THE 27TH ICMI STUDY

MATHEMATICS EDUCATION AND THE SOCIO-ECOLOGICAL

DISCUSSION DOCUMENT

Contents Page

Queries can be emailed to:

Alf Coles (alf.coles@bris.ac.uk), or Kate le Roux (kate.leroux@uct.ac.za).

1. Introduction and Background

This document announces a new ICMI Study 'Mathematics Education and the Socio-Ecological,' the 27th such study to be conducted by the International Commission on Mathematical Instruction (ICMI). The ICMI Studies are a major activity of ICMI. Their global aims are to contribute to a better understanding of the challenges faced by mathematics education in our multidisciplinary and culturally diverse world and to collaborate in advancing to their resolution. The first ICMI Study was launched in 1980. More detailed information can be found on the ICMI web page.

As a named topic, the 'socio-ecological' is relatively new compared to many others in the field. Yet there is wide recognition of the urgent need for thought leadership to consider what is and might be the role of mathematics and mathematics education in multiple, intersecting, social, political, and ecological issues such as climate change, poverty, inequality, health crises, discrimination, and marginalization. A one-day, online, ICMI symposium in March 2023 was dedicated to the 'socio-ecological'. It brought together 170 participants from diverse contexts to discuss work in this area of interest, in sites such as classrooms, universities and community spaces, in interdisciplinary relations with other subjects, and including issues such as teacher education, research practice and policy (see the proceedings here). The work discussed at this symposium and other forums, as set out further below, demonstrates the substantial interest in, generative substance of, and commitment to, research that locates mathematics and mathematics education within the socio-ecological.

Thus the 27th ICMI Study will bring together – in a Study Conference and culminating in a ICMI Study volume based on the Conference activities – an expert reference group comprising scholars, with diverse representation within the ICMI community, and across mathematics education sites and contexts. The task of this group is to reflect on 'the state of the art' by analysing the growing research and practice in the areas of mathematics education and the socio-ecological, offered from diverse traditions including, and not limited to: critical mathematics education; decoloniality; ethnomathematics; feminist thought, Indigenous ways of knowing; and mathematical modelling. Furthermore, the Study hopes to harness such contributions and anticipate new possibilities, questions, and recommendations for research, innovation and action for mathematics education located in the complexity of social and ecological interdependencies. The Study will build community (including interdisciplinary relations) and open space towards new directions in mathematics education, as it relates to the socio-ecological across local and international levels.

2. Rationale for ICMI Study 27

The need for ICMI Study 27 has been brought into stark relief by multiple, intersecting, recent events − long experienced and documented by some, and newly by others − that highlight the rapidly changing, uncertain, precarious nature of the world; climate-change induced extreme weather events, public health crises, biodiversity loss, forced movement, growing poverty and inequality, rising totalitarianism, and reality-denying fake news (e.g. Latour, 2018; Roy, 2020; Tsing et al., 2017; van Dooren, 2014). All have made visible disproportionate impacts on racial, ethnic, class, geographical and other historically minoritized groups, for whom precarity is not new. And emerging from such precarity is growing awareness of the inseparability of human and ecological concerns. The startling events pointed to above, and many others, are connected in systems of nested, interdependent relations between humans and between humans and the Earth, that cross multiple scales of space and time. Indeed, events evidence, starkly, the destructive limits of dominant, human-centric contemporary relations, variously named 'neoliberalism', 'racial capitalism', or 'the consumer-industrialist society'.

The current conditions of our world, as described here, are not simply the context of neutral mathematics and mathematics education practices. Mathematics education, as curriculum, pedagogy, research, policy, and so on, produces 'knowers', users of this mathematics. While these practices may be put to work towards sustainable, ethical relations, they may also – intentionally, or not – (re)produce related historical epistemic, ontological, linguistic, cultural, social, and ecological injustices (e.g. Skovsmose, 2021; Valero, 2023). Mathematics education cannot be assumed to function as an individual or social 'good', and the socio-ecological precarity of the world brings the role of mathematics education into question. Thus, there is a need for mathematics and mathematics education to expand from considering socio-political dimensions of life (e.g. Jurdak et al., 2016), to also considering: what does the socio-ecological condition of the world mean for mathematics (education), and what might mathematics (education) mean for this condition?

The past two decades have seen the emergence of and growth in mathematics education scholarship that attends to and conceptualizes – to varied extents – the 'ecological', and its relation to mathematics education and society. While such scholarship may draw on psychological perspectives (e.g. Louie & Zhan, 2022), most lies in critical traditions that view mathematics (education) as historical, social, and political practices. We briefly illustrate some strands of that past work, noting that the Study itself will analyse these and other traditions in detail, we are by no means exhaustive in our choices below.

Critical mathematics education (CME) has demonstrated the potential of mathematics to 'read' and 'write' (Gutstein, 2006, following Freire, 1970) the contemporary ecological condition of the world, (e.g. Barwell, 2013; Coles et al., 2013; Skovsmose, 2023). More recently, CME is increasingly conceptualizing the social world (in particular, technology or mathematics-in-action) as having an impact on the ecological (e.g. Coles & Helliwell, 2023; Hauge & Barwell, 2017; Ödmo, Björklund Boistrup, & Chronaki, 2023; Steffensen, Herheim, & Rangnes, 2023). Socio-critical modelling, which promotes modelling as a practice for critically understanding the world, has extended from focusing on social inequities to explore human action on ecologies of the planet, in phenomena such as global warming (e.g. Basu & Panorkou, 2020), waste management (Villarreal, Esteley, & Smith, 2015), and fish stocks (Yanagimoto & Yoshimura, 2013). Critical traditions in mathematics education have focussed on peoples marginalized by coloniality and neoliberal globalisation, indeed those groups long and increasingly most affected by events located in the (inter)action of humans and the Earth, increasingly foreground these interdependencies. For example, ethnomathematics is concerned with how diverse socially and culturally situated ways of knowing and doing mathematics are used in social, cultural, political, economic and environmental practices (Rosa et al., 2012, citing D'Ambrosio, 2007). D'Ambrosio (2015) has long called attention to environmental realities in ethnomathematics, with recent examples including sustainability of Indigenous lands (e.g. de Mattos & de Mattos, 2020), and proposals for an ethno-biomathematics (Eglash, 2023). Indigenous ways of knowing foreground the ways of knowing, acting, being, and using language of variously named Indigenous communities. This work offers important direction on how to act against binaries and hierarchies of culture/nature and so-called Western/Indigenous mathematics, binaries that perpetuate the idea that mathematics can be separated from well-being or ecological considerations (e.g. Anania & Stiglitz, 2023; Gutiérrez, 2017, 2019; Kulago et al., 2021).

For thinking about mathematics education, in terms of the social *and* ecological, scholars also recruit (related) perspectives commonly considered 'outside' of the field, such as decoloniality, (eco)feminism, ecojustice, ethics, Indigenous futurity, linguistics, new materialism, philosophy, and posthumanism (e.g. Barwell et al., 2022; Borba, 2021; Boylan, 2017; Chronaki & Lazaridou, 2023; de Freitas & Sinclair, 2014; Gutiérrez, 2022; Khan, 2020; Kirby, 2011; Madden, 2019; Rubel & Nicol, 2020; Wolfmeyer, Lupinacci, & Chesky, 2017).

Mathematics education forums are increasingly creating opportunities for research, from all these perspectives, dedicated to mathematics education and the socio-ecological. Such forums have included four journal special issues: *Mathematics education and the living world* (edited by Boylan & Coles, 2017); *Mathematics for "citizenship" and its "other" in a "global" world: Critical issues on mathematics education, globalisation and local communities* (edited by Chronaki & Yolcu, 2021); *Mathematics education in a time of crisis—a viral pandemic* (edited by Chan, Sabina, & Wagner, 2021); and *Innovating the mathematics curriculum in precarious times* (edited by le Roux, et al. 2022). Recent relevant research also includes conferences, not only research papers, discussion groups, and panels, but notably plenary presentations, for example, the 12th International Conference of Mathematics Education and Society (e.g. Barwell, 2023), and the 47th Annual Conference of the International Group for the Psychology of Mathematics Education (e.g. Coles, 2023; Valero, 2023).

A striking characteristic to emerge from a range of the contributions above (and the March 2023 ICMI Symposium) is the relational nature of the reported mathematics education research. Many studies involve ongoing, interdisciplinary and transdisciplinary relations with other knowledges, practices, languages, and values. Such work involves ongoing collaborative relations between researchers, teachers, students, communities, activist movements, government and non-government institutions, natural scientists and social scientists. The contributions move between context and materiality, and abstraction. A coherent thread is researchers' attention in these relations to notions of power, responsibility, answerability, activism, care, agency, and democracy. At the same time, such work is strengthened by the diversity of theoretical perspectives (and interpretations thereof), being brought to and given meaning in local experiences of mathematics education in the socio-ecological, all of which are manifestations of global sustainability concerns.

This ICMI Study 27 is an important, necessary, and timely opportunity to address particular concerns about mathematics education and the socio-ecological. As suggested by the preceding, illustrative, review of existing scholarship, there is a need for an analytic description of the growing dialogue across perspectives and voices, from across the globe, of those working on issues in mathematics education that span social (including political) and ecological (environmental) problems, and ethical concerns.

3. Aims of ICMI Study 27

Areas of mathematics education, such as those cited in Section 2, have long adopted critical approaches to relations between mathematics education and the social and/or ecological. Yet, academic thought no longer has the "luxury" (Sitas, 2023, p. 55) of critique alone; there is a need for critique alongside, for example, creativity and speculation (da Silva, 2022). There is an urgency for thought leadership on new possibilities, questions, and recommendations for research, innovation, and action for mathematics education and the socio-ecological, and to build community (including interdisciplinary relations) to act in new directions at local and international levels. There is a sense that the pace of change in the world is vastly outstripping knowledge of, and indeed capacity to 'know', the socio-ecological condition (Sitas, 2023). Haraway (2016) argues that "bounded individualism," characteristic of Western thought is "unavailable to think with, truly no longer thinkable" (p. 5).

The topic of ICMI Study 27, 'Mathematics Education *and* the Socio-Ecological,' locates mathematics education *in* the complexity of social and ecological interdependencies, or frames mathematics education within the socio-ecological. This includes, for example, interdependent relations between all humans (individual and community; bodies, thoughts, emotions); the living and inanimate natural world; material technologies; languages; and concepts. These relations cross multiple scales of space (local, regional, national, global) and time (pasts, presents, futures). The complexity of bringing together the social-ecological and mathematics education, (re)produces a number of tensions. Such tensions are not yet well understood (beyond simple binaries), with considerable methodological, empirical, and ethical implications. Significantly, van Dooren (2014, p. 3) argues that it is only when we come to understand the complexity of our interdependencies that we may have a sense of the obligations we (as mathematics educators) have "to hold open space in the world" for all living beings.

ICMI Study 27 aims to explore different theorizations of the socio-ecological and the role of mathematics education therein, and the implications for mathematics education research and practice. The Study is arranged around four themes:

(A) Aims of mathematics education;

(B) Scales of mathematics education;

(C) Resources of and for mathematics education;

(D) Mathematics education futures.

These themes are singular in that they provoke particular questions for mathematics education, but are inherently related. We anticipate that these related themes will further develop during the Study process. Each theme description, below, invites engagements with notions of the social and ecological *and* their interdependencies (what we refer to as the 'socio-ecological'). These invitations also recognise that, while we all relate to and experience the 'socio-ecological' in some form, our experiences will be different, on account of our place-based histories and presents. Thus, the Study will itself offer conceptualizations of mathematics education and the socio-ecological. Each theme description identifies tensions emerging from mathematics education positionings in the complexities of the social, ecological and their relations. We view these tensions as creative, as generating new questions about and for mathematics education, and prompting new imaginaries of presents and futures. Departing from these socio-ecological conceptualizations, each theme then asks of the thinking and practices of mathematics education specific questions related to: knowledge; curriculum; pedagogy; learning materials; professional development; philosophy; theory; methodology; and so on.

Taken together, the four themes recognise the presents (and their histories) in the field of mathematics education, and make space/create opportunities for scholars to find lines of openings for the field, to position themselves for thinking, acting and being in contemporary and future socio-ecological realities. The first theme focuses on the aims of and conceptualizations of mathematics education in different spaces in our pasts and presents, and for our futures. It asks how those aims and their underpinning philosophical assumptions shape possibilities for social-ecological framings of mathematics education, including the curriculum. In the second theme, scales of mathematics education, we focus our attention on how mathematics education's interactions in the complexities of the social and ecological occur at multiple scales, of the local, regional, national and global. We are interested in how these interactions play out – within and across spaces and borders, in pasts, presents and futures – with respect to the enactment of knowledge, curriculum, and teacher professional development. The third theme, resources of and for mathematics education, considers how practices, concepts and tools are reconceptualized, or used differently, when the social and ecological are acknowledged as entangled. And, finally, the fourth theme, mathematics education futures, considers our ways of conceptualizing research and practice in mathematics education for sustainable futures, for mathematics education located in uncertain and complex socio-ecological interdependencies and ethics.

4. Themes, Sub-themes, and Invitations/Questions

Theme A. Aims of mathematics education

This theme highlights the importance that our underlying assumptions and motivations have in articulating the potentialities of a socio-ecological framing of mathematics education. We know that there is much disparity amongst educators around the aims of mathematics education, with some being constitutionally opposed to a focus on socio-ecological issues in the classroom, while others being more amenable to them, and even centring them. Not to mention that socio-ecological issues are variously conceptualized as well. These differences in aims and conceptualizations are not particular to this moment. The aims of mathematics education have changed over time and across contexts; interrogating them has become increasingly important as mathematics education is a central area of the compulsory school curriculum and of many other forms of further education. As the socio-ecological becomes a focus of attention, inviting us to think not only of the relation between mathematics and society, but also the conditions of human life on Earth – which have now become precarious in many parts of the world – the aims of mathematics education require renewed attention. The current multiple interconnected crises we find ourselves in prompt questions about the forms of knowledge and knowing that are relevant in education, the effects of such knowing in shaping peoples' identities and qualifications, and the possibilities for individuals and communities to mobilize themselves and their knowing into the creation of new possible futures.

As we work to create new approaches to mathematics education that could adequately engage in socio-ecological issues, it is worth examining our philosophical positionings with respect to the aims of mathematics education and engage directly in exploring multiple tensions concerning:

- The reasons for providing mathematics education and to whom.
- The functions of mathematics education in current crises.
- The types of peoples, with their identities and qualifications, we want to enable through mathematics education.
- The expected gains for individuals, communities, and societies.

We arrange these concerns in two sub-themes.

Sub-theme A1. Examining the aims of mathematics education

We are interested in how the aims of mathematics education, in different times and spaces, shift/reify/transform if we locate mathematics education in the particular socio-ecological interdependencies and complexities identified above. We ask:

A1.1 What have our aims around mathematics education traditionally been, and what philosophies and theories have informed these aims? And with what implications for our presents and futures?

A1.2 What would our aims (have to) be if we centre the socio-ecological? And what philosophies and theories might help us develop or make possible such aims? For example, how might relational theories that privilege human and non-human respect and responsibly inform educational aims? How might Indigenous theories, that centre the care-taking of land, frame the aims of education in ways that consider socio-ecological interdependencies and complexities?

A1.3 How do the aims in A1.1 shape/constrain/offer openings for the thinking demanded of us in A1.2?

Sub-theme A2. Examining mathematics as a subject of education

Mathematics education research has often been focused very specifically on mathematics; how mathematics might improve reasoning or contribute to progress or democratic participation, or, on the other side, lead to oppression and anxiety. Some mathematics educators, however, have leaned more on education, seeing that as the primary field of action, with mathematics being less centred. A more mixed approach of mathematics education, as equal partners, is also possible. No matter where along the continuum between these two positions researchers find themselves, there are controversies around what counts as both mathematics and education. We offer the following questions:

A2.1 With the addition of the socio-ecological to the mix, how are mathematics, education, or mathematics education inflected?

A2.2 Does the socio-ecological focus compel a shift towards other views of mathematics (e.g., more applied or interdisciplinary understandings of mathematics)?

A2.3 Does a socio-ecological focus dramatize the centrality of education, making mathematics more of a possible context?

A2.4 Which other kinds of meanings and possible relationships can be thought for mathematics education in the socio-ecological?

Theme B. Scales of mathematics education

Mathematics education has perhaps become accustomed to focusing on one, or a limited number, of connected sites, where interactions of relevance are considered to be enacted. We are now confronted with the realization that such interactions are connected within and across sites (e.g., the classroom and home; the school and the life out of school) and occur at multiple scales simultaneously (e.g., local, regional, national, and global). Positioning mathematics and mathematics education in the complexities of the socio-ecological requires attention to territories of interaction, by which we mean the networks of dense relationships between communities, human and non-human entities (animals, plants, rivers, mountains, spirits, etc.), stories, myths, emotions, and the spaces by/with which they are created/associated in pasts, presents, and futures in which the multiple practices of mathematics education are enacted. How do scales of interaction play out in making mathematics education? We identify tensions in:

- How we impose/(re)constitute boundaries to organize education and the effects of such boundaries, prompting us to consider: what are the histories of these boundaries; who creates them and the power that defines them; for what purposes; with what implications, and for whom; what are alternatives?
- The different scales of interventions in mathematics education and how they interact, with implications for listening and acting at these various scales.
- The many voices within and across territories themselves (e.g., human, non-human, elder, teacher, student, doctor, policy maker, socio-ecological activist), voices that are polyphonic and even conflicting. In this sense, environments also have many voices.

Sub-theme B1. Relations between the local/global, historical, ecological, and political

We are interested in how mathematics is enacted with/in bodies/territories and stories, and how bodies/territories and stories are enacted with/in mathematics. Any given body/territory will have many (even contradictory) voices. So, attending to scales helps illuminate whose voices/stories are amplified and whose are muted. Attending to scales helps us to think about what are/might be appropriate actions, and by whom these should be undertaken.

B1.1 Whose stories/histories are included in mathematics (education), at what scales, and how does that relate to who is considered in the presents or futures of mathematics (education)? For example, what power structures exist that repeat and sustain an uneven power distribution between territories and make them (and the communities in relation) easier to govern? What role might the stories/histories of non-human entities play in mathematics?

B1.2 How and why have certain communities developed small scale/local innovations around socio-ecological issues in mathematics education? How has that reflected the voices of those engaged in mathematics as a human, cultural, political, and ecological activity?

B1.3 What is/might be the role of mathematics (education) in supporting communities' defense of their stories/histories and territories?

Sub-theme B2. Curriculum innovations and different voices located in the socio-ecological

We are interested in the methodologies for capturing small-scale/local curriculum innovations and sharing the ways that voices of those engaged in mathematics as a human, cultural, political, and ecological activity are reflected. For instance, how do national/international curricular agendas impact local and micro (classroom-level) teaching practices; how do specific communities collaborate on those practices; and how are these communities defined?

B2.1 What have we learned from trying to adopt small scale/local curriculum innovations that frame mathematics within the socio-ecological in a range of scales (local, national, regional, global) and how do local ideas travel? What are the possibilities for dialogue across scales?

B2.2 What tensions do communities face in developing, implementing, and communicating local curricular innovations to address the socio-ecological crises they live?

Sub-theme B3. Learning from site-specificities

We are also interested in sharing the ways that networks of collaboration, if any, have been helpful for communities to face their local socio-ecological problems. A crucial issue for research in mathematics education would be to make explicit what transdisciplinary knowledge has been constructed through such collaborations, and what the role of mathematical knowledge in such collaborations is.

B.3.1 How do we better prepare educators, researchers, and students to simultaneously think about local and global issues in mathematics education with respect to the planet? In what way(s), if any, does a socio-ecological perspective (e.g., learning from non-humans) serve as a proper foundation for thinking about site specificity and wider relevance?

B3.2 How do communities and educators solve local tensions between curricular innovations and official programs and how do they share solutions with other teachers and school communities, while not ignoring local specificity?

Theme C. Resources for and of Mathematics Education

This theme is concerned with the (re)conceptualization and use of different forms of resources, defined as: *practices*; *concepts, constructs and objects*; and *tools which have agency in doing/performing mathematics*. The theme and two sub-themes are located within a milieu constituted by socio-ecological concerns and their inter-relatedness with mathematics education. What issues are at stake when we conceptualize resources, and their use, in a critical manner, not assuming they are only beneficial to mathematics education and the socio-ecological? Elaborations on the theme are underpinned by a series of interconnected questions related to tensions we identify in these interdependencies.

Practices: Practices include ways of knowing and doing mathematics, modes of reasoning, argumentation, and acceptable means of knowledge creation within a learning community (e.g., mathematical modelling). Approaches employed to foster or facilitate learning by both the teacher (pedagogies) and the learner themselves are therefore also considered practices. This also means that pedagogical approaches, as practices, are in themselves a mode of knowledge creation – both in/for the learner and the teacher.

Concepts, constructs and objects: Concepts, constructs and objects, including for instance, variables, algebraic expressions, geometrical objects, statistical processes (e.g., sampling) and techniques (e.g., integration), represent the foundations of disciplinary knowledge within mathematics. These concepts, constructs and objects, in conjunction with mathematical practices and tools, constitute a relevant part of what is considered mathematics by society in general.

Tools which have agency in doing/performing mathematics: Tools that enable the knowing/doing of mathematics include physical tools (e.g., rulers, compasses), representational tools (e.g., maps, ready reckoners, comparative charts), and digital tools (e.g., calculators, computers, virtual reality, augmented reality). Tools can take the form of technologies designed specifically to support engagement with mathematical tasks (e.g., Computer Algebra Systems, Dynamic Geometry Software, Data Analysis Applications) or generic technologies that can be used to perform mathematical activity (e.g., spreadsheets, pedometers). There is currently much interest (and concern) about tools involving artificial intelligence as they relate to education.

Tools can also be considered in a much broader sense to include the quality of spaces in which teaching and learning take place and the spaces in which students spend time outside school. At issue here are the opportunities to use tools to learn – online and in-person – in these spaces. Spaces can refer to teaching and learning conditions in educational institutions, communities, and homes, and include: physical conditions, including electricity, water; physical security; and availability and accessibility of digital tools. These opportunities vary within and across local scales, according to complex historical, socio-political, and socio-economic factors, thus connecting tools with issues related to equity, inclusiveness, and social justice.

How these different forms of resources are (re)conceptualized and utilized when located in socio-ecological interdependencies gives rise to tensions to which mathematics is called on to respond, for example tensions regarding:

- Resources enabling and constraining new relationships, and the nature of relations (both old and new) enacted by resources.
- Resources leading to marginalization and empowerment of different groups, and issues relating to values in the enactment of resources.
- The visibility/transparency of resources in relationships and interdependencies.
- Agencies of resources in predicting and creating futures.

Sub-theme C1. What and how resources are/may be used in relation to socio-ecological concerns

In this sub-theme, we are concerned with how resources can be used for reading, interpreting, and understanding socio-ecological interdependencies.

C1.1 What is the role of mathematical resources in innovation for addressing challenges associated with the socio-ecological – exacerbating current issues or generating new ones? What are the tensions around how tools are utilized to both enable (new thoughts, new practices) and constrain (including by values embedded in their design and use)?

C1.2 How are mathematical resources used in understanding, interpreting and responding to the socio-ecological?

C1.3 How are mathematical resources used in shaping or evaluating claims and reports related to the socio-ecological by expert and non-expert commentators, government agencies, and alternative-to-main-stream sources of information? How are resources used when supporting or refuting arguments about the nature, and current and future state of the socio-ecological?

C1.4 What are the agencies of mathematical resources in fostering/avoiding the social ecological crisis we live in and will be inherited?

C1.5 Which mathematical resources should be the foundation of informed participatory and critical citizenship? Which should be acquired as required within specific contexts?

Sub-theme C2. How resources are embedded within histories, values and ideologies

C2.1 How does the increasing entanglement of humans with mathematical resources impact on responses to the socio-ecological? How will the disentanglement of mathematical resources from humans (e.g., artificial intelligence) or 'different' humans influence the significance of the socio-ecological?

C2.2 How are ideological and aesthetic dimensions of mathematics and mathematics education present in the use of mathematical resources?

Theme D. Mathematics Education Futures

This theme focuses on possible sustainable futures, futures for mathematics education located in uncertain and complex socio-ecological interdependencies and ethics. We recognise the possibilities to define 'futures' in different ways, for example, futures as a mapping of the present; futures as a folding of pasts and presents; futures as plural and varied (having different characteristics); futures as dependent on the actor; futures as imagining new stories, restorying or creating counterstories.

We identify tensions emerging in these interdependencies and framings, regarding:

- Multiple senses and experiences in mathematics education, of hope, creativity, imaginations, actions, uncertainties, criticality, fears, helplessness, and violences. Prompting us to ask questions of: who hopes; who owns hope; who can dream and hope; who hopes for whom/what; futures for whom/what; who/what is included/excluded, and whose hope and aspirations? Questions of: what and how to enact ethical mathematics education?
- The enfolding of mathematics education's pasts and presents in mathematics for thinking through science to shape, imagine and restory futures.

Sub-theme D1. Contexts and communities of education that can/have yet to be imagined

D1.1 Where might mathematics learning that cultivates hope and sits with critical realities of sustainable practices happen?

D.1.2 How could future schools (re)conceptualize and (re)organise themselves to respond to the varied characteristics of plural futures?

D1.2 How is awareness of socio-ecological complexities within mathematics education preparing ourselves to respond to the changing needs of a complex, uncertain, changing world that can never be fully known?

D1.3 How does knowledge and ethics embedded in informal and cultural practices equip us to use a socio-ecological lens towards sustainability?

D1.4 How and with whom/what might mathematics educators ‘speak with’, ‘come together with’ for sustainable futures: mathematicians and practitioners of mathematics; mathematics instructors and teachers of mathematics; policy makers and curriculum developers; other disciplines, etc.?

Sub-theme D2. Knowledges, curriculum and pedagogies that can/have yet to be imagined

D2.1 What mathematical concepts lend themselves to speculation about futures?

D2.2 What pedagogies and ethics can cultivate criticality and hope?

D2.3. How do we prepare future citizens, and what are their responsibilities from a socio-ecological perspective towards achieving sustainability?

D2.4 How could a socio-ecological approach to mathematics education equip learners to face the changing futures towards sustainability?

Sub-theme D3. Practices and ethics of mathematics education research that can/have yet to be imagined

D3.1 What theories and ethics do and might guide us to understand what socio-ecological interdependencies and complexities can offer to us so as to attain sustainability?

D3.2 What methodological approaches are suitable in the face of interdependencies, complexity, uncertainty? What methodological approaches can sustain hope?

D3.3 Are concepts such as ‘theory’ and ‘methodology’ useful for mathematics education research for sustainable futures?

5. References

Anania, K., & Stiglitz, C. (2023). Touching variables: Decolonial approaches and new tools for ecological data visualization. *Leonardo*, *56*(6). 579-585. https://muse.jhu.edu/article/908016/summary

Barwell, R. (2013). The mathematical formatting of climate change: Critical Mathematics Education and post-normal science. *Research in Mathematics Education*, *15*(1), 1–16 https://doi.org/10.1080/14794802.2012.756633

Barwell, R. (2023). Dialogue, responsibility and mathematics education. In R. Marcone, P. Linardi, R. Milani, J. P. A. de Paulo; A. Moura Queiroz, & M. T. da Silva (Eds.), *Proceedings of the 12th International Conference of Mathematics Education and Society* (pp. 19-50). MES.

Barwell, R., Boylan, M., & Coles, A. (2022). Mathematics education and the living world: A dialogic response to a global crisis. *The Journal of Mathematical Behavior*, *68*, 101013. https://doi.org/10.1016/j.jmathb.2022.101013

Basu, D., & Panorkou, N. (2020). Utilizing mathematics to examine sea level rise as an environmental and a social issue. In A. Sacristán, J. Cortés-Zavala, & P. Ruiz-Arias (Eds.), *Proceedings of the 42nd Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 1064-1068). PME-NA.

Borba, M. C. (2021). The future of mathematics education since COVID-19: Humans-with-media or humans-with-non-living-things. *Educational Studies in Mathematics*, *108*(1-2), 385-400. https://doi.org/10.1007/s10649-021-10043-2

Boylan, M. (2017). Towards a mathematics education for ecological selves: Pedagogies for relational knowing and being. *Philosophy of Mathematics Education Journal*, *32*. https://education.exeter.ac.uk/research/centres/stem/publications/pmej/pome32/Boylan-submitted.docx

Boylan, M. & Coles, A. (2017). Is another mathematics education possible? An introduction to a Special Issue on "Mathematics education and the living world: Responses to ecological crisis". *Philosophy of Mathematics Education Journal*, 32. https://education.exeter.ac.uk/research/centres/stem/publications/pmej/pome32/index.html

Chan, M. C. E., Sabena, C., & Wagner, D. (2021). Mathematics education in a time of crisis—A viral pandemic. *Educational Studies in Mathematics*, *108*(1-2), 1-13. https://doi.org/10.1007/s10649-021-10113-5

Chronaki, A., & Lazaridou, E. (2023). Subverting epistemicide through 'the commons': Mathematics as re/making space and time for learning. In E. Vandendriessche & R. Pinxten (Eds.), *Indigenous knowledge and ethnomathematics* (pp. 161-179). Springer.

Chronaki, A., & Yolcu, A. (2021). Mathematics for "citizenship" and its "other" in a "global" world: Critical issues on mathematics education, globalisation and local communities. *Research in Mathematics Education*, *23*(3), 241–247. https://doi.org/10.1080/14794802.2021.1995780

Coles, A. (2023). Teaching in the new climatic regime: steps to a socio-ecology of mathematics education. In M. Ayalon, B. Koichu, R. Leikin, L. Rubel, & M. Tabach (Eds.), *Proceedings of the 46th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 1, pp. 17-33). PME.

Coles, A., Barwell, R., Cotton, T., Winter, J., & Brown, L. (Eds.). (2013). *Teaching secondary mathematics as if the planet matters*. Routledge/Taylor & Francis Group.

Coles, A., & Helliwell, T. (2023). The role of mathematics teacher educators in preparing teachers of mathematics to respond to global challenges within their classrooms. *London Review of Education*, *21*(1), 1-13. https://doi.org/10.14324/LRE.21.1.02

D'Ambrosio, U. (2007). The role of mathematics in educational systems. *ZDM*, *39*(1-2), 173-181. https://doi.org/10.1007/s11858-006-0012-1

D'Ambrosio, U. (2015). From mathematics education and society to mathematics education and a sustainable civilization: A threat, an appeal, and a proposal. In B. Greer, & S. Mukhopadhyay (Eds.), *Proceedings of the Eighth International Mathematics Education and Society Conference* (Vol. 1, pp. 19-30). MES.

Da Silva, D. F. (2022). *Unpayable debt*. Sternberg Press.

De Freitas, E., & Sinclair, N. (2014). *Mathematics and the body: Material entanglements in the classroom*. Cambridge University Press.

De Mattos, J. R. L., & de Mattos, S. M. N. (2020). Ethnomathematics in the Brazilian Indigenous context. In M. Rosa & C. Coppe de Oliveira (Eds.), *Ethnomathematics in action: Mathematical practices in Brazilian Indigenous, urban and Afro communities* (pp. 71-90). Springer.

Eglash, R. (2023). Ethno-biomathematics: A decolonial approach to mathematics at the intersection of human and nonhuman design. In M. C. Borba & D. C. Orey (Eds.), *Ubiratan D'Ambrosio and mathematics education: Trajectory, legacy and future* (pp. 289-303). Springer.

Freire, P. (1970). *Pedagogy of the oppressed*. Herder & Herder.

Gutiérrez, R. (2017). Living mathematx: Towards a vision for the future. *Philosophy of Mathematics Education Journal, 32*. https://education.exeter.ac.uk/research/centres/stem/publications/pmej/pome32/index.html

Gutiérrez, R. (2019). *Mathematx: Towards a way of being*. In Subramanian, J. (Ed.), Proceedings of the 10th International Mathematics Education and Society conference. MES

Gutiérrez, R. (2022). A spiritual turn: Towards desire-based research and Indigenous futurity in mathematics education. *Journal for Research in Mathematics Education*, *53*(5), 379-88. https://doi.org/10.5951/jresematheduc-2022-0005

Gutstein, E. (2006). *Reading and writing the world with mathematics: Toward a pedagogy for social justice*. Routledge.

Haraway, D. J. (2016). *Staying with the trouble: Making kin in the Chthulucene*. Duke University Press.

Hauge, K. H., & Barwell, R. (2017). Post-normal science and mathematics education in uncertain times: Educating future citizens for extended peer communities. *Futures*, *91*, 25-34. https://doi.org/10.1016/j.futures.2016.11.013

Jurdak, M. E., Vithal, R., de Freitas, E., Gates, P., & Kollosche, D. (2016). *Social and political dimensions of mathematics education.* Springer. https://doi.org/10.1007/978-3-319-29655-5

Khan, S. (2020). After the M in STEM: Towards multispecies' flourishing. *Canadian Journal of Science, Mathematics and Technology Education*, *20*, 230-245. https://doi.org/10.1007/s42330-020-00089-4.

Kirby, V. (2011). *Quantum anthropologies: Life at large*. Duke University Press.

Kulago, H. A., Wapeemukwa, W., Guernsey, P. J., & Black, M. (2021). Land, water, mathematics, and relationships: What does creating decolonizing and indigenous curricula ask of us? *Educational Studies*, *57*(3), 345-363. https://doi.org/10.1080/00131946.2021.1892690

Latour, B. (2018). *Down to earth: Politics in the new climatic regime* (English edition. ed.). Polity Press.

Le Roux, K., Brown, J., Coles, A., Helliwell, T., & Ng, O.-L. (2022). Editorial for a special issue on innovating the mathematics curriculum in precarious times. *Research in Mathematics Education*, *24*(2), 117-127. https://doi.org/10.1080/14794802.2022.2090422

Louie, N., & Zhan, W.-Y. (2022). A socio-ecological framework for research in mathematics education. *Journal for Research in Mathematics Education*, *53*(5), 365-371. https://doi.org/10.5951/jresematheduc-2022-0003

Madden, P. E. (2019). *Evaluating mathematics curriculum from anti-colonial and critical mathematics perspectives.* Doctoral dissertation. Boston College

Ödmo, M., Björklund Boistrup, L., & Chronaki, A. (2023). A teacher education statistics course encounters climate change and critical mathematics education: Thinking about controversies. In R. Marcone, P. Linardi, R. Milani, J.P. A. de Paulo; A. Moura Queiroz, & M. T. da Silva (Eds.), *Proceedings of the 12th International Conference of Mathematics Education and Society* (sixth sketch, pp. 1307-1321). MES.

Rosa, M., D'Ambrosio, U., Orey, D. C., Shirley, L., Alangui, W. V., Palhares, P., & Gavarrete, M. E. (2016). *Current and future perspectives of ethnomathematics as a program.* Springer Nature.

Roy, A. (2020). *Azadi*. Penguin.

Rubel, L. H., & Nicol, C. (2020). The power of place: Spatializing critical mathematics education. *Mathematical Thinking and Learning*, *22*(3), 173-194. https://doi.org/10.1080/10986065.2020.1709938

Sitas, R. (2023). Publics, politics, place and pedagogy in urban studies. In A. Pande, R. Chaturedi, & S. Daya (Eds.), *Epistemic justice and the postcolonial university* (pp. 51-63). Wits University Press.

Skovsmose, O. (2021). Mathematics and crises. *Educational Studies in Mathematics*, *108*(1-2), 369-383. https://doi.org/10.1007/s10649-021-10037-0

Skovsmose, O. (2023). *Critical Mathematics Education*. Springer International Publishing.

Steffensen, L., Herheim, R., & Rangnes, T. E. (2023). Wicked problems and critical judgment in school mathematics. In N.S. Kennedy & E. Marsal (Eds.), *Dialogical inquiry in mathematics teaching and learning: A philosophical approach* (pp. 79-102). Lit Verlag.

Tsing, A. L., Bubandt, N., Gan, E., & Swanson, H. A. (Eds.). (2017). *Arts of living on a damaged planet: Ghosts and monsters of the Anthropocene*. University of Minnesota Press.

Valero, P. (2023). Mathematical subjectivation: Death sentence to the planet or chances for a terrestrial life? In M. Ayalon, B. Koichu, R. Leikin, L. Rubel, & M. Tabach (Eds.), *Proceedings of the 46th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 1, pp. 53-68). PME.

Van Dooren, T. (2014). *Flightways: Life and loss at the edge of extinction.* Columbia University Press.

Villarreal, M. E., Esteley, C. B., & Smith, S. (2015). Pre-service mathematics teachers' experiences in modelling projects from a socio-critical modelling perspective. In G. A. Stillman, W. Blum, & M. S. Biembengut (Eds.), *Mathematical modelling in education research and practice: Cultural, social and cognitive influences* (pp. 567-578). Springer.

Wolfmeyer, M., Lupinacci, J., & Chesky, N. (2017). EcoJustice mathematics education: An ecocritical (re) consideration for 21st century curricular challenges. *Journal of Curriculum Theorizing*, *32*(2), 53-71.

Yanagimoto, A., & Yoshimura, N. (2013). Mathematical modelling of a real-world problem: The decreasing number of bluefin tuna. In G.A. Stillman, G. Kaiser, W. Blum, & J.P. Brown (Eds.), *Teaching mathematical modelling: Connecting to research and practice* (pp. 229-239). Springer.

6. Call for Contributions to ICMI Study 27

The International Program Committee (IPC) for ICMI 27 Study invites submissions from across the globe, of those working on issues in mathematics education that span social (including political) and ecological (environmental) problems, and related ethical concerns. We encourage collaborations involving researchers, teachers, teacher educators, policy makers, and other stakeholders from diverse contexts and sites of education. Empirical and theoretical contributions (we value those that are analytical and innovative, rather than solely descriptive) should primarily respond to one of the four study themes, and a subtheme therein, as described in Section 4: (A) Aims of mathematics education; (B) Scales of mathematics education; (C) Resources of and for mathematics education; and (D) Mathematics education futures.

Authors should nominate the theme and one sub-theme in which they would like their paper considered, by examining the content and questions outlined in the topic sections presented above. It may be the case that interconnections between sub-topics emerge and warrant attention; consequently, papers may be re-allocated by the IPC if beneficial.

6.1 Conference location and dates

The ICMI Study 27 Conference will take place from January 22 (Wednesday) to January 26 (Sunday), 2025, in Quezon City, Philippines. All details, including registration fees and a submission portal will be available on the Study website: https://icmistudy27.sciencesconf.org.

As an IPC we grapple with the ethical contradictions in relation to, on the one hand, the carbon and wider ecological impact of an in-person conference and, on the other hand, the inclusivity that comes from generative in-person engagement in an ICMI Study. While acknowledging their limitations, we seek to make various gestures of 'mitigation': in reducing travel for the Study overall we have chosen to prioritise a small, in-person Study Conference; as an IPC, we have met virtually to create this document; we are committed to attending to the ecological footprint of the Conference itself; we will look to offering opportunities for individual and collective action towards mitigation, during the Conference; and a Study aim is for the generative potential of discussions to work towards addressing socio-ecological priorities beyond the Conference.

6.2 Submission

A template for the submission of papers is available on the 27th ICMI Study website (https://icmistudy27.sciencesconf.org), on the 'Call for Contributions' page. Papers have to be written in English (the language of the Study Conference) according to the template instructions, with a maximum of 8 pages.

Consistent with the aims of ICMI studies to be inclusive and to grow the field, the IPC invites early career researchers to engage in a pre-submission process. Assistance will be offered to scholars who can show they have limited academic support. This assistance does not include the writing of the text in English, and we encourage research collaborators to support one another as may be needed.

6.3 Deadlines

Submissions must be made online no later than *June 15*, *2024*, but earlier if possible. Papers will be reviewed and decisions made about invitations to the conference. Notifications of decisions will be sent to the corresponding/main author between *July 30 and August 15*, *2024.*

Information about the venue, registration, costs, travel, and accommodation will be made available on the 27th ICMI Study website (https://icmistudy27.sciencesconf.org).

Summary of dates:

1. Call for proposals (paper submission): from February, 2024
2. Pre-submission support deadline: May 30, 2024
3. Deadline for proposals (paper submission): June 15, 2024
4. Invitations to participate mailed: between July 30 and August 15, 2024
5. Registration: opens on July 30, 2024, and closes November 1, 2024
6. Proceedings published online: December 31, 2024
7. Conference Opening: January 22, 2025

6.4 Beyond the Submission of Contributions

Outcomes from the conference activity provide the foundations for an edited volume published open access by Springer as part of the New ICMI Studies Series. While the volume will focus on the four themes and the contributions and discussions about these in the Proceedings and at the Conference, the final organisation and authorship of the volume will only take shape following, and as a consequence of, the discussions raised during the Conference. It must be appreciated that there is no guarantee that papers accepted in the Study conference proceedings will appear in the volume. Furthermore, chapters in the volume may be an amalgamation of several presented papers and not all participants in the Conference are guaranteed to become co-author of a chapter in the study volume. At the same time, the IPC will be looking for some participants to take significant writing roles in the Study volume.

7. Members of the International Program Committee

Co-chairs

Alf Coles (UK, alf.coles@bristol.ac.uk)

Kate le Roux (South Africa, kate.leroux@uct.ac.za)

IPC Members

Marcelo Borba (Brazil, marcelo.c.borba@unesp.br)

Arindam Bose (India, arindam.bose@tiss.edu)

Vince Geiger (Australia, vincent.geiger@acu.edu.au)

Rochelle Gutiérrez (USA, rg1@illinois.edu)

Mariam Makramalla (Egypt, mariam.makramalla@ngu.edu.eg)

Armando Solares-Rojas (Mexico, asolares@cinvestav.mx)

Nathalie Sinclair (Canada, nathalie_sinclair@sfu.ca)

Paola Valero (Sweden, paola.valero@su.se)

Catherine P. Vistro-Yu (Philippines, cvistro-yu@ateneo.edu)

Ex-officio members

Frederick K.S. Leung (ICMI President, Hong Kong SAR, icmi.president@mathunion.org)

Jean-Luc Dorier (ICMI General-Secretary, Switzerland, icmi.secretary.general@mathunion.org)