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SURVEY PAPER

Mathematics teaching and teacher education against marginalisation, or towards equity, diversity and inclusion

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Abstract
The interrogation of often unintended practices of marginalisation has gained focus in research on mathematics teaching and mathematics teacher education throughout the last decades. In this introductory survey paper, work against marginalisation in these contexts of mathematics education is viewed in terms of work towards equity, diversity and inclusion. Based on this interpretation, we present a framework on awareness and practice of equity, diversity and inclusion in mathematics teaching and mathematics teacher education research. We then use this framework and a survey method of mapping review to identify and comment on a selection of studies. As a result, we illustrate three research moves towards equity, diversity and inclusion, in the form of interconnected themes: (1) Widening the understanding of the mathematics and the mathematics education curricula (2) Improving the practice and discussion of mathematics teaching (3) Unpacking ideologies in mathematics teaching and mathematics teacher education. We finally examine the themes and the special issue papers together to foreground commonalities regarding awareness of discriminatory discourses and practices of creating and distributing opportunities for all groups, including those historically and currently marginalised. Despite the important increase of equity-driven principles of awareness, we conclude that mathematics education research on teaching and on teacher education needs more examples of practices whose development has been proved to challenge marginalisation.

Keywords Mathematics teaching · Teacher education · Marginalisation · Equity · Diversity

1 Introduction

This is the introductory paper to a special issue focused on mathematics education against marginalisation in two contexts: mathematics teaching (across educational levels) and mathematics teacher education (pre-service and in-service). In the first place, the thinking and development of mathematics teaching and teacher education from this perspective require some specific interpretation of the phrase 'against marginalisation'. We understand work against marginalisation as work towards equity, diversity and inclusion. Both framings in terms of 'against' and 'towards' entail the social dimensions of mathematics teaching and mathematics teacher education, in line with stances around the sociocultural-political axis of mathematics education (Planas & Valero, 2016). Nonetheless, whereas 'against' implies a negative action in opposition to someone or something, 'towards' rather implies a positive action, and is more representative of how we see the construction of domains of mathematics education that are concerned with aspects of equity, diversity and inclusion. A basic idea in this paper, and throughout the collection of papers in the special issue, is precisely that mathematics teaching and teacher education work against marginalisation represents positive work towards equity, diversity and inclusion.

Our interpretative mapping between 'against marginalisation' and 'towards equity, diversity and inclusion' asks, in turn, for some specific interpretation of the latter phrase. What may it mean for studies of mathematics teaching or teacher education to move the domain towards equity, diversity and inclusion? These three concepts have been used in mathematics education research for quite a long time, as is the case for other fields of the social sciences and humanities, in which an 'equity, diversity and inclusion turn' has been cited (see, e.g., Séguin, 2022, for arguments around the widespread use of the EDI–Equity, Diversity,

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Inclusion–acronym). Almost twenty years ago, a milestone was the coining of the category 'Equity, diversity and inclusion' in which participants could submit research reports to the 2005 Conference of the International Group for the Psychology of Mathematics Education (PME29). That category was in use for several years, and the concepts were collocated with no explicit separation between them. Today, researchers who submit reports for evaluation at PME conferences can select topics such as 'Culture, language and multilingualism', 'Equity and gender issues', and 'Special needs education'. The COVID-19 crisis contributed to prompting the debate about equity, diversity and inclusion in mathematics education. Chan et al. (2021) reflected on mathematics teachers and teacher educators who had experienced the pandemic as an opportunity to re-examine their teaching and inequities that seem to persist, including unequal access to the internet, computers and tablets, and unequal availability of space and time at home. While marginalisation is mainly associated with social class and classism in some contexts (see Xenofontos & Hizli Alkan, 2022, for perspectives of mathematics teachers in Scotland) and with race and racism in some others (see Louie, 2018, for a mathematics teacher who notices the strengths of African American and Latinx students in the United States), it also implicates issues such as ability and ableism, or gender and sexism. Chan et al. (2021), for example, reported gender biassed experiences of mathematics teachers and teacher educators regarding home care of children and online teaching during the lockdown.

Following this introduction, we explain the elements of a framework for mathematics teaching and teacher education research, with the dimensions of awareness and practice in relation to the concepts of equity, diversity and inclusion. To provide examples of studies that can be seen through this framework, we then present and apply a survey method for tracing and discussing studies that complement those compiled in the special issue. We group the studies by means of themes that can be documented for mathematics teaching and teacher education research. In the last section, we conclude about the need for more equity-driven studies that inform mathematics teaching and teacher education practices.

2 A framework on equity in mathematics teaching and teacher education research

In this section, we present a framework that seeks to characterise some of the intersections between equity, diversity and inclusion, on the one hand, and research on mathematics teaching and mathematics teacher education, on the other. Situated outside of the framework are the research practices that do not recognize or deliberately contribute to reducing the opportunity gap for historically marginalised groups in mathematics teaching and mathematics teacher education. By this opportunity gap, we mean a gap in the professional and educational opportunities of different groups due to unequal distributions of socioeconomic resources and disparities that come from social representations around their ability status, race, ethnicity, age, gender, language, rurality, age, and more. The framework thus addresses the relevance of placing together the concepts of equity, diversity and inclusion in research contexts of mathematics teaching and mathematics teacher education, and it assumes that all groups, regardless of which side they are on in the opportunity gap, will benefit from recognizing and reducing this gap.

Despite the attention to aspects of equity (Vithal et al., 2024), diversity (de Abreu et al., 2018) and inclusion (Roos, 2019) in mathematics education research, more joined-up views of these three concepts are key. Besides, instead of confining equity, diversity and inclusion to a small number of mathematics education research contexts often focused on school learners, more widened views are key, specifically in relation to mathematics teaching and teacher education and their participants. We concur with Séguin (2022) that equity, diversity and inclusion are often characterised either separately or as if they were the same or interchangeable, and their applicability confined to a few sites of practice. We see the three concepts as different but strongly connected, and applicable to any site of mathematics education research. An equity-driven concept of inclusion, for example, transcends the assumption that inclusion is just about people with special needs. It connects with the principles that we are all diverse, not only some of us, and we do not all have the same conditions for participation in certain contexts. In this respect, like in Scheiner et al. (2024), we prefer the order of equity, diversity and inclusion to other permutations such as diversity, equity and inclusion, because we believe that equity precedes and comes along with diversity and inclusion, and it is the foundation upon which these two can thrive. Below, we summarise our related understanding of the EDI concepts.

Equity. In the contexts of mathematics teaching and teacher education, our concept of equity implies that any mathematics teacher, educator, student teacher and teacher educator are given opportunities to act and develop their full learning and professional potential regardless of circumstances and historical legacies that may negatively impact on them. A research focus on equity is explicitly aware of the existence of historically marginalised, under-represented and under-served communities in mathematics teaching and teacher education, and the possibility, through practice, of reducing imbalances, biassed representations and systemic

discrimination experienced by these communities. Equity in this respect is close to the ideas of fairness and of being fairly represented and affirmatively valued (Mintos et al., 2019). In our framework, thus, such a focus is distinct from and in tension with studies with an interest in equity interpreted as equality or sameness, which overlook the unequal conditions, overlapping disadvantages and structural barriers that different groups of mathematics teachers and educators, student teachers and teacher educators face in their work and learning. For example, it is not unusual to find research that takes the experience and circumstances of particular groups as the reference for other groups. A study with teachers working in conditions of poverty that replicates a developmental initiative with teachers in mainstream schools may overlook specific demands, needs and supports, and may not contribute to reducing existing disadvantages. If the same initiative is implemented with no adjustment of the pedagogic content, notwithstanding the unique circumstances and historical legacies around each group of teachers, opportunities for professional learning and development may be compromised.

Diversity. In the contexts of mathematics teaching and teacher education, our concept of diversity is equity-driven, which means that it is not only descriptive of a range of differences existing in these contexts, but it also implies practice towards making differences visible and mobilising them as resources in the development of educational and learning goals. A research focus on diversity is overtly aware of the existence of individual and group differences in one or more of a range of variables–age, ethnicity, religion, gender, ability status, socioeconomic class, race, sensorial experience, language…– amongst participants in mathematics teaching and teacher education, as well as the possibility of learning from and drawing on these differences. In our framework, such a focus is distinct from and in tension with studies with an interest in diversity as differences to be fixed and relative to a group taken as exemplary. The interpretation of diversity as deficit remains common in research which does not assume the plurality of voices (Civil & Hunter, 2019) in the practices of mathematics teaching and teacher education, and which mainly refers to representing or giving access to 'diverse' people. For example, a study on learning to teach mathematics with autistic student teachers, which considers them and their abilities through the lens of a disorder, wrong minds or behaviours to be fixed, would not be recognised, in our framework, as having a focus on diversity. Such a deficit perspective constrains the possibilities for transforming discriminatory societal discourses and for identifying creative processes of becoming mathematics teachers with all student teachers by allowing neurodivergent voices to be recognised, empowered and amplified.

Inclusion. In the contexts of mathematics teaching and teacher education, our concept of inclusion is equity-driven as well, which means that it is not only representative of inviting a variety of groups into these contexts, but it also implies practice towards fostering cultures that are supportive of collaboration in the development of educational and learning goals. A research focus on inclusion shows explicit awareness around the existence of discursive and physical spaces of mathematics teaching and teacher education in which access is restricted, and around the possibility of creating open and safe spaces in which any individual or group can bring knowledge and be supported by others. Thus, in our framework, inclusion is not about simply placing together some groups in a physical teaching site. Our focus is distinct from and in tension with special education studies that do not interrogate the socio-cultural-political mediators around policies and pedagogies of remediation and assimilation. Certainly, there is a small minority of people on the extremes of specific spectrums for whom the construction of a mathematics education profession may be too challenging, but this is a small minority of the people in remedial programs or with restricted access to the profession. We consider inclusion a practice grounded on equity and on the existence of diversity and close to the ideas of collaboration and collective work (Owens & Suh, 2023). Mainstream and marginalised groups are then not excluded from the collective work of becoming engaged with each other in the professional and learning spaces and, by doing this, gaining knowledge. For example, a study that identifies the diverse groups in a teacher education classroom and examines teaching strategies facilitating their participation may have a focus on inclusion by examining enriched meaning making and collective engagement through heterogeneous teamwork.

From our understanding of the EDI concepts, we come to the crossing dimensions of *awareness* of historically-produced discriminatory discourses–e.g., ableism, racism, sexism, classism–, and *practice* of mathematics teaching and teacher education that enacts opportunities of access and participation. These dimensions and their relationship are crucial, because research has shown that awareness of what it entails to teach and learn to teach mathematics is not reflected ineluctably in time to act or practice (Essien et al., 2016). Table 1 relates the two dimensions of the framework to principles of engaging in awareness, and of creating and distributing opportunities in practice.

Our framework is thus organised into the dimensions of awareness and practice and the concepts of equity, diversity and inclusion, adapted to be considered in mathematics teaching and mathematics teacher education research. We approach awareness and practice of equity, diversity and inclusion in relation to other important concepts, such as

Table 1 Framework dimensions and examples of equity-driven principles

Dimensions	Examples of equity-driven principles
Awareness	Engaging in greater awareness of the importance of: • diversity in professional, educational and mathematical knowledge and in ways of expressing learning; • inclusive and exclusionary conditions and discourses in the preparation of future teachers of mathematics; • historical marginalisations and associated disadvantages in the processes of becoming mathematics educators; • differential needs and demands across groups of mathematics teacher educators and pedagogic communities;…
Practice	Creating and distributing more opportunities for: • ensuring that language diversity informs data collection methods in sites of mathematics teacher education; • collaboration across groups with diverse life experiences and professional backgrounds in mathematics education; • conversations about equity and inequity with groups of future teachers of mathematics and teacher educators; • diverse forms of verbal and non-verbal participation in public communication on mathematical pedagogies and ways of knowing;…

culturally responsive pedagogy, social justice, critical mathematics or ethnomathematics (see more related concepts in Noland & Lunney Borden, 2023). We take the umbrella of equity, diversity and inclusion for simplicity, because these concepts share affinities with many others often gathered within the socio-cultural-political axis of mathematics education (Planas & Valero, 2016). They together expand to accounts for work, e.g., from a decolonial lens to address inequity faced by Indigenous communities, from a disability justice lens to challenge ableist constraints imposed on some groups of people who think, behave or learn differently, or from a heterogeneity lens to identify educational and learning opportunities in any mathematics or mathematics education classroom.

Figure 1 shows the three concepts of our framework within a shared space for the two dimensions of awareness and practice. The two concentric ovals, around the inner oval with the domain contexts in this special issue, suggest the tensions between a focus on equity, diversity and inclusion and a focus on sameness, deficit and assimilation in mathematics teaching and teacher education research. By representing the concepts of the framework in the outer oval, we signify the expanding number of studies reporting processes towards equity as fairness, diversity as asset and inclusion as collaboration. The place of the special issue papers is the outer oval, at a distance from the middle oval. For instance, Graven and Jorgensen (2024) write about non-deficit approach means aimed at actively valuing the home habitus of the communities and caregivers in their study; Roos and Bagger (2024) write about workshops that facilitated collaboration, as teachers explored how to promote mathematics education that creates possibilities for inclusion and equity; Rosa and Orey (2024) write about learning and educational opportunities when the members of two cultures encounter each other through collaborations; and Healy et al. (2024) write about teachers discussing issues of sameness and inclusion when one of them expressed concern that

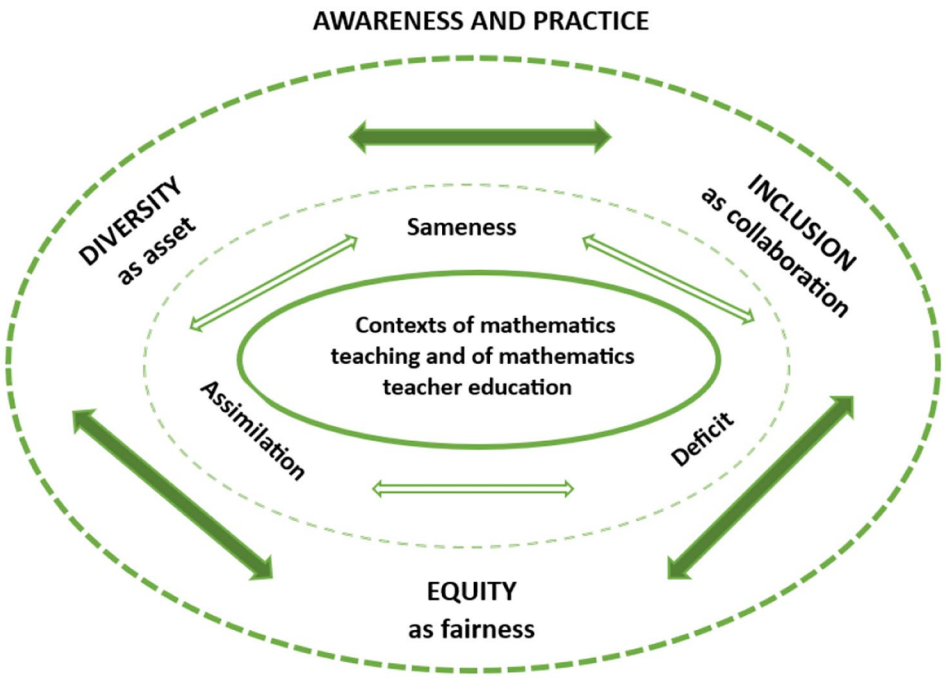

Fig. 1 Representation of tensions inherent to our framework

if the same thing was not taught to the blind student, then this was not inclusion. The special issue papers interact with the present framework by considering the importance of awareness and practice of equity, diversity and inclusion in contexts of mathematics teaching and mathematics teacher education research. We will come back to this collection of papers and their contribution in the final section.

3 Survey methodology

Compared to the mathematics education research surveys of Vithal et al. (2024) with a focus on equity, de Abreu et al. (2018) with a focus on diversity, and Roos (2019) with a focus on inclusion, the present survey is specific for the research contexts of mathematics teaching and mathematics teacher education and it presents a multiple-layered focus with attention to studies that exemplify awareness and practice of equity, diversity and inclusion. A purpose of our survey is to bring together studies that in other surveys, or more generally in mathematics education research, may not appear connected, mainly due to distinctions between special education and general–or unspecial– education dominated by ableist discourses on disability (Yeh et al., 2020). We do not question the singularity and valuable contributions of special education in mathematics but argue for its close relation to the body of studies that are equity-driven. The method for the collection of data did not intend to cover a large sample of studies. We rather intended to map out literature that illustrated a variety of joint representations of equity, diversity and inclusion. In this respect, we conducted what Grant and Booth (2009) call a mapping review. We started with a broad identification of literature through keyword searches. The first outcomes involved further review work to choose a subset of studies with attention to awareness and practice of equity, diversity and inclusion in mathematics teaching and teacher education.

We searched in three online databases: the library of educational research, ERIC; the collection of social sciences research within Web of Science, which provides evidence of impact; and the library of the behavioural and social sciences, PsycINFO, which allows a progressive narrowing of results. Despite data duplication, we wanted more than one database because different databases have unique contents. We selected these three following the choices in Roos (2019). We started by searching in English for "diversity AND mathematics education", "equity AND mathematics education" and "inclusion AND mathematics education". We then narrowed the Boolean intersections by making a further selection of studies that addressed aspects of "mathematics teaching" and "mathematics teacher education" (e.g., "inclusion AND mathematics education AND mathematics teacher education"). Our search was not systematic in the sense of including as many related keywords as possible such as social justice and culturally responsive pedagogy (Nolan & Lunney Borden, 2023), or such as teacher professional development and mathematical instruction. The resulting map with more keywords and more or alternative bibliographic databases would have been different, at least because more studies would have been eligible for discussion. We are aware that relevant studies could also have been found in sources other than major bibliographic databases, which generally over-represent English language publications and work from the so-called Global North authors.

The initial search method brought up more than 60 journal papers per Boolean intersection between one of the concepts in the framework and one of the two research contexts in focus. Since we wanted to use the findings of the survey to explore research themes that cross issues of equity, diversity and inclusion approached in similar terms to those adopted in our framework, for the publications that were new to the two of us, we read the abstracts. At this stage, we were attentive to mentions of awareness of historically-produced discriminatory discourses and mentions of practice for creating and distributing opportunities for all the research participants. When the reading of the abstract was not sufficient to identify the authors' approaches, one of us read the publication including the references cited. The map resulting from our filtering through the framework reduced the initial map approximately to 20 journal papers per Boolean intersection and a total of 120. Given the huge size of the databases and the wide semantics of the keywords in the Boolean searches without year restriction, this quantity reflected a relative dearth of journal papers, in English and filtered by our reading. We then combined two methods for the selection of fewer studies, all of which are discussed in the next two sections of the current paper. Of the 120 journal papers, we selected 2014–2023 papers that the two of us agreed were representative of equity-driven approaches and responsive to both awareness and practice. That is, we chose papers that not only reported awareness of equity, diversity and/or inclusion, but also proposed and illustrated educational and professional practice.

The second method was developed to widen the time window and provide some historical sense of research and core authors with significant influence on the moves towards equity, diversity and inclusion in mathematics teaching and mathematics teacher education research. This method consisted of a citation analysis (Akin, 1998) aimed at identifying older mathematics education publications that were cited in ten or more of the 120 journal papers. We met to discuss which of the publications (books, chapters, journal papers, articles) resulting from the citation analysis could be associated with research on aspects of equity, diversity and

inclusion. It was also important to check the extent to which some authors and their works were present within each of the papers, hence substantially guiding or shaping decisions adopted in those works. In all this, we decided not to choose two or more publications from the same author or group of authors, because that would allow us to show more of the many authors that have contributed to where we are at present.

4 Findings about research moves towards equity, diversity and inclusion

In this section, we summarise findings from our survey work. These findings allow us to discuss the richness and nuances of issues of diversity, equity and inclusion as they have emerged in mathematics teaching and teacher education over decades of social, cultural and political research. The survey work enabled us to notice the role of diversity discourses in mathematics education and the centrality of cultural diversity in the historical underpinning and advancing of a range of equity-driven studies in mathematics teaching and teacher education. In exploring cultural diversity in mathematics, Bishop (1988) contributed to developing the argument that mathematics must be understood as a kind of cultural knowledge, "which all cultures generate but which need not necessarily 'look' the same from one cultural group to another" (p. 180). This idea prompted the diversification and complexification of diversity as more than cultural in mathematics education, and all this in turn progressively prompted awareness of the many sources of diversity and reasons other than culture for exclusion and inequality. A general finding crossing our survey is therefore the historical role that awareness of cultural diversity in mathematics played as a catalyst of equity-driven research in mathematics education, which today acts as a catalyst of equity-driven research in the contexts of mathematics teaching and teacher education.

The concrete findings from the examination of journal papers and seminal publications are reported below in the form of three themes: (1) Widening the understanding of the mathematics and mathematics education curricula (2) Improving the practice and discussion of mathematics teaching (3) Unpacking ideologies in mathematics teaching and mathematics teacher education. These themes are findings supported by the survey data, responding to the question of how are awareness and practice of equity, diversity and inclusion taken into account in the publications examined. For each theme, we comment on two seminal publications, which are intellectual antecedents cited in several papers from our survey. We then comment on three journal papers about mathematics teacher education and three about mathematics teaching. This small representation of the total of 120 journal papers enables us to illustrate the variety of reasons researched in relation to historical and current marginalisations, in mathematics teaching and mathematics teacher education, namely, culture, language, ethnicity, race, ability status, gender and social class.

4.1 Widening the understanding of the mathematics and mathematics education curricula

Mathematics and mathematics education curricula can preserve marginalisation in different ways, by reproducing certain values of the educational systems or by their political effect on the teaching of mathematics or of mathematics education. The ways in which curricula are defined, developed and implemented play a crucial role in preserving educational systems and values that contribute to marginalisation of different groups of learners. Bishop (1994) considered diversities of cultures and ways of being, learning and knowing, at the levels of the intended curriculum (what we wish to teach), the implemented curriculum (what we actually teach), and the attained curriculum (what is learned by students). These three levels assist us in noticing that, if not carefully reflected, the curricula can act to reduce the opportunities of historically marginalised groups to participate in mathematics as well as their opportunities to construct positive relationships with mathematics. In the development of ethnomathematics, the position of D'Ambrosio (1990) was "no less than radical curriculum change" (p. 23), for moves towards a new social order that includes diverse groups of people and their ways of knowing. Since D'Ambrosio (1990) and Bishop (1994), the moves around widening the understanding of the mathematics and mathematics education curricula have made visible some of the limits and inequities embedded in static notions of mathematical and pedagogic knowledge in teaching and teacher education.

In mathematics teacher education research, Eikset and Meaney (2018) point to a recognition that, although difficult to accomplish, curricula need to include understanding about diversity in mathematics classrooms, specifically language diversity. These authors identify three lines of discourse to be included: (a) the discourse that mathematics teaching should support students with diverse backgrounds; (b) the discourse about the importance of teacher educators reflecting on their own practices; and (c) the discourse about mathematics teacher educators raising critical issues. Reflection on these lines could produce greater opportunities for teachers and student teachers to fulfil their learning and professional potential, leading to more equitable educational settings. In the context of attending to the needs of marginalised students in higher education, Hagman (2021) focuses on college Calculus programs, successfully serving

a majority White or Asian and male populations. This author refers to diversity as attending to the demographics of students, equity as attending to the experience of those students, and inclusion as attending to their full participation in sites of mathematical practice. She claims that a critical aspect of attending to equity, diversity and inclusion is to design practices that are not intended to change students (to assimilate them to the normalised content of the program), but rather to change the content of the curricula, institutional practices and structures to support collaboration between groups for equitable experiences. Reporting on their dialogue with three mathematics teacher educators, Boylan and Woolse (2015) explore teacher education to understand how the beginning teachers negotiate their relationships to social justice, including conversations around equity and inclusion. They argue that teacher education programs should expand the curriculum to create room for pedagogies of discomfort and inquiry. This would invite mathematics teacher educators to extend their pedagogies to embrace additional principles of respect and compassion.

In mathematics teaching research, Padilla and Tan (2019) focus on the classroom practices of dis/abled learners to consider how inclusive mathematics teaching involves equity-driven mathematics curricula. Their vigilance regarding dis/ability in mathematics curricula relates to raising teachers' awareness of how difference is produced. They argue that elevating issues of social construction, discriminatory practices and marginalisation will guide more productive and liberating forms of educational research and advocacy for, with and of individuals with dis/abilities. This invitation to evaluate the unjust contexts is crucial as it could lead to a better awareness and derived practice of teachers' sense of EDI, regardless of the curricular content or the system mandates. Rubel and McCloskey (2021) examine equity in their question on what contexts are used and why, when a teacher contextualises school mathematics. They suggest reflexive practices in teacher education programs to guide mathematics teachers to recontextualize common pedagogic practices. They also invite these programs and teachers to be aware of the contextualisation of mathematics: as a neutral practice, as eliciting and validating students' experiences, or as addressing the political implications of one choice over another. In all this, these authors recognise diversity as an asset in a form of staying away from the generic that limits identity negotiation and overlooks the inequalities that such contextualisation of mathematics creates. Yeh and Otis (2019) argue that the mathematics curriculum is centred around a narrow set of goals, such as individualistic gain, employment and economic competitiveness, which are in contradiction with practices of inclusion and collaboration. From these authors' perspective, these individualistic views contribute to reproducing inequities in classrooms, and to standardising representations of cultural hegemony and gender normativity in school mathematics textbooks. They propose a transformative pedagogy to support the development of justice-oriented mathematics curricula.

4.2 Improving the practice and discussion of mathematics teaching

While the first theme groups mathematics education studies with a focus on curricula, the second theme groups studies with a focus on mathematics teaching. The focus is different but, again, principles of awareness and practice of equity, diversity and inclusion are shared through a variety of research choices and methods. For the second theme, a body of studies relates the school practice of mathematics teaching and/or its discussion in teacher education contexts to the opportunity gap between historically marginalised and privileged communities of teachers and student teachers. One way to challenge marginalisation is to work towards classroom practices that build on learners' diverse contributions around mathematically demanding tasks, utilising the diversity of the mathematics of learners as an asset, and teacher education practices that build on the discussion of approaches to diversity and inclusion. In order to foster the diversity of mathematical knowledge and meaning in teaching, Skovsmose (2006) argued for overcoming the limits of the prototype mathematics classroom by creating and researching contexts of interdisciplinarity and opportunities for critical reflection. Adler (2001), with the dilemmas of teaching mathematics in multilingual classrooms, also gave direction to many teacher education and teaching studies developed in school contexts of inequity, poverty, language diversity, with groups disadvantaged for a variety of reasons. In line with Skovsmose (2006) and Adler (2001), pedagogical practices such as culturally responsive teaching, teaching for social justice and critical mathematics education are present in several of the papers mapped. Many of these papers report studies aimed at making mathematics or mathematics education more relatable to participants from different backgrounds and life experiences.

In mathematics teacher education research, there are studies directly related to learning how to improve mathematics teaching in university teacher education settings. Mintos et al. (2019) propose learning explicitly about issues of equity to make awareness in addressing the inequities that persist in mathematics teaching and learning. These authors explore how pre-service mathematics teachers learn from and about these issues. In courses with mathematics content, equity is mostly related to access and achievement, whereas in general education courses equity is related to power and identity. The focus on what is taught in mathematics content courses provides the student teachers opportunities to

develop professionally and to be more equipped to incorporate practices attuned with EDI, in their future mathematics classrooms. Considering students' diverse social, economic, and academic backgrounds, Yılmaz et al. (2021) examine teachers' perspectives of factors that support or hinder how equity is attended to in mathematics teaching during the COVID-19 pandemic. These authors note mathematics teachers' beliefs, expectations for students, access to resources, students' socioeconomic status, and language as barriers to equitable mathematics teaching. Madkins and Morton (2021) highlight the role of mathematics teacher educators in disrupting anti-Black racism with elementary teacher candidates. They utilise the concept of political clarity, describing it as the understanding of the sociopolitical realities that shape the learners' experiences, and how inequalities work to produce and maintain differential learning experiences for those marginalised. In order to understand equitable practices, mathematics teacher educators must guide teacher candidates to gain political clarity that will inform their future teaching practice.

In mathematics teaching research, Leung et al. (2020) select authentic mathematical tasks in a way that honours different communities' heritage and history, hence promoting equity and inclusion. Such a focus is potentially transformative in welcoming different groups of students into the interactions of mathematics classrooms. Hodge and Cobb (2019) compare two theoretical orientations for research on issues of equity and teaching in the mathematics classroom. The cultural alignment orientation is grounded in a view of culture as a network of relatively stable practices that capture daily life of a group. In this view, the source of inequities in students' mathematics learning is identified as discontinuities between home and school practices, leading to lack of collaboration and hence less inclusion. Drawing on the second orientation, these authors explain that the goal of mathematics teaching is not simply to ensure that reform recommendations reach all students. Rather, issues of cultural diversity and equity in mathematics teaching also involve scrutinising instructional goals with regard to their contributions to a democratic community. Zahner and Wynn (2023) criticise the pedagogic use of learning trajectories in mathematics education as teaching scaffold and situate their critique in relation to equity and biassed assumptions about diverse learners and their learning trajectories. In the examination of equity and inclusion of linguistically diverse learners in mathematics classrooms, these authors' results show the relevance of the linguistic features of the mathematics tasks and of the languages of teaching, which are aspects rarely considered in the design, implementation and evaluation of the learning trajectories.

4.3 Unpacking ideologies in mathematics teaching and mathematics teacher education

The first and second themes stand for mathematics education studies focused on curricula and teaching, hence directly related to the practice dimension in our framework. The third theme is different in that it is more closely related to the awareness dimension. It stands for research focused on EDI ideologies at work in contexts of mathematics teaching and mathematics teacher education, and how varying levels of awareness of these ideologies are or can be raised by participants and researchers in these contexts. This theme presents a body of studies that reflect on diversity, equity and inclusion as matters of ideological importance to resist marginalisation in mathematics teaching and mathematics teacher education. A frequent reference in the papers traced is Ernest (2002). Here, arguments against the absolutist image of mathematics as difficult, cold, abstract, ultra-rational and masculine is a source of awareness in better understanding issues of diversity and inclusion so that practice can be challenged and improved. The second sets of ideas are foundation to the ideas of diversity, of mathematics and experiences, as well as inclusion. Martin (2003) offers a critical view of equity rhetoric in mathematics education, arguing the need to situate issues of equity in broader socio-cultural- political discourses, beyond classrooms and curricula. This author argues that the learners who comprise the 'margins' must become equal participants in the discussions around mathematics equity, as well as equal participants in finding remedies that address curricular concerns and social justice.

In mathematics teacher education research, Allen and Trinick (2022) show how Māori mathematics teacher educators have used mathematics as a vehicle to support the revitalisation of the Māori language, through the legacy of colonialism, promoting equity. This author shows the pivotal role of mathematics and mathematics teacher education in Aotearoa/New Zealand in both the loss and revitalisation of Māori language, culture and dignity. Reporting from the grassroots teaching and drawing on the ideological side of mathematics teacher education, Neumann (2014) explores diversity, equity and inclusion in relation to gender. She interrogates the norms of teacher education, exploring hidden beliefs and inequitable teaching practices in mathematics education. The awareness of and analysis of inequitable teaching practices guide mathematics teachers and teacher education programs to better understand issues of EDI, and to deliberate on what influences their decisions and actions, promoting equity values. From another ideological perspective, Nicol et al. (2020) engage in critical dialogue about colonial discourses and practices in school mathematics teaching. In their journey as mathematics teacher educators,

this group of authors reflects on the task of decolonising mathematics education from inside colonial structures in Canada. They explain that if theories, philosophies and strategies of diverse ways of being and knowing are not recognised, educators can unintentionally perpetuate practices that lead to the exclusion of some groups from mathematics.

In mathematics teaching research, Boaler and Sengupta-Irving (2016) reflect on issues of equity, diversity and inclusion as they relate to learners with different perceived levels of mathematical achievement. These authors argue that, in order to promote equity-focused mathematics teaching, students should be given responsibility and agency. Boaler and Sengupta-Irving explain that some teachers might shy away from including students with low mathematical achievement into collaborative activities, thinking students might be incapable of acting responsibly. Yet their data suggested the opposite to this belief. When students are given spaces to express authority and agency, they act responsibly and appreciate challenging mathematical demands. Reinholz and Shah (2018) describe a form of participatory equity as a condition in which both participation and participation opportunities are distributed fairly during mathematics teaching and learning. These explicit mentions of meanings related to diversity, equity or inclusion provide a basis for instigating ideas and challenging orthodoxies, of our own principles or of our research field. For example, Krause and Wille (2021) refer to studies on learning mathematics in a second language, to how proficiency in the language of instruction is related to mathematics learning, and to the existing gap around students with hearing difficulties whose first language is sign language. These authors call our attention to the loss of learning opportunities because mainstream societal ideologies of mathematics teaching and of communication represent sign languages, their users and generally signing in relation to deficit and lacking something important for mathematics thinking and learning.

5 Conclusion and next steps

In this introductory survey paper, we have presented a framework on awareness and practice of equity, diversity and inclusion in mathematics teaching and mathematics teacher education research. We have discussed some of the publications surveyed along the elements of the framework, as well as three research moves documented in the form of three broad themes. In this concluding section, we first go back to the framework to examine together the survey findings and the special issue papers from the perspective of the presence of equity-driven principles of engagement in awareness and of creation and distribution of opportunities, in research contexts of mathematics teaching and mathematics teacher education involving historically and currently marginalised groups. Although we choose a few studies, we can think of many ways of guiding and engaging in awareness and practice related to EDI, and for each principle we can think of many studies. Given the methods and decisions sustaining our survey and the current special issue, any of the papers could illustrate awareness and practice of equity, diversity and inclusion.

In our survey work, we came into studies aligned with equity-driven principles of awareness, some of which reported equity practices in mathematics teaching or mathematics teacher education. Awareness is a fundamental, non-trivial starting point, but it does not necessarily lead to the enactment of practice. The distance between awareness and practice does not reflect the level of awareness or knowledge of inequalities, and high awareness of inequalities in a context may not motivate the conduction of transformative practice (Essien et al., 2016). Because of this, we note and value the detection of equity-driven papers that document awareness and teaching or teacher education practice. For example, Padilla and Tan (2019) state the function of anti-ableist ideologies of mathematics teaching and school curricula worldwide in the understanding of inclusion as concerning all groups of students and people. Krause and Wille (2021) state the importance of pedagogical knowledge about how students with hearing difficulties learn mathematics to increase the opportunities to learn to teach school mathematics in all classrooms. Hodge and Cobb (2019) state that equitable instructional practices in urban mathematics classrooms need to be designed and developed in collaboration with the students' cultures and diverse forms of participation. Still, Boyland and Woolsey (2015) state that socially-oriented approaches to mathematics teacher education may lead to better addressing what is problematic for mathematics teachers and teacher educators in the closer community.

All the papers in this special issue are also aligned with equity-driven principles of awareness and practice. For example, the paper of Noland and Bjerke (2024) invites mathematics teacher educators from across Canada and Norway to reflect on disruptive mathematical pedagogies that can support future teachers in their critical thinking of marginalisation. Their focus is on exploring inequitable and unjust classroom practices of school mathematics and in becoming a mathematics teacher. The paper of Sakonidis and Klothou (2024) uses participatory methods in the researched program with Muslim teachers of mathematics in the Muslim minority primary schools of Western Thrace, Greece. The paper of Schmidt et al. (2024) states the relationship of socioeconomic status and race to the creation of opportunities to learn in mathematics teaching in the United States schooling system. The paper of Stathopoulou et al.

(2024) establishes ways to report on their own culture in research with prospective teachers of mathematics learning their profession in collaboration with Roma young prisoners. Through the concept of Common Space, these authors aimed to challenge the hierarchical relationships between students and teachers, through an understanding of issues of EDI, focusing on equal contribution, recognition and equal participation. The paper of Trinick and Allen (2024) elaborates an equity-driven framing, considering fair inclusion of Māori's knowledge, culture and language as important assets in mathematics education programs of Māori-medium initial teacher education of mathematics. One more equity-driven principle can be found in the paper of Vistro-Yu and Verzosa (2024), when these authors combine data collection methods to enact the participation of different mathematics teachers in the Philippines, in research on structural conditions of marginalisation imposed on them.

Other papers of the special issue address methodological choices around equity, diversity and inclusion. As elaborated in the papers of Roos and Bagger (2024) and of Scherer and Bertram (2024), these choices in the research process raise ethical dilemmas in the representation of the participants in ways that aim to be respectful and inclusive of the diversity of voices and needs. There are studies with participatory approaches that put the voices and questions of teachers, student teachers and teacher educators at the centre of the research activities, in relations of partnership that replace clinical interviews with conversations and teamwork. This is the case in the papers by Makramalla and Stylianides (2024) in the collaboration with teacher professional networks in Egypt's mathematics education reform; of Graven and Jorgensen (2024) in the collaboration with mathematics teacher educator researchers working with marginalised families in South Africa; of Turner et al. (2024), in the teaching of mathematical modelling in connection with components of a culturally responsive pedagogy in the United States; and of Quintos et al. (2024), in relation to work with parents and teachers in a mathematics learning partnership program, again in the United States. In the CAPTeam project with pre-service and in-service teachers in Brazil and the UK, Healy et al. (2024) chose lesson video clips and prompts which showed the mathematical practices and thinking strengths of sensorially diverse students who, for example, spoke with their hands. Other video clips and prompts could have encouraged deficit understandings of these students, by suggesting limited use of spoken language. How some groups of students were seen in the research and represented in the professional tasks was very much a matter of the methodological decisions taken.

Although the distance between awareness and practice of equity, diversity and inclusion in mathematics teaching and teacher education research is not new, its narrowing may be occurring too slowly, in the sense of a slow increase of equity studies that address awareness and practice. This reflection leads us to finish this section and the paper with a comment on research that is still needed. We see a need for more equity studies that identify or design and implement mathematics teaching and teacher education practices, which in particular assess the quality of these practices from the perspective of their impact on different groups of people and on reducing the opportunity gap. Even though practices are always situated and results must be interpreted within the research and considered with caution in other contexts, mathematics education research on teaching and on teacher education needs more examples of practices whose development has been proved to challenge marginalisation. The papers in the current special issue contribute to increasing the set of examples of practices which can encourage thinking and enacting ways of mathematics teaching and teacher education that gives any mathematics teacher, educator, student teacher or teacher educator opportunities to act and develop their full learning and professional potential. This special issue therefore brings the field a bit further.

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References

Adler, J. (2001). Lessons from and in curriculum reform across contexts?. *The Mathematics Educator*, *12*(2).

Akin, L. (1998). Methods for examining small literatures: Explication, physical analysis, and citation patterns. *Library & Information Science Research*, *20*(3), 251–270. https://doi.org/10.1016/S0740-8188(98)90043-3.

Allen, P., & Trinick, T. (2022). Creating space for indigenous knowledge in Māori-medium mathematics classrooms. *International Journal of Qualitative Studies in Education*, 1–14. https://doi.org/10.1080/09518398.2022.2025473.

Bishop, A. J. (1988). *Mathematics enculturation: A cultural perspective on mathematics education*. Springer.

Bishop, A. J. (1994). Cultural conflicts in mathematics education: Developing a research agenda. *For the Learning of Mathematics*, *14*(2), 15–18.

Boaler, J., & Sengupta-Irving, T. (2016). The many colors of algebra: The impact of equity focused teaching upon student learning and engagement. *The Journal of Mathematical Behavior*, *41*, 179–190. https://doi.org/10.1016/j.jmathb.2015.10.007.

Boylan, M., & Woolsey, I. (2015). Teacher education for social justice: Mapping identity spaces. *Teaching and Teacher Education*, *46*, 62–71. https://doi.org/10.1016/j.tate.2014.10.007.

Chan, M. C. E., Sabena, C., & Wagner, D. (2021). Mathematics education in a time of crisis: A viral pandemic. *Educational Studies in Mathematics*, *108*, 1–13. https://doi.org/10.1007/s10649-021-10113-5.

Civil, M., & Hunter, R. (2019). Promoting equitable teaching in mathematics teaching education. In C. Xenofontos (Ed.), *Equity in mathematics education: Addressing a changing world* (pp. 179–200). Information Age Publishing.

D'Ambrosio, U. (1990). The role of mathematics education in building a democratic and just society. *For the Learning of Mathematics*, *10*(3), 20–23.

De Abreu, G., Gorgorió, N., & Boistrup, L. B. (2018). Diversity in mathematics education. In T. Dreyfus, M. Artigue, D. Potari, S. Prediger, & K. Ruthven (Eds.), *Developing research in mathematics education: Twenty years of communication, cooperation and collaboration in Europe* (pp. 211–222). Routledge.

Eikset, A., & Meaney, T. (2018). When does a difference make a difference? Teaching about language diversity in mathematics teacher education. *Nordic Studies in Mathematics Education*, *23*(3–4), 225–246.

Ernest, P. (2002). Empowerment in mathematics education. *Philosophy of Mathematics Education Journal*, *15*(1), 1–16.

Essien, A., Chitera, N., & Planas, N. (2016). Language diversity in mathematics teacher education: Challenges across three countries. In R. Barwell, et al. (Eds.), *Mathematics education and language diversity: The 21st ICMI Study* (pp. 103–119). Springer.

Grant, M. J., & Booth, A. (2009). A typology of reviews: An analysis of 14 review types and associated methodologies. *Health Information and Libraries Journal*, *26*, 91–108. https://doi.org/10.1111/j.1471-1842.2009.00848.x.

Graven, M., & Jorgensen, R. (2024). Early numeracy opportunities through number stories with marginalised families. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-023-01537-9.

Hagman, J. E. (2021). The eight characteristics for successful Calculus programs: Diversity, equity & inclusion practices. *PRIMUS*, *31*(1), 70–90. https://doi.org/10.1080/10511970.2019.1629555.

Healy, L., Nardi, E., & Biza, I. (2024). Interdependency, alternative forms of mathematical agency and joy as challenges to ableist narratives about the learning and teaching of mathematics. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-024-01565-z.

Hodge, L. L., & Cobb, P. (2019). Two views of culture and their implications for mathematics teaching and learning. *Urban Education*, *54*(6), 860–884. https://doi.org/10.1177/0042085916641173.

Krause, C. M., & Wille, A. M. (2021). Sign language in light of mathematics education. *American Annals of the Deaf*, *166*(3), 352–377.

Leung, F. S., Radzimski, V., & Doolittle, E. (2020). Reimagining authentic mathematical tasks for non-STEM majors. *Canadian Journal of Science Mathematics and Technology Education*, *20*(2), 205–217. https://doi.org/10.1007/s42330-020-00084-9.

Louie, N. L. (2018). Culture and ideology in mathematics teacher noticing. *Educational Studies in Mathematics*, *97*, 55–69. https://doi.org/10.1007/s10649-017-9775-2.

Madkins, T. C., & Morton, K. (2021). Disrupting anti-blackness with young learners in STEM: Strategies for elementary science and mathematics teacher education. *Canadian Journal of Science Mathematics and Technology Education*, *21*, 239–256. https://doi.org/10.1007/s42330-021-00159-1.

Makramalla, M., & Stylianides, A. J. (2024). The role of teacher professional networks in Egypt's mathematics education reform. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-024-01567-x.

Martin, D. B. (2003). Hidden assumptions and unaddressed questions in mathematics for all rhetoric. *The Mathematics Educator*, *13*(2), 7–21.

Mintos, A., Hoffman, A. J., Kersey, E., Newton, J., & Smith, D. (2019). Learning about issues of equity in secondary mathematics teacher education programs. *Journal of Mathematics Teacher Education*, *22*, 433–458. https://doi.org/10.1007/s10857-018-9398-2.

Neumann, M. D. (2014). Preservice teachers' understanding of gender equity in K-6 mathematics teaching. *Teacher Education and Practice*, *27*(1), 90–118.

Nicol, C., Gerofsky, S., Nolan, K., Francis, K., & Fritzlan, A. (2020). Teacher educator professional learning with/in place: Storying the work of decolonizing mathematics education within a colonial structure. *Canadian Journal of Science Mathematics and Technology Education*, *20*(2), 190–204. https://doi.org/10.1007/s42330-020-00080-z.

Nolan, K. T., & Bjerke, A. H. (2024). Moving beyond reflection and toward disruption in the post-field context of mathematics teacher education. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-024-01547-1.

Nolan, K., & Lunney Borden, L. (2023). It's all a matter of perspective. *For the Learning of Mathematics*, *43*(2), 8–14.

Owens, S., & Suh, E. K. (2023). Queering the language of inclusion: Implications from a content analysis of inclusion language in developmental education scholarship. *Journal of School Leadership*. https://doi.org/10.1177/10526846231209433.

Padilla, A., & Tan, P. (2019). Toward inclusive mathematics education: A metatheoretical reflection about countering ableism in mathematics standards and curriculum. *International Journal of Qualitative Studies in Education*, *32*(3), 299–322. https://doi.org/10.1080/09518398.2019.1576941.

Planas, N., & Valero, P. (2016). Tracing the socio-cultural-political axis in understanding mathematics education. In A. Gutiérrez, G. C. Leder, & P. Boero (Eds.), *The second handbook of research on the psychology of mathematics education: The journey continues* (pp. 447–479). Brill.

Quintos, B., Turner, E., & Civil, M. (2024). Parents and teachers collaborating to disrupt asymmetrical power positions in mathematics education. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-024-01555-1.

Reinholz, D. L., & Shah, N. (2018). Equity analytics: A methodological approach for quantifying participation patterns in mathematics classroom discourse. *Journal for Research in Mathematics Education*, *49*(2), 140–177.

Roos, H. (2019). Inclusion in mathematics education: An ideology, a way of teaching, or both? *Educational Studies in Mathematics*, *100*, 25–41. https://doi.org/10.1007/s10649-018-9854-z.

Roos, H., & Bagger, A. (2024). Ethical dilemmas and professional judgment as a pathway to inclusion and equity in mathematics teaching. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-023-01540-0.

Rosa, M., & Orey, D. C. (2024). Exploring cultural dynamism of ethnomodelling as a pedagogical action for students from minority cultural groups. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-023-01539-7.

Rubel, L. H., & McCloskey, A. V. (2021). Contextualization of mathematics: Which and whose world? *Educational*

Studies in Mathematics, *107*, 383–404. https://doi.org/10.1007/s10649-021-10041-4.

Sakonidis, C., & Klothou, A. (2024). Socio-political features shaping the mathematics teaching and professional identities of Muslim minority teachers in Western Thrace. *ZDM–Mathematics Education*.

Scheiner, T., Brodie, K., Planas, N., Darragh, L., Halai, A., Potari, D., Santos Trigo, M., & Walkoe, J. (2024). Addressing equity, diversity and inclusion in academic publishing: Key initiatives from JMTE. *Journal of Mathematics Teacher Education*. https://doi.org/10.1007/s10857-024-09636-4.

Scherer, P., & Bertram, J. (2024). Professionalisation for inclusive mathematics—teacher education programs and changes in preservice teachers' beliefs and self-efficacy. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-024-01580-0.

Schmidt, W. H., Guo, S., & Sullivan, W. F. (2024). Inequality in USA mathematics education: The roles race and socio-economic status play. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-024-01593-9.

Séguin, M. (2022). The changing diversity and inclusion landscape of Canadian universities: The Université De Montréal case. In J. Marques, & S. Dhiman (Eds.), *Leading with diversity, equity and inclusion: Approaches, practices and cases for integral leadership strategy* (pp. 341–355). Springer.

Skovsmose, O. (2006). Research, practice, uncertainty and responsibility. *The Journal of Mathematical Behavior*, *25*(4), 267–284. https://doi.org/10.1016/j.jmathb.2006.11.002.

Stathopoulou, C., Appelbaum, P., Fovos, I., & Chrysikou, V. (2024). Common spaces matter: Curricular experiences through mathematics with young prisoners and prospective teachers. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-024-01558-y.

Trinick, T. (2024). P. Allen (Ed.), Wayfinding in an indigenous initial teacher education mathematics programme. *ZDM–Mathematics Education*https://doi.org/10.1007/s11858-024-01589-5.

Turner, E., Aguirre, J., Carlson, M. A., Suh, J., & Fulton, E. (2024). Resisting marginalization with culturally responsive mathematical modeling in elementary classrooms. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-023-01542-y.

Vistro-Yu, C. P., & Verzosa, D. M. B. (2024). Navigating around marginalizing complexities: The case of mathematics teachers in the Philippines. *ZDM–Mathematics Education*. https://doi.org/10.1007/s11858-024-01571-1.

Vithal, R., Brodie, K., & Subbaye, R. (2024). Equity in mathematics education. *ZDM–Mathematics Education*, *56*(1), 153–164. https://doi.org/10.1007/s11858-023-01504-4.

Xenofontos, C., & Hizli Alkan, S. (2022). They're coming into school hungry, they're not ready to learn. Scottish teachers' perceptions of marginalization in school mathematics. *Eurasia Journal of Mathematics Science and Technology Education*, *18*(6), em2116. https://doi.org/10.29333/ejmste/12071.

Yeh, C., & Otis, B. M. (2019). Mathematics for whom: Reframing and humanizing mathematics. *Occasional Paper Series*, *2019*(41), 84–98. https://doi.org/10.58295/2375-3668.1276.

Yeh, C., Ellis, M., & Mahmood, D. (2020). From the margin to the center: A framework for rehumanizing mathematics education for students with dis/abilities. *The Journal of Mathematical Behavior*, *58*, 100758. https://doi.org/10.1016/j.jmathb.2020.100758.

Yılmaz, Z., Gülbağcı Dede, H., Sears, R., & Yildiz, S. (2021). Are we all in this together? Mathematics teachers' perspectives on equity in remote instruction during pandemic. *Educational Studies in Mathematics*, *108*, 307–331. https://doi.org/10.1007/s10649-021-10060-1.

Zahner, W., & Wynn, L. (2023). Rethinking learning trajectories in light of student linguistic diversity. *Mathematical Thinking and Learning*, *25*(1), 100–114. https://doi.org/10.1080/10986065.2021.1931650.