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BOOK REVIEW

A Notice to Novices: What Can We Learn from "*How Should I Know?*": A Book Review of *How Should I Know? Preservice Teachers' Images of Knowing by Heart in Mathematics and Science*[1]

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Kathleen Nolan's (2007) book, *How Should I Know? Preservice Teachers' Images of Knowing by Heart in Mathematics and Science*, is a "critical qualitative study of mathematics and science epistemologies" (p. 33), particularly preservice elementary teachers' (PSETs) views of what it means to know mathematics and science. In this book, Nolan uses data from individual and focus group interviews and observations to describe the experiences of PSETs as both learners and future teachers. As Nolan suggests, the main point of this book is, "that this research is not about the content of the subjects so much as it is about the preservice teachers' perceptions of, and experiences in knowing in these subject areas" (p. 32). She seeks to understand how and why these perceptions and experiences come about. Nolan uses these experiences to critique the conditions and epistemologies that exclude some groups of learners from fully engaging in mathematics and science learning and proposes alternative ways of teaching and learning mathematics and science.

Nolan uses multiple voices and perspectives in this work, including those of the participants, colleagues, and other scholars from a variety of disciplines (e.g., education, psychology, social sciences, and visual arts) to discuss methodological choices and broader epistemological issues. She leverages these voices to interrogate what it means to learn and teach mathematics and science and proposes alternatives to commonly accepted norms and practices in mathematics and science education. The participants' perspectives are used to frame a vision for helping all preservice teachers (PSTs) to experience success in teaching and learning mathe-

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matics and science. Some particular strengths of this book, besides Nolan's multivocal approach to inquiry, include her reflexivity and transparency, her use of a variety of narrative tools (e.g., metaphor, poetry, narrative, pictures, format, and author reflections), and the interweaving of theoretical perspectives throughout the text.

My motivation for this review is aligned with my goal as a novice researcher to find exemplars of qualitative research informed by various theoretical perspectives and research methodologies. To facilitate the development of qualitative research in a climate of continued focus on empirical research in education, it is important to highlight qualitative studies and publications that are unique, innovative, and rigorous, but that also have practical implications for mathematics, science, and teacher education (St. Pierre, 2002). I am also interested in seeing applications of the many ontological and epistemological perspectives and learning theories that I have read. I find it valuable to see these theories exhibited in qualitative research to develop a clearer conception of these perspectives and an awareness of what they look like experientially. I also think that it is important to imagine how these theories can be linked to urban mathematics education and mathematics teacher education.

Summary of the Content

In the beginning chapters of this book, Nolan introduces us immediately to the participants, eight white female PSETs. First, they are introduced with a transcript of their discussion of "reasons and/or influences behind [their] beliefs about math and science knowing" (Nolan, 2007, p. 1) and then more formally with contextual information. Nolan presents this transcript simultaneously with a lesson about constructing a kaleidoscope. The use of metaphor is a prominent tool that Nolan uses to highlight specific themes and to critique dominant discourses and ways of knowing in mathematics and science education. Nolan introduces the participants and describes how they became part of the study and particular experiences, characteristics, or perceptions they share with her.

In the preface following the introduction, titled "postMODERN conSCIENCEness: Reflections on Light," Nolan provides an overview of the book and brings attention to specific experiences and discourses in mathematics which shaped her participants' conceptions of science and mathematics. She highlights the focus on gender and gendered experiences in mathematics and science. She also reveals the significance of the language, formatting, artistic tools, and metaphors she uses in the book. Nolan explains the epistemologies that inform her theoretical framework and methodological choices in data collection and re-presentation. For example, postmodern epistemology frames her choice of re-presenting a variety of participants' stories that counteract the dominant discourse about mathematics and

science knowledge and practice. Borrowing a term from Peters and Lankshear (1996), Nolan suggests that her participants' narratives could best be viewed as a "kaleidoscope of counternarratives…since the voiced experiences of the preservice teachers run counter to and challenge the official grand narratives" (p. 30). This assertion can be seen as amplifying voices and featuring stories told in PSETs' words that are not prominently featured in discussions on what counts as knowledge, what it means to learn mathematics, and personal experiences of students who struggle with mathematics. Nolan (2007) chooses to focus on light as a metaphor for the "explorations of preservice teachers' thinking on what it means to know in mathematics and science" (p. 31). This chapter gives insight into the researcher's choices and provides some significant background that prepares the reader for the unique journey that follows in the remaining chapters. Nolan uses feminist epistemologies to critique light and vision as the dominant representations of knowledge and ways of knowing in mathematics and science.

Overview of Chapters

In Chapter One, Nolan discusses the sources of knowledge, unpacks the conceptualization of light as a metaphor for knowledge, and highlights the resulting implications for teachers and learners. She draws from feminist and postmodern thought to challenge accepted conceptions of knowledge and enlightenment. She defines luminous light sources as those individuals who are considered teachers and experts in mathematics and science, and non-luminous light sources as students and others who absorb the knowledge transmitted by luminous light sources. Nolan argues that this conceptualization is problematic because it assumes a fixed conception of knowledge. It could also perpetuate the impossible expectations we have for new teachers to become instant luminous sources of knowledge. Nolan draws on the light metaphor because it has many properties and characteristics that are figuratively linked to knowledge and knowing, but she also demonstrates its limitations. While Nolan critiques the conception of knowledge as light, she also seeks to reconfigure this metaphor to address its problematic aspects as it relates to knowledge and how it is shared.

Chapter Two is divided into three parts: (a) "Part I: The Rectilinear Propagation of Light," (b) "Part II: Particle and Wave Theories of Light," and (c) "Part III: Formation of Shadows." In Part I, Nolan draws from seminal literature (e.g., Bruner, 1996; Dewey, 1938; von Glasersfeld, 1996) to discuss and critique the traditional model of education and the need to revisit the configuration of an instructional model of "information transfer from teacher and textbook to student" (p. 84). She also presents aspects of a progressive model of education that involves engaging students' wills and building on what they already know. In this section, she concludes with a discussion of the impact of perceptions and attitudes on views of learning. In Part II, Nolan compares the particle and wave theories of light with

theories of knowledge. This chapter draws on the ambiguity around theories related to the physical nature of light. In physics, light is considered both a particle and a wave as it has properties of both. Nolan argues that an analogous conceptualization is appropriate for understanding. She notes that it is valuable to have pieces of information related to particular concepts in mathematics and science, but it is also important to see how these pieces fit into a larger framework of continuously connected ideas. Part III is partly devoted to participants' experiences as female learners in mathematics and science and how these experiences are mitigated by teachers, the curriculum, and gender-focused ideologies. Nolan presents quotes from participants that highlight the gender biases that seemed to be ingrained in the discourse they experienced in mathematics and science. These messages, whether intentional, careless, or playful, seemed to discourage the PSETs in the study from actively pursuing mathematics and science or at least communicated the possibility that they were not the right fit for advanced studies in mathematics and science. Overall, this chapter delves into the messages expressed and internalized by PSETs as they experienced mathematics and science education.

Chapter Three focuses on answering the question of how the learner comes to know and how learners, particularly the participants in this study, communicate about their knowledge of and interactions in mathematics and science. Nolan also discusses the refraction metaphor for knowing. During the refraction process, light is transformed within refractive materials and the transformations vary with the nature of those materials; analogously, the process of coming to know takes place within the learner and knowledge transformation takes place when the learner actively constructs his or her knowledge. This process is also unique to the learner; thus, it is unrealistic for educators to have identical learning and achievement goals for all students.

In Chapter Four, Nolan restates, summarizes, and further unpacks some of the notable statements made by participants. For example, an exchange is quoted where some participants express their enjoyment of inquiry-based lessons in science, but are unsure of how these lessons might help students learn the "underlying concepts" that would be building blocks for their later science classes. She then harnesses participant experiences and expressed thoughts to highlight the importance of experiential learning, which is supported by scholars and teacher educators with multiple worldviews. She proposes "reimag(in)ing" mathematics and science education as open, engaging, and creative activities and reconceptualizing knowing and knowledge by recognizing past experiences and building on them to cultivate deeper understanding and meaningful learning experiences for all students. Her proposal to find ways to broaden access and engagement in mathematics and science, especially to students who have typically been underserved, aligns with the goals of urban education and those who enact emancipatory paradigms and pedagogies. In the next section, I discuss the strengths of Nolan's work.

Distinctive Features of this Study that Indicate Credibility

Nolan uses multiple pieces of data from her participants' and her own reflections to provide rich description in conjunction with literature that strengthens credibility in the text. Tracy (2010) defines credibility as "the trustworthiness, verisimilitude and plausibility of the research findings" (p. 840). Some tenets of credibility are thick description, crystallization, triangulation, multivocality, and member reflections. Credibility is also closely tied to the ethical qualities of the work (Howe & Eisenhart, 1990; Tracy, 2010). Data from the participants were obtained through multiple individual and focus group interviews, member-checking interviews, and some informal written communication. Multiple voices are re-presented throughout the book. Every chapter from introduction to conclusion includes a mix of participant, scholar, and the author voices. Particularly noteworthy is that while she interprets the meaning of participant responses, Nolan presents their own words and unpacks her interpretations in conversations shared throughout the book.

Support from a Variety of Scholarship

Moss and colleagues (2009) support the conception that rigorous research should demonstrate an awareness of the history, ethics, and philosophy of the chosen phenomenon, problem, or methodology and should build on the work of past researchers. Nolan highlights the results of other studies to support her claims and to provide a foundation for her arguments. For example, she draws on other studies to claim that many PSETs enter their teacher education programs with a palpable dislike or disinterest in mathematics and science (both teaching and learning). She notes one of the conclusions of Hill's (1997) study that "in mathematics methods courses, most PSTs view mathematics as a set of rules and procedures to be memorized" (Nolan, 2007, p. 81). This quote is consistent with her opinion that PSTs' conceptions of mathematics will not only influence their attitudes toward mathematics, but also the pedagogical strategies they enact and their willingness to teach in ways that are different from what they experienced as learners. Nolan situates all of the ideas she discusses in prior work and includes summaries of research-related concepts in excerpts called "Inside Research" found throughout the book. She also incorporates colleagues' perspectives by including their quotes in the "RESPONSibilities" snippets distributed throughout the chapters.

Reflexivity

Another distinctive feature of this work is the reflexivity of the researcher. This reflexivity is a particular strength exhibited by Nolan's transparency, sincerity, and openness, which are hallmarks of ethical studies (Tracy, 2010). Nolan is open about herself and her experiences throughout the text by revealing her qualifica-

tions, experiences in teaching, and feelings about mathematics and science. Even though she is well qualified in mathematics and physics, Nolan expresses the following sentiment: "The hairs on the back of my neck stand on end, and I break out in a cold sweat when I think someone is about to ask me a question that tests my 'knowledge' in math and science" (Nolan, 2007, p. 21). These insights into Nolan's background, research interests, methodological choices, tensions, and thought processes also make her motivations and biases visible to the reader. This transparency demonstrates a high level of trustworthiness and provides additional perspective and context for interpreting the study and its findings. *Reflexions* are passages inserted into the text to explore topics in more depth, expand on or clarify statements in the text, and provide glimpses into Nolan's thought processes. *Inside (my) Research* sections give added insight into her decisions about the project, details about her reasoning, and dilemmas she experienced in data collection and analysis.

Use of Learning Theories

Another distinctive feature of the book is how Nolan was able to implicitly and explicitly integrate a variety of learning theories throughout her work. Because her work is motivated by postmodern assumptions, crystallization and multivocality are essential parts of her work. Nolan also uses a feminist lens to deconstruct, challenge, and critique the common assumptions about knowledge and knowing, especially in mathematics and science. Because Nolan uses feminist theory prominently in this work, a focus on gender is evident at multiple levels. She highlights the achievements of women in science and mathematics, and seeks to counter the common discourses that women are not suited for mathematics and science by giving participants pseudonyms inspired by women who made significant contributions in mathematics and science (e.g., physicist Ursula Franklin and mathematics ecologist Evelyn Pielou). She shares different stories of women in mathematics and science through the "HER story" features. Through her use of multiple epistemological and pedagogical lenses, she also seeks to strengthen the case for multiple and alternative perspectives on teaching and learning to accommodate more women, rather than trying to change women to fit mathematics and science. She uses feminist epistemology to unpack the notion of the expert and posits that the view of "knowledge as light" and seeing as a metaphor for knowing can be interpreted as gendered and hegemonic.

Moreover, Nolan often points to the literature for solutions for more engaging pedagogy, especially ways to engage students as active participants in science and mathematics learning. Enactivist theory posits that the individual is not just an observer, but also an active participant in the surrounding world, both physically and cognitively (Ernest, 2010). Freire (1970/2000) argues against the "banking" model of learning or the knowledge as commodity view. He urges active engagement of students in the learning process to ensure that it is meaningful to them (Lave, 1996).

Nolan (2007) proposes that science should be viewed as "participation with natural phenomena" (p. 195). She also envisions mathematics and science as corporal endeavors involving the whole individual. She proposes that these disciplines mix inquiry with drama, storytelling, reflection, or writing and that there should be a focus on the journey or the process of problem solving, rather than right or wrong answers. Overall, Nolan recommends that we reconceptualize mathematics teaching and learning as active, rather than passive pursuits.

Discussion

This book provides a valuable contribution to the body of work related to qualitative studies that use unique approaches to inquiry. The experiences and perspectives shared from the participants and unpacked with the help of other scholarly work prove to be an effective combination. Nolan uses her original framework of ideas related to inquiry and knowledge for the organization of the text. There are ideas expressed in this book that teacher educators, teachers, PSTs, and other stakeholders in education can benefit from hearing. The postmodern and feminist perspectives she describes inform her data collection, analysis, interpretation, and representation consistently. Her use and interpretation of epistemologies and learning theories is implicitly and explicitly represented throughout the narrative as she discusses perspectives about knowing mathematics and science. These theories not only influence what she chooses to say, but how she chooses to present data, existing literature, and her own ideas. Particularly powerful was the prominent role that the participants' perspectives and voices play in the text; this approach is consistent with the feminist paradigm, which informs the research design. The participants' perspectives are integrated into every topic allowing the reader to envision some aspects of mathematics and science education through their eyes.

Nolan also makes a case for the deconstruction of mathematics and science discourse, pedagogy, and learning as we know it. Her presentation of concerns related to norms that could exclude some learners challenge others to consider the social and political implications of their actions as educators, mathematicians, and scientists. While this work does not emphasize racial or cultural diversity nor is it situated in an urban setting, the critical lens that she uses and the emphasis on empowering participants can inform the work of scholars in urban mathematics education. This critique could also be extended to ways of knowing which exclude or marginalize the experiences and funds of knowledge (Moll, Amanti, Neff, & Gonzalez, 1992) of students from African American, urban, or culturally diverse backgrounds because these ways of knowing are often undervalued or overlooked in conventional schooling. Critiquing discourses and opening dialogue about alternative ways of knowing mathematics can help to inform educators' positioning of students in urban settings as more empowered and active mathematics learners.

Conceptions of mathematics as an active endeavor enriched by multiple perspectives, cultures, and experiences align with the work of educators who seek to empower marginalized students in mathematics and the teachers who work with them (e.g., Moll et al., 1992; Tate, 1995; Turner et al., 2012). In addition, Nolan also questions whether *high quality* research should only include studies designed to limit researchers' interactions with participants, require rigid objectivity, and exclude researchers from the narrative. Nolan's methodological example could also lend credence to the investigative approaches of researchers who work with marginalized populations and employ participatory or liberatory epistemologies and approaches, especially within urban contexts. The distinctive features of qualitative methodology she describes could inform research studies in urban mathematics and science education, particularly those studies that seek to broaden participation in urban communities at all levels and to amplify diverse voices that are not typically included in conversations about knowledge, teaching, and learning in mathematics and science.

Nolan's work also highlights the importance of learning from the perspectives and experiences of future teachers. In particular, she shows that it is essential for all PSTs to reflect on their lived experiences as mathematics and science learners in the contexts of their teacher education programs, and for mathematics and science teachers, teacher educators, and researchers to listen to and reflect on the meanings of these experiences. This work would be helpful in understanding and addressing the lack of diverse teacher candidates who perhaps may have responded to negative learning experiences in mathematics and science by choosing alternative paths of study at the university level or not completing coursework in preparation for teaching careers. This point is particularly important given the need for diverse teacher candidates in urban settings because of the cultural and social capital they may bring to the table. Having future teachers reflect on their experiences as mathematics and science learners could also be very enlightening for teacher educators, especially if examined through racial or cultural lenses. It could also be of value to those interested in seeing how PSETs view mathematics and science to inform the creation of learning opportunities to support positive conceptions of teaching and learning among diverse students. More generally, this book might help teachers think about ways that they create mathematics and science classrooms where all learners feel encouraged to participate and thrive, especially our most vulnerable students.

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