One day I bumped into my former teaching assistant in microbiology, Stuart Lee, then a PhD student working with Michael. Stuart asked if I would like to meet Michael because he was looking for a research assistant. I eagerly agreed and thus began my post-graduate journey into a multidisciplinary bricolage.

One of my first field experiences as a participant observer and observer participant was situated in a salmon hatchery. Michael suggested that I take rigorous notes, video and photographs whenever I observed something “interesting.” The first day of fieldwork began like this: Michael picked Stuart and I up at around 4:30 A.M. and drove two and a half hours to the hatchery. Michael introduced me to most of the workers and promptly vanished, following around a fish culturist to help him with his daily chores. Being an initially shy person, I was quick on Stuart’s heels, not quite knowing what to do with myself. Stuart gave me a tour of the hatchery and we eventually caught up with Michael. I watched and listened as Michael asked a fish culturists questions about what he was doing—gently pouring brilliant orange salmon eggs over a hatching bed—at the same time helping by exchanging full buckets with empty ones. Over the course of the next couple of years, I learned by watching and doing alongside Michael and other graduate students.

I realized that I was being provided with very unique opportunities for learning and participating in social science research culture. Not only did I do fieldwork and interviewing alongside Michael and on my own, I learned how to write in the same way. I successfully led and published three papers in international peer reviewed journals in fulfillment of my Masters’ degree. But of course, my success was only realizable through transactions within my research group, with the department that awarded my degree, with those that agreed to participate in my study, and so on. Through living aspects of Michael’s personal narrative I have been inspired as a researcher and environmental activist and so too will this book inspire others to push multiple disciplinary boundaries.

Leanna Boyer
University of Victoria

LIVING THEORY

Michael lived his theory. No, that’s not enough—that doesn’t explain it.
– Who asked you to explain anything? This is a story.
FOREWORD

– I’m a scientist, that’s what I do.

Michael lived theory. I started my graduate studies, with Michael, “fresh”—no formal training in education, or any social science, and lots of training as a scientist. I was both excited and a little perplexed about the lack of course work I’d be doing for my PhD in science education. How was I going to learn anything? I was even a little more taken aback when, after about two months of doing a little field work, he insisted that I start writing my first published paper. “Graduate studies is a training to become a PhD—and PhDs do research and write papers, so that is what you are going to do.” I was a little stunned, but I took his point—having read, by then, enough articles in practice theory to understand what he was talking about. I learned my practice theory through performing the practices of the community I was about to enter.

We shared a love for bodies—no, not the tanned ones on the beach—but bodies, flowing together in teamwork over a model, a log, a map; dancing the same re-wind-able dance in video images—gesturing, traversing, making sounds, being disciplined. I fed from his approach that anything we say about learning must be grounded in this, a body, existing in space, entirely interwoven with a community—other bodies, sometimes—the artifacts, instruments, detritus of a local or a global community. Bodies enacting utterances, doing work socially through speech—positioning, sharing, convincing—in a dialogue that has gone on for ages, and will continue for many more—situated, local, shared, historical. We lived this theory, our researches focusing on lived lives, physicality, and action, my vision of the world and its rich connections changing me forever.

But no, that’s not enough—this lived-ness is not only what made the lasting impressions on me, now looking back after five years. “I just hit my head against the wall. And again. Until it falls over,” he yelled to me over the sound of the music pumping through the undergrad lounge. I’d been working with him for a month or so, and we were discussing life strategies; I, quite proudly, had just described my own careful and opportunistic approach to life (“strategic” I called it). Never quite heard anyone speak so clearly or bluntly about how they went after life. I’m glad I heard him say that—because it made all the other challenges make sense. As a grad student, I had support to go to whatever conferences I wanted to—but I had to suggest them and present at them. I had support to write about whatever it was I wanted to—but I had to suggest and initiate. I could go wherever I wanted to with my research, but it was up to me to do it—and justify it. Like a small puppy emerging from its cage, my actions got bigger and bolder, and I became more and more comfortable in a world of bigger imagination and action.

And so, now, I am confident in “thinking big” and telling a big story—I also realize how this is a rare skill, or a skill rarely nurtured; I am not afraid to approach the “powerful” and state my case as best I can; I feel comfortable with those who think ambitiously and are willing to work for their ambitions. This body:mind set is what I believe was the biggest benefit I received from working and studying with Michael.

– there, I wrapped it up—quite nicely, don’t you think?
FOREWORD

– that’s no scientist writing, you’re writing like a policy wonk—I’m surprised you didn’t offer any “lessons learned” . . .
– well, I guess we become what we do . . .

Stuart H. Lee
Environment Canada

FROM BENEATH THE SKULL INTO THE CLASSROOM: A REAL TOOLKIT FOR UNDERSTANDING THE CULTURE AND PRACTICE OF SCIENCE EDUCATION

Today, when I think about education, I think in terms of culture and practice. Back when I was a teacher and a beginning researcher, I thought in terms of what was happening beneath the skull. The work described in this book largely contributed to this change.

I started my PhD study at the dawn of this millennium after having been a high school biology teacher and curriculum developer for six years. As a teacher, I encountered students who often struggled with quantitative concepts in biology and teaching materials that did not provide appropriate resources for children to overcome these difficulties. I therefore started a developmental research study aimed at the improvement of teaching quantitative concepts in biology education. The culture of science education research, at the time, mainly adopted a constructivist perspective. To understand what happened under the skull during science teaching and learning appeared to be the Holy Grail of the discipline.

I started to explore constructivist frameworks dealing with modeling and inquiry to better understand why students struggled with quantitative concepts in biology, like the concepts represented in heart-related graphs such as ECG and blood pressure. The literature in this field sounded very interesting and plausible, but was absolutely not helpful for understanding students’ problems and setting up my research. There appeared to be a huge gap between the constructivists’ texts in the common science education research handbooks dealing with students’ thinking and what actually happened in the classroom (Lijnse, 2000). Apparently, few tools were available to better understand this practice.

During this time I happened to find an article about graphing written by Michael in the Journal of Research in Science Teaching, which he wrote with Michael Bowen and Michelle McGinn during the research period described in chapter 9 of this book (Roth, Bowen, & McGinn, 1999). This article changed my entire thinking about students’ problems with quantitative concepts in biology education. Thanks to the anthropological framework on graphing, I suddenly understood why students had “difficulties” with interpreting complicated graphs. Rather than the grey mass in the head—to which I had no access after all, I became interested in the culture and praxis of science education. As a result, my PhD research radically improved. I therefore became interested in Michael’s work and my path finally led me to writing this foreword on his invitation while I am now working together with him as a research fellow.

Looking back, I think Michael’s work has something particular which makes it tremendously useful in educational research. On the one hand, it is genuine and
honest—in this book he admits to have been looking for the Holy Grail since the very beginning of his research career. On the other hand, he pushed a unique boundary by finding out that the philosopher’s stone cannot be found in an individual’s head. Instead, he developed a rich toolkit to better understand science education as a collective practice, that is, between teachers and students, in the classroom, in front of the laboratory desk, with textbooks and chalkboards, and in many more situations and moments in which real people are together.

In our research group, Michael surprises us almost daily with new tools for understanding the situations we encounter in the field. In the same way the pieces in this book will surprise the reader as they are the key works in Michael’s rethinking—moments during which he invented critical conceptual tools for understanding particular highly problematic aspects of education. This book is therefore a treasure chest full of clues for improving, reframing, and evaluating one’s own research and, hence, a better understanding of the practice of science education. More so, Michael’s auto/biography places these tools in the context of his personal life. As such, we read how his human being mediated the culture and history of a discipline and the theories it produces. Reading this book, therefore, will provide the reader something that often lacks in academic books: a real sense of being together and learning with the writer.

Michiel van Eijck
University of Victoria

MICHAEL ROTH’S CONCEPTIONS OF SCIENCE EDUCATION RESEARCH AND SCIENTIFIC LITERACY

Michael Roth asked me to write an introductory note on the present book. It is a great pleasure to do that as I think that his contribution to science education over the past two decades is outstanding. I admire the work he has done—especially the many non-middle-of-the-road ideas he has developed. It was a particularly fruitful time for my doctoral students Michael Komorek and Jens Wilbers and for me when Michael spent three months at our institute in 2005. We carried out a study on learning processes in the field of deterministic chaos and published a number of papers in various journals (e.g., Roth & Duit, 2003). I write the following lines as a good friend—however as a critical friend. In fact, my own position on what orientation science education should take and which research emphases are needed to improve science teaching and learning are partly different from what Michael presents in this book.

Revolutionary versus Evolutionary Changes

There are many “revolutionary” changes in Michael’s professional life. It seems that to a certain extent he is an “unadjusted” person who is courageous enough to question the normal way of doing things and tries to find alternative ways of living and working. He studied physics at a well know university in Germany—but that was not his first choice. He then changed the whole context of social embedding by
immigrating to North America. He held a number of positions before finally settling at the University of Victoria in Canada—but not primarily as a science educator—where holds the position of a Lansdowne Professor of Applied Cognitive Science. The selection of his work in the present book shows that his work exceeds the boundaries of “normal” science education work. Clearly science education in its very nature is an interdisciplinary research domain drawing on various reference domains like history and philosophy of science, pedagogy, psychology, linguistics, ethics, and many others. However, genuine contributions of science educators to these research domains are comparably rare. This is different for Michael who widely publishes also in these domains. It seems to me that border crossing is a key feature of his professional but also of his personal life.

Compared to Michael’s non-linear development my own development is much more linear. I studied physics and mathematics to become a Grammar School teacher in Kiel (Germany). It so happened that the IPN (Institute for Science Education) just started with research and development work when I was looking for a place where I could do a Master’s thesis in 1968. It dealt with students’ conceptions in the field of basic electricity drawing on Piaget’s ideas of assimilation and accommodation, on Ausubel, Bruner, and the German tradition of Bildung (Duit, Niedderer, & Schecke, 2007). In a way we were constructivists then without knowing what it is (Duit, 2007). I am still working at the IPN and my research work is based on an inclusive constructivist perspective (Duit & Treagust, 2003). My major research concerns have been studies in the domain of conceptual change (with a particular emphasis on the role of analogies in teaching and learning science). In the past decade my work has comprised studies on the practice of physics instruction and attempts to improve the situation as investigated by teacher professional development projects. In a nutshell, it seems that my own professional development is somewhat evolutionary—not revolutionary. In a similar way my attempts to improve science instruction are also based on evolutionary strategies, taking into account the present state of practice and envisioning a sequence of minute changes that may be made by the present actors.

Activity Theory as a Major Focus

It is interesting to see that rather early in Michael’s work major features of activity theory have played a significant role. Starting from attempts in the late 1980s and early 1990s to overcome the certain one-sidedness of radical constructivist epistemological perspectives by variants of social-constructivist ideas, Michael has developed his own view. He merged sociocultural, phenomenological and activity theory oriented approaches. This view provides the framework for his actual research and his ideas about reconsidering science education as a research and development domain as well as about scientific literacy needed to live and act in the world. With regard to his empirical research the emphases are basically the same since his early studies on his own physics instruction. Research primarily has served as a means to develop his theoretical perspectives. This orientation is the particular strength of his work. A certain weakness, however, may be seen in the
fact that Michael has changed emphases of his research rather quickly. When we readers of his work were still dealing with a certain issue he already was far ahead investigating various other features such as the role of gestures in cognition. It is left to us to take up the push to investigate what this means for changing actual practice? It seems so.

Scientific Literacy

A final remark concerns Michael’s conception of scientific literacy. I was very impressed when I read Michael’s ideas of scientific literacy in the Educational Researcher (McGinn & Roth, 1999). It was a totally new emphasis to discuss the role of aids activists (i.e., lay groups) in considerations on the kind of scientific literacy needed for participating in significant problems society is faced with. Michael outlines his ideas more fully in chapter 11 of the present book. His focus is that scientific literacy should be seen as a construct that concerns society as a whole and should not be restricted to views of scientific literacy as a set of competencies the individual should posses. I agree. However, such a construct may only develop if the individuals composing society hold some sort of competencies or abilities that may create the social construct. What are these competencies and abilities? We have the same problem in social-cultural or social-constructivist perspectives of learning. Clearly, a key insight of these perspectives is that not only “in-the-head” conceptions are co-constructors of knowledge but also the social setting in which learning occurs. However, also the individual has to learn something he or she may use in the particular social setting. In other words, the individual and the social are complementary features to be taken into account.

Coda

I owe Michael Roth a number of significant and most valuable new ideas and challenges to rethink my views of science education research and development. It seems that a science educator thinking and working in a more linear fashion needs to be shaken by more revolutionary thinkers—to actually be able to help to improve instructional practice.

Reinders Duit
IPN Leibniz Institute
University of Kiel

PRODUCING CHALLENGES

Wolff-Michael Roth’s “Keyworks” book illustrates his breadth of scholarship and depth of knowledge regarding sociocultural issues that influence students’ learning in science and the context in which teachers teach. For the past 20 years, Michael’s research has introduced wide and diverse theoretical perspectives, research methodologies and frameworks from many other social science areas into science edu-
FOREWORD

cation. In addition, as a feminist scholar, I have enjoyed the challenge of reading his work and making the connections from Michael’s theoretical ideas and research to my research interests or to re-frame his research from a feminist perspective to interpret its meaning for feminist scholarship, particularly, feminist science education.

I resonate with Michael’s observations of taking the path less traveled because I too left my home country to pursue intellectual opportunities and my “academic fortune.” The first annual meeting of the National Association for Research in Science Teaching (NARST) conference that Michael attended at Lake of the Ozarks was also my first NARST but I did not intersect with Michael on a regular basis until several years later when we collaborated with Ken Tobin’s research group in Philadelphia. During this time I began to appreciate Michael’s unwavering commitment to constantly and consistently frame research from theoretical perspectives, and his willingness to discuss those frameworks and theoretical ideas with all the members of the research group—Ken, the graduate students, the teachers, the high school students and me. In person, Michael’s enthusiasm and interest in research is infectious and admirable and his dedication to disseminating that work incomparable. His autobiographical chapter illustrates how a teacher can incorporate research into her/his classroom and can use that what is learned from the research to improve teaching and learning. Moreover, Michael continues to “work at the coalface,” analyzing classroom data at the micro and meso levels to further explore and explain students’ science learning and teachers’ practices. For example, Chapter 7, Linguistics and Gesture Studies, provides science education another connection into their field of linguistics and gestures. Science education researchers have suggested that science is a “foreign language” and if you have traveled in countries where you do not speak the language, gestures are foregrounded as a communication tool. Such can also be the case for our students in science classes, and Michael’s study provides the significant details in theoretical background and research methodology for readers to quickly understand the importance of gestures for students’ cognitive development in science.

Michael’s Keyworks also illustrate his intellectual and professional bravery, from his constant commitment to and unconscious connections to theoretical frameworks and his ongoing pursuit of learning from scholars in the philosophical, sociological, and philosophical arenas, incorporating those ideas into his research and then discussing those new interpretations and theoretical ideas through conference talks and presentations and his numerous publications. Michael constantly seeks to expand knowledge and make new connections with current knowledge—different and evolving. Moreover, he has exhibited that bravery when questioning the current paradigms and dogma in science education, using his privileged position as a named professor to challenge journal editors or the incorporation of religion into science education research.

For example, in the chapter on Phenomenology, Michael’s research challenged the status quo and dominant assumption within science education that laboratory experiences and demonstrations enhance and promote students’ learning and understanding in science. He also notes that students’ different physical location in
the class influences their observations. The chapter on *Alternative Ways of Writing* illustrates how Michael incorporates different social theories into his research and to produce a new approach to illustrating and re-presenting research, in this example, the *metalogue*. The metalogue has enormous potential because, from a feminist perspective, the forum allows all research participants to voice their understandings and interpretations. Metalogues provide a forum for socially constructed knowledge, and within feminist research that type of knowledge and the knowledge the knower brings into a setting are highly valued.

This chapter also provides insights into how teacher practices can shut down students’ engagement in science, especially underrepresented students. Rhonda’s discussions of the demonstration illustrated that she has been attentive and engaged in the class but Mr. Sparks did not acknowledge students’ different observations or their diverse lifeworlds. The chapter illustrates that co-education is not the same education, that is. Just because girls and boys are in the same space, they do not necessarily receive the same education. This can also be applied to under-represented students.

A majority of my research has focused on science teacher education, especially from a socio-cultural context, and Michael’s research on coteaching and cogenerative dialogues, along with Ken Tobin’s has impacted my research and the administration of a science teacher preparation program. Again, Michael’s research introduced me to new theoretical frameworks, such as Pierre Bourdieu’s theory of practice and Yrjö Engström’s activity theory. Michael’s theoretical study on coteaching and cogenerative dialogues as the structure for student teaching provided the foundation for a new direction in my research and teaching practice. Within the science teacher education program that I coordinate, we use coteaching and cogenerative dialogues to teach the methods course and the seminar associated with student teaching. Student teachers coteach a majority of their classes and cogenerative dialogues are primary structures for curriculum planning among the science teachers. The science student teachers are placed as a group within one school district. Student and cooperating teachers and the university personnel build a community that is focused on students’ learning and the ongoing improvement of science teaching. The cooperating teachers’ identity now includes teacher educator.

Michael’s *Keyworks* contribution provides a snapshot of his twenty odd years of research in science education. Michael’s breadth of knowledge from diverse areas of scholarship and his ability to read those works in multiple languages provide him with unique skills to synthesize those ideas, plan and execute research to explore his research questions, and then disseminate new knowledge through his writings, his work with graduate students and collaborations with scholars throughout the world. Michael’s thirst for knowledge and understanding of how students learn and teachers teach science is unquenchable and these keyworks represent the foundation of his research in science education.

*Kathryn Scantlebury*

*University of Delaware*