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Introduction to the Special Issue on Teaching Inquiry (Part I): Illuminating Inquiry

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Running Head: Illuminating Inquiry

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Biographical Sketches

Brian Katz is faculty at Augustana College; during the development of this special issue, he was an Associate Professor of Mathematics and co-director of the Center for Faculty Enrichment. He received his PhD from the University of Texas at Austin, where he met others interested in inquiry-based learning, including

Elizabeth. His research interesting include students' learning of proof in inquiry environments. In addition to his editorial work with PRIMUS, Brian is an MAA author and editor, serves as the chair-elect for the SIGMAA IBL, and is passionate about offering professional development for instructors interested in using inquiry in their classrooms.

Elizabeth Thoren is a Visiting Assistant Professor at Pepperdine University. She received her PhD from the University of Texas at Austin, where she met Brian and was also introduced to inquiry-based learning. She then spent six years with the Center for Inquiry at the University of California, Santa Barbara where she developed materials for explorations-based courses. She is currently developing inquiry courses for future elementary teachers and other non-majors when she is not distracted by a toddler.

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Abstract

We provide an introduction to the special issue on Teaching Inquiry, through its motivation and themes. We focus here on Part I: Illuminating Inquiry.

Keywords: teaching inquiry, interdisciplinary inquiry, pre-service teachers, Realistic Mathematics Education, student experience, equity, coherence

Introduction

This editorial is an introduction to Part I of a two-volume special issue on Teaching Inquiry, which contributes to a much larger discussion within the community of mathematics educators. The inspiring quality of papers in this issue helps move this discussion forward; we hope they will spark even more conversation and progress.

Our entry point into this discussion and the genesis of the idea for a special issue on Teaching Inquiry resides at the intersection of two experiences common to many mathematics educators.

First, as scholars of mathematics, we have experienced a huge and intimidating gulf between the expectations of coursework in our roles as students and the task of asking our own questions in our roles as researchers. And we are the few who elected to study mathematics extensively; this gulf between prescribed tasks and open-ended, self-generated exploration is likely even wider for people whose formal relationship with the discipline ended earlier or more abruptly. We believe that all people should feel empowered to ask and explore mathematical questions throughout their lives, and we are interested in supporting that outcome.

Second, as educators, we have tried to make space for students to practice asking and exploring mathematical questions with the aim of narrowing the gulf identified above. We have seen students with significant math anxiety offer impressive questions and deep insight. We have also seen high-achieving students become overwhelmed without an algorithm to follow. More generally, we believe that all people are capable of meaningful mathematical inquiry; however, the infrastructure and skills needed to support meaningful inquiry depend on context, and we acknowledge the challenge of meeting these diverse needs.

The central claim of this editorial is that all people can and should be empowered to participate in mathematical inquiry through structured educational experiences embedded in our curricula. We hope to that this editorial contributes to this discussion by emphasizing and clarifying the importance of designing these curricula for equitable access and intentional coherence.

Many educators and scholars agree with our claim about the importance of

equity of access to inquiry experiences and their outcomes. For example, Sandra Laursen [6] and many others advocate for the benefits of universal access to inquiry experiences, citing findings that these experiences close achievement and affective gaps. Beyond mathematics, the Association of American Colleges and Universities (AAC&U) has identified engaging students in exploring contested questions as one of the ten high-impact practices [1] for college outcomes and has recently gone further to advocate that every student engage in "Signature Work", which is integrative exploration of questions articulated by and meaningful to the student [2].

The papers in this special issue incorporate equity themes in multiple ways. They cite the work of Carol Dweck [5] on growth mindsets to justify the claim that all students can reap the benefits of learning to respond to adversity with persistence; they use Laursen's work [6] to justify the claim that inquiry experiences can raise all students up to a level playing field; they represent a notable effort to use inclusive language, especially around gender; and they offer strategies for incorporating "low-threshold and high-ceiling" activities that democratize access to authentic mathematics while also supporting differentiated instruction in the classroom. Taken together, the courses discussed in this issue represent a wide range of contexts, including courses for students who may historically not have had access to mathematical inquiry experiences. Most importantly, these papers describe classrooms that value, support, and even require diverse student voices having authority. We see each of these moves as evidence that teaching inquiry is tied to questions of equity and inclusivity in ways that are moving the larger discussion of teaching mathematics forward.

Similarly, intentional design is critical for successful implementation of inquiry experiences, and this design should develop coherence among all course

elements, from the course activities to the implicit messages they communicate. An instructor building a mathematical learning experience applies a set of beliefs about how students learn, the kinds of work students are capable of doing, and the nature of the discipline; this set of beliefs in an inquiry classroom may be very different from what students have previously experienced or have come to accept. As a result, instructors must be intentional in supporting students' understanding of these beliefs; moreover, instructors must be consistently intentional when building a course to guarantee that all of its components express a consonant set of beliefs and support students' authentic participation in the discipline at all levels.

Many educators and scholars also tout the importance of embedding inquiry experiences in our curricula. For example, the Committee on Undergraduate Programs in Mathematics (CUPM) Curriculum Guide advocates that students "experience open-ended inquiry" [3, p. 10]; the CUPM Guide helps departments be intentional about this implementation by offering a list of thirteen ongoing responsibilities related to curriculum oversight [pp. 55-59]. The CUPM Guide goes further to integrate mathematics intentionally into the Liberal Arts so that students come to view "mathematics as a way of knowing that enriches all human activity" [p. 61]. Moving from the departmental to national level, it seems critical that future teachers experience inquiry as students, designed intentionally and coherently, if they are going to lead classrooms in which their own students participate in inquiry, and the closely related Common Core Standards for Mathematical Practice [8]. Moreover, inquiry experiences impact these teachers' conceptions of mathematics as a discipline, conceptions that are expressed to children and in turn impact the national discourse about mathematical and quantitative reasoning. (See for example Dan Meyer's call to make-over math class [7] or Keith Devlin's

foray into the discussion of the role of learning algebra in secondary school [4].) Intentionality is at the core of the successful implementations of inquiry described by each paper in this special issue. In each case, the instructors are helping students view inquiry as a normal part of participating in a mathematical community.

As important as equitable access and intentional coherence are to this discussion of teaching, the conversation cannot stop there; we must also iterate our design efforts with feedback coming from reflection on our teaching. As educators, we have experienced the joy of listening to student thinking, which teaches us about the depth and diversity of student experiences, reminds us how many teaching challenges remain open, and highlights areas of our own understanding that must be developed or revised. These experiences leave us with two related questions: what is inquiry, and how do we support its development in students?

We have organized the papers in this two-volume special issue around the ways that they contribute to the discussion of these two questions. Part I, entitled "Illuminating Inquiry", focuses on the nature of inquiry, from discussions of its theoretical foundations and generalizations across disciplines to descriptions and analyses of the experience of inquiry from the inside. Part II, entitled "Implementing Inquiry", focuses on approaches to offering inquiry experiences, from discussions of strategies to change student and instructor behaviors to descriptions and analyses of course design and project structures. Of course, a reader will find insight into both the nature of inquiry and approaches to achieving it in any paper in either part, and each part contains ideas for both instructors who have experience teaching with inquiry and those who are hoping to start.

Illuminating Inquiry

Taken together, the papers in this half of the special issue will help the reader develop a more nuanced conception of inquiry itself, and in turn this nuanced understanding will help the reader make informed design choices when offering inquiry experiences to all students.

The first two papers in this part of the special issue share a common focus on aspects of inquiry that cut across disciplines. The first paper, "It Is All About Inquiry: A Cross-disciplinary Conversation about Shared Foundations for Teaching" by Firkins Nordstrom and Sumner, is a dialog between mathematics and composition, demonstrating transdisciplinary commonalities as well as particular strengths of each discipline for teaching inquiry. The second paper, "Teaching Inquiry with Linked Classes and Learning Communities" by Piercey and Cullen, describes a learning community in which students use their study of both mathematics and professional writing to see common value in both.

The next few papers emphasize teachers' understandings of inquiry, specifically teachers who are our students; we anticipate that readers will also consider themselves as teachers using these ideas. The third paper, "Teaching Inquiry to High School Teachers through the Use of Mathematics Action Research Projects" by Miller, explores projects in which in-service teachers experience inquiry in an advanced mathematics context and bring this experience into their teaching. The fourth paper, "Reflections on Transformative Experiences with Mathematical Inquiry: The Case of Christine" by Flores, Phelps, and Jansen, shares an unusually long-term case study of the student experience with inquiry using paired reflections from her experience as a graduate student and, years later, as a faculty member. Both of these papers highlight

the ways that inquiry experiences allow future teachers to understand and offer similar experiences for their own students. The fifth paper, "The Development of Teacher Knowledge in Support of Student Mathematical Inquiry" by Slavit and Lesseig, exposes some of the components of expertise beyond content mastery needed to teach with inquiry while offering a strategy for teaching future teachers these components.

Sandra Laursen, reflecting on interviews with mathematics educators in the inquiry-based learning community, has observed that practitioners often jump directly into discussions of techniques and resources without explicit mention of the teaching problems they are trying to solve. The next set of papers, along with the previous paper by Slavit, addresses this gap by offering sophisticated lenses for understanding the challenges specific to teaching with inquiry. The sixth paper, "Constructing an Inquiry Orientation from a Learning Theory Perspective: Democratizing Access through Task Design" by Greenstein, Buell, and Wilstein, makes a key distinction between teaching methods and a teacher's theory of learning in order to provide a theoretical grounding for discussions of inquiry-oriented instruction. The seventh paper, "An Example of Inquiry in Linear Algebra: The Roles of Symbolizing and Brokering" by Zandieh, Wawro, and Rasmussen, is a careful analysis of both student and instructor roles in an inquiry-oriented classroom, focusing on ways that symbols appear and evolve. This paper offers a model in which students maintain ownership of the inquiry while being connected to the discipline's established norms and symbols.

The final papers in this part of the special issue focus on understanding the student experience in inquiry environments. The eighth paper, "Student Perceptions of a Mathematics Major for Prospective Elementary Teachers with an Inquiry Based Philosophy" by Cook and Borkovitz, gives a detailed view

of the student experience with inquiry-based classrooms in a department with a programmatic-level commitment to teaching with inquiry. The ninth paper, "Teaching Inquiry with a Lens toward Curiosity" by von Renesse and Ecke, focuses on instructor strategies for building a classroom environment that truly teaches curiosity, grounded in psychology and cognitive science literature.

By framing this part of the special issue as Illuminating Inquiry, we have emphasized the ways in which these papers help the reader develop a more nuanced conception of inquiry itself. Of course, these papers also contain interesting ideas about equitable access, intentional coherence, and the implementation of inquiry experiences for students, which is highlighted in Part II. Papers in the forthcoming half of this special issue offer additional strategies for modifying instructor and textbook language to make space for inquiry, for building student ownership of course material with assignment structures and carefully selected content domains, and for helping students understand and initiate component skills of mathematical inquiry as well as further insight into the nature of inquiry.

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Introduction to the Special Issue on Teaching Inquiry (Part II): Implementing Inquiry

Running Head: Implementing Inquiry

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