

Dana L. Zeidler *Editor*

A Moral Inquiry into Epistemic Insights in Science Education

Personal and Global Perspectives
of Socioscientific Issues

With Contrib. by
Ly Do

Contemporary Trends and Issues in Science Education

Volume 61

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Editor

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 Springer

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ISSN 1878-0482 ISSN 1878-0784 (electronic)
Contemporary Trends and Issues in Science Education
ISBN 978-3-031-63381-2 ISBN 978-3-031-63382-9 (eBook)
<https://doi.org/10.1007/978-3-031-63382-9>

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The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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This volume is dedicated to the scholarly family of colleagues who supported this venture and continue to inspire present and future generations of educators in science education, as well as educators in related disciplines around the globe. It is also dedicated to those past, present, and future generations of scholars that we are fortunate to work with. Further, this work is certainly dedicated to each of our own individual families who constantly support and guide us. Finally, on a personal level, I would like to dedicate this work to Annie, Judy, John, Christopher, Matthew, and Sophie—who brought me into the fold to become a part of their family. (D.L.Z.)

Foreword

If you are familiar with the label “socioscientific issues” (SSI), which denotes a major domain of research and practice in the field of science education, and/or you know (or know of) Dana Zeidler, a science education scholar whose name is synonymous with SSI, then you have ample reason to get and read this book.

Or so you think!

I venture to say that you might think you know Dana Zeidler or fully grasp SSI theory, research, and practice, as well as its global reach. I thought I knew the person and the work. I was *mistaken*.

If you made it to this paragraph and are reading these words, then you likely are still deciding whether to get your hands on this unique volume and read through its content. Maybe you picked up the volume off the publisher’s table at conference or a store shelf somewhere or, more likely, are scrolling down some limited preview of the book on the publisher’s or a vendor website. You likely skimmed the table of contents and were struck by the uniqueness (or oddity) of the book’s structure. The book is unique in that it is neither sole authored nor an edited work—at least, not in the traditional sense of authored and edited books. It is rare for a book editor to write several opening chapters in an edited volume just to set the stage for invited authors to make their contributions. You might also have realized that the book is, at once, inward looking and deeply personal, as well as a collective, multi-lensed, global effort. This book is unique.

So, should you get the book and read it? My answer is an unequivocal yes. At the same time, I have reasons to doubt this answer. You still need to decide.

For full disclosure, I have known Dana Zeidler for close to three decades now, since I first met him in the company of my doctoral adviser, the late Norman Lederman. Dana and Norm went through their doctoral programs in science education together at Syracuse University. Over the years, I got to know Dana and work with him professionally, having contributed chapters to two of his edited books. We also participated together in more than a dozen conference symposia and presentations over the years. From 2016 to 2020, Dana and I co-edited the *Journal of Research in Science Teaching* (JRST).

Dana is a valued colleague and close friend. I thought I knew him well!

No doubt, Dana is the authority in the domain of SSI in science education. He is among a few colleagues in the field who can lay claim to having founded a whole domain of research and practice that has gained a wide global following and that continues to be vigorously adopted, researched, practiced, expanded, and transformed. Dana is widely published in the premier science education research journals and has helped shape the field through his co-editorship of *JRST* and the most recent *Handbook of Research in Science Education*, as well as several book series. His scholarly work is widely used, having been cited by more than 2,500 documents in SCOPUS to date, and garnering more than 17,000 citations on *Google Scholar*, and counting. Dana's contributions, and the rigor and impact of his work and leadership in science education, have landed him multiple distinctions and accolades—too many to list here. These include receiving the *Distinguished Contributions to Science Education Through Research Award* from NARST in 2016. So, if you want to take a deep and current dive into SSI, this is the book to read. You are getting the story from the horse's mouth.

I vouch for the author. I know Dana. Or so I thought!

Would you still want to get and read this book if I were to share with you some personal “brute facts” about Dana that paint a completely different—even shocking—picture of the moral character of the person he really is? Intellectual integrity dictates that I must, especially given the central role that moral character and ethical conduct play in SSI theory and practice. Brute facts, I should note, is a phrase that Dana himself uses repeatedly in this volume to articulate his SSI theory.

Here are the brute facts:

As a high school student, Dana Zeidler was handcuffed and arrested for allegedly assaulting police officers in an attempt to prevent them from injuring a helpless fellow student who was protesting in the midst of a riot. His first year in college, Dana wrote academic papers, as well as letters to his probation officer to demonstrate that he was on good behavior. It would take an expensive lawyer to eventually get charges against Dana to be dropped by a “friendly” judge.

This was not the end of it.

During his college years, Dana Zeidler spent time in a maximum-security prison in upstate New York in the company of hardened criminals and dangerous inmates. He socialized with these individuals and was on a “first-name-basis” sort of relationship with many of them. In transacting their mutual business, Dana managed to establish rules of engagement with this cohort of characters to ensure they achieved their common interests without disturbing the peace. Dana somehow managed to ensure the sharp implements he and his associates used did not seep into the prison's general population. Even more interesting, is the brute fact that he was a repeat visitor with this “community.” Dana came back again inside the prison walls, albeit his later associations were less peaceful and involved heated arguments, among other interesting forms of socialization.

I am not betraying Dana by divulging his secrets. I was as shocked as you might be right now by these revelations. These brute facts are laid out in all their glory and intrigue in the introductory chapters of this book for you to read and, in some cases, see in explicit visual documentation of events.

Would you still want to get and read this book? My colorful skirting with the truth of the aforementioned “brute facts” aside, my advice is an unequivocal yes and an even stronger endorsement of the book!

The book makes two major contributions. First, it expounds SSI theory and practice from the perspective of its founder. Dana and his collaborators and colleagues have written much about SSI over the past two decades as they worked to birth, develop, synthesize, and elaborate SSI theory and its associated elements. The book opening chapters offer a powerful synthesis and elaborate primer into this domain of research and practice, which would have utility for both novice and veteran scholars and practitioners interested in SSI. Here, Dana explicates a powerful argument for how SSI theory and practice extend the often expounded, important contributions of precollege science education to learners’ understanding of science content and processes in preparation for more advanced studies, and development of scientific ways of thinking and scientific literacies in preparation for citizenry in our scientifically laden world. Specifically, Dana argues that science education also could and should contribute, and demonstrates how SSI enables this contribution, to the character, moral, and ethical development of students in our precollege schools, indeed to the cultivation virtue, character, and independence among students.

Next, the book takes the reader on a *tour de force* of global perspectives on, and issues related to, SSI. Chapters, representing 16 nations and 40 scholars, explore a broad array of SSI-related educational issues from around the globe, ranging from the metalevel political lens of national emancipation and justice, to ontological and epistemological questions, to various syntheses of sub-domains of SSI research. Other chapters address more specific questions about the place and role of SSI in national science education policies and curricula, examining student learning of various SSI topics and acquisition of relevant skills, and investigating teachers’ instructional practice and professional development related to SSI, among other interesting and leading-edge topics.

The second major contribution of the book is rather unique and equally, if not more, important. It offers a *rare, rich, and nuanced* rendering of the often deployed and true statement that “every scholarly journey is deeply personal.” The statement should not be taken to mean that scholarly journeys are undertaken alone or are lonely endeavors. Far from it, scholars are members of their professional communities. Successful scholars understand and take full advantage of what their colleagues and communities offer in terms of socialization, distributed intelligence and insights, and work and supports to be able to expand our understanding, build new knowledge, and extend positive impacts in the sphere of influence of our chosen domain of scholarship and practice.

The statement also bears the meaning that scholarship is “deeply personal” in the sense that scholars often spend lengthy stretches of time alone and expend enormous personal effort in the seclusion of their offices or preferred places of work. In many instances, they are on their own: They read and work hard to synthesize ideas, struggle with analyzing and interpreting their data, write and rewrite manuscripts, and find their own colorful way through frustrations of receiving, initially rejecting wholesale, and eventually reconciling themselves to dealing with (often anonymous

and, to them, unjustifiably harsh) critiques of their work as they revise their way once and again into publication and communal acknowledgment. This, however, is not the sense in which I mean to invoke this statement.

The sense of “every scholarly journey is deeply personal” I am after here goes a level deeper. It speaks to how each of us journeys into the world of ideas from within the inescapable window of our *individual, personal histories* and, particularly, those *critical junctures* in our personal and societal lives that shape or transform our growing up. These unique personal junctures equip us with what Dana calls “a predisposition to inquiry in unfamiliar territory” and often enable us to make novel, and hitherto unmade, connections among seemingly unrelated ideas in supposedly disparate scholarly fields. The forming of these new connections is the *single* most important factor in advancing human knowledge and understanding.

In this book, Dana takes us on a deeply personal journey and explores those critical junctures in his personal life that jumpstarted a journey of discovery during his doctoral studies and invited him to explore and, more importantly, make novel connections among an array of disciplines. The latter included science education, sociology, moral philosophy, developmental psychology, social justice, and various subfields that ranged from moral reasoning to ethical conduct, moral judgment, and moral decision-making. Concepts in these scholarly fields were the ingredients that eventually gave birth to the field we now identify as SSI, where the (once very novel) connections made (by Dana) are now so obvious to us and seem to would have come naturally to any of us who might have read across these fields—assuming that reading across these varying fields would have happened as a chance occurrence to start with. To my mind, this is the beauty and power of what Dana achieves in this book, namely, the rich and nuanced way he interlaces his personal and scholarly journeys to unearth hidden connections between the two. Suddenly, my colorful twisting of the brute facts of Dana having been arrested, corresponded with a parole officer during college, lawyered by his family out of a trial, and ventured to interact with prison inmates; all these take on a rather different and deeply satisfying turn into a narrative that is at once insightful and educative.

It goes without saying that Dana was not aware of these connections as they occurred, that the book is an intentional, introspective, and reflective journey few of us undertake. Dana took the journey, and did that convincingly and masterfully, as well as with integrity and authenticity. As an empirically textured case study in how scholarly journeys are deeply personal, the book is uniquely instructive to novice scholars and inviting of the more seasoned ones to appreciate their uniqueness and the most important asset they bring to their scholarship journey and professional communities, namely, *themselves*. Dana’s book is a testament to the crucial importance that our diversity, in *all* its myriad forms, is constitutive for advancing our collective scholarship and advancing our goal to do good in the world—and SSI, literally, aims to do good in the world.

Finally, and this is personal. You could tell from my aforementioned accolades that I am a fan of Dana as a phenomenal scholar, generous colleague, and close friend. I thought I knew him very well. Reading this work made me realize that he

is all that and *more*. Dana is deeply ethical, unwaveringly moral, and, simply put, a *superbly good* human being. I am fortunate to have him as a friend.

Enjoy!

University of North Carolina
Chapel Hill, NC, USA

Fouad Abd-El-Khalick

Preface

The doctrine of scientific disconnection from social morals goes all the way back to the ancient Greek belief that thought is independent of society, that it stands alone, born without parents. Ancient Greeks such as Socrates and Pythagoras paved the way for the fundamental principle behind science: that truth stands independently of social opinion. It is to be determined by direct observation and experiment, not by hearsay. Religious authority always has attacked this principle as heresy. For its early believers, the idea of a science independent of society was a very dangerous notion to hold. People died for it.

The defenders who fought to protect science from church control argued that science is not concerned with morals. Intellectuals would leave morals for the church to decide. But ... this political battle of science to free itself from domination by social moral codes was in fact a moral battle! It was the battle of a higher, intellectual level of evolution to keep itself from being devoured by a lower, social level of evolution. Once this political battle is resolved, ... re-ask the question, “Just exactly how independent is science, in *fact*, from society?” The answer ... is, “not at all.” A science in which social patterns are of no account is as unreal and absurd as a society in which biological patterns are of no account. It’s an impossibility (Pirsig, 1991, p. 140).

In Part I of this book, the serendipitous personal experiences described in Chaps. 1, 2, and 3, from being arrested to teaching in a maximum-security prison, served as the impetus for developing the underlying presuppositions embedded in *The Construction of a Framework for Socioscientific Issues* described in Chap. 4. That framework serves as a roadmap to think about SSI as a kind of moral inquiry into epistemic insight, presented in Chap. 5, that is informed by recent philosophical, conceptual, and empirical intersections of scholarship connected to SSI.

But what does a moral inquiry into SSI look like beyond a personal foundational formulation of this framework? What impact has the SSI framework had on the perceptions of scholars around the globe? What are their perceptions of the “State of the Art” connected to SSI-related topics, moral inquiry, and epistemic insight? It is understood that no one person, or even a team of scholars, represents the sum total of diverse perspective related to SSI. However, having representation from differing

geographical and sociocultural perspectives about research, policy, and practice of SSI-related work, remained an open question. I was particularly interested in what other scholars thought ought to be advocated, in relation to those areas, as well as what were possible “blind spots,” sticky wickets, problematic or overlooked areas, and what fruitful/emerging directions might the SSI framework be directed towards in future research?

To that end, Part II of this book aims at presenting perspectives that converge on those questions. I am humbled that 40 scholars representing sixteen countries agreed to contribute to this volume. These countries include Australia, Brazil, Canada, Cyprus, and Spain (together sharing concerns about Ocean Literacy impacting both countries), Greece, China, Lebanon, Portugal, Spain, South Africa, South Korea, Sweden, Taiwan, Turkey, United Kingdom, and the United States. Collectively, these contributors representing global perspectives about SSI-related themes are collectively better situated to address those questions than my singular personal perspective. However, I argue in this volume that the experiences which left their mark on my slate have managed to intersect and resonate with others around the globe who hold in common a sociocultural view toward the role of human flourishing in science education. I am indebted to these scholars for their insights and dedicated efforts to advance moral inquiry and epistemic insight as it related to functional scientific literacy. They have contributed significantly to the field of science education.

These dedicated efforts are also bracketed first by a Foreword from Dr. Fouad Abd-El-Khalick, and second by an Afterword from Dr. Benjamin C. Herman. I asked these particular individuals to serve in those “bookend” roles because of their expertise in research and scholarship in the field. They too have been deeply invested and immersed in advancing science education toward fruitful and progressive directions. But that expertise aside, both have been part of a journey connected to my personal well-being as a colleague and a friend. Some things are just brute facts.

Tampa, FL, USA

Dana L. Zeidler

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About the Editor

Dana L. Zeidler (AAS, BS, MS, PhD) is a distinguished university professor and the department chair of Teaching and Learning in the College of Education at the University of South Florida, Tampa, Florida. He has developed a global research program in the field of science education centered on socioscientific issues—taking a sociocultural approach to teaching and learning about how moral and ethical issues can be a means to foster the formation of epistemological sophistication and character in the pursuit of scientific literacy. Accordingly, his research incorporates aspects of argumentation and discourse, moral reasoning and character formation, epistemology, place-based immersive scenarios, and the nature of science. Dr. Zeidler’s passion is sharing his pursuit of moral inquiry in science education with students and colleagues around the world helping to progress the field in fruitful directions.

Contributors

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Michel Pisa Carnio is a Brazilian professor and researcher at the Federal University of São Carlos, in the city of São Carlos, Brazil. He has a master's and doctorate in Science Education from the São Paulo State University and a postdoctorate with a focus on public educational policies from the Maringá State University. His work is permeated by references from critical theory and historical-dialectical materialism, in dialogue with Brazilian and Latin American authors who defend a humanized and emancipatory scientific education. He works in the areas of science and biology teaching and teacher training, focusing on CTSA education and socioscientific issues. He is currently developing critical studies on the relationship between human beings and nature in this world in crisis, on the possibilities of citizenship training in a social context averse to democracy, and on the construction of possible paths for training science and biology teachers at the university-school interface.

Kennedy Kam Ho Chan (BSc, PGDE (distinction), M.Phil, PhD) is an associate professor at the Faculty of Education, the University of Hong Kong. He is passionate about enhancing student learning experiences in science by improving the teaching quality of science teachers. His research interests include pedagogical content knowledge, teacher noticing, and the use of video in teacher education. He is particularly interested in the situated and dynamic aspects of teacher expertise and has conducted a number of studies to characterize, assess, and develop these aspects of teacher expertise in Hong Kong.

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António Pedro Costa is a principal researcher at the Research Centre on Didactics and Technology in the Education of Trainers (CIDTFF). He also collaborates with the Artificial Intelligence and Computer Science Laboratory at the University of Porto, Portugal. He is one of the authors of the qualitative data analysis *software* webQDA (www.webqda.net). He coordinates two qualitative research conferences (www.ciaiq.org; www.wcqr.info). He is the author of more than 300 publications in international conferences and journals.

Vaile Dawson is Professor of Science Education at the University of Western Australia. Originally a medical researcher and then a science teacher, she has conducted educational research with science teachers and their students at the secondary and tertiary level in Australia, Indonesia, and India for over 30 years. Her research expertise spans climate change education, genetics education, scientific literacy, initial teacher education, critical thinking, and teaching in disadvantaged schools. The key outcome of this research is to ensure that all young people receive a quality science education that enables them to make informed decisions about issues that impact their current and future lives. She has been awarded external research funding from various organizations, including the Australian Research Council. Vaile has co-edited five highly respected and widely used initial teacher education textbooks for prospective school science teachers that celebrate the role of science inquiry and science for all.

Polliane Santos de Sousa is a Brazilian researcher, with a degree in Physics and a master's degree in Science Education from the State University of Santa Cruz, and a PhD in Scientific and Technological Education from the Federal University of Santa Catarina. Currently, she serves as a faculty member at the Teacher Training Center of the Federal University of Recôncavo of Bahia and has dedicated herself to deepening studies on an ethical-critical scientific and technological education, focusing on overcoming situations of social injustice experienced by school communities. Drawing on the educational principles of Paulo Freire, she has been furthering studies on curriculum organization based on thematic approaches. Moreover, she investigates the shaping of research on socioscientific issues in Brazil, establishing connections of this field with Latin American theoretical frameworks such as those of Paulo Freire, Milton Santos, and Enrique Dussel.

André Vitor Fernandes dos Santos is a Brazilian researcher holding a degree in Biology and with master's and doctoral degrees in Education from the Federal University of Rio de Janeiro. He serves as a professor at the University of Brasília, campus of Planaltina. With a focus on science education, policy education, and curriculum, in his works we can find an integration between critical and post-critical references, focusing on the analysis of educational policies, especially curriculum and assessment policies, with the aim of constructing “a” curriculum history. His studies have been focusing on how neoliberal ideology has been articulating with disciplinary traditions, reshaping what we conceive as school knowledge and, therefore, on how and who we should be as teachers and students. By focusing on these themes, his work has been making visible the systems of reasoning that underlie the formulation of public policies, opening spaces for us to reimagine new futures through engagement in disputes over the meaning of the world.

Paulo Gabriel Franco dos Santos is a Physics graduate with a master's and doctorate in science education from São Paulo State University, and postdoctoral research at the University of Havana, serves as a professor at the University of Brasília, campus of Planaltina. With a focus on teacher education, socioscientific issues, and critical perspectives in scientific education, he has conducted researches at regional, national, and international levels, particularly in collaboration with Latin American and Caribbean partners. Currently, his academic endeavors encompass teaching, research, and university extension, with a special emphasis on socioscientific issues, science, technology, society, and environment (STSE) education, as well as in-depth exploration of peripheral, racial, and class-related challenges. His work is directed toward the transformation and nurturing of dreams and strategies for the creation of another possible reality through Brazilian and Latin American scientific education.

María Evagorou is an associate professor at the Department of Education, University of Nicosia, Cyprus. Her scholarly activity focuses on exploring and enhancing young students' and pre-service teachers' argumentation skills within socioscientific issues (SSI). More specifically, the emphasis of her work is on students' and teachers' talk when they engage in the discussion of SSI and aims to explore ways in which teachers can be supported in their effort to include SSI in their teaching. Through the engagement with SSI, Maria aims to promote responsible citizenship. Maria has worked as a principal investigator and senior researcher on various EU and local projects, served as a member on the JRST editorial board, and as a strand coordinator for ESERA. She has published widely in international referred journals and recently co-edited a book titled *Science Teacher Education for Responsible Citizenship: Towards a pedagogy of Relevance Through Socioscientific Issues*.

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The New Biology: A Battle between Mechanism and Organicism, Harvard University Press; Briggs, A. & Reiss, M. J. (2021) *Human Flourishing: Scientific Insight and Spiritual Wisdom in Uncertain Times*, Oxford University Press; and Barmania, S. & Reiss, M. J. (2018) *Islam and Health Policies Related to HIV Prevention in Malaysia*, Springer.

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Part I
Personal Perspectives of the Socioscientific
Issues Framework

Chapter 1

Introduction: Daring to Be Wise About Serendipity



Dana L. Zeidler

1.1 Sapere Aude

A good number of decades ago, when I was in graduate school, the uber goal of science education was the pursuit of science literacy. It is important to note that the emphasis at that time, was on *science* literacy, in contrast to how we tend to frame its analogue contemporaneously as *scientific* literacy. The point is, if you approached a science educator in the 1970s and 1980s to describe the major goal of science education, that person (likely a male) would offer a description of science literacy that was technocratic in nature. The space-race following the Soviets launch of Sputnik, and other residual artifacts from the “Cold War” had been won by the United States, and many of the “alphabet soup” curriculums (e.g., BSCS, IPS, PSSC, SAPA, SCIS) tended to still focus on content-related skills aimed at producing the next generation of engineers and scientists. The intent was also to include more “activity-based” curricula that stood in contrast to “traditional” lecture-based courses that required students to be passive note-takers and receivers of information. The idea that science could be better connected to other social factors began to make their appearance with the emphasis on “Science for All Americans” (AAAS, 1990). DeBoer (1991, 2014) and Kyle et al. (1983) provide good overviews of this time period. I realize I am presenting an “American” perspective of science literacy here, and I am by no means suggesting that the US should have been the “gold standard,” then or now, in the development, implementation and impact of science curriculum. But I do know, based on my own understanding of the global literature, that the US did tend to set the tone for much science education research agendas in countries around the world.

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Switzerland AG 2024

D. L. Zeidler (ed.), *A Moral Inquiry into Epistemic Insights in Science Education*, Contemporary Trends and Issues in Science Education 61,
https://doi.org/10.1007/978-3-031-63382-9_1

It was during that time, for reasons explained elsewhere (e.g., Zeidler, 2014; Zeidler & Sadler, 2011), that the conversation shifted from speaking about science literacy to scientific literacy. That shift, while subtle, implied that the focus was no longer relegated to science-content understanding but moved in a direction toward understanding the *character* of science, or nature of science (NOS) (Lederman & Lederman, 2014). This was important because the emphasis was no longer solely on content-understanding, but rather on conceptual understanding of the activity of science, important to both science majors as well as non-science individuals. Those decades of past, I was in graduate school at Syracuse University (New York) with my friend and colleague, Dr. Norman Lederman. They were both fun and heady days, to be sure. Those days were *our* Enlightenment—as least it seemed that way for us. We often spoke of the distinction between science and scientific literacy, and the implications of what that distinction held for the field. At the same time, I was beginning to suggest that those mainstream conceptions of science, and even scientific literacy, were short-sighted, and not inclusive enough to meet the problems and issues that confronted science education (Rudolph, 2019), both from a US-perspective as well as a global perspective. Norm’s ideas and mine were synergistic and we were both excited to do our part to shift the conversation, for those who would listen, and for those who we could convince, to the notion of functional scientific literacy (FSL). I began to argue the point (Zeidler, 1984; Zeidler & Schafer, 1984) that being scientifically literate necessarily entailed the condition of a moral context. Achieving FSL, in other words, would mean being able to make decisions about scientific issues that were embedded in the social fabric of our society as well as the organic and physical world in which we dwell in a manner that produced eudaimonia, best translated from the Greek as “human flourishing.”

The arguments I have made over the years boil down to this: In order to reach an operational threshold of FSL, one must necessarily engage in the realm of ethical conduct and moral reasoning. This view suggests that notions about conventional inquiry in science education (e.g., process skills such as controlling variables, making observations and predictions, using the 5-E model, etc.) must also include another domain of inquiry skills. Perhaps we can refer to this as a domain of *moral inquiry*. Therefore, FSL will need to attend to what we will refer to later (Chap. 4), as brute facts about the prudent nature of human beings, and how moral education may elevate those brute facts to allow passage through a threshold of normative expectations as one enters the house of reflective consciousness.

The research program that I was developing then was the beginning of the Socioscientific Issues (SSI) framework, and I have been pleasantly surprised at its genesis and global impact since those early days to the present. More recently, another colleague, Dr. Troy Sadler, and I have written a review of literature of SSI from 2014 to 2022 for the third edition of the *Handbook of Research in Science Education*, and we have identified well over 400 scholarly research articles, 68 book chapters, and 42 dissertations directly connected to the SSI research program during that time (Zeidler & Sadler, 2023). I offer this as one form of empirical evidence, that the topic of SSI is omnipresent and relevant to science education, as well as to fields external to the field, at this point in time and for the foreseeable future. It is