

Chapter 1

Opening Lines: An Introduction to the Volume

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Abstract In this opening chapter, the editors set the stage for the wide-ranging description and discussion of work in mathematics education awaiting readers of this volume. They define how the phrase “work in mathematics education” is to be understood for this volume and explain how the 25 chapters are grouped according to intended beneficiaries of the work. The editors describe the genesis of the book: how the idea arose in June 2015 and how it was intended to be an extension of the conversation that would take place at the 2016 Joint Mathematics Meetings panel on “Work in Mathematics Education in Departments of Mathematical Sciences,” co-sponsored by the Association for Women in Mathematics (AWM) Education Committee and the American Mathematical Society Committee on Education. To entice the reader to explore the volume, the editors highlight some of the contents and note common themes and connections among the chapters. This chapter also summarizes the multi-stage process that brought the idea for this book to fruition so that the reader may understand the selection and peer review process. As many of the chapters do, this one closes with a final reflection by its authors on their involvement in this project.

Keywords Work in mathematics education • Mathematical sciences departments • AWM Education Committee

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1.1 Introduction

Many members of the mathematics community in the United States are involved in mathematics education in various capacities. Indeed, through its professional societies and many of their committees, the mathematics community has been working for many decades on improving mathematics education at all levels (See Sect. 25.4.2). Government agencies, private foundations, and the professional societies themselves have funded a great many projects with this goal. Many of these projects involved the efforts and contributions of members of departments of mathematical sciences.

This volume focuses at the level of the people doing the work, often collaboratively, in mathematics education. The contributors tell how their work has been informed by research findings and educational theories. They describe impacts that go well beyond their own classrooms; some have published articles in professional journals about their work. Some authors discuss how their work might be adapted for use elsewhere or direct the interested reader to additional resources. This volume does not contain research articles; instead the authors narrate their efforts and successes (supported in many cases with data collected locally). The volume seeks to initiate a conversation in the mathematical community about difficult issues of how work in mathematics education is perceived and valued.

1.2 Our Definition of Work in Mathematics Education

This volume in Springer's Association for Women in Mathematics Series, *Mathematics Education: A Spectrum of Work in Mathematical Sciences Departments*, offers a sampling of the work in mathematics education undertaken by members of departments of mathematical sciences.¹ For the purposes of this volume, we will take the phrase "work in mathematics education" to mean:

endeavors concerning the teaching or learning of mathematics, done by mathematical scientists or mathematics educators in their professional capacity.

Examples of work encompassed by our definition (and appearing in this volume) include:

- Mathematical outreach,
- Mentoring of those learning or doing mathematics,
- Work with pre-service and in-service teachers of mathematics,
- Development or dissemination of instructional content, materials, activities or teaching practices in mathematics,

¹Throughout the volume, the word "mathematics" is often used as shorthand for "mathematical sciences."

- Efforts aimed at effecting departmental or disciplinary change relative to the teaching and learning of mathematics,
- Scholarly study (whether considered scholarship of teaching and learning or mathematics education research) of any of the above.

Each chapter illustrates one or more of these to varying degrees.

1.3 The Organization and Goal of the Volume

The participants in and the intended beneficiaries of any work in mathematics education are an important consideration. Collectively, the work described in this volume involves students at all levels from kindergarten through graduate school, K-12 teachers, college and university faculty and administrators, and in some cases the general public. To emphasize this, we have organized the book into five parts according to the primary beneficiaries of the work:

- The readers of this volume (Part I),
- Pre-service and in-service teachers and graduate student instructors (Part II),
- STEM majors (Part III),
- Students in general education courses (Part IV), and
- The general public and the mathematical community at large (Part V).

The writing style is expository, not technical, and should be accessible to and inform a diverse audience of faculty, administrators, and graduate students. Contributors were asked to describe their work, its impact, and how it has been perceived and valued. Some have been willing to be quite candid about the last of these. The overarching goal for publishing this volume is to inform the readership of the breadth of this work and to encourage discussion of its value to the mathematical community and beyond to society at large.

1.4 The Genesis of this Volume

In early June 2015, Kristin Lauter, then President of the Association for Women in Mathematics (AWM), emailed two of the editors, Jacqueline Dewar and Pao-sheng Hsu, in their capacity as co-chairs of the AWM Education Committee. She wrote:

Maura [Mast] and I met with Springer at the AWM Symposium and we discussed ideas for new volumes [in the Springer AWM Series]. Maura suggested the idea of a volume on math education, and it would be natural for you to lead this effort, and perhaps tie it to the panel you are organizing in January and get contributions from the speakers on your panel. You could also solicit other contributions from people in the community (personal communication, June 9, 2015).

So from the very beginning, this volume was envisioned as an extension of the conversation that would take place at the 2016 Joint Mathematics Meetings² (JMM) panel, “Work in Mathematics Education in Departments of Mathematical Sciences.” Dewar and Hsu agreed to undertake the task of putting together such a volume and invited Harriet Pollatsek, a member of the AWM Education Committee, to join them in this effort.

1.4.1 The Panel that Inspired this Volume

Discussions within the AWM Education Committee during 2014–2015 prompted and shaped the proposal for the panel. The panel, which took place on January 7, 2016, in Seattle, WA, was co-sponsored with the American Mathematical Society’s Committee on Education. Beth Burroughs, Professor, Montana State University, a member of the AWM Education Committee and a contributor to this volume, moderated the panel. Four panelists discussed their work in mathematics education and reflected on its impact and how it has been received in their respective departments:

- Curtis Bennett, Professor and former Associate Dean for Faculty Development and Graduate Studies, Loyola Marymount University,
- Brigitte Lahme, Professor and Department Chair, California State University, Sonoma,
- Yvonne Lai, Assistant Professor, University of Nebraska, Lincoln,
- Kristin Umland, then Associate Professor, University of New Mexico.

Three of the panelists (Bennett, Lai, and Umland) contributed to this volume. Other commitments prevented the fourth panelist from doing so, but she provided other support. A summary of the panelists’ remarks can be found in Dewar and Hsu (2016). At the end of the panel a lively discussion with the audience of approximately 60 people ensued.

1.5 The Process that Resulted in this Volume

Prior to this, the volumes in the Springer AWM Series grew out of research conferences or symposia and are collections of research papers. This one, inspired by the JMM Panel, is the first book in the series on mathematics education and is

²The Joint Mathematics Meetings conference is jointly sponsored by two major professional societies: the American Mathematical Society and the Mathematical Association of America. It also hosts sessions by other associations, such as the Association for Symbolic Logic, the Association for Women in Mathematics, the National Association for Mathematicians, and the Society for Industrial and Applied Mathematics. Approximately 6000 have attended each year from 2014 to 2016.

expository. In order to present a broad spectrum of work in mathematics education, we recruited beyond the original panel participants. Throughout the process we sought to represent a wide diversity in terms of the type of work in mathematics education, the career stage (early, mid, or late) of the contributor, the institutional type of the contributor (liberal arts, comprehensive and research-intensive institutions, and several secondary schools), as well as gender and ethnicity. The three editors, all mathematicians who have had long careers in mathematics and collegiate education, drew upon many networks of colleagues and scoured abstracts of papers presented at national meetings to develop a list of potential contributors. Thirty-four invitations were extended to submit a 500–1000 word proposal for an expository contribution about their work in mathematics education including how it is received by and affects its intended audience, how the work has affected the proposer’s career, and how it has been received by the proposer’s colleagues, department, and institution.

The three editors reviewed and discussed each proposal and gave feedback for expanding the proposal into a full chapter draft. Meanwhile, we recruited 41 mathematical scientists and a social scientist as reviewers for the chapters that would be submitted. We aimed to enlist reviewers who had expertise in the type of work in mathematics education that would appear in the volume, and also reviewers who would, in essence, be “general readers.” Each submitted chapter was then subjected to a single-blind review by at least three individuals—one expert reviewer, one general reviewer, and at least one editor. In addition, each editor read all of the submissions. The editors discussed the reviews and returned all the formal review material along with a joint editorial report and advice for revising the chapter. The revised submissions were again read by all three editors, and some further editing was done or requested. The result of a nearly year-long intensive process is this volume.

1.6 Reflections on the Volume

With any work in mathematics education, mathematics and its related sciences should be a central feature. Equally important are the participants involved: students, faculty, and sometimes the general public. This volume represents a selection of work in mathematics education by members in departments of mathematical sciences.

For some authors, the work focuses on courses or topics in the core undergraduate mathematics curriculum, including those for the mathematics *majors*³ and non-majors: *calculus* (Cohen et al., Tomlinson), statistics (Johnson, Williams and Martonosi), linear algebra (Bremser, Wawro), differential equations (Sumner, Tomlinson), group theory (Maycock, Yackel), number theory (Bremser), non-Euclidean geometry for teachers (Burroughs and Burke), introduction to mathemat-

³The words in bolded italic in the next few paragraphs are the 11 items listed as aspects of a department’s work by the AMS Task Force on Excellence (Ewing 1999, p. 12).

ical modeling (Sumner), complex variables (Tomlinson), and history of mathematics (Sumner). Also included are first-year seminars (Bremser, Catepillán, Fung, Sumner) and capstone courses (Bennett, Cohen et al., Williams and Martonosi).

Teacher preparation is an important mission of a department and plays a critical role in the health of the discipline. Several chapters (Bennett, Bremser, Burroughs and Burke) document different aspects of this work within the department, including one (Lai et al.) that describes the preparation of graduate teaching assistants to be future mathematics faculty. Bremser, Karakok et al., Seshaiyer and Kappmeyer, and Umland and Black work with K-12 teachers outside of the physical space of a department.

Indeed, **outreach** takes different forms: in addition to Math Circles for teachers and Math Circles for students (Karakok et al.), there are talks with the public at the National Museum of Mathematics (Greenwald) and traveling workshops for teachers and college faculty (von Renesse).

Several authors include designs of a **graduate** course for teachers: Bremser, Sumner, and Wawro.

For the large number of students who need a course that is mathematically before the **precalculus** level, there is a discussion about teaching college algebra and intermediate algebra (Lai et al.). For **general education** students, there are two versions of a quantitative reasoning course, a class that serves many in place of college algebra (Lopez et al.) and an interdisciplinary seminar (Fung). There are also a course for liberal arts students using dance movement (von Renesse) and a course in ethnomathematics (Catepillán) on mathematics in non-Western cultures.

Several authors (Catepillán, Fung, von Renesse) describe **interdisciplinary** courses they created. Sometimes the first-year seminar is the venue for these courses.

In terms of teaching methods, many authors discuss their preference for inquiry-based methods (Bremser, von Renesse), several want students to discover the mathematics they are learning (Maycock, von Renesse, Yackel), several use “tactile” techniques (Karakok et al., Tomlinson, Yackel), and one employs a flipped or blended approach (Tomlinson). Many use student projects and research (Bennett, Bremser, Catepillán, Cohen et al., Johnson, Sumner, Williams and Martonosi). Several chapters in the volume (Chaps. 11, 12, 20, 22, and 23)⁴ focus on the use of writing. Another format in the form of a “Clinic” is discussed in the chapter by Williams and Martonosi (Chap. 12) where students produce “deliverables” for real clients. Greenwald describes some mathematical activities she and a colleague have developed from animated sitcoms, bringing popular culture into the classroom.

We asked our authors to provide any information on assessments of what they have done. Quantitative methods were used in two chapters (Chaps. 17 and 22) and many others employed qualitative methods to assess some aspects of the work.

One kind of work that this volume does not contain is a research paper, although some authors (Bennett, Burroughs and Burke, Johnson, Wawro) report on the **research** they did. All use research or professional guidelines to support and inform

⁴The reader will find both “write to learn” and “write-to-learn” appearing in a chapter, as they do in many texts in the literature in writing across the curriculum.

their work. As editors, we made no attempt to distinguish what is from what is not “research” or “scholarly” work in mathematics education. Instead, there is a chapter on language use among different communities (Chap. 2, Hauk and Toney). As a research mathematician, Bennett (Chap. 4) gives a glimpse of his struggle with the language in mathematics education.

We want the reader to evaluate each piece of work on its merits. Two mathematicians (Cordero and Mast) who have moved to administration provide their perspectives as academic leaders on the value of the kind of work described in the volume. The chapter by Umland and Black delineates several categories of work that they label “scholarly” while noting that “traditionally [these would not be] considered research” (Chap. 9, p. 127). The authors then detail specific ways to evaluate each type of work based on the tangible product it produces.

External funding does make a difference in much of the work. In fact, over half of our chapters acknowledge that the work was supported by outside funding. One entire chapter is devoted to a description of the Carleton College Summer Mathematics Program, a funded program that has built a community of women becoming mathematicians (Richardson).

Several authors also connect their work with a “social justice” theme in paying special attention to students in groups underrepresented in mathematics: ethnic minorities such as Native American, Hispanic, African American and those with economic hardship. Also included are first-generation college and university students, as well as students who work or are considered “non-traditional” (Bremser, Catepillán, Lopez et al., Cohen et al., Johnson, von Renesse). Catepillán’s ethno-mathematics course qualifies as a *diversity* course at her university. Some programs are specifically aimed at underrepresented groups (Seshaiyer and Kappmeyer).

The word “change” used to describe an institutional transformation appears explicitly in two chapters in the volume. In one, Cohen et al. describe how their department managed a change in departmental culture: faculty collaborated, shared ideas and results, and provided mutual support. In the other, Holm discusses efforts toward achieving systemic change in the teaching of undergraduate mathematics. Our authors are from different types of institutions that vary in governance, mission, and culture. From the descriptions of their work, we also get a glimpse of the complexities in the enterprise we call mathematics education.

Collaboration is a key word in this volume. Even in chapters with one author, many describe the work they do as a collaborative effort. Support from their institutions, colleagues, and students is also crucial for the work that these authors do. From their reports, we see that the authors have different backgrounds, with a majority on a more or less straight-forward career path, some with a small twist (Bennett, Bremser). Black was and Kappmeyer is a K-12 teacher. Some have changed their careers: Kappmeyer was a civil engineer; Johnson worked as a statistician in medical and in marketing research; Craviotto left a university position to work in a school district; more recently, Umland has moved from academia to a non-profit organization working on K-12 curricular materials.

While some of the courses and work described in this volume are not preparing students for the content of a next mathematics course per se, they will shape stu-

dents' views of mathematics and their habits of learning mathematics. These views and habits are important for all students whether or not they continue with a course of studies in or using mathematics. All of them will carry experiences from the courses into their lives as parents, members of the work force, citizens who vote, or decision-makers in society.

1.7 Reflection on Our Involvement

From the start, our primary goal has been to draw attention to the breadth and variety of work in mathematics education done in departments of mathematical sciences and to encourage discussion of its value. We will be very satisfied if the volume creates opportunities for those discussions. But, we also hope that the many examples contained in this volume will not just inform, but inspire, readers.

Through our involvement in this project we have learned about a great deal of notable work in mathematics education. We have been impressed by the imagination and dedication, not just of our contributors, but also of all those involved in the work that is described in this volume. Our original belief in the value of this work to the mathematical community, the academy, and society has been further strengthened through the examples presented here. We offer this volume to our readers for their consideration.

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