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Introduction to the Virtual Special Issue: Mathematics That Underpins Social Issues

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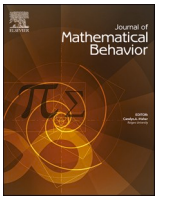

Introduction to the virtual special issue: Mathematics that underpins social issues

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ABSTRACT

This Virtual Special Issue on *Mathematics in Society: Exploring the Mathematics that Underpins Social Issues* features 13 articles which expand our understanding of how people build, retain, communicate, apply, and comprehend mathematical ideas as they relate to social and societal issues. The focus is on education research that explores the ways in which mathematics and a mathematical worldview can influence choices, on educational, personal and societal levels. We take a broad view and raise questions about what it means to be mathematical in society, and we consider the multifaceted ways in which abilities to derive and interpret information presented mathematically are also necessary in and for society.

There are long-standing and ongoing calls for making mathematics[1] meaningful, relevant, and applicable outside the classroom (Consortium for Mathematics and its Applications (COMAP) & Society for Industrial and Applied Mathematics SIAM, 2016; National Governors Association, 2010; (NCTM), 1989, 2000, 2014). We consider it imperative that teachers have the opportunity to experience a mathematics classroom in which the goal is to teach mathematics as a powerful tool to understand the world so that they, in turn, can prepare students who are able to "apply the mathematics they know to solve problems arising in everyday life, society, and the workplace." (CCSS, 2010, p.7). In other words, we agree with advocates who call for "instruction that includes the mathematics deemed necessary for success in the current [school] system while simultaneously providing students an opportunity to use mathematics to expose and confront obstacles [in society]" (Bartell, 2013, p.1). Addressing social and societal issues within mathematics classes is a multidimensional endeavor, which can have benefits both to learners' appreciation of the relevance of the subject matter to world issues and to fostering positive socio-cultural identities and agency (e.g., Bateiha, 2010; Gutiérrez, 2013; Gutstein, 2006; Shockey & Gustafson, 2007). However, prototypical expectations for school mathematics conflict with the complex and messy ways in which mathematics truly underpins society, and experiences that allow teachers to co-develop mathematical and societal awarenesses are important for fostering shifts in expectations that will support enriched and more inclusive pedagogical knowledge (Mamolo, 2018).

The relevance and importance of numeracy, defined as "having some appreciation and understanding of information that is presented in terms of numbers" (Ginsburg, 2014), for making sense of the world is well acknowledged. However, the ways in which mathematics underpins and informs social and societal issues extend well beyond the realm of number sense and numeracy. For instance, mathematical topics such as covariational reasoning, spatial visualization, geometry, computational modeling, optimization,

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[1] In this introduction we use the term mathematics to be inclusive of mathematics, statistics, and data science.

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data science, combinatorics, and probability are central to understanding societal issues related to understanding the world and ones place in it (Thanheiser & Koestler, 2021), climate change (e.g., Barwell, 2013), income inequality (Mamolo et al., 2018; Thanheiser & Sugimoto, 2020), policing and social policies (e.g., Hughes-Hallett, 2015), voting and human rights (Duchin, 2018), bias and jury selection (Lockwood et al., 2020), and democracy and citizenship (Engel, 2017).

Our call emerged in response to the growing impetus to extend conventional limitations on what constitutes productive mathematical behavior, thinking, and ways of engaging in and for the world. Mathematics is a tool for understanding, analyzing, and changing the world (Frankenstein 1983; Freire, 1970; Freire & Macedo, 1987; Gutstein, 2006), and definitions of mathematical literacy refer broadly to individuals' capacity for "formulating situations mathematically, employing mathematical concepts, facts, procedures, and reasoning, and interpreting, applying, and evaluating mathematical outcomes" (OECD, 2017, p.53). Yet, a narrowing of curriculum over time has led to a skewed perception of the relevance and importance of mathematical understanding, negatively affecting the development of informed and socially conscious citizens (Raymond, 2018). de Freitas & Sinclair (2020) call for a disruption of such narrow views of mathematics, and they contest the limited, and limiting, definitions of so-called mathematical ability.

The purpose of this SI is to highlight educational research into the variety of mathematical content, skills, reasonings, behaviors, and disciplinary values needed for, and used when, understanding and making decisions about social and societal issues - both in professional and personal life. In addition, the goal is to advance the ways in which research in mathematics education can shed light on the uses, awarenesses, knowledges, and needs of mathematics in and for society.

Both co-editors of the special issue, Ami Mamolo and Eva Thanheiser, started their careers with a more explicit focus on traditional mathematics and have shifted their attention to include foci on context and on equity and justice. As such this special issue and our collaborative work on it are part of our journey as mathematics educators.

1. Reflection on the Articles appearing in this SI

This special issue consists of 13 articles which reflect the breadth and depth of the SI topic. A common thread that weaves through the SI is the question of what it means to be mathematical in society and how might we foster such awareness in teachers and students. Different authors have considered this from different angles, focusing on (i) broad conceptual ideas that can disrupt narrow and destructive assumptions about mathematics and mathematical knowledge (i.e., Barwell et al., 2022; Gutiérrez et al., 2023; Thanheiser, 2023), (ii) opportunities and challenges in fostering such awarenesses amongst teachers and teacher candidates (i.e., Andersson & Register; Bailey & McCulloch, 2023; Harper & Kudaisi, 2023; Jung & Wickstrom, 2023; Kacerja & Julie, 2023; Kalienec-Craig & Rios, 2024; Mamolo et al., 2022), and (iii) possibilities for student reasoning, achievement, and identity formation (i.e., Bose & Farsani, 2023; Chorney et al., 2024; Radke et al., 2023). Many of these papers take an explicitly critical stance, questioning the neutrality of mathematics (and statistics), with some papers additionally decentering humanity and raising questions about what mathematics and mathematics education could be. We share a visual representation of the key themes addressed in this SI in Fig. 1. The visual was created as a word cloud from the abstracts of the articles.

Across the 13 papers various contexts are explored. The first paper discusses various ways one can interpret the word mathematics and uses incarceration rates as an example (Thanheiser, 2023). This is followed with a paper examining mass extinction and ecological crises (Barwell et al., 2022) and a paper on political knowledge in teaching mathematics (Gutiérrez et al., 2023). The next set of papers examine mock parent teacher conferences and the rights of learners (Kalienec-Craig & Rios, 2024), the Body Mass Index and rate and proportion (Kacerja & Julie, 2023), climate science and computational modeling (Mamolo et al., 2022), mapping crime and access to data (Andersson & Register, 2023), the production and consumption of data representations (Bailey & McCulloch, 2023), bathroom bills and informal inference (Radke et al., 2023), work practices and decision making with respect to income generation (Bose & Farsani, 2023) and fairly distributing school funding and socio-critical modeling (Jung & Wickstrom, 2023), The final papers focus on

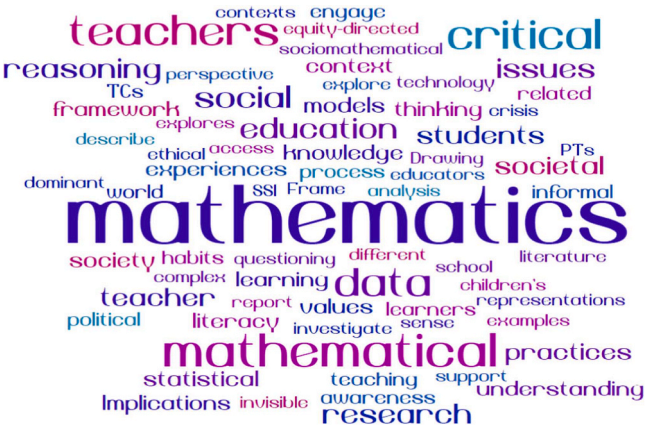

Fig. 1. World cloud of key themes across papers in the SI.

food insecurity and geometry (Harper & Kudasi, 2023), and political redistricting, fairness and proportional reasoning (Chorney et al., 2024).

What it means to think about and do mathematics is central to many of the papers and took on various meanings, such as making the invisible visible (Bose & Farsani, 2023), comparing various "truths" (Radke et al., 2023), reasoning critically (Bailey & McCulloch, 2023; Kacerja & Julie, 2023), ethically (Andersson & Register, 2023), and socio-mathematically (Chorney et al., 2024), thinking computationally (Mamolo et al., 2022), developing models (Jung & Wickstrom, 2023), various interpretations on what it means to be good in mathematics (Harper & Kudasi; Kalienec-Craig & Rios, 2023), and foci on various narratives about mathematics (Gutiérrez et al., 2023). Thanheiser (2023) lays out various frames of mathematics in the first papers of this issue summarizing prior work on this theme, with attention toward the impact on students' learning and identity. Barwell, Boylan, and Cole (2022) extend our thinking further to explore a dialogical relationship amongst mathematics, mathematics education and the living world.

In total the papers in this special issue call for a broadening of what we understand as mathematics, how we support learners of mathematics, and how we foster awarenesses for teaching mathematics. Gutiérrez et al. (2023) suggest that "stories about how mathematics are defined, who can do mathematics, and what mathematics are to be used for are socially constructed and … teachers need sustained opportunities to identify and unpack the narratives" (p.13). Unpacking teachers' perspectives on the experiences of confusion, struggles, and mistakes may be an avenue for humanizing mathematics (Kalinec-Craig & Rios, 2024), as is leveraging students' experiences in authentic ways to support their identity development and engagement (Harper & Kudasi; Radk, et al., 2023; Thanheiser, 2023). Teachers' identities and critical awareness also play important roles in how we can strive to reach our goals for a more responsive, socially and environmentally responsible approach to mathematics education (Andersson & Register; Bailey & McCulloch, 2023; Jung & Wickstrom; Kacerja & Julie, 2023; Mamolo et al., 2022).

Across the papers, schooling in general and mathematics education in particular are seen as preparations for life within societies rather than as prerequisites for the next class. This includes re-consideration of learning spaces outside of school, reasoning practices, focus on the students as human beings in a classroom, focus on teachers and teacher educators and their responsibilities towards their students, who need to understand mathematics so they can disrupt oppression, respond to crisis, and work towards social justice. Mathematics education needs to embrace the consumption and production of information in a way that allows for critical engagement and makes visible what might otherwise be invisible. Toward these ends, and in line with Barwell et al. (p.8), we look to what might come next, and ask "What could the contribution of mathematics education research be?".

CRediT authorship contribution statement

Eva Thanheiser: Writing – original draft, Conceptualization. **Ami Mamolo:** Writing – review & editing, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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