Mathematics Education and the Socio-Ecological

ICMI Symposium 20th March 2023

Held Online

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Contents

Foreword

The ICMI Symposium on “Mathematics Education and the Socio-Ecological” will take place on 20th March 2023 (GMT).

These pre-conference proceedings contain the abstracts of all the work being presented.

The organisers of the symposium would like to thank ICMI for their support of this venture.

This symposium has been brought together as a collaborative initiative, involving K. le Roux, A. Coles, R. Barwell, M. Borba, A. Chronaki, R. Gutiérrez, M. Makramalla, A. Parra, M. Rosa, A. Solares-Rojas, J. Subramanian and L. Hennessy.

Scientific Programme

Symposium 1

09.30-11.00 GMT

Opening plenary panel: Jodie Hunter, Berinderjeet Kaur, Lara Lalemi, Jeff Murugan

11.20-12.10 GMT

Parallel Research Reports

12.30-13.20 GMT

Parallel Research Reports

14.00-15.10 GMT

Plenary Talk: Willy Alangui, Armando Solares-Rojas

Discussant: Rochelle Gutiérrez

Symposium 2

14.00-15.10 GMT

Plenary Talk: Willy Alangui, Armando Solares-Rojas

Discussant: Rochelle Gutiérrez

15.30-16.20 GMT

Parallel Research Reports

16.40-17.30 GMT

Parallel Research Reports

18.00-19.30 GMT

Closing plenary panel: Omar Arellano, Liz de Freitas, Mariam Makramalla, Mogens Niss

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Symposia chairs: Alf Coles and Kate le Roux

Symposia support: Lauren Hennessy

I

Plenaries

The abstracts in this section are from plenary panellists (across two panels) and the plenary talk (which was common to both symposia).

1

PLENARY PANEL 1

Jodie Hunter - Position statement

Massey University, Aotearoa/New Zealand

I begin by locating myself as an Indigenous person of Kuki Airani (Cook Island) heritage with my family as part of Tangata Moana (Pacific diaspora) who settled in Aotearoa/New Zealand. My ancestors navigated Te Moana-nui-a-Kiwa (the Pacific Ocean region) in vaka (canoes) that held between 100 – 200 people using their knowledge of the stars, cloud formations, and the ocean. Indigenous knowledge systems are the local and cultural knowledge unique to groups of people and their societies. This includes values and ways of living and being. These systems have been fundamental to survival and encompass holistic multidisciplinary systems that underpin practices related to food production, health, conservation, and education.

In Aotearoa/New Zealand, similar to many other countries, ongoing colonisation has rendered Indigenous knowledge systems invisible within schooling systems and particularly in mathematics education. Arguably this has led to cultural dissonance for both Indigenous Māori and Pacific students and a representation of

mathematics in the Western schooling system as abstract and culturally neutral. Efforts towards shifting mathematics education to begin to value and privilege Indigenous ways of knowing and being have been slow and challenging. Currently there has been ongoing criticism of policy shifts being undertaken within Aotearoa/New Zealand to build on Indigenous knowledge across the curriculum including in science and mathematics. For example, both New Zealand based scientists and other academics such as Richard Dawkins dismissed mātauranga Māori (Māori knowledge systems) as simply being based on myths rather than "real" science. This highlights the debate about the role of Indigenous knowledge systems within schooling and the validity of approaches that draw on this.

Although my experience has been in Te Moana-nui-a-Kiwa, these debates and issues of whose and what knowledge counts are occurring across international contexts. My perspective is that as mathematics educators working within socio-ecological approaches, we should view Indigenous knowledge as a taonga (treasure) that adds new dimensions and enriches both our work and perspectives.

Berinderjeet Kaur - Citizenship education via mathematics education and the socio-ecological

National Institute of Education, Nanyang Technological University, Singapore

A critical aspect of school curriculum in Singapore is Character and Citizenship Education (CCE). The 4 goals of CCE are good character, resilience and wellbeing, active citizenship, and future readiness. All school subjects, including mathematics must contribute towards CCE. This is somewhat same as the Austrian curriculum, as noted by Steflitsch and Kanatschnig (Symposium 2), which emphasizes the development of an understanding of "political, economic, legal, social, ecological,

and cultural" contexts and calls for orientation towards guiding values such as humanity, tolerance, or environmental awareness. Though all these goals are to be reached in every school subject, Steflitsch and Kanatschnig state that in Austria for mathematics within mathematics teaching is prevalent. Mathematics instruction emphasizes inner-mathematical knowledge, rules, and procedures without connecting these to real-world contexts.

In Singapore, traditionally during mathematics instruction, teachers manifest mathematical empowerment same as teachers in Austria except that real-life contexts are prevalent but social empowerment is lacking (See Fosse and Hauge for domains of empowerment) and this is pervasive across schools. Though at times teachers may design activities such that students do mathematics outside of the class, critics are quick to ask "where is the mathematics"? Mathematics trails were first introduced to schools by the author in the late 1990s. Teachers have always viewed such activities as enrichment or end of year activities, mainly as time fillers.

Several presentations at these symposia offer good insights to mathematics teachers in Singapore and Austrian schools and elsewhere about mathematics education and citizenship. Some of the presentations are as follows. Geiger and colleagues (Symposium 1) offer insights on citizenship and mathematics education by drawing on recent disasters around the world. Villamor and Vistro-Yu (Symposium 1) draw on the theoretical perspectives of critical mathematics education proposed by Skovsmose (1994) and demonstrate how social development issues, such as waste management may be addressed via mathematical modelling activities using appropriate real-life tasks. Bissell and colleagues (Symposium 2) note that teachers teaching mathematics for just and sustainable futures have three potential responsibilities namely - valuing difference of opinion, developing critical thinking,

and supporting students with managing a greater understanding of the climate emergency.

References

Skovsmose, O. (1994). Towards a critical mathematics education. *Educational Studies in Mathematics*, 27 (1), 35-57.

Lara Lalemi - Contextualising HE mathematics education for students

University of Bristol, UK

Mathematics, similar to other subjects in STEM higher education, has been impacted by cultural, political, and economic systems that have shaped it (Gandolfi, 2021). The process of colonialism, specifically, has played a substantial role in the evolution of mathematics, with European colonial powers utilizing STEM knowledge to extend their influence and dominance over other regions of the world.

One of the ways in which mathematics was colonised was through the marginalisation of non-European mathematical traditions and practices. European colonial powers often used mathematics as a tool of oppression and control, requiring that it be taught in schools as a means of imposing European values and worldviews. This often resulted in the erasure of Indigenous mathematical traditions and practices, and the suppression of cultural diversity in the field. An example of this is the journey of the ancient African mathematical tradition,

Bamana Sand divination, to the modern-day computer passing through many European mathematicians' hands without recognition of the origin and significance (Eglash, 1997). In addition to these historical impacts, colonialism has also had more subtle but persistent effects on mathematics today. For example, the Eurocentric bias that was reinforced during the colonial period continues to shape the way mathematics is taught and practised.

Although mathematical education is often seen as divorced from historical, political context, it is not. Though much of the mathematical pedagogy may not be able to be decolonised or changed, one way of expanding the curriculum for students is through assignments which can be framed to enable students investigate non-Western concepts, cultures and customs, for example: Professor Ron Eglash's research (1999) which explores the fractal geometry of traditional African architecture and develops interactive simulation tools that students in American inner-city schools used to create computational models of fractals. Examples used with students included replicating computational models of cornrow hairstyles and Native American weaving patterns (Eglash, 1999). These themes gave the students opportunities to reflect on their own cultural identity and its relationship to maths and technology. This intervention raised the achievement levels of participating minority students in mathematics, and positively influenced their technological career aspirations (Eglash, 1999).

In addition of thinking about the ontology, epistemology and axiology of the mathematics education alongside assessment, we must also consider how to include students in the conversation, themselves. It was students who reignited the drive to decolonise education and academia in 2015 across the world, starting with #RhodesMustFall. Much of the work I have done has focused on bringing higher education university students into the conversation of what it means to decolonise

or contextualise their STEM curriculum as shown in Figure 1. Students have an appetite to know and understand the conversation around decolonising and diversifying STEM, yet few avenues exist for them to explore these concepts at a level that is accessible to them. We must strive to create more ways for students to become involved in this work, if we wish it to have a greater more diverse legacy.

Figure 1: *Panel discussion to first- and second-year STEM students at the University of Bristol led by the PhD student Lara Lalemi as part of the lecture series on Science and Society.*

References

Eglash, E. (1997) *American Anthropologist, 99,* 112–122.

Eglash, E. (1999). *African Fractals: Modern Computing and Indigenous Design*, Rutgers University Press.

Gandolfi, H. (2021) *Curriculum Journal*, *32*, 510–532.

Jeff Murugan - Position statement

University of Cape Town

Unlike many of my colleagues at this Symposium, I am not a specialist in mathematics education. However, what I am is a mathematics educator, a mathematical physicist and a father of young children just beginning their own educational journeys. As such, I believe I have an interesting perspective to contribute to this conversation around the interplay between socio-ecological context and mathematics education.

My position on the question is that, on the one hand, it is obvious that social context will shape education, and scienti c/mathematical education in particular. This fact is true from the first industrial revolution, driven by the thermodynamics of steam, to the space race of the 1970's and 1980's that precipitated the introduction of the "new math" syllabi that flooded US high schools. On the other, to paraphrase Sherlock Holmes, there is nothing more deceptive than an obvious fact. Indeed, much of the modern-day schooling system is still very much rooted in a mildly post-first industrial revolutionary mindset, rigid and unyielding at its core while society has moved on in a much more uid way. I believe that mathematics is everywhere, from the ow of tra c to the dance of sub-atomic particles trapped in a magnetic eld, to the spread of a virus in a population, and it should be taught in a

way that makes that manifest. It is essentially about pattern recognition, a point of view that is woefully unappreciated in primary and secondary (and even tertiary) educational systems which lean more toward rigidly enforced rules that are as excluding as they are archaic. To rectify this, especially in the context of the current rise of artificial intelligence, I argue that it is crucial that the teaching of mathematics change in a fundamental way if human beings are to remain relevant to knowledge creation.

2

PLENARY TALK

Wilfredo Vidal Alangui - I feel my knowledge is important: Learning math and culture with elders and knowledge holders

College of Science, University of the Philippines Baguio, Baguio City, Philippines

In my presentation, I shall give a brief background on the Philippine government's program for Indigenous Peoples' Education (IPEd) and talk about a project called Indigenizing Science and Mathematics that I am a part of and which is jointly implemented by the Indigenous Peoples' Education Office of the Department of Education (IPsEO-DEPED) and the Science Education Institute of the Department of Science and Technology (SEI-DOST). Under this project, I shall highlight efforts to involve community elders and knowledge holders in the implementation of "indigenized" mathematics lessons as an integral component of mathematics instruction. This strategy hopes to ensure that indigenous students learn both mathematics competencies (through the facilitation of the classroom teacher) and

cultural competencies (with elders as collaborators). I shall link this effort of engaging community elders as resource persons and education collaborators to the experiences of PAMANA KA, a school for Indigenous Mangyan students in the island of Mindoro, Philippines. Having continually collaborated with this school since 2016, I intend to share some of my personal insights on how PAMANA KA is able to consistently engage Mangyan elders and knowledge holders in the implementation of a culturally relevant and sustaining mathematics education (CRSME) to their Mangyan students. Based on these experiences, I shall argue that the elders and knowledge holders as collaborators serve as a critical link between mathematics education and the socio-ecological. I shall give some insights on the impact of such collaborations not only on the students and teachers, but to the elders as well, and identify some challenges in sustaining the engagement of community elders and knowledge holders in the delivery of CRSME.

Armando Solares-Rojas - The Atoyac river museum: a community-based interdisciplinary educational experience to face socio-ecological crises in rural communities in Mexico

Mathematics Education Department, CINVESTAV, Mexico

The global ecological crisis is pressuring about 220 million people in Latin America who face poverty, no health access, industrialization, loss of ecosystems, no water supply, pollution, and corruption (Carriquiriborde et al., 2014). In this presentation, I will share some results of the "Community, Science and Education" project (UK EPSRC EP/T003545/1), which aims to bring education close to the concerns and needs of communities suffering severe socio-ecological crises in Latin America

(Solares-Rojas et al., 2022). I will focus on the work we developed in the Atoyac river basin in Tlaxcala state, central Mexico, a region highly affected by water contamination produced by factories and urban wastewater discharges (Montero-Montoya et al., 2020). Based on a dialogic collaboration, teachers, community leaders, environmental and health scientists, and mathematics and science educators designed activities that articulate contents of different subjects (Sciences, History, Geography, Spanish and Mathematics), welcoming in the classrooms the participation of different voices: teachers, scientists and people from their community, with their history and culture. We looked to set out the role of mathematics as a tool to study socio-ecological issues. Furthermore, the local socio-ecological problems, not the official curricular contents, are at the centre of attention. We consider that this experience could be of interest to support others in thinking about similar opportunities in communities facing socio-ecological crises.

Acknowledgements to the United Kingdom Engineering and Physical Sciences Research Council (EP/T003545/1) for supporting this project. https://red-comunidadcienciaeducacion.org/

References

Carriquiriborde P., Mirabella P., Waichman A., Solomen K., Van den Brink P., & Maund S. (2014). Aquatic risk assessment of pesticide in Latin America. *Integrated Environmental Assessment and management, 10*(4), 539-542. https://doi.org/10.1002/ieam.1561

Montero, R., López, R., Méndez, A., Galicia, I., García, G., Serrano, L., Beltrán, R., Rosado, S., Albores, A., Oropeza, L., Hernández, L., Mercado, F., Alvarado, E., Herrera, S., & Arellano, O. (2020). Increased micronucleus frequencies in reticulocytes of children exposed to industrial pollution: oxidative stress and the

OGG1 S326C polymorphism. *Mutation Research, 853,* 503170. https://doi.org/10.1016/j.mrgentox.2020.503170

Solares-Rojas, A., Arellano-Aguilar, O., García González, M. M., López-Vargas, M. R., Coles, A. and Méndez Serrano A. (2022). Mathematics education and social-environmental crises: an interdisciplinary proposal for didactic innovation with rural communities in Mexico, *Research in Mathematics Education*. https://doi.org/10.1080/14794802.2022.2062781

Rochelle Gutiérrez - Restor(y)ing mathematics in the Socio-ecological: A plenary response to Willy Alangui and Armando Solares-Rojas

University of Illinois, United States of America

Partly in response to the movements of Black Lives Matter and Land Back[1] on Turtle Island[2]; land and water rights severely threatened globally (e.g., Brazil and India) as well as proposed constitutions and new laws that name lands and waters as persons who have rights (e.g., Bolivia, Australia, and Chile); climate justice; Truth and Reconciliation processes in Canada and South Africa that have major implications for Indigenous education; a queer and trans movement; and a global pandemic that has shifted education to embrace socioemotional learning and care for one another, the global mathematics education community is situated in a unique moment to reconsider mathematics in helping us to get free and heal. The presentations by Willy Alangui and Armando Solares-Rojas offer excellent examples of teachers, students, community elders, scientists/mathematicians, and researchers engaged in long-term and complex relationships with Indigenous

communities where mathematics plays a role. In particular, they showcase how community members serve as important knowledge holders beyond content that needs to be learned in schools.

As we work within a socio-ecological framing, several questions arise from these projects: What might be the roles of mathematics? And, who should decide? For example, should mathematics serve as tools to help us identify socioecological injustices and transform society, to serve local (Indigenous) communities who, in Solares-Rojas' case, are most impacted by contamination from local factories? That is, should mathematics help us "read and write the world" (Gutstein, 2006) and is doing so in times of crises any different? Beyond considering the roles of mathematics, how might the moment we are in help us expand what we consider mathematics in the first place? Ethnomathematics has long had as an underlying principle to challenge Western mathematics (D'Ambrosio, 2006; Powell & Frankenstein, 1997) and Alangui's work shares that goal. In what way(s) are our research projects taking seriously the idea that the (school) mathematics that got us to this moment is not the (school) mathematics that will get us out? What is involved in radically dreaming towards a mathematical future that helps us re-attach to each other and to our more-than-human relatives? What is the language needed to describe relations between various mathematics and mathematical forms as well as between various mathematicians (Gutiérrez, 2017; 2019)?

The practice of futurity within Indigenous communities has existed since time immemorial, with past, present, and future intertwined and with a focus on (re)membering and healing (Harjo, 2019). Elsewhere, I have argued for a lens of restor(y)ing mathematics (Gutiérrez, 2021; 2022) in connection to a "spiritual turn" our field is entering (Gutiérrez, 2022). In their presentations, I will highlight some

of the ways mathematics is defined and serving in the function of restoring and/or restorying.

References

Alangui, W. V. (2023, March). *I feel my knowledge is important: Learning math and culture with elders and knowledge holders*. An invited plenary in the International Council of Mathematics Instruction (ICMI) Symposium: Mathematics Education and the Socio-ecological. Virtual convening.

D'Ambrosio, U. (2006). *Ethnomathematics: Link between traditions and modernity*. Sense.

Powell, A. B., & Frankenstein, M. (1997). *Ethnomathematics: Challenging Eurocentrism in mathematics education*. SUNY.

Gutiérrez, R. (2017). Why mathematics (education) was late to the backlash party: The need for a revolution. *Journal of Urban Mathematics Education,* 10(2), 8-24. Available at https://journals.tdl.org/jume/index.php/JUME/issue/view/23

Gutiérrez, R. (2017). Living mathematx: Towards a vision for the future. *Philosophy of Mathematics Education Journal*, 32(1), 1-34. Available at http://socialsciences.exeter.ac.uk/education/research/centres/stem/publications/pı

Gutiérrez, R. (2019).*Mathematx: Towards a way of being*. In Subramanian, J. (Ed.), Proceedings of the 10th International Mathematics Education and Society conference. Hyderabad, India. Downloadable at (click on Proceedings I) http://mes10.uohyd.ac.in/mes/program/conferenceProceedings.php

Gutiérrez, R. (2021, April 25). *Restor(y)ing mathematics teacher education*. A Division K Invited Session at the Annual Meeting of the American Educational Research Association. San Diego, CA.

Gutiérrez, R. (2022). A Spiritual Turn: Towards Desire-Based Research and Indigenous Futurity in Mathematics Education. *Journal for Research in Mathematics Education*, 53(5), 379-388.

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

Harjo, L. (2019). *Spiral to the stars: Mvskoke tools of futurity*. University of Arizona. https://doi.org/10.2307/j.ctvh4zjdg

Solares-Rojas, A. (2023). *The Atoyac River museum: A community based interdisciplinary educational experience to face socio-ecological crises in rural communities in Mexico*. An invited plenary in the International Council of Mathematics Instruction (ICMI) Symposium: Mathematics Education and the Socio-ecological. Virtual convening.

[1] Land Back is a movement that does not simply demand lands to be returned to Indigenous communities to secure Indigenous futurity; it also involves dismantling structures of White supremacy (e.g., National Parks service, Border patrol, police, and the military–industrial complex).

[2] "Turtle Island" is the term some Indigenous groups use for North America.

3

PLENARY PANEL 2

Elizabeth de Freitas - Metamorphic mathematics and down-to-earth abstraction

Adelphi University

I advocate for an Anthropocene mathematics that might better reckon with its Modernist anthropocentric fantasies of transcendence and confront the current remixing of earth and politics under new climatic regimes. I will not defend mathematics in the name of human exceptionalism, but rather as a posthuman worlding practice that engages the pluralist metamorphic nature of truth. This is not about the relativity of truth, but about the truth of relativity. This would be a mathematics animated by and animating terrestrial attempts to negotiate various polarized and weaponized perspectives within the Capitalocene.

Abstraction is not the enemy. The speculative power of mathematics, whereby abstractions are engendered, is not only a 'cultural' act of constructing symbolic form, but also accentuates and affirms thought's capacity to become radically alien to itself. As much as old white geologies encode within them an extractive logic that

is a major cause of ecological destruction and current science distrust, there is an urgent need to reconsider the significance of mathematical thinking in these post-truth conditions, where viral affect shapes our collectivity. Theories of mathematical activity, of part and whole relationality, must gather the new demands of an earthbound people (a thousand black anthropocenes) who are engaged in new risky forms of diplomacy, and new dependency relations with a live planet.

Imagine a mathematics that is not a global force of reductive sameness, but a mathematics that actually uncovers agencies through its concept creation; a mathematical modeling that is not representational but realizing. Such a mathematical practice involves the invention of concepts that make perceptible (principally to humans) the existence of non-human agencies, thereby expanding the opportunities for more-than-human alliances within a pluralist ecology, and ultimately assembling a more inclusive political body. This is a mathematics that is implicated in the proliferation of agency across the political ecology; claims about particular creatures (volcanoes, wolves, bacteria, electrons) are *entirely ground* in the relational performances of those characters. In other words, this is a mathematics that is focused on creating opportunities or experiments that reveal nonhuman agency, and thereby making visible new forms of life. This would be a very different onto-epistemic-ethical space for a newly earthbound mathematics, as a practice committed to caring for the plurality and generativity of the earth.

We want our students to imagine a mathematics that might reterritorialize the earth as a multiple earth shared across differences. Space is a historical appropriation, a matter of *spacing and gaining ground* – and hence spatial and metric imaginaries are both mathematical and material, abstract and situated, speculative and embodied. Territory is not just a site where we belong, but also something that

engenders, actuates, dramatizes, dies – we need a mathematics suitable to such a metamorphic zone. Consider these provocations: How might we cultivate alternative spatial imaginaries in our students, and create conditions for cosmic post-colonial geometries? What would it look like to make mathematical models of many worlds and multiple earths without building another imperialist Globe? What will be the role of the infinite in a mathematics that better knows its limits? How will the objectivity of chance become part of a new probability? What kinds of third-way reasoning and logic (modal, fuzzy, temporal, quantum) do we want students to learn, as a warranting of truth, on this multiple earth?

Mariam Makramalla - Why has the planet reached this state?: Questions of power and ownership in mathematics education

University of New Giza, Egypt

When considering the social, cultural and increasingly complex political nature of our mathematics classrooms from a scholarly stance, it is hard not to agree that mathematics educators have a role and a responsibility towards the society in which their learners are situated (Apple, 2012). This responsibility has, in recent years, gained increasing clarity to both the mathematics education practitioner body and the mathematics education scholarly body (Graven & Heyd-Metzuyanim, 2019). That said, I align myself to other scholars (Ball, 2012) in arguing that this degree of agency has been always known to educational policy makers.

In some of my previous studies (Makramalla, 2020) I have sought to plot out in detail the evolution of the teacher role and level of agency across different socio-political contextual settings. One of my main findings unveiled the intentional pursuit of policy makers to firstly disguise the impact mathematics education has on its stationed society and to secondly underrate the role mathematics education has to play in responding to ecological questions and wider questions of sustainability. In turn, this meant that mathematics teachers were consistently and intentionally made oblivious to their role and authority as agents of change in the classroom micro-culture.

With this in mind, it doesn't come to me as a surprise that as mathematics education scholars we are at a point where we are questioning ourselves about the interrelatedness between the socio-ecological, the socio-political and mathematics education. Instead of starting off from a point of assured interconnectivity between the socio-political, the socio-ecological and mathematics education, we have been -over the years- politically steered to view these matters as existing in silos (Herrera & Torres, 2006). With this abstract, I want to call for an investigative inquiry that would bring together the multiple threads and layers that have been intentionally held separate, in an attempt to regain our degree of ownership and agency as mathematics educational scholars and practitioners to its full potential.

References

Apple, M. (2012). *Education and power*. New York: Routledge.

Ball, S. (2012). *Foucault, power and education*. London: Routledge.

Graven, M. & Heyd-Metzuyanim, E. (2019). Mathematics identity research; the state of the art and future directions. *ZDM*, 51(1). 361-377.

Herrera, L. & Torres, C. (2006). *Cultures of Arab Schooling: Critical ethnographies from Egypt*. New York: State University of New York Press.

Makramalla, M. (2020*). Contextualising Educational Reform in Egypt: An embedded case study of mathematics teachers' perceptions about problem solving*. [Doctoral Dissertation,

University of Cambridge].

Mogens Niss - A position statement

Roskilde University, Denmark

My overall take on the symposium in general and on the "the socio-ecological" theme in particular is of an analytic nature. While realising - and endorsing – that mathematics education by its very nature is intrinsically tied to cultural, social, and political perspectives and values, I strongly believe that (a) any academic discourse about these matters has to be based on focused issues, clear concepts and analyses, and that (b) this also pertains to – and is possible for - the stances and values adopted by participants in the discourse.

Against that background, I propose to approach the socio-ecological theme for mathematics education by posing two questions. The first question is:

A.What can socio-ecological issues do for mathematics education?

and the second question is:

B.What can mathematics education do for the dealing with socio-ecological issues?

These two questions are certainly not in opposition to one another, but they are certainly not identical either. Hence, they shouldn't be mixed up in our discussions.

The point of departure for Question A is that mathematics education is perceived as an overarching societal enterprise geared towards serving a wide and complex variety of purposes to foster and further the social, economic, technological, cultural, and political welfare of society. The question then is what the socio-ecological *problématique* can offer to this enterprise and how its affordances can be brought to fruition. In relation to Question A, socio-ecological issues are but one set of affordances along with numerous others that may benefit mathematics education at large.

The point of departure for Question B is that the multitude of socio-ecological issues – together constituting the existing socio-ecological crisis in a broad sense – are our primary concern, and that we are seeking ways to effectively deal with these issues. The question then is what mathematics education can offer to this endeavour and how its affordances can be implemented. In relation to Question B, mathematics education is but one contribution among numerous others that may help dealing with socio-ecological issues.

Whether we focus on Question A or on Question B, there are important balances to consider.

In my contribution to Panel 2, I will argue that there are positive answers to both Question A and Question B. Socio-ecological issues do, in fact, have significant contributions to make to mathematics education, and mathematics education does, in fact, have significant contributions to make to our attempts to deal with socio-ecological issues. Interestingly enough, there is a common element in those contributions: The construction, critical analysis and use of mathematical models of

socio-ecological phenomena and processes as a component of the teaching and learning of mathematics.

II

Symposium 1

These abstracts were accepted for presentation at Symposium 1 on 20th March 2023

4

TRANSFORMATIVE PROFESSIONAL LEARNING FOR SOCIO-ECOLOGICAL ACTIVISM IN MATHEMATICS EDUCATION

Mark Boylan

Sheffield Hallam University, UK

This ICMI symposium responds to and amplifies the calls for a socio-ecological engagement in mathematics education. I focus on the challenges of addressing this for teacher education and specifically post-qualification teacher professional learning. For teachers to engage with the socio-ecological crises means rethinking the nature of teacher professionalism. To contribute to imagining possibilities of what this can and should mean, I bring into generative tension two sets of concepts and bodies of literature. First, reconceptualisations of mathematics education that focus on the importance of forms of relationality in mathematics education that centre the socio-ecological (for example, Barwell, Boylan and Coles, 2022, Boylan,

2017, Gutiérrez, 2017). Second, examples of transformative professional learning that can foster critical professionalism – here drawing on a conceptual review of relevant literature (Boylan, Adams, Perry and Booth, 2023).

Transformative professional learning, here, refers to professional learning with political intent or purpose, that engages with issues of power within education, and is rooted in teacher agency. Critical professionalism encompasses various descriptions of democratic, activist and transformative professionalisms. These contrast with prevailing managerialist forms of professionalism (Sachs, 2003) that position teachers as technicians and subordinates all other educational purposes to the interests of the industrial growth economy.

Looking across constructs from socio-ecologically engaged mathematics education and transformative professional learning, I propose an analytical frame for considering potentials for transformative socio-ecologically orientated professional learning. This centres on: modes of professional learning; educational purpose and ethical orientation; forms of sociality; knowledge processes and intended outcomes; and material and systemic arrangements. The latter including resources and organisational structures. I illustrate this framework by identifying selected examples from outside mathematics education that suggest the potency of connecting with social activism and movements beyond mathematics education. Although the scale of these examples is limited, they offer suggests for forms of professional learning that differ from those generally used to in mathematics teacher professional learning that serves current school mathematics. Making such connections may be particularly important in education systems where policies to limit teacher agency and overtly pro-capitalist ideologies prevail.

References

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://www.sciencedirect.com/science/article/pii/S0732312322000815

Boylan, M. (2017). Towards a mathematics education for ecological selves: Pedagogies for relational knowing and being. *Philosophy of mathematics education journal,* 32, 1-15. http://socialsciences.exeter.ac.uk/education/research/centres/stem/publications/pı submitted.docx

Boylan, M., Adams, G., Perry, E., & Booth, J. (2023). Re-imagining transformative professional learning for critical teacher professionalism: a conceptual review. *Professional Development in Education*, 1-19. https://www.tandfonline.com/doi/abs/10.1080/19415257.2022.2162566

Gutiérrez, R. (2017). Living mathematx: Towards a vision for the future. *Philosophy of Mathematics Education Journal* (2017), p. 32

Sachs, J. (2003). The activist teaching profession. Open University Press.

5

CLI.MATH – FOSTERING REFLECTION OF DATA-BASED ARGUMENTATIONS ON CLIMATE CHANGE IN MIDDLE SCHOOLS

Christian Büscher

University of Duisburg-Essen, Germany

Following early calls for a Critical Mathematics Education (Skovsmose, 1994), researchers in mathematics education have provided increasingly sophisticated and topic-specific conceptualizations of needed criticality (e.g. Critical Statistical Literacy, Weiland, 2017). Recently, this work of specification has been continued by researchers uncovering the high critical demands posed by statistical and mathematical products in media (Gal & Geiger, 2022). But whereas the research discourse is well-suited to specify the general need for critical abilities, few empirical reports exist on suitable practical approaches for developing criticality or on students' learning pathways towards critical literacy.

This research report provides insights into the results of a Design Research project (Prediger et al., 2015) that aims to develop students' critical statistical literacy in middle school mathematics classrooms using climate change contexts (Büscher, 2022). A digital learning environment was developed that fosters students' knowledge of Arctic sea ice decline as well as their ability to reflect on data-based claims produced by others. 12 design experiments with 24 Grade 5 students were conducted in Germany and captured video data was analyzed using a qualitative category-generating approach combining deductive and inductive steps of analysis.

The research report will illustrate links between theory and practice of the socio-political and socio-ecological in mathematics classrooms. The presentation will introduce a theoretical model that differentiates the abilities required by students to critically reflect on data-based arguments (Büscher, 2022). It will also provide detailed empirical insights into students' learning pathways from undifferentiated reactions to arguments towards differentiated reflection. This developing reflection is not only supported by context knowledge of ecological contexts, but also of the role of arguments in social contexts. The research report will also provide practical design principles and tools for teachers to use to foster their students' critical statistical literacy in middle schools.

A 20-minute presentation will be followed by 20 minutes of discussion. The aim of the discussion is to generate an overview of different approaches for developing students' criticality and of empirical reports on students learning to become critical. In this way, connections can be made between different researchers as well as with practitioners, possibly remediating the gap between well-established critical theory and yet unconnected practical approaches to developing critical literacy.

References

Büscher, C. (2022). Design Principles for Developing Statistical Literacy in Middle Schools. *Statistics Education Research Journal 21*(1), article 8. https://doi.org/10.52041/serj.v21i1.80

Gal, I., & Geiger, V. (2022). Welcome to the era of vague news: A study of the demands of statistical and mathematical products in the COVID-19 pandemic media. *Educational Studies in Mathematics, 111*(1), 5–28. https://doi.org/10.1007/s10649-022-10151-7

Prediger, S., Gravemeijer, K., & Confrey, J. (2015). Design research with a focus on learning processes: An overview on achievements and challenges. *ZDM, 47*(6), 877–891. https://doi.org/10.1007/s11858-015-0722-3

Skovsmose, O. (1994). *Towards a Philosophy of Critical Mathematics Education*. Springer Netherlands. https://doi.org/10.1007/978-94-017-3556-8

Weiland, T. (2017). Problematizing statistical literacy: An intersection of critical and statistical literacies. *Educational Studies in Mathematics, 96*(1), 33–47. https://doi.org/10.1007/s10649-017-9764-5

6

TOWARDS DIVERSE ECOLOGIES OF KNOWLEDGE: OPENING ‘EPISTEMOLOGIES OF THE SOUTH’ FOR MATHEMATICS TEACHER EDUCATION AT THE PERIPHERIES OF EUROPE

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De Sousa Santos (2014, 2018) and in much of his scholarly work argues passionately that ‘there is no global justice without cognitive justice’. With this well cited phrase he wants to denote, through his many studies, that what today we call a civilized society of limitless development and growth is based on how advanced global capitalist relations tend to absorb all domains of our social and biological life. This process of life absorption is understood in a continuum of exclusions, oppressions, and discriminations with detrimental effects not only on traditional economies, cultures, rituals, habits, and politics but also on local epistemologies of

children's and adults' learning and knowing. And, in this process, certain lives but also particular forms of knowledge and modes of learning have been or become (and continue to become) extinguished, enclosed, silenced, marginalized, and forgotten. For Santos and his collaborators, this is due to how the Western paradigm of modern science from the 17th century onwards has colonized and capitalized not only our lands and territories but also our common understandings of what is knowledge, knowing and learning. Moreover, they urge us to ally with a growing recognition of the world as a biodiverse culture and nature grounded in ecologies of knowledge that privilege the contributions made by diverse epistemologies of the south (i.e. local, indigenous, traditional forms of learning and languages). It is, thus, pertinent to ask how this line of thinking might support not only a colonial critique but also a decolonial approach to mathematics education itself.

In this paper, we discuss issues related to diverse ecologies of knowledge from our work in mathematics education (teacher education, research) at two distinct peripheries of Europe: Greece and Sweden. Both of these countries do not belong to what has been considered as the heart of Europe's legacy, yet their effects can be appreciated either at a symbolic (i.e. Greece for its ancient doxa) or economic level (i.e. Sweden for its infrastructure). At the same time, they both belong geopolitically at the peripheral margins of Europe, they are small scale countries (approx. 10 million inhabitants each) with histories of agricultural land relations, solidarity communes and diverse cultures (with distinct languages and traditions of which the presence of Sami and Roma are indicative). Recently, they both receive big numbers of refugees. Greece is seen, by and large, as the gate to Europe for people escaping Eastern and African countries hoping for a temporary stay whilst Sweden (along with other north European countries) is often captured as the desired destination for a modern working life. It is within this complex context, that as we carry our

work as teacher educators and researchers, we tend to experience the need for opening spaces in our teacher education and research enactments for us and our student-teachers so that instead of waving out the complexity of both our histories and current local and global circumstances, to weave mathematics and mathematics education through this very complexity. The paper will present examples of our current research initiatives and experimentations in the teacher education program to work with marginalized youth in urban and rural workshops, to study with activists in local settings supporting migrant students or to bring mathematics in outdoor and embodied activity. This work has been inspired by current concerns of mathematics education becoming a terrain of neoliberal values and by De Sousa Santos call for diverse ecologies of knowledge -a call that seems pertinent also for the 'socio-ecological' call of this symposium.

References

Chronaki, A., & Lazaridou, E. (2019). *Mathematics Education out in the Rural Scape: Experimenting with a Radical Democracy for the Commons*. 10th International Conference Mathematics Education and Society, January 28 - February 2, Hyderabad, India.

Chronaki, A., & Lazaridou, E. (in press). *Subverting epistemicide through 'the commons': Mathematics as re/making space and time for learning.* In Vandendriessche, Eric and Pinxten, Rik (2021, editors). Indigenous Knowledges and Ethnomathematics. Springer publishers.

Coles, A., le Roux, K., & Solares, A. (2022). Towards a socio-ecological perspective of mathematics education. In C. Fernández, S. Llinares, A. Gutiérrez, & N. Planas (Eds.), *Proceedings of the 45th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 171-178). PME.

De Sousa Santos, B. 2018. *The End of the Cognitive Empire: The Coming of Age of Epistemologies of the South*. Duke University Press.

De Sousa Santos, B. 2014. *Epistemologies of the South: Justice against Epistemicide*. Paradigm Publishers.

7

RESPONSIBILITY AND ANSWERABILITY: MATHEMATICS EDUCATION AND THE LIVING WORLD,A DIALOGIC RESPONSE TO A GLOBAL CRISIS

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Life on Planet Earth is changing in response to the actions of humans to a degree that can be considered a crisis. We believe mathematics educators have not yet responded adequately to the challenges of this crisis. We are aware that the language we use to talk about crisis can be problematic. We do not wish to evoke a sense of a temporary hiatus, nor to erase the multiple ecological crises which have beset marginalised communities throughout history. What does seem new, however, is the global nature of the ecological changes taking place. In this session

we will offer a relational, dialogic perspective on mathematics education, and specifically a dialogical ethics, that can support mathematics educators in thinking through and enacting responsibilities. A dialogical stance leads to an ethics calling on our answerability and responsibility in relation to the living world.

Both Bakhtin and Levinas' ethical thought offer possible sources for such an ethics. There is some previous interest in their ethical stance in mathematics education (e.g. Barwell, et al., 2022; Boylan, 2017; Guillemette & Radford, 2022) which we build on here. Bakhtin proposes that we think about ethics in terms of answerability or answerable acts, which he defines as follows: "An answerable act or deed is precisely that act which is performed on the basis of an acknowledgment of my obligative (ought-to-be) uniqueness" (1993, p. 42). I act ethically if I act on the basis of an acknowledgement of my unique obligations to others – what Bakhtin refers to as "the I for the other". An on-going obligation is towards the living world, which demands answerability from each one of us.

As we argue in Barwell, et al. (2022), answerability can be seen as a complementary notion to Levinas's "call to responsibility" (2011, p. 134). For Levinas (2011), it is through recognition by an Other, through responsibility, that we come to recognise ourselves as a subject. That Other might be another human or some other, living or non-living, part of the world. We answer the world, in acknowledging the uniqueness of our potential, and we recognise others for the uniqueness of theirs. And it is through *being* recognised in such a way by others that we gain the capacity for answering ourselves. We point also to alignment and dissonance between these ethical approaches and others, in particular feminist and posthuman theory that also seek an ethics of 'response-ability' (Haraway 2012).

In the session at the ICMI Symposium, we plan to use the time to engage in dialogue with participants. We will present the key ideas around ethics, outlined above, and then propose a series of prompts for discussion, about future directions for mathematics education.

References

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

Bakhtin, M. M. (1993). *Toward a philosophy of the act* (Eds. V. Liapunov & M. Holquist; Trans. V. Liapunov). University of Texas Press.

Levinas, E. (2011). *Totality and infinity: An essay on exteriority*. Springer.

Murray, J. (2000) Bakhtinian answerability and Levinasian responsibility: Forging a fuller dialogical communicative ethics. *Southern Journal of Communication, 65*(2–3), 133–150.

Guillemette, D., & Radford, L. (2022). History of mathematics in the context of mathematics teachers' education: A dialogical/ethical perspective. ZDM–Mathematics Education, 1-13.

Haraway D 2012. Awash in urine: DES and Premarin® in multispecies response-ability. WSQ: Women's Studies Quarterly, 40 (1/2): 301-316.

8

EXPLORING PROSPECTIVE MATHEMATICS TEACHERS' MATHEMATICAL PROFICIENCY, CRITICAL CITIZENSHIP, AND TRANSLANGUAGING IN A SOCIAL-ISSUE-THEMED MATHEMATICS COURSE

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In the Philippine, the emergence of COVID-19 pandemic highlighted some conditions that threatened the breakdown of social order. Reports revealed ineffective management of pandemic, breach of protocols, worsening of violence

and impunity, coercive civil measures and rampant social media-borne misinformation. In the light of these conditions, the present study aimed to design a pre-service secondary mathematics teachers' course that would reflect the need to incorporate mathematics as a tool to address these issues. Skovsmose's (2014) critical mathematics education, Kilpatrick et al.'s (2001) mathematics proficiency, and Li's (2018) translanguaging were used as theoretical perspectives. Drawing on online ethnographic practitioner research approach that employed both quantitative and qualitative data-gathering methods (Skageby, 2011) the study explored the tension between the need for pre-service secondary mathematics teachers (PSMTs) to be mathematically proficient and the need to develop skills for critical citizenship through translanguaging. A total of twenty PSMTs who were third year Bachelor of Secondary Education major in Mathematics (BSEd Math) students from the University of Science and Technology of Southern Philippines participated in the study during the first semester of academic year 2022-2023. They were randomly selected from an intact class to attend as students in the researcher-designed eight-week course which included the conduct of four social-issue-themed mathematics lessons. All lessons were conducted by the first author and were structured following the *launch-explore-summarize* instructional model (Schroyer & Fitzgerald, 1986) highlighting content review and introduction of the issue, group task, whole-class discussion, and individual reflection. Quantitative data sources were the researcher-developed mathematics proficiency and critical citizenship pre-test/post-test. Qualitative data sources were the researcher's observation of PSMTs' communication of mathematics proficiency, critical citizenship and translanguaging practices during groupworks, and whole-class discussions. The results of the study hoped to provide practical and theoretical guidance for a successful implementation of socio-analytic mathematics at the PSMTs' level. These results could provide basis for the reconceptualization of the

current frameworks of the Philippine pre-service mathematics teacher education in order to realize and accommodate a socio-analytic dimension of mathematics.

References

Kilpatrick, J., Swafford, J., & Findell, B. (2001). Adding it up: Helping children learn mathematics. Washington, DC: National Academy of Sciences – National Research Council. Retrieved from http://www.nap.edu/ catalog/9822.htm

Li, W. (2018). Translanguaging as a Practical Theory of Language. *Applied Linguistics*, *39*(1), 9–30. https://doi.org/10.1093/applin/amx039

Shroyer, J. & Fitzgerald, W. (1986). The mouse and the elephant: Measuring growth, Middle Grades Mathematics Project, Menlo Park, CA: Addison-Wesley

Skageby, J. (2011). Online ethnographic methods: Towards a qualitative understanding of community practices. *IGI Global*. DOI: 10.4018/978-1-60960-040-2.ch025

Skovsmose, O. (2014). Critical Mathematics Education.In: Lerman S. (eds) Encyclopedia of Mathematics Education. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-4978-8_3

9

MATHEMATICAL KNOWLEDGE STRUCTURES OF SOCIO-CULTURAL COMMUNITIES: THE CASE OF SIBUYAN MANGYAN TAGABUKID

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Founded on the perspectives of ethnomathematical research by D'Ambrosio (1985), this paper seeks to explore the inherent mathematical knowledge systems of *Sibuyan Mangyan Tagabukid*, a socio-cultural community in Sibuyan Island, Romblon, Philippines. Specifically, it aims to document the mathematical knowledge structures found in the socio-cultural practices and activities of the community under study. It is anchored on Freudenthal Institute's Theory of Realistic Mathematics Education where real-life situations experienced by learners are used as starting points in creating a meaningful learning experience (Van den

Heuvel-Panhuizen and Drijvers, 2020). In this study, documented mathematical knowledge systems from the socio-cultural practices and activities of the community will be recommended for integration into the instructional materials used in formal schools. Furthermore, the study utilizes the ethnomathematical research framework (Alangui, 2010; Prahmana & D'Ambrosio, 2020) to gather relevant and significant data. In analyzing the data gathered through unstructured interviews, it will utilize the reflexive thematic analysis (Braun & Clarke, 2020). Through this research, the results are expected to contribute to the preservation of the indigenous knowledge systems and practices of socio-cultural communities, especially the *Sibuyan Mangyan Tagabukid*. Furthermore, it is also expected that these contribute to vertical mathematization and contextualization of instructional materials and activities.

References

Alangui, W. (2010). *Stone walls and water flows: Interrogating cultural practice and mathematics*. (Doctoral Thesis, The University of Auckland, Auckland, New Zealand). http://hdl.handle.net/2292/5732

Braun, V., & Clarke, V. (2020). One size fits all? What counts as quality practice in (reflexive) thematic analysis?. *Qualitative research in psychology*, *18*(3), 328-352. https://doi.org/10.1080/14780887.2020.1769238

D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics, 5*(1), 44-48. http://www.jstor.org/stable/40247876

Prahmana, R. C. I., & D'Ambrosio, U. (2020). Learning Geometry and Values from Patterns: Ethnomathematics on the Batik Patterns of Yogyakarta, Indonesia. *Journal on Mathematics Education*, *11*(3), 439-456. https://doi.org/10.22342/jme.11.3.12949.439-456

Van den Heuvel-Panhuizen, M., Drijvers, P. (2020). Realistic Mathematics Education. In: Lerman, S. (eds) *Encyclopedia of Mathematics Education*. Springer, Cham. https://doi.org/10.1007/978-3-030-15789-0_170

10

MATHEMATICS AND SUSTAINABILITY IN AN INTERDISCIPLINARY PROJECT

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The data in this study is taken during the practicum of four fourth-year preservice teachers with a major in mathematics education. They developed an interdisciplinary project related to clothing and sustainable development where they involved the subjects of social studies, natural science, and mathematics. The class was in 9^{th} grade, and the project lasted three weeks. The project started with an assignment where the students wrote a reflective text about their own clothing habits to make the project relevant for the students. Then they worked in groups on different aspects of the clothing industry and the consumption of clothes, and at the end of the three weeks the students gave an oral presentation.We ask how the preservice teachers facilitated student empowerment. Data consists of video recordings, audio recordings and student assignments. Recordings are transcribed.

Empowerment development involves fostering self-belief, taking control, and participating in activities (Ernest, 2002). Ernest (2002, p.1) characterizes four domains of empowerment concerning mathematics and its uses: mathematical empowerment, social empowerment, epistemological empowerment, and the professional empowerment of the mathematics teacher. Mathematical empowerment is associated with traditional mathematics education and is about having confidence in knowing how and when to use mathematics in school. Social empowerment is more connected to the use of mathematics outside the classroom, to the power of using and understanding mathematics in society. Epistemological empowerment refers to both mathematical and social empowerment and is about having confidence in applying mathematics in new situations. The fourth, the professional empowerment of the mathematics teacher, is not handled here.

There are several examples in our material of how the preservice teachers work to encourage and empower the students. The first task given to the students is to write a reflection note on their own clothing habits. Those students who are concerned about sustainable development, and act thereafter, may feel empowered by this assignment. Some of the students do not know what to write, and it seems that these students copy each other. These may have been disempowered by the task.

The second task is to work in groups and choose a topic related to the textile industry. The preservice teachers have given short lectures on relevant knowledge, but the students are supposed to find information on the Internet in addition. The students are given freedom, trust and responsibility. However, the preservice teachers discovered that the students retrieve numbers and statistics uncritically from the internet, so that they arrange two mathematics lessons on being aware of questionable aspects of statistics. The students contribute to making a list of what they should be aware of when including statistics in their projects.

We suggest that trying to empower students through projects on sustainable development can cause the opposite, and at the seminar we would like to have an interactive discussion on possible pitfalls.

References

Ernest, P. (2002). Empowerment in mathematics education. *Philosophy of Mathematics Education Journal*, 15. http://people.exeter.ac.uk/PErnest/pome15/empowerment.htm

11

BREAKING SILOS THROUGH STREAM EDUCATION AND USING THE WISDOM PROFILE TO ENGAGE WITH CULTURE

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What is an integral approach to STEM education that addresses the socio-ecological aspects for sustainable development in rural schools? We present the theory and practice of the same in breaking the silos of individual subject learning to transdisciplinary learning of Mathematics, Environmental Sciences, language and art.

India is a country of diversity with many disempowering ISMs coming from strong socializations especially in rural India. How can we use our wisdom profile

(Monica, 2017) to broaden the social profile to be an asset of inclusion rather than exclusion both for society and the environment.

The theoretical framework is based on the work of Sri Aurobindo to make a national education that is integral (Aurobindo, 1921), Seymour Papert's theory of constructionism (Papert, 1986), and more recent work by Dr. Monica Sharma on radical transformational leadership based on the conscious full spectrum response model (Monica, 2017).

In this paper we will focus on approaches we had adopted in Isai Ambalam a rural school in South India in making culture and celebrations of Pongal, Karthigai Deepam, Aadi festival, Christmas inclusive, eco-friendly, meaningful and engaging not only socially, but also integrated in STREAM (Science Technology Research Engineering Arts and Mathematics) education with awareness of the environment.

The stories behind the festivals were seen from the perspective of universal values (like equality, care for people and planet, responsibility, well-being) as well as an opportunity for changing lifestyle at school and home to be more healthy and environmentally conscious. For example, we looked at traditional sweets that are made with jaggery instead of refined sugar as sweets in celebrations. Children studied about the health benefits as well as made these sweets at the school and then at home with parents. In Karthigai Deepam we made traditionally Maavali, a natural palm flower based charcoal firework that is non-polluting and only creates sparks based on human powered centrifugal force. In Pongal, we looked at Kolam (the traditional patterns) and also looked at breaking the social patterns on only girls/women doing so. In addition, we looked at traditional strategy game of Aadu Puli as a tournament. We explored the Indian solar calendar used in Tamil Nadu and planned the Aadi festival with planting seasonal vegetables in our school

garden. We also studied about Monsoon, graphed and compared rainfall data in the month of Aadi in different states of India. We had studied the palm leaf craft for a week to make 3D objects like birds, stars, fish. For Christmas we decided to make our own decorations with palm leaf craft. We also made many innovative fair games and engaged with children from other schools with.

References

Aurobindo, Sri. (1921). The Human Mind, A system of National Education, *Tagore & Co. Madras* (pp.1-8).

Monica. S. (2017). Radical Transformational Leadership: Strategic Action for Change, *North Atlantic Publishing*, at Berkeley, California (pp.63-73, pp.236).

Papert, S. (1986). Constructionism: A new opportunity for elementary science education. *Cambridge, MA: M.I.T Media Laboratory, Epistemology and Learning Group* (NSF Grant Proposal).

12

CITIZENSHIP AND MATHEMATICS EDUCATION IN A TIME OF DISRUPTIVE EVENTS

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We live in a time of disruptive events – the result of both natural phenomena and human activity. These events include cataclysmic geological events (e.g., earthquakes and tsunami), recent disasters such as the COVID-19 pandemic, and long-term crises associated with the ecology and climate, economic instability, and ongoing wars. The impacts of such events include growing levels of poverty, unemployment and associated health issues, and large-scale migrations. These challenges make it imperative to re-examine how mathematics education can prepare future citizens to be informed of global challenges, and their potential consequences, and to promote a just, inclusive and equitable society (Maass et al., 2019). Remaining informed, however, is increasingly demanding, because of a rapid

expansion in the use of mathematics and statistics in societal discussions about disruptive events, including justification of planned or implemented policy responses. If citizens are to participate in decision-making processes that shape policy and strategy direction related to global challenges, they must be able to comprehend and critically evaluate a growing range of sophisticated mathematical and statistical products and evidentiary claims across many media channels (Gal & Geiger 2022).

With the above challenges in mind, we will raise questions regarding the nexus between Mathematics Education and Citizenship Education, which is the focus of the survey paper from a new issue of *ZDM Mathematics Education* (under development). In this article, we identify five demands citizens must accommodate to remain informed of the disruptive events and associated challenges faced by society: *1. complex mathematical and statistical information and arguments regarding global disruptions; 2. international initiatives related to sustainable development; 3. international initiatives related to sustainability; 4. The use of modeling-based systems in the public sphere;* and *5. an increased need for critical capabilities.* The session will detail these and related demands, and provide opportunity for discussion about the knowledge and skills, dispositions, and practices required for informed, active and responsible citizenship from a Socio-Ecological perspective. Implications for future directions for mathematics education practice and research will also be examined.

References

Gal, I., & Geiger, V. (2022). Welcome to the era of vague news: A study of the demands of statistical and mathematical products in the COVID-19 pandemic media. *Educational Studies in Mathematics, 111*(1), 5-28.

Maass, K., Geiger, V., Ariza, M. R., & Goos, M. (2019). The role of mathematics in interdisciplinary STEM education. *ZDM Mathematics Education, 51*, 869-884.

13

MATHEMATICAL MODELLING OF THE EFFECT OF CLIMATE CHANGE ON THE SPREAD OF MALARIA IN NIGERIA AS A CASE TO ENHANCE MATHEMATICS LEARNING AND SOCIOECOLOGICAL ENGAGEMENT FOR HIGH SCHOOL STUDENTS

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Malaria is a major disease susceptible to shifting environmental factors. The precise contribution of climate to the spread of malaria outbreaks is still hotly contested. However, warm, tropical areas of the world are where this disease is most prevalent. Anthropogenic climate change could shift the region where malaria

transmission may occur if seasonal climate forecasts are accurate. In many African nations, particularly Nigeria, malaria is an endemic and potentially fatal illness. In 2019, Nigeria had the highest number of global malaria cases and accounted for 23% of malaria mortality globally (WHO, 2019).

We will examine a modification of the human host-mosquito vector system model developed in Yiga et al. (2020) to investigate the dynamics of malaria transmission. Epidemiological classes are used to segment the entire human population, and those exposed advance to the infectious class at some rate. This vector model considers human exposure to mosquito bites during harsh weather due to unwillingness to use a treated mosquito net. Thus, this model offers a reliable foundation for forecasting outside the realm of available climatologic knowledge.

The model reveals that unless improved control measures are taken to target the dominant resistant strain, the endemic is likely to continue in Nigeria. There is a complex relationship between climate change, infectious diseases, and the impacts on the social and ecological dimensions involved. This analysis exemplifies the need for a socio-ecological turn, as proposed by Coles (2022). If utilized as a case study in high school mathematics classrooms, in addition to developing mathematical skills and knowledge, it creates a space for "exploring uncertainty, risk and global, ecological issues" (Coles, 2022, p. 214) and encourages students to use mathematical reasoning to critically examine the effects of human and more than human influences on the social and ecological dimensions of marginalized and frontline communities worldwide.

With the global rise in environmental issues, using disease modelling in high schools can aid in early awareness of the importance of climate change and potentially encourage their interests as future policymakers and scientists who

would be conscious of the relationship between climate change and infectious disease emergence.

In our session, we will discuss this mathematical model and its link to socioecological issues in Nigeria, but through critical discussion and analysis, the potential extension to other diseases impacted by climate change globally. Through theoretical considerations of this work toward a socio-ecologically grounded, enhanced mathematics education, we will propose implications for future research and modes of inquiry in the high school mathematics classroom.

References

Coles, A. (2022). A socio-ecological turn in mathematics education: Reflecting on curriculum innovation. *Paradigma, 5*(1), 207-228.

World Health Organisation (WHO). (2019). World malaria report 2019.

Yiga, V., Nampala, H., & Tumwiine, J. (2020). Analysis of the model on the effect of seasonal factors on malaria transmission dynamics. *Journal of Applied Mathematics, 2020.*

14

COLLABORATIVE PROBLEM SOLVING BETWEEN CLASSES AS A WAY TO TEACH AND LEARN MODELLING: THE ResCo PROJECT

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Modeling and the socio-ecological

Modeling is considered a key competence in many curricula. It makes the link between mathematics (mathematical models) and the real world or other disciplines. Developing the capacity of modeling, of understanding models, their uses and limitations, and of distinguishing a model from what it models, is fundamental for addresssing the socio-ecological issues, and contributes to critical mathematics education, STEM activities and other inter-disciplinary work.

The ResCo team of the IREM of Montpellier is a collaborative research team with researchers and teachers, working on the development of modeling in secondary-school classrooms – grades 6-12 (Modeste & Yvain Prébiski, 2020). To do so, the team develops problems called "realistic fictions" which are proposed each year to 80 to 120 classes (around 2500-3000 pupils) who collaborate to solve this problem.

The "realistic fictions" and the ResCo device

Our framework is based on the notions introduced by Freudenthal (1991) of horizontal mathematisation (which leads from the world of life to the world of symbols) and vertical mathematisation (which corresponds to the work within mathematics).

Our problems are "realistic fictions" conceived as Adaptations of a Professional Modeling Problem (FRAPPM) and should meet the following criteria (Yvain Prébiski & Modeste, 2019, Yvain-Prébiski, 2021):

To lead students 1) to reflect on the system to be modeled; and to bring them to become conscious of: 2) The necessity to develop a model to solve a problem; 3) The necessity to make choices to mathematically address the problem; 4) The importance of the question set to them during the development of the model; 5) The work behind the development of the model requires mathematical work within the chosen model to answer the questions.

In recent years, many FRAPPM have been designed and implemented on the following topics: tree growth, animal population evolution, warehouse optimal

positioning, glass cuts optimization, package designing, building evacuation, public transports organization, maritime borders issues…

The collaborative problem-solving device is based on exchanges between classes, grouped by three, working on the same problem, for 5 weeks (at least 1 hour/week). In the first week, the classes receive the problem and develop questions about it that are sent to the other classes. In the second week, the classes receive the questions and work on them to send answers. In the third week, classes work on the answers received, and a "relaunched realistic fiction" is sent to all the classes, which sets out choices for modeling the problem, based on the exchanges between classes, and allowing them to continue to work together on the same modeled problem. Weeks 4 and 5 are devoted to mathematical work on the modeled problem.

The work of the first three weeks – the question-and-answer phase and the work on a specific choice of model – contributes directly to the modeling skills mentioned above.

In the symposium, we will present the realistic fictions and the ResCo device, and illustrate and justify how it contributes to the development of modeling in students, and how this is a key-feature for addressing socio-ecological issues.

References

Freudenthal, H. (1991). *Revisiting mathematics education*. Dordrecht: Kluwer Academic.

Modeste, S. Yvain Prébiski, S. (2020) Collaborations between teachers and with academics in an irem group on a collaborative problem-solving device, ICME Study 25, Lisbon, Portugal

Yvain-Prébiski, S. (2021). Didactical adaptation of professional practice of modelling : a case study. Dans F.K.S. Leung, G.A. Stillman, G. Kaiser, & K.L. Wong (Dir.), *Mathematical Modelling Education in East and West. International Perspectives on the Teaching and Learning of Mathematical Modelling*. (pp. 305-319). Springer. https://doi.org/10.1007/978-3-030-66996-6_26

Yvain Prébiski, S., Modeste, S. (2019) Design of situations fostering horizontal mathematization: benefits from epistemological analysis of experts' practices. CIEAEM 71, Braga, Portugal.

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DESIGNING A LEARNING ENVIRONMENT USING PISACOMAT (PISA-MATHEMATICS-COVID19) FOR SECONDARY SCHOOL

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Changes and learning crises have hit significantly among Indonesian students due to the advent of socioecological challenges. Students in Indonesia suffered significant learning loss in affective, cognitive, and skill development. The Indonesian government issued a new policy at the end of 2021 as an extra option for implementing learning recovery in the form of a new paradigm curriculum or independent curriculum (IC). This policy develops students' soft skills and character based on the Pancasila student profile (PSP), focuses on essential material

like literacy and numeracy, and carries out flexibly differentiated learning based on students' abilities and adjusts to the context and local content.

We utilized PISA 2022 framework as a benchmark of the quality education consisting of 3C (contents, context, and competencies). We used contents covered in numeracy (algebra, numbers, geometry and measurement, and data and statistics) adjusted to the curriculum's learning outcomes. The contexts investigated are the effect of COVID-19, which encourages students to resist socioecological challenges. Competence is measured starting from knowledge, application, and reasoning. As IC is a new policy, many teachers, prospective teachers, and educational researchers need guidance on developing and applying it. In addition, there needs to be more learning materials and assessments with PISA criteria for Indonesian students.

This study aims to develop a learning environment for PISA Mathematics in the context of COVID-19 (PISAComat) that is valid and practical and potentially affects using five levels of Guskey. Design research with the type of development studies is used as the grand framework, which consists of 3 stages: preliminary & design, formative evaluation, and assessment. We described data collection qualitatively through questionnaires, document reviews, observations, walkthroughs, interviews, and tests.

The study produced the PISAComat learning environment (PLE) with the component of Virtual Zoom Meeting (VZM), PISAComat Website (WPC), and Classroom. The products of this PLE are PISAComat activities and questions with PISA 2022 framework. These PISAComat activities and questions focus on algebraic content, the context of the multiplier effect of COVID-19, and the competencies for understanding (L1), application (L2), and reasoning (L3). In addition, the PLE has potential effects using Guskey's five levels, namely, 1) 84% of

teachers were satisfied with the benefit of PLE; 2) 86% of teachers were able to design their teaching materials with PISA characteristics; 3) Principals, teachers and students are fully supported in developing PLE; 4) 84% of teachers were able to implement their developed teaching materials in the classroom; and 5) students emerged numeracy skills, namely using various numbers and symbols in solving situations, analyzing data in various forms of infographics, and interpreting the results of the analysis to predict and make a decision.

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A TEACHER EDUCATION COURSE ON CLIMATE CHANGE AND CRITICAL MATHEMATICS EDUCATION

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In this study we discuss the possible controversies faced by both a teacher and student-teachers when Critical Mathematics Education (CME) and climate change are being brought into a specific teaching setting, part of a teacher education program at a large university in Sweden. Driven by core ideas of CME, mathematics has been conceived as a formatting power for articulating issues of climate change (Coles et al. 2013). Mathematics can, potentially, change how such socio-ecological problems are perceived and formatted as solvable, predictable and so forth. In the particular case of teaching statistics, the teacher has to make certain choices concerning what data to look at since the particular data might suggest certain description or, solutions at the expense of others. In parallel, the teacher

wonders how all these might influence the student-teachers who come into the statistics course with diverse needs and expectations. It is with these thoughts in mind (i.e., dilemmas that can lead to irresolvable problems) that the course teacher (and the first writer of this paper) enters this study (i.e., course plan and its enactment). Latour (2005) discards an abstract definition of the social and in his well-known book "Reassembling the Social" focuses on its material understanding as relationships between actants. The notion of 'actant' is grounded in Active Network Theory and signifies both human and non-human participants in a complex network as being capable of producing a particular effect and, thus, having agency (Smelser & Baltes, 2001). The relationship that we as a collective iterate over time, in assemblages, is a way of thinking of how things are done and, thus, a way to map the 'social' as a highly controversial terrain. Taking this theory into account along with the teacher's dilemmas (as described above), we here perform an inquiry that aims to map potential actants and their relationships, as they are core in a teacher's experience to plan and enact a statistics course that engages the theme of climate change through CME. For this inquiry, both the teacher's logbook (or course diary notes) and student-teachers' interviews are analyzed. The analysis so far, locates instances where the teacher connects to different actants such as the climate change phenomenon, the curricula, the course plan, and student-teachers. In some instances, these actants suggest ways of doing, decisions to make or choices that contradict each other and hint toward controversial issues. These all become evident in signs of hesitation by the teacher at moments of planning or enactment. They, moreover, reserve to create different narratives about what mathematics should be utilized and demands reflexive choices by the teacher over which narrative to follow. Such hesitations might also be traced back to how the arguments for choosing one narrative over the other are being constructed. In short, the analysis shows that since diverse arguments can be narrated, one might be left with the feeling of missing something in just following one. It is a rather

vulnerable situation the teacher is in; risking being hold accountable for not dealing with the mathematical content that has good arguments for it to be dealt with.

References

Coles, A., Barwell, R., Cotton, T., Winter, J., & Brown, L. (2013). *Teaching secondary mathematics as if the planet matters.* London: Routledge.

Latour, B. (2005). *Reassembling the social: an introduction to actor-network-theory.* Oxford University Press.

Smelser, N. J., & Baltes, P. B. (Eds.). (2001). *International encyclopedia of the social & behavioral sciences* (Vol. 11). Amsterdam: Elsevier.

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THE MODELLING OF INFILTRATION PHENOMENA IN THE COMMUNITY OF CIVIL ENGINEERS IN TRAINING

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The mathematical content in engineering careers is significant (CACEI, 2020) and Civil Engineering is no exception, although it requires a robust mathematical training at the previous educational level, there are difficulties in its teaching and it has a decisive impact on the training of civil engineers. This causes students, teachers and society in general to demand questions that have more to do with the utilitarian sense and not with the functional aspect of mathematical knowledge (Cordero, 2008). To this effect, it is common, in university environments, to question the relevance of school mathematics for the daily life of the civil engineer.

The lack of water is a vital problem in many cities, and there is a need to resort to new forms of supply, such as subway water resources, i.e. the use of groundwater. It is also essential to know the degree of water contamination to make this form of supply feasible. Both problems are addressed and analyzed by civil engineers. There are means to determine the rate at which water is contaminated, which is known by means of the infiltration capacity in soils, which is determined by the infiltration meter or by applying Horton's Equation (Aparicio, 2004). In both cases, data collection is important, being in the second case the essential use of graphing in the determination of the type of soil to be evaluated. According to Mongil and Navarro (2012), infiltration is a hydrological process that is one of the main components of the hydrological cycle; therefore, it is a process that has been widely studied and the subject of numerous attempts at modeling, which is not simple due to its large number of factors. The application of a mathematical model is more effective to know the behavior and velocity of this probable pollutant, as well as its radius of action. The connotation of the Modeling Category, according to Cordero et al. (2022), represents a variety of modeling in which a principle is considered: the functionality of mathematical knowledge that is proper to people should be in a reciprocal and horizontal relationship between mathematics and the everyday. Therefore, the water infiltration rate will be studied by means of Horton's equation, in which the use of graphs is essential for the determination of parameters and coefficients for soil characterization. It is through the trend behavior category of the functions that the movement of water through the soil surface and into the soil produced by the action of gravitational and capillary forces is identified (Aparicio, 2004). In the same way, the variation of parameters can be seen when the theoretical curve is adjusted to the real curve. In other words, we see the equation as an instruction that organizes behaviors; it is also a function whose parameters are adjusted in different ways.

References

Aparicio, F. (2004). Fundamentos de Hidrología de Superficie. Limusa.

Cacei (2020). Marco de referencia 2018 para la acreditación de programas de ingeniería. Criterios e indicadores. Recuperado de: http://cacei.org.mx/nvfs/nvfs02/nvfs0210.php#

Cordero, F. (2008). El Uso de las Gráficas en el Discurso del Cálculo Escolar. Una visión Socioepistemológica. Investigaciones sobre enseñanza y aprendizaje de las matemáticas: Un reporte Iberoamericano. Ediciones Díaz de Santos.

Cordero, F., Rosa, M., Clark-Orey, D. and Carranza, P. (2022). Modelling in the Life of People: An Alternative Program for Teaching and Learning of Mathematics. In Rosa Milton, Cordero Francisco, Orey Daniel & Carranza Pablo (Editors). Mathematical Modelling Programs in Latin America. A Collaborative Context for Social Construction of Knowledge for Educational Change. Chapter 1, 17-42. Cham, Switzerland: Springer. ISBN: 978-3-031-04270-6.

Mongil, J. y Navarro J. (2012). Infiltración y grupos hidrológicos de suelos en las laderas de los páramos (Valladolid). Cuadernos de Investigación Geográfica 38 (1): 131-153.

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TOWARD MATHEMATICS EDUCATION ON THE ANTHROPOCENE

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There is an iconic answer from German climatologist Johann Thalhuber to the following question: What is the difference between a 2-degree or a 4-degree increase in the Earth System? He answers: simply our civilization. This remark highlights the urgency and necessity to put the big dilemma of our contemporaneity in our research agenda: ecological collapse. Not just a change or crisis, but rather a collapse. In this scenario, I think is insufficient just try to produce new strategies to teach mathematics or new frameworks to prepare prospective mathematics teachers. The collapse is not a context to apply or build concepts, ideas, and mathematics procedures or even a possibility to produce news theorizations in Mathematics Education. The ecological collapse, an emergency in the Anthropocene, is our survival condition. The idea of Eurocentric Mathematics (binary, neutral, universal), with its ways of thinking (abstractions, generalizations;

inductive and deductive process), institutionalized in the central narratives of modernity/coloniality (improvement, development, and progress) is the big problem.

With these few remarks about one picture of our contemporaneity (of course in different state-nations the situation is different), I propose a research project with the mathematics schools in Brazil, with master and doctorates students in Post-Graduate Mathematics Education and basic school mathematics teachers.

The main objective of this project is to investigate processes of meaning production of mathematics teachers in working groups (WG), with implementations of activities based on everyday life categories, with ecological collapse as a center. Through a qualitative research investigation and taking the Model of Semantic Fields (LINS, 2001) as our main theoretical-methodological reference, we intend to set up working groups with mathematics teachers from Basic Education and discuss, problematize and produce with activities based on everyday life categories related to ecological collapse. The production of data will take place through audio recordings, filming, reports of the meetings, and the production of interviews with participants of the working group. The WGs are constituted, in some cases, with basic school students and, in other cases, with mathematics teachers. One central discussion in the WGs is the Ecological Collapse in attempts to dialogue with other materialities, demands, and problems in post-humanist and post-anthropocentric approaches. It is not a matter of investigating the uses of school mathematics, having as a motto the ecological collapse to contextualize the teaching and learning processes. It is an urgent and necessary invitation to problematize mathematics together with economic, political, philosophical, and cultural processes, with the effects of ecological collapse.

References

Danowski, D. Viveiros de Castro, E. (2022) *Há mundos por vir? Ensaio sobre os medos e os fins.* Florianópolis: Editora Cultura e Barbárie,

Latour, B. (2021) Onde Aterrar? Como se orientar politicamente no antropoceno. Rio de Janeiro: Bazar do Tempo.

Lins, R. C. (2001) The production of meaning for Algebra: a perspective based on a Theoretical Model of Semantic Fields. In: Sutherland, R. *et al***.** *Perspectives on School Algebra*. (pp. 37-60) Netherlands: Kluwer Academic Publishers.

Viola dos Santos, J. R. (2018) Grupo de Trabalho como Espaço Formações (ou: arte de produzir efeitos sem causa). *Perspectivas da Educação Matemática*. (UFMS 11(26), p. 365-392. https://periodicos.ufms.br/index.php/pedmat/article/view/7701

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EPISTEMIC CULTURE OF CLIMATE MODELLING

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In the confident discipline of climate sciences, there has been no denying that uncertainties exist all the time, this shaky and yet so confident discipline left the Humboldtian climatology behind as the new age models in this discipline added to the uncertainty, when it also said, “all models are wrong but some models useful” (Box, 1976). Nevertheless, climate sciences and specifically, the modeling community continues to draw expertise from varied epistemes, forming an aggregate of ‘epistemes’ and ideally presenting itself in favor of the unity of the sciences in the form of CLIMATE SCIENCE. In effect, a kind of political exercise, the desire for such modeling comes from the ambition to take action, to do something, in an *urgent* mode of action. Climate change and science with all this uncertainty, urgency, and risks around are best understood as post-normal science, wherein the science is not just to be limited to the fundamentals inside a laboratory,

but is informed by a desire for a reflective knowing, wherein the facts remain uncertain and values are in dispute, and TRUE scientific facts simply don't determine the correct policy conclusions (Funtowicz & Ravetz, 1993). Going away from the old Humboldtian climatology after the cold war years, the new holism of the models and climate sciences imagined the "Earth as a system", and of the complete unity of variable complex systems within. This reduction of "the Earth to a system", wherein one system out of this whole could be manipulated and understood in isolation, was to reduce the earth's socio-ecological complex to a purely physical system(s). This strides away from the real socio-ecological complex, where the earth is not just about one unit of ecology, but an aggregate of ecologies, distributed around. The models project unity but are in fact a messier form of science. This latter fact ultimately exposes their uncertainty. The post-normal science models began by taking over the discipline of Humboldtian climatology but now are spread far beyond. The inseparability of social, ecological, health, spatial, and political issues of the climate change issue and yet the reduction to mere equations, simulations, and epistemic cultures leaves out another dimension of participation and continuous dialogue between, with, and amongst the socio-ecological for participating in this post-normal form of science. The present study tries to examine the specifics of how climate modeling is done vis-à-vis socio-ecological complexes. The methodology followed is active participation in two workshops related to modeling with the objective to understand the models as well as the epistemic practices. While another component would deal with community perspectives related to the climate and their approach to understanding climate and climate change. In so far as the study problematizes climate modeling exercises, the aim remains to basically effectively critique the mathematics behind it.

References

Box, G. E.P. (1976). Science and Statistics. *Journal of the American Statistical Association*, *71*(356), 791-799. https://www.tandfonline.com/doi/abs/10.1080/01621459.1976.10480949

Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the post-normal age. *Futures, 25*(7), 739-755. https://doi.org/10.1016/0016-3287(93)90022-L

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MATHEMATICS EDUCATORS SUPPORTING PRE-SERVICE TEACHERS TO ENGAGE STUDENTS IN ENVIRONMENTAL SUSTAINABILITY

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This research focuses on how mathematics teacher educators can support and encourage pre-service teachers to engage their students in environmental sustainability issues through mathematical modelling. As part of the new curriculum in Norway (Ministry of Education and Research, 2017), schools shall facilitate students' learning of sustainability and develop competencies in making responsible choices, acting ethically, and with environmental awareness (p. 15). In the national guidelines for teacher education (National Council for Teacher Education, 2016), it is stated that teacher education should qualify pre-service teachers to teach sustainability as an interdisciplinary topic, supporting students

"learning about, attitudes to and actions for" sustainability (p. 9). Barwell (2018) describes that mathematics education has an important role in contributing to an understanding of the challenges of environmental sustainability due to the prevalence of mathematics in these issues. For instance, mathematical modelling is part of describing, predicting and communicating about climate change. Barbosa (2006) emphasises how mathematical modelling can be an approach to important societal issues relevant to students' daily lives. Examples from a mathematics teacher education course (1–7th grade) and three teacher educators are used to reflect on how mathematics teacher educators can support and encourage pre-service teachers to engage students in sustainability issues. Empirical data includes PowerPoint slides from the teacher educators and pre-service teachers' mandatory assignments. Preliminary findings show that the teacher educators used the mathematical modelling activity as an entry point to engage their pre-service teachers in critical societal issues, like sustainability and climate change issues. They exemplified how this could be done with students, initiated discussion and collaborative work, referred to relevant literature, and encouraged their pre-service teachers to use mathematics to facilitate students' interpretation, descriptions, and predictions of their reality. They were raising awareness of and enabling students to take a standpoint towards environmental issues. Developing environmental awareness, acting ethically and making responsible choices as a citizen, a student, a pre-service teacher, or a teacher educator is not straightforward. Therefore, mathematics teacher education needs more research on implementing these issues in their teaching.

Plan for discussions: The presentation will include interactive questions guiding the following discussion.

References

Barbosa, J. C. (2006). Mathematical modelling in classroom: A socio-critical and discursive perspective. *ZDM, 38*(3), 293–301. https://doi.org/10.1007/BF02652812

Barwell, R. (2018). Some thoughts on a mathematics education for environmental sustainability. In P. Ernest (Ed.), *The philosophy of mathematics education today* (pp. 145–160). Springer.

Ministry of Education and Research. (2017). *Verdier og prinsipper for grunnopplæringen - overordnet del av læreplanverket [values and principles for primary and secondary education].* Retrieved from https://www.regjeringen.no/no/dokumenter/verdier-og-prinsipper-for-grunnopplaringen/id2570003/

National Council for Teacher Education. (2016). *National guidelines for the primary and lower secondary teacher education programme for years 1–7.* Retrieved from https://www.uhr.no/_f/p1/i9667e583-aa3b-4f25-a8fe-64af8b199072/national_guidelines_for_the_primary_and_lower_secondary_teache

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ENGAGING HIGH SCHOOL STUDENTS IN MATHEMATICAL MODELLING FOR CRITICAL CITIZENSHIP

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The growing globalization and rapid technological advancement influence all of individuals' lives. These advances are accompanied with greater challenges which every person has to face. To prepare students for this obscure reality, education experts devise mechanisms to enhance the teaching and learning approaches; thereby, helping students become ready for their future. More specifically, mathematics teachers are encouraged to provide teaching and learning activities that will help students connect mathematics and the world, as well as encourage students' active engagement in classes. One approach in innovating teaching and learning is mathematical modelling. Its integration to school curricula is important

in order to prepare students for their day-to-day experiences and professional lives. This preparation necessitates the development of a strong sense of agency among students where they can be equipped with knowledge, skills, and attitudes to meaningfully contribute to society, its people, and events, within the environmental, economic, and social contexts. The development of student agency is viewed to be an important consideration when designing learning tasks for students.

This ongoing study is anchored on the theoretical perspectives of critical mathematics education (CME) of Skovsmose (1994), which support addressing social development issues and views mathematics education as a contributor towards critical citizenship. This study makes use of the theory of human agency by Bandura (2001) in describing student agency in learning mathematics. The transdisciplinary lesson and unit framework by O'Donnell (2018) is also considered in organizing mathematical modelling tasks on solid waste management.

This study focuses on discussing mathematical modelling tasks centred around solid waste management issues. This teaching innovation assists high school students not only in the improvement of their mathematical understanding, but also in strengthening their environmental education. By creating mathematical modelling tasks in this way, high school students can learn to become more concerned about their natural and social environment, and can come up with strategies for a sustainable living; thereby, indicating that mathematics is understood to develop critical citizens. In this way, students' perceptions towards learning mathematics may be enhanced, allowing them to understand the utility of mathematics in the world, and develop in them mathematical understanding and critical citizenship.

References:

Bandura, A. (2011). Social cognitive theory. Handbook of social psychological theories, 2012, 349-373.

Jazby, D. (2017). Is Mathematics Education Worthy? From Mathematics for Critical Citizenship to Productivity Growth. Mathematics Education Research Group of Australasia.

OECD 2030 Learning Framework

O'Donnell, C. (2021). Discover, Understand, Act: A STEM Education Framework for Empowering Youth to Address the Global Goals. Diplomatic Courier, UNGA 2021 Special Print Edition.

Skovsmose, O., & Niss, M. (2008). Critical mathematics education for the future. In ICME-10 Proceedings: Proceedings of the 10th International Congress on Mathematical Education. IMFUFA, Roskilde University.

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TRANSFORMING THE CULTURE OF MATHEMATICS EDUCATION RESEARCH TO EMBRACE SUSTAINABILITY VALUES

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My role editing a major journal in the field of mathematics education is a commitment to reflect the values of the field but also to lead the field. Balancing these is a tension. Recently, I have been asked to share my views about the appropriateness of journals in our field expecting authors to address sustainability goals—as part of the plenary panel of the upcoming Psychology of Mathematics Education (PME) conference. My poster at this ICME symposium will outline my ideas in progress on the question. Conversations with colleagues during the poster session would be an opportunity for me to prepare for the panel discussion, and also a source of dialogue and wisdom for my editorial roles. I expect these

conversations will be valuable to others too: I will ask what they can do to promote sustainability values.

The climate crisis is closely intertwined with social crises. Crisis theorists explain how these combined social forces underpin increasingly frequent global crises with increasing intensity. Our field is increasingly accepting of the validity and importance of research that addresses socio-political aspects of mathematics education. Some see this change as a socio-political turn, others see it as a split in the field. Not all scholars in our field address socio-cultural aspects. I see that the field's take-up of environmental sustainability is further behind yet.

Global movements to recognize the importance of climate- and social-crises, coupled with our field's weak uptake of these things, motivates reflection on how scholars could move the field. Questions I want to discuss include:

1. Is it enough to have some strong work addressing socio-cultural and environmental crises? Or should our field expect *all* studies to justify themselves in terms of social and environmental needs?
2. Whose voices and perspectives would adjudicate whether a study's justifications address social and environmental needs sufficiently?
3. How could key people (committed to promoting sustainable communities and environments) draw the field toward responsible action?

In brief, my tentative plan for the PME panel is to say that in ten or fifteen years the field will expect scholars to justify their studies in terms of sustainability needs because the social and environmental conditions will make this increasingly compelling. The field is not there yet. But savvy scholars will begin to justify their work in these ways. Those first adopters will be cited a lot as the field grows to

recognize the warrant for this kind of justification—especially the scholarship that justifies in this way studies that are not directly related to sustainability.

As a climate activist/organizer in my community, I am compelled to reflect on all my actions in terms of sustainability. I do not usually explicitly relate my research and teaching focused on positioning and culture as efforts for sustainability. But I could justify my choices in this way. I hope to lead others to consider their scholarly choices through this lens.

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EXAMINING SOCIO-ECOLOGICAL FACTORS THAT INFLUENCE TEACHERS' ADAPTIVE EXPERTISE IN INTERDISCIPLINARY MATHEMATICS AND SCIENCE IN PRIMARY EDUCATION

Wanty Widjaja, Colleen Vale, Amanda Berry, Jan van Driel, Lihua Xu, Joe Ferguson, & Gahyoung Kim

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In contemporary education contexts, teachers are increasingly expected to become adaptive experts who respond to unfamiliar, unexpected, and complex situations quickly, and apply professional knowledge flexibly, innovatively, and creatively. While the notion of adaptive expertise is not new (Hatano & Inagaki, 1986; Hatano & Oura, 2003), its characteristics and development remain an under-researched

area in education (Soslau, 2012; Anthony, Hunter & Hunter, 2015) with limited empirical evidence regarding either "the characteristics of adaptive teachers or their impact on students" (Parsons et al., 2018, p. 207). As a critical component of quality teaching, adaptive expertise is essential for teachers to innovate their teaching to enhance student learning and interest, yet little is known about its development.

Empirical research on teachers' adaptive expertise has illustrated how teachers learn and develop effective teaching behaviours through situation specific observations and interpretations of their actions in these situations (Allen, Matthews & Parsons, 2013; Anthony, Hunger & Hunter, 2015; Yoon et al., 2019; Männikkö & Kusu, 2019). Yoon et al. (2019) argue that discipline-specific adaptive expertise "addresses the need to not only have acquired content and pedagogical knowledge, but to have a deep understanding of it in order to use such knowledge effectively" (p.892), as well as flexibly and deliberately.

An ecological perspective in education research focuses to understand children's learning and development (see e.g., Esmonde, 2009; Spencer et al., 1997). Louie and Zhan (2022) adapted Bronfenbrenner's (1977) five layers of socio ecological framework: individuals' learning, development, sense making and experiences; moment-to-moment interactions through which learning occurs; constellations of meanings and relations in semi stable local settings; interrelations between local settings; and extra local structures, practices, and ideologies and drew on van Es et al (2022)'s notion of "multidimensional [teacher] noticing" to highlight "the importance of coordinating attention across multiple layers of social activity" (p. 367).

This paper will report on a case study of five teachers from two primary schools in Victoria, Australia. The teachers worked in pairs to co-design, co-teach, and co-

reflect the interdisciplinary lesson series. Using cross-case analysis of the interview data, teacher annotations on lesson plans, and video fragments for each lesson sequence, teacher adaptive expertise related to teaching interdisciplinary mathematics and science will be examined. The initial analysis focuses on the first two layers of Louie and Zhan's (2022) socio-ecological framework to better understand how adaptive expertise can be fostered in the context of interdisciplinary mathematics and science. Practical implications of socio-ecological research for fostering primary school teachers' adaptive expertise in interdisciplinary mathematics and science.

III

Symposium 2

These abstracts were accepted for presentation at Symposium 2 on 20th March 2023

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EPISTEMOLOGICAL THOUGHTS: MATHEMATICS EDUCATION TO SUSTAIN THE COMMONS

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In 2021, UNESCO introduces Four Pillars of Education to Sustain the Commons. The common is "what is shared, commoning as what is done together, and the common good as what is built and cared for by individuals together": *1. Learning to co-construct together* – To highlight the social dimensions of learning, this pillar orients towards *learning together*. Pillar one also acknowledges the diverse and networked dimensions of knowledge. *2. Learning to collectively mobilise* – The second pillar is related to skills that enable collective action. Focusing on collaboration capability this pillar aims to empower learners to take action. *3. Learning to live in a common world* – the challenge for humans living on planet earth is to make healthy, sustainable ways of co-living: with one another and with the planet" to engage with "common humanity and with the natural world of which we

are a part". *4.* The fourth pillar is created to attend to the balance of individualism and relationality, by emphasising *learning to attend and care*. This pillar puts our relationships with one another and with a more-than-human world at the centre of our practices of teaching and learning. These four pillars of education to sustain the commons are fascinating but at the same time they raise a question: What epistemological perspectives could underpin these pillars? In addressing these questions, I use the concept of the interrelation epistemology (Abtahi, 2022).

Interrelation epistemology

This epistemology starts with an understanding of what knowledge is. Interrelation epistemology does not see individuals in possession of intellectual ability. Instead, knowledge is perceived as knowing one's 'position' in interpreting and engaging with the webs of other things that one is in relation with. Here, the aim is to capture the idea that knowledges are mutually dependent and are interrelated to one and the common.

Similar to the UNESCO (2021) argument, interrelation epistemology is not in search of understanding how one becomes to know a specific knowledge (such as fractions or algebra). Instead, this epistemology is seeking to understanding the position of relationality that the acquired knowledge puts the individual in. That means the question moves away from "how do we better teach fractions to students so that they learn it, even better?" The question instead becomes: "by knowing fractions, what webs of others and things the child becomes in-relation with?" As being *-in-relation* implies, this former question leads us to not only think about fraction as a knowledge, but also think about ethics and responsibilities that comes by being-in-relation (to other humans and things) by acquiring that knowledge. Here, the knowing (the knowledge of fractions) does not only make the individual

knowers powerful, but also it provides basis for an understanding of relationships and interdependencies. This understanding of knowledge (as one's position in the network of relations with other things) immediately brings forth two crucial elements of being in-relationships: ethical awareness and responsibilities.

References

Abtahi, Y. (2022). What if I was harmful? My experience of teaching of the dominant mathematics *Educational Studies in Mathematics Journal.* 108. 1-17. https://doi.org/10.1007/s10649-021-10117-1

UNESCO (2021). Reworking Four Pillars of Education to Sustain the Commons. Retrive from https://en.unesco.org/futuresofeducation/ideas-lab/sobe-reworking-four-pillars-education-sustain-commons

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THE MAGICAL ECOLOGY OF MATHEMATICS: A GRAND ABSTRACTION FOR RECONNECTING OUR BODIES TO OUR ENVIRONMENT

Peter Appelbaum

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Is ‘mathematics’ the medicine we need to heal our planet? Are mathematics educators healers? David Abram (1996) described magicians he met, rarely understanding their healing work as primary. These magicians rarely live in the heart of the village; they are always out at the edge of the village, among the rice paddies or in a cluster of wild boulders. Their skills sublate human modalities, acting between human and more-than-human communities (animals, plants, trees, even whole forests are considered living, intelligent forces). The analogy with mathematics educators is reasonable: any healing result of mathematics education would be a nice by-product of what we do.

The magic of mathematics blossoms when generalizing and introducing representations enables super-human sleights of hand (Mason et al., 1982), conjuring otherwise imperceptible connections and structures, predicting and controlling, inventing and exploring beyond the senses, promoting new relationships with imagination (Appelbaum 2008). Mathematics is such an intense form of animism that it effectively eclipses all of the other forms of animistic participation in which we might otherwise engage— with leaves, stones, winds … In its most caricatured form, mathematics is a magic epitomizing a detached, distanced, dominating, colonizing relationship with our environment. With Abram, we might declare: "I don't think there is a way … to really woo our culture back into a reciprocal or sustainable relation with the land until we draw folks back to our senses, because our sensing bodies are our direct contact with the rest of the natural world. It is not by being abstract intellects that we are going to fall in love again with the rest of nature. It's by beginning to honor and value our direct sensory experience" (Abram, in London, 2023).

One might conclude that embodied, outdoor, environmental tree-hugger math can heal our planet. I instead present a collage of snapshots from my embodied mathematics seminars that use magical mathematical arts to challenge learners in examining their relationship to their bodies – juggling, origami, kumihimo, African dance, etc. Intersecting questions trigger activity and community: "What does a representation accomplish – as magic, as detachment from our senses, as reclamation of relation with the Earth?" and "How can mathematical magic be a by-product of a different kind of healing?" The primary seminar work uses the mathematical arts to heal relations in our village and with our land, to balance equilibrium between humans and the more-than-human. The snapshots illustrate theoretical directions for socio-ecological mathematics education.

The magicians Abram met simultaneously offer prayers and ritual gestures to the other animals, and to the powers of the earth and the sky; without this, they might heal someone in the community and someone else would fall sick, and then they would heal that other person, and someone else would fall sick. The (mathematical) magician's task is to ensure from the edges of our village that we always return something back, to maintain a two-way flow guaranteeing that that the boundaries between human culture and the rest of nature stay porous and overlapping.

References

Abram, D. (1996). The spell of the sensuous: Perception and language in a more-than-human world. Vintage.

Appelbaum, P. (2008) Embracing Mathematics: on Becoming a Teacher and Changing with Mathematics. Routledge.

London, S. (2023). The ecology of magic: An interview with David Abram. http://scott.london/interviews/abram.html.

Mason, J., Burton, L. & Stacey, K. (1982) Thinking Mathematically. Addison Wesley.

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THE CLIMATE IS CHANGING. AND WHAT ABOUT MATHEMATICS EDUCATION?

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Mathematics classes in engineering education generally discuss mathematical topics that arose before the 18th century; causal and linear relationships typical of the deterministic paradigm are presented; and, without expressions of the use of mathematics in other non-mathematical subjects or in engineering. Climate change imposes new challenges on engineers, thus requiring knowledge and skills that are underemphasized or ignored in their current training. Incorporating climate involves giving an understanding of the fundamentals of climate science and its effects. What mathematics is used and how is it used? Complexity theory allows us to understand the complexity of the phenomenon itself and the sophisticated global response it requires. In this paper we present some elements of the problem, the literature review and the theoretical-methodological basis of a doctoral research in

the making, within the Soltsa Socioepistemological Program (see Cordero et al. 2022, for more details). Cordero et al. (2022) propose a Socioepistemological modelling category that favours the learning of the meanings of mathematics from the construction of reference frameworks based on an epistemology of uses of mathematical knowledge to value, in mathematics education, the functional justification demanded by other disciplines. Based on the category of mathematical modelling (Cordero et al., 2022) and a capitalocene perspective, we propose two phases for the study. First, to construct an epistemology of the uses of mathematical knowledge with a capitalocene perspective in a situation of climate change. And, second, a didactic-experimental one, where the epistemology of uses of mathematical knowledge is strengthened and the uses of mathematical knowledge of engineering students are analyzed. This will be done with the support of the technological tools at our disposal to recreate this type of situations, simulation through agent-based modelling. It is intended to build a proposal to introduce in the mathematics class, nonlinear relationships and a functional mathematics of a pressing problem of humanity, climate change.

References

Cordero, F.; Mendoza-Higuera, E. J.; Pérez-Oxté, I.; Huincahue, J. & Mena-Lorca, J. (2022) A Category of Modelling: The Uses of Mathematical Knowledge in Different Scenarios and the Learning of Mathematics. En M. Rosa, F. Cordero, D. Orey & P. Carranza (Eds), Mathematical Modelling Programs in Latin America. A Collaborative Context for Social

Construction of Knowledge for Educational Change (pp. 247-267). Springer, Cham. https://doi.org/10.1007/978-3-031-04271-3_12

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“THE TIMES THEY ARE A-CHANGING”: A NEED TO DEVELOP RISK LITERACY

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Contemporarily we are witnessing an increase of the number of crises worldwide. All these macro-crises add micro-crises (Skovsmose, 2021) to challenges people face day by day. Mathematics education looks for ways of coping with this growing uncertainty, in research, curriculum reforms and teacher education. However, research, reforms and change in teacher education are slow processes. As the problems are pressing, we can neither wait until our sluggish school systems change and adjust teaching. We rather need to prepare students for their future world *now*, helping them to improve resilience.

In line with this, we conduct a design-based-research study on developing risk literacy in stochastics education in school. Design-based-research has two advantages. It enables us to iteratively design a lesson series that fosters developing

risk literacy and – in its cyclic procedure – it directly researches the implementing of the design, leading to conceptualize risk literacy and theorize the teaching-learning processes to identify conditions that most likely foster risk literacy.

Risk literacy is demonstrated by the ability to handle uncertainties in an informed way, in most cases related to both the probability and the expected value of an unwanted event. According to Martignon & Hoffrage (2019, p. 31) two aspects are relevant: Identification of risks and uncertainties, and decision. Leaning on these aspects, risk literacy can be developed through statistical reasoning where recognizing and critically evaluating uncertainties and risks are involved (Gigerenzer, 2012). In doing so, one's relationship to risk influences evaluations and decision processes, whereby a component of care comes naturally into play, for example care in relation to oneself, and the environment we live in. Therefore, developing risk literacy involves an ethical component guiding the research questions: *What are key facets of risk literacy in statistics education in school? Which conditions foster the development of risk literacy?*

To answer these questions, our design and data analyses will be informed by Inferentialism (Brandom 2000) and its assumption that students define and redefine concepts, e.g., risk, in the Game of Giving and Asking for Reasons (GoGAR) when solving statistical problems of decision-making (Bakker & Derry, 2011).

In our design we have employed risk in combination with the use of probabilities, expected value, mean value and dispersion related to statistical problems of decision-making the students could cope with. The problems provided space for decision-making processes related to statistical key concepts and individual risk-relationships. We conducted three iterative design cycles of a lesson series in grades 9 and 10; our data consist of video recordings, students' worksheets and field notes.

Besides a preliminary concept of risk literacy based on various facets we identified, we have made a crucial observation: While the two early career teachers easily provided the students with space for expressing their relation to risk and care, the experienced teacher did not, although he was open-minded and the lesson series was carefully prepared together with him. This finding substantiates a well-known phenomenon: teaching practices developed over years resist a-changing. Open-mindedness, didactical material and didactical instruction are not enough to change teaching.

References

Bakker, A., & Derry, J. (2011). Lessons from inferentialism for statistics education. *Mathematical Thinking and Learning,* 13(1–2), 5–26. https://doi.org/10.1080/10986065.2011.53829

Brandom, R. (2000). Articulating Reasons. Harvard University Press. https://doi.org/10.4159/9780674028739

Gigerenzer, G. (2012). Risk literacy. In *This will make you smarter: New scientific concepts to improve your thinking* (pp. 259-261). Harper Perennial.

Martignon, L. & Hoffrage, U. (2019). *Wer wagt, gewinnt? Wie Sie die Risikokompetenz von Kindern und Jugendlichen fördern können*. Hogrefe. https://doi.org/10.1024/2235-0977/a000283

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

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WHO'S AFRAID OF THE BIG BAD WOLF? HOW MATHEMATICS MEDIATES OUR RELATIONSHIPS WITH OTHER SPECIES AND SOME IMPLICATIONS FOR EDUCATION AND RESEARCH

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In February 2021, the Wisconsin Department of Natural Resources established a quota of 119 wolves for the first permitted wolf hunt in many years. Hunters succeeded in killing 216 wolves in less than 3 days. A subsequent study modelled the wolf population in the state in April 2021 as being 695–751 individuals, amounting to a 27–33% decrease compared with one year earlier (Treves, Santiago-Ávila & Putrevu, 2021). At a time of mass extinction and a biodiversity crisis, this behaviour seems like madness. Similar hunts or culls have been reported elsewhere in North America and Europe in recent years.

When I first read about this cull, as well as feeling quite disturbed, I noticed that the reports included quite a bit of mathematics. I have observed before that mathematics is used to describe, project and communicate about biodiversity, climate change and other ecosystemic questions (Barwell, 2018). I have also noticed that mathematical information referred to in public news reporting is often just the tip of a substantial amount of mathematical work and which can be incorporated into government policy, political debates or polemics. The news about the Wisconsin wolf cull seemed to fit this pattern.

In this presentation, I take the Wisconsin wolf cull as a case of mathematics mediating the relationship between humans and other species. I examine some of the mathematics behind the headlines to illustrate how mathematics can be part of an overarching narrative of human domination and control of other species and of the ecosystem in general. This narrative is deeply embedded in the discourses of late-modern capitalism. Prompted by critical mathematics education, I then turn to the question of how this mediating relationship can be uncovered, questioned and reworked in the context of mathematics education, whether in school, teacher education or research. My tentative response involves setting mathematics in relation to ways of knowing less often considered in mathematics classrooms. I exemplify these ideas with reflections on poems and stories about wolves as a counterpoint to mathematical narratives.

References

Barwell, R. (2018) Some thoughts on a mathematics education for environmental sustainability. In Ernest, P. (Ed.) *The philosophy of mathematics education Today*, pp. 145–160. Springer.

Treves, A., Santiago-Ávila, F. J. & Putrevu, K. (2021) Quantifying the effects of delisting wolves after the first state began lethal management. *PeerJ: Life and Environment 9*:e11666

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CAN TEACHING MATHEMATICS CONTRIBUTE TOWARDS AWARENESS AND ACTION FOR SUSTAINABLE, JUST FUTURES?

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In this session we wish to address the questions of how we teach the current curriculum and address issues vital to the planet? We consider, given mathematics has a crucial role in modelling and communicating global issues such as climate change, what is our responsibility as mathematics teachers in giving students the skills to be aware of such uses and misuses?

We will discuss possible responses to these questions through considering a particular mathematical task (see: https:// www.metlink.org/climate-change-

secondary-maths- resources/) which was created by the first author and trialled in school by the second author. The resource begins by asking 'What do you notice?' and 'What do you wonder?' in response to watching a video of Greta Thunberg and George Monbiot introducing trees as a natural climate solution (see: https://www.youtube.com/watch?v=-Q0xUXo2zEY). The task goes on to consider the broader question of carbon sequestration from tree planting and how this compares to the rate of deforestation in the Amazon.

Through our work, both in designing and in trialling these resources, we have identified three potential responsibilities of the teacher (Bissell et al., 2022), should they choose to work with their students on learning about maths and climate change:

1. Valuing difference of opinion

It is challenging for teachers to manage differences of opinion and conflicting student beliefs, which may be deeply entrenched. Classrooms where disagreement is allowed and welcome can provide a safe environment for students to talk about difficult issues.

2. Developing critical thinking

We recognise a tension between, on the one hand, offering hope and positivity and, on the other, offering honesty while raising awareness of the scale and seriousness of the climate emergency. By developing students' criticality, we hope to allow them to take ownership of, and trust in, their own senses of hope and reality, supporting them to challenge overly simplistic 'solutions'.

3. Supporting students with managing a greater understanding of the climate emergency

We, as teachers, feel a responsibility to support students, both emotionally and also in how to act upon, and with, any greater understanding of climate change which might result from our work. If our responsibility as mathematics educators ends with the mathematics and raising awareness of the scale of the emergency there is a danger that we communicate to our students that this is *their* problem to solve, not ours. Perhaps we should also be offering ways of acting positively and empowering students to make their voices heard to those in power.

In the session, we will discuss the design considerations (Johnson et al, 2017) behind the task described above and offer some more detail on the experiences of teaching with the task. We will then broaden out to discuss the three issues proposed above.

References

Bissell, A., Malkin, E., McWilliam Woods, J., Rolph, B. and Coles, A. (2022). Can mathematics teaching help save the planet? *Mathematics Teaching 284*, 9-14.

Johnson, H.L., Coles, A. & Clarke, D. (2017). Mathematical tasks and the student: navigating "tensions of intentions" between designers, teachers, and students. *ZDM Mathematics Education 49,* 813–822. https://doi.org/10.1007/s11858-017-0894-0

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SOCIO-ECOLOGICAL POSSIBILITIES IN VIDEO PRODUCTION BY MATHEMATICS TEACHER AND STUDENTS

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This research aims to discuss the potential of socio-ecological discussion as digital videos are produced by students and teachers. Production of video with mathematical content can be understood as a multimodal media that allows teachers and students to express their mathematical ideas through different settings, such as script, clothes, software, orality, and writing, among others. This approach can favor the production of knowledge, especially combined with the motivations and particularities of each student, once they study mathematics to understand and explain the content in the best way on the video (Domingues & Borba, 2021). Discussing teaching and learning mathematics with technology, the

notion of humans-with-media is imbedded in the idea that humans and non-human actors shape each other. During the pandemic, it was possible to realize that housing matters in production of knowledge. It is very different to try to solve a mathematical problem in a crowded house in a slum or in a spacious, luxurious apartment. This was associated with the agency of non-living things, such as the house, internet access, and even the coronavirus changed how humans live, expressing the impact of inequality in knowledge production (Borba, 2021). A socio-ecological perspective in mathematics education - that can be related to video production - emphasizes the importance of considering the perspectives and experiences of marginalized actors, as well as the ecological challenges they face, such as pollution and climate change, and the adaptations they make to address these issues (Coles, le Roux & Solares, 2022). The teaching, research, and outreach project (https://www.festivalvideomat.com/), the Digital Videos and Mathematics Education Festival, which is virtual and f-2-f project based in Brazil, shows this relationship through videos produced by teachers and students with mathematical content, that discuss, for example, the social and environmental impacts of a mining dam collapse that happened in Brumadinho/Brazil in 2018 (GPIMEM, 2020) and another that present the traditional counting of the indigenous Rikbaktsa people (GPIMEM, 2021). This type of real-world topics that students and teachers present in their videos are an example of the potentiality of video production in the mathematics classroom. Students and teachers producing videos with mathematical content can be a potential environment for the socio-ecological perspective in the mathematics education. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001 and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) Grant 309992/2020-6.

References

Borba, M.C. (2021) The future of mathematics education since COVID-19: humans-with-media or humans-with-non-living-things. *Educ Stud Math, 108*, 385–400. Retrieved from: https://doi.org/10.1007/s10649-021-10043-2

Coles, A., le Roux, K. & Solares, A. (2022). Towards a Socio-Ecological Perspective of Mathematics Education. In C. Fernández, S. Llinares, A. Gutiérrez, & N. Planas (Eds.), *Proceedings of the 45th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 171-178). PME.

Domingues, N. S. & Borba, M. C. (2021) Digital video festivals and mathematics: changes in the classroom of the 21st Century. *Journal of Educational Research in Mathematics*, 31(3), 257-275. Retrieved from: https://doi.org/10.29275/jerm.2021.31.3.257

GPIMEM (2020, December 16) Ensino Fundamental - Mar de Lama: Modelagem na Educação Matemática - III FVDEM (Legends in English) [Video file]. Retrieved from https://www.youtube.com/watch?v=YpCteGqjxd0&t=5s

GPIMEM (2021, January 30) 118 Outros Sistema Tradicional de Contagem do Povo Rikbaktsa [Video file]. Retrieved from https://www.youtube.com/watch?v=ATGgiPTwIuw&list=PLiBUAR5Cdi61ylU9-09NUEwqdqtWnsFry&index=7

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WHERE (OR WHO) IS THE MATHEMATICS IN SOCIO-ECOLOGICAL MATHEMATICS EDUCATION RESEARCH?

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Socio-ecological approaches examine learning as emerging alongside an interactive set of influences from different environmental levels, resources, and lived experiences. As early career researchers who are committed to this approach within the context of mathematics education, we often experience the question "where is the math?" as a gatekeeping and dismissive one, implying that this type of work neglects what the audience values the most. In this proposal, we seek to make this question generative, asking it from a stance of curiosity and appreciation to different forms of socio-ecological perspectives across the field. Where and what is mathematics, in complex socio-ecological contexts? Are learners outside the

mathematics they are learning or inside it? Are they learning alongside it or in interaction with it?

We consider various literatures that account for the sociopolitical and socio-ecological contexts of mathematics education. We map these literatures in accordance to where learning has been located with regards to mathematics and how mathematics has been framed. We suggest six initial categories that answer the question "where and what is the math": math as (1) a context, (2) a tool to understand the world, (3) a discipline with a fixed body of content, (4) an historicized practice (5) a governing technology, and (6) an agentic being.

First, research accounting for socio-ecological influences on learning through funds of knowledge, culturally responsive pedagogies, and third spaces models often treats mathematics as a *context* in which learning happens. Second, models of critical mathematics education or social justice mathematics often frame mathematics as a *tool* for better understanding the world (e.g., Gutstein, 2006). These frameworks, however, are sometimes adopted to teach mathematics as a *fixed body of knowledge*– by instrumentalizing students' cultural resources or real-world math problems– which we consider the third frame. By contrast, a fourth approach takes mathematics as a set of *historicized practices and discourses* developed within different communities and cultures, whereby learners develop identities and forms of participation that are recognized within it (e.g., d'Ambrosio, 1985; Sfard, 2008). Some scholars, rooted in the sociological work of Foucault and Marx, treat math as a *governing technology* (e.g., Chronaki, 2018) that disciplines people and power. Others, drawing from Indigenous ways of being in relation with more-than-humans and/or from feminist new materialist ontologies, are framing mathematics as an *agentic being* (e.g., de Freitas & Sinclair, 2013). We imagine there may be many more approaches.

We argue that these "identities" or "locations" of mathematics invite attention to different relationships between learners and mathematics. In this session, we will present an initial mapping of the different approaches to mathematics in different strands of research and share an emerging assessment of what each one offers mathematics education research. Then we will invite audience members to propose additional ways of conceptualizing where (or who) mathematics is or could be, and consider together how expanding our understandings of where (or who) mathematics is and how it functions can enrich the uses of socio-ecological models of learning in teaching and mathematics education research.

References

Chronaki, A. (2018). The unbearable lightness of Dis|appearing mathematics: Or, life and reason for the citizen at times of crisis. *Mathematics Enthusiast, 15*(1–2), 8–35.

d'Ambrosio, U. (1985). Ethnomathematics and its place in the history of mathematics. *For the Learning of Mathematics, 5*(1), 44–48.

de Freitas, E., & Sinclair, N. (2013). New materialist ontologies in mathematics education: The body in/of mathematics. *Educational Studies in Mathematics, 83*(3), 453–470.

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

Sfard, A. (2008). *Thinking as communicating: Human development, the growth of discourses, and mathematizing.* Cambridge University Press.

Note. This work is collaborative, and the authors' names appear in alphabetical order.

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A RAY OF HOPE IN THE SOCIO-ECOLOGICAL TURN IN MATHEMATICS EDUCATION - WHAT DOES IT TAKE FOR GRADE-3 STUDENTS TO BUILD A VILLAGE? THE NEW BRUNSWICK CONTEXT

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Imagine the pristine landscapes of many remote regions in Canada, which generate associations with repose, tranquility, and rejuvenation. Life conditions in remote areas in Canada are expected to also allow their residents to thrive in and through their surrounding environments. Researchers from the CompeTI.CA (ICT Competencies in the Atlantic Canada) network were invited to six schools situated in the Western part of New Brunswick to collaboratively work with local

communities and teachers on social innovation. The initiative involved working with local partners to initiate students into STEAM-related opportunities through making experiences using a variety of materials and technologies (Freiman, 2020). Students and teachers proudly shared with us: "when team members arrived at [one school in western New Brunswick,] they were literally pulled by three Grade 3 students over to a project that filled the foyer of their school. Researchers were soon captivated by a passionate, 40-minute long story about how a [miniature] model [of the] community, made from cardboard, wires, tape, and blinking lights was produced by the students' entire class." (Freiman and Lingley, 2021).

By capturing a process of making, we learned how 9-10 year old students constructed 3D-models of public buildings situated on two sides of the river that crossed their village and the village bridge. The miniature model was connected to laptops where a computer code that the children wrote activated a recording of the story of each building providing visitors with a guided tour (Freiman et al, 2021). In the interviews, students shared their pride of and connectedness with their village. One student said: "it looked like we were the teachers!" With the projects' affordances of rich mathematical experiences, one striking example was brought out by a child who described how they determined the size of each building: "We first looked through the window but it was hard to see how high the buildings are; then it was suggested to take one building as one [unit] and then see that the [one next to it] is a half-high [and] the other is double-high." The children were not merely telling their stories. They were living multiple layers of personal and collective socio-ecological perspectives. It was clear from students' lived experiences that they made their village known to others while being caring hosts. In our presentation at the symposium, we hope to share our insights and examples from students' innovation, creativity, and advocacy and suggest agency and place-

based perspectives to the socio-ecological turn in mathematics education (Chinn, 2012; Coles, 2022).

With this story of children becoming attached with their local community and getting interested in contributing to its growth and development, we suggest a counternarrative to the crisis narrative by bringing the socio-ecological perspective as a paradigm shift in thinking about one's relationship with their environment. Within this perspective, instead of attending to issues framed within environmental racism in the context of Canada, we suggest allowing the introduction of a social innovation that builds paths towards solving local environmental issues. Changing the vector from crisis narrative to agency through the design of 3D constructions of one's village may provide a trajectory to the socio-ecological perspective in mathematics education.

References

Chinn, P. W. (2012). Developing teachers' place-based and culture-based pedagogical content knowledge and agency. *Second international handbook of science education*, 323-334.

Coles, A. (2022). A socio-ecological turn in mathematics education: Reflecting on curriculum innovation. *Revista Paradigma, 43*(Edición temática 1), 207-228.

Freiman, V. (2020). Issues of teaching in a new technology-rich environment: Investigating the case of New Brunswick (Canada) school makerspaces. *STEM Teachers and Teaching in the Digital Era: Professional Expectations and Advancement in the 21st Century Schools*, 273-292, Springer.

Freiman, V., Robichaud, X., & Lingley, J. (2021). Exploration des technologies dans un contexte collaboratif et interdisciplinaire. Source de créativité et de bienêtre pour chaque élève. EdCan, https://www.edcan.ca/articles/exploration-des-technologies/?lang=fr

Freiman, V., & Lingley, J. (2021). Creativity During Pandemic: A Blog Series Introduction. Brilliant Labs, https://blog.brilliantlabs.ca/creativity-during-pandemic-a-blog-series-introduction/

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CIVIMATICS[1] – INSIGHTS OF AN INTERDISCIPLINARY APPROACH TOWARDS MATHEMATICAL MODELLING

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Description of the theoretical and practical work to be presented: Mathematics, as well as mathematics education, comes with a political dimension. A relatively well-known example of this is mathematical modelling, which is an educational goal in many schools and universities worldwide. Current research greatly highlighted the social importance of assumptions and simplifications in modelling (in this context, often described as socio-cultural modelling or normative modelling). However, this found its way only into a few classrooms and curricula until now, and interested mathematics teachers recognize the lack of appropriate teaching materials on this topic. Similarly, in civic education (in other contexts also described as political or

social education), the mathematical background of modelling is often not adequately reflected, so the significance of assumptions and simplifications is not recognized, alternative modelling is not apparent, and results often have to be understood as unquestionable facts. Without a reflection on the role and impact of certain assumptions, the modeling results then prove to be mathematically forced by the exact calculation. As a result, relevant points for discussion are lost, and the societal scope for action can only be insufficiently democratically negotiated.

Within the CiviMatics-Project we thus developed a didactical framework for teaching around normative modelling. Following an interdisciplinary approach to mathematics and civic education, concrete learning scenarios were developed and evaluated in several mathematics and politics school and university contexts.

Relation to the socio-ecological: Originally, we used the context of climate change as a starting point for our materials on normative modelling (e.g., modelling a carbon footprint of different food; modelling subventions around heating; modelling scenarios around electromobility). However, evaluating our learning scenarios and gaining empirical insights with students and teachers, we realized specific potentials and challenges that came with our setting (e.g., the interdisciplinarity of socio-ecological issues and subject cultures in contrast). Thus, we are now trying to integrate further perspectives for a greater framework for teaching about the socio-ecological.

Plan for session time: A short project presentation of the developed framework, as well as learning scenarios, will be given. Empirical insights of the scenario's evaluation will be presented and discussed with a focus on socio-ecological education.

References

Niss, M. (2015). Prescriptive modelling: Challenges and opportunities. In G. A. Stillman, W. Blum, & M. Salett Biembengut (Eds.), *Mathematical modelling in education research and practice* (pp. 67–80). Springer.

Reinhardt, S. (2013). Teaching for democratic learning. In M. Print & D. Lange (Eds.), *Civic education and competences for engaging citizens in democracies* (pp. 99–109). Rotterdam: Sense.

Skovsmose, O. (1994). Towards a critical mathematics education. *Educational Studies in Mathematics, 27,* 35–57.

[1] CiviMatics is co-funded through the ERASMUS+ program of the European Union. See www.civimatics.eu for further information as well as a list of all project members who contributed.

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BECOMING A MATHEMATICS TEACHER FOR CLIMATE JUSTICE

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We face unprecedented challenges in the world today. Issues of ecological sustainability such as climate change, loss of biodiversity and depletion of natural resources are impacting on all of our lives and futures. Some societies are more exposed than others to the direct impacts of climate change, and certain policy and practice responses based on mathematical models and related sets of assumptions, can exacerbate or even cause inequitable outcomes within and across nations and between current and future generations. Despite a growing understanding of how mathematics is implicated, at every level, in issues relating to climate change (Barwell, 2013), the National Curriculum for Mathematics in England (Department for Education, 2021) still pays no attention to the intersection of mathematics and ecological sustainability.

With a lack of recognition at policy level, there are few formal professional development (PD) opportunities for mathematics teachers in England with a focus on ecological sustainability. Developments in this area tend to be initiated by individuals who are personally motivated to engage with climate-related issues in their practices. In this empirical study, we explore a small-scale PD programme for secondary mathematics teachers in England, stemming from the personal motivation of two teacher educator-researchers (Tracy and Lauren), with a focus on teaching mathematics for climate justice (a phrase we use to unite the social and the ecological and to capture issues relating to climate change, the ecological crisis, and the associated injustices for societies around the world). Ten secondary (aged 11-18 years) mathematics teachers participated in three full-day workshops over the course of an academic year, designed and facilitated by a team comprising a mathematician, two teacher educator-researchers, a site-responsive artist and curator, a creative writer, and a geographical scientist. Drawing on the expertise of the various members of our interdisciplinary team, we designed the PD around a series of arts-based activities alongside the consideration of formal scientific representations of climate justice, as a way drawing on multiple forms of knowing to support participants in becoming mathematics teachers for climate justice.

For the symposium, we focus on the story of one participating teacher, Karl. We use data collected in the form of recorded workshop observations, field notes and interviews to co-create a layered text (Lather, 1997; Rath, 2012) as a way of expressing and theorising aspects of Karl's becoming in the context of the PD described. The layered text consists of three layers: A third-person narrative telling the story of Karl's becoming in relation to the PD activities; Karl's first-person narrative informed by his journal entries (both during and beyond the PD workshops) and his wider experiences of becoming a mathematics teacher for climate justice; and a formal-analytical layer. During the symposium, we will

'perform' the layered text to demonstrate the complexity involved in navigating issues of climate justice as a mathematics teacher, and to illustrate different ways in which teaching mathematics for climate justice can be realised. Implications from this study for a socio-ecological turn in mathematics *teacher* education will be the focus of a discussion.

References

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

Department for Education (2021). *National curriculum in England: mathematics programmes of study*. https://www.gov.uk/government/publications/national-curriculum-in-england-mathematics-programmes-of-study/national-curriculum-in-england-mathematics-programmes-of-study

Lather, P. A. (1997). *Troubling the Angels: Women Living With Hiv/aids*. Routledge. https://doi.org/10.4324/9780429503429

Rath, J. (2012). Poetry and participation: Scripting a meaningful research text with rape crisis workers. *Forum: Qualitative Social Research, 13*(1), https://doi.org/10.17169/fqs-13.1.1791

Renert, M. (2011). Mathematics for Life: Sustainable Mathematics Education. *For the Learning of Mathematics, 31*(1), 20–26.

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NOTICING MULTILINGUAL AND NON-DOMINANT STUDENTS' STRENGTHS FOR LEARNING MATHEMATICS

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Historically, mathematics education has excluded people from non-dominant communities and focused narrowly on economic and military supremacy. Given the existential threats facing the world (e.g., climate change, pandemics), mathematics education needs to use decolonial and antiracist perspectives to include and support those learners heretofore excluded. Mathematics education needs to include multiple worldviews to enhance and expand the construction of a scientific knowledge base (Medin & Bang, 2014). In order to amplify the voices of historically excluded learners and invite potential innovations, mathematics researchers and educators must acknowledge these voices and the knowledge(s) they bring.

This research paper showcases the strengths multilingual and non-dominant learners bring to school for learning mathematics. We use decolonial and antiracist theoretical frameworks focusing on learners' strengths from two sets of literature, research in mathematics education and in science education. This research assumes that learners from multilingual communities bring assets to classrooms, and the examples we use contradict deficit views of these students as mathematics learners. We summarize and illustrate three recommendations for research and teaching: (1) noticing learners' strengths, (2) recognizing mathematical practices (Moschkovich, 2017, 2019), and (3) "desettling" colonial models to expand what counts as STEM practices (Bang et al, 2012). Although the examples are drawn from classroom-based research in the United States, those theoretical stances and recommendations have important implications that extend to other settings (communities, nations, or learning environments).

Our plan for using the session time (during Symposium 2) is to share two 10-minute presentations that summarize the theoretical framing and assumptions from decolonial and antiracist perspectives and use transcripts or student work to illustrate the recommendations. There will be 20 minutes for discussion of the data in small groups, including of next steps for research and practice.

References

Bang, M., Warren, B., Rosebery, A. S., & Medin, D. (2012). Desettling expectations in science education. Human Development, 55(5–6), 302–318.

Huitzilopochtli, S., Foxworthy Gonzalez, J., Moschkovich, J. N., McHugh, S. R., & Callanan, M. A. (2021). Noticing Multilingual and Non-dominant Students' Strengths for Learning Mathematics and Science. In *Multilingual Education Yearbook 2021* (pp. 155-173). Springer, Cham.

Medin, D. L., & Bang, M. (2014). Who's asking? Native science, western science, and science education. Cambridge, MA: MIT Press.

Moschkovich, J. N. (2017). Considering silence and precision: Communication practices that support equitable mathematical discussions for marginalized students. In R. Hunter, M. Civil, B. Herbel-Eisenmann, N. Planas, & D. Wagner (Eds.), *Mathematical Discourse that Breaks Barriers and Creates Space for Marginalized Learners,* 61-83.Rotterdam, Netherlands: Sense Publishers.

Moschkovich, J. N. (2019). Code-switching and mathematics learners: How hybrid language practices provide resources for student participation in mathematical practices, reasoning, and communication. In J. MacSwan & C. Faltis (Eds.). *Codeswitching in the Classroom: Critical Perspectives on Teaching, Learning, Policy, and Ideology,* 88-113. New York, NY: Routledge.

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A LINK BETWEEN STUDENTS' GRAPH REASONING AND THEIR ATTITUDES TOWARD MATHEMATICS AND GRAPHS

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There is a complex relationship between students' attitudes toward mathematics and their mathematical thinking, and it is essential that researchers engage in methods to embrace this complexity (Goldin et al., 2016). Drawing on Di Martino and Zan's (2011) model, we adopt a multifaceted view of attitude towards mathematics, encompassing emotional disposition, perceived competence, and view of the subject. We report on a mixed methods study in which we employed structural equation modeling (SEM) to investigate a relationship between college algebra students' (n=599) attitudes toward mathematics and their graph reasoning in dynamic situations.

College algebra is an introductory undergraduate U.S. mathematics course with a long list of content topics and texts focusing on procedures rather than concepts. Students of color, lower income students, and first generation to college students are overrepresented in courses such as college algebra, and stakeholders need to work to address systemic challenges inherent in the course design and implementation (Bhattacharya et al., 2020). Our study takes place within a larger project to promote mathematical reasoning and instructional transformation in college algebra.

Employing two different online instruments, an attitude survey and a graphing assessment, we collected responses from 599 college algebra students across four U.S. postsecondary institutions. Students completed the survey and assessment concurrently, near the end of the course. With our attitude survey (see Table 1), we adapted Pepin's (2011) survey, to include open-ended prompts about students' attitudes toward mathematics and graphs. The graphing assessment was an instrument that we developed and validated. It had six items; each included a video animation of a dynamic situation, a check for understanding, four graph selections representing relationships between attributes in the situation, and a text box to explain reasons for the graph selection.

Table 1

Attitude Survey

Item	Prompt
Q1	I like/dislike math because ____
Q2	I can/cannot do math because ____
Q3	Mathematics is ___
Q4	I like/dislike graphs because ___
Q5	I can/cannot make sense of graphs because ____

We used an interpretive approach to qualitative analysis to address complexities in students' attitudes toward mathematics and their graph reasoning. We coded students' attitudes along four dimensions: Positive (e.g., I like math.), Mixed (e.g., I can do math but not when I'm frustrated.), Negative (e.g., I dislike graphs.), and Detached (e.g., Math is about numbers.). We coded students' graph reasoning based on the framework from Johnson et al. (2020), which included four different forms of graph reasoning. After qualitative coding, we transformed the qualitative codes into numerical codes for statistical analysis.

Using SEM, we found a significant relationship between students' emotional disposition and perceived competence to math and graphs (Items Q1, Q2, Q4, Q5) and their graph reasoning. More positive attitudes linked to more robust graph reasoning.

Broadly, with our study, we work to raise the status of reasoning and foreground students' attitudes in courses where skills and procedures have dominated. Implications include expanding what (and who) counts in mathematics to disrupt barriers for students' learning.

References

Bhattacharya, N., Sánchez, A. O., Mosqueda, E., & Cooper, C. R. (2020). Redesigning the gateway college algebra course with inclusive and asset-based pedagogy. In G. A. Garcia (Ed.), *Hispanic serving institutions in practice* (pp. 97–117). Information Age. https://books.google.com/books?hl=en&lr=&id=8KPbDwAAQBAJ&oi=fnd&pg=PA97&dq=+%22college+algebra%22

Di Martino, P., & Zan, R. (2011). Attitude towards mathematics: a bridge between beliefs and emotions. *ZDM: The International Journal on Mathematics Education, 43*(4), 471–482. https://doi.org/10.1007/s11858-011-0309-6

Goldin, G. A., Hannula, M. S., Heyd-Metzuyanim, E., Jansen, A., Kaasila, R., Lutovac, S., Di Martino, P., Morselli, F., Middleton, J. A., Pantziara, M., & Zhang, Q. (2016). *Attitudes, beliefs, motivation and identity in mathematics education: An overview of the field and future directions*. Springer Nature. https://library.oapen.org/bitstream/handle/20.500.12657/27855/1/1002149.pdf

Johnson, H. L., McClintock, E., & Gardner, A. (2020). Opportunities for reasoning: Digital task design to promote students' conceptions of graphs as representing relationships between quantities. *Digital Experiences in Mathematics Education, 6*(3), 340–366. https://doi.org/10.1007/s40751-020-00061-9

Pepin, B. (2011). Pupils' attitudes towards mathematics: a comparative study of Norwegian and English secondary students. *ZDM: The International Journal on Mathematics Education, 43*(4), 535–546. https://doi.org/10.1007/s11858-011-0314-9

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IN THE QUEST FOR JUSTICE: A PEDAGOGICAL EXPERIMENTATION WITH MATHEMATICS AND THE COMMONS IN EARLY CHILDHOOD EDUCATION

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Although the idea of the commons in economy, ecology and political theory is not new, there is a renewed interest today for imagining new governing strategies that could address and, potentially, counter local passivity to neoliberal capitalist enclosures, ecological catastrophes and oppressive injustices over human and nonhuman actors alike and, for this, education including mathematics education is pivotal (Means et. al, 2017, Chronaki & Lazaridou, 2019, Coles et. al, 2022). Facing the devastating socio-ecological problems of our contemporary times that, despite risk, complexity or uncertainty, demand urgent action instead of passivity or denial,

it is timely to consider how we could address them in mathematics education as curricular praxis. Thus, our specific questions are: whether and how complex issues of a socio-ecological nature could enter adequately the mathematics classroom of the early years, how the 'commons' of our ecology could be discussed with young children and, what might be the role played by mathematics to tap into ethical issues of justice as they relate with our commons. In order to address the above questions, the paper reports on a current project aiming to co-create experimental pedagogic spaces that encounter purposefully potential linkages amongst mathematics and the commons. By preparing and staging classroom discussions, events and tasks concerning our earthly resources, our classroom commons, and sharing in justice, the ethical aspects of greed, possession, loss, extinction along with power relations become a matter of concern.

The ethnographic fieldwork concerning this project lasted two months. Methods for collecting data included participant observation, conversational interviews, and reflexive accounts based on fieldwork notes, personal diaries and collegial meetings minutes. The analysis for this paper accounts two interrelated aspects. *First,* on documenting the pedagogical experimentation as a non-teleological process of a continuous series of preparing and performing eventful acts in the classroom that depend highly on teacher's caring and passionate engagement with children's agentic becoming. *And second,* on highlighting some of the significant moments of this process such as; the importance of co-designing and co-creating as an open process/product allowing time for the novel, the joyful or the unexpected, the orchestration of activity focusing on pedagogical work for opening specific concepts and their in-between connections, the inclusion of 'others' beyond the immediate classroom participants (e.g. family, friends, adjacent classrooms, people in the park) that allow children's public presence through the materiality of making stories, artifacts, posters–etc., the emphasis placed on the senses through the

dramaturgic modes of narrative, theater, drawings, choreographies and writing. Finally, the paper reflects on critical dilemmas arising from this project on how we report research on teaching that experiments with socio-ecological challenges and argues that, as this type of work deals with unfolding complex connections across phenomena of, often, an unknown nature, it requires for teachers, researchers and children to act beyond and against the confines of their comfort zones such as standard curriculum or personal knowledge -a move that maybe not everybody is prepared to take, but, still, a necessary one.

References

Chronaki, A., & Lazaridou, E. (2019). *Mathematics Education out in the Rural Scape: Experimenting with a Radical Democracy for the Commons*. 10th International Conference Mathematics Education and Society, January 28 - February 2, Hyderabad, India.

Coles, A., le Roux, K., & Solares, A. (2022). Towards a socio-ecological perspective of mathematics education. In C. Fernández, S. Llinares, A. Gutiérrez, & N. Planas (Eds.), *Proceedings of the 45th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 171-178). PME.

Means, A., J., Ford, D., R., & Slater, G., B. (2017). *Educational Commons in Theory and Practice.* doi: 10.1057/978-1-137-58641-4_2

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PROBABILITY EDUCATION AGAINST YOUTH GAMBLING ADDICTION

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Gambling addiction in young people is growing steadily following the success of online gambling platforms. The relationship between mathematical literacy and the risk of developing gambling problems is not conclusive. Some studies find that young people with basic probabilistic knowledge develop more responsible habits or that problem gamblers have less understanding of the principles of chance (Turner et al., 2008). However, other research, based on simulations, indicates that at the moment of gambling participants make similar errors regardless of their prior probabilistic knowledge (Lambos & Delfabbro, 2007; Pelletier & Ladouceur, 2007). It seems that it is not possible to define a typical profile of problem gamblers, but rather a process of falling ill with common characteristics. In this process, the

first gambling experience plays a decisive role, as it will mark the person's later relationship to gambling (Bărboianu, 2019).

The aim of this project is to offer a first approach to gambling, an alternative to that offered by betting establishments, to young people from an educational centre located in a neighbourhood particularly affected by the problem. The experience arises from the concerns of some of the professors from three departments of the School of Education and Psychology of the University of Cordoba (UCO) regarding the current problem of gambling in the city. The project was funded by the UCO's Social Innova call for initiatives for the transfer of scientific knowledge for social purposes, with the collaboration of an association of gamblers in rehabilitation, neighbourhood associations and the centre's teaching staff.

The teaching intervention follows a project-based methodology. The theoretical contents (combinatorics, Laplace's Rule, dependent and independent events, use of contingency tables and tree diagrams…) serve the general purpose of designing games of chance by groups of students in the 4^{th} year of Compulsory Secondary Education (ESO) (15-16 years old) that will be tested in the celebration of a final casino, attended by students from lower grades as players.

The preventive nature of the intervention, carried out in the 2021/22 school year, was explored from two perspectives: i) to diagnose risk profiles in the relationship with gambling in the students of the whole school (using the CAGI - Canadian Adolescent Gambling Inventory); and ii) to evaluate the effect of participation in the workshop on the myths associated with gambling (GBQ - Gamblers' Beliefs Questionnaire, with pre and post application).

The first results of the GBQ (N pre-test: 72; N post-test: 51) in the 4th ESO participants indicate the validity of the intervention in decreasing the belief in myths related to gambling. In the current academic year, intervention is being carried out in five educational centres with the support of the Provincial Public Administration, incorporating psychosocial awareness workshops into the current intervention (Williams et al., 2012). Additionally, resources for teachers are being developed, such as a teacher's handbook and a training course.

Plan for the session: Contextualisation (4min). Teaching proposal including videos of the implementation in the school (8min). Research proposal (4min). Initial results and current development of the project (4min).

References

Bărboianu C. (2019). The Epistemology of the Near Miss and Its Potential Contribution in the Prevention and Treatment of Problem-Gambling. *Journal of gambling studies*, *35*(3), 1063–1078. https://doi.org/10.1007/s10899-018-09820-1

Lambos, C., & Delfabbro, P. (2007). Numerical Reasoning Ability and Irrational Beliefs in Problem Gambling. *International Gambling Studies*, *7*(2), 157–171. https://doi.org/10.1080/14459790701387428

Pelletier, M. F., & Ladouceur, R. (2007). The effect of knowledge of mathematics on gambling behaviours and erroneous perceptions. *International Journal of Psychology*, *42*(2), 134–140. https://doi.org/10.1080/00207590600788047

Turner, N. E., Macdonald, J., & Somerset, M. (2008). Life skills, mathematical reasoning and critical thinking: A curriculum for the prevention of problem gambling. *Journal of Gambling Studies*, *24*(3), 367–380. https://doi.org/10.1007/s10899-007-9085-1

Williams, R. J., West, B. L., & Simpson, R. I. (2012). Prevention of Problem Gambling : A Comprehensive Review of the Evidence and Identified Best Practices.

In *Report prepared for the Ontario Problem Gambling Research Centre and the Ontario Ministry of Health and Long Term Care*. hdl.handle.net/10133/3121

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MAPS FOR UNDERSTANDING EXPERIENCE. CHILDREN'S SPATIAL DESCRIPTIONS OF THEIR CRITICALLY POLLUTED ENVIRONMENT

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I intend to present an analysis of oral, written, and drawn work of children who live nearby the Atoyac River basin, the third most polluted river in Mexico, due to excessive industrial discharges (Velasco, 2017). That work comes mainly from magazines elaborated by third-grade students in the frame of the *Memorial Museum of the Atoyac River*, a collaborative project between teachers, researchers, and community leaders designed to elaborate and implement didactical proposals to address the socio-environmental problem of the region in school.

My presentation will focus on the spatial references appearing in the magazines, highlighting two main ideas. First, I will point out the relationship between that spatial knowledge and the transformation of the experience that children and their families have had in that disputed territory. To do this, I draw on research related to critical intercultural studies, like the one carried out by Pinxten (1991), that give value to cultural ways of speaking about geography that do not necessarily align with the criteria of space representation used in maps and try to understand their complexity. In particular, I pay attention to how the students imply time and their local knowledge of the river in their space representations.

Secondly, I will pose questions about the conditions under which the maps can be a tool for students to deepen their understanding of the spread of diseases, de-territorialization, and reconfiguration of economic activities, all processes derived from the industrial pollution in the region they inhabit. I refer, for example, to the maps elaborated by toxicologists to show where diseases related to the chemicals contained in industrial discharges are most frequent among the population. Nevertheless, given the considerable complexity of these maps made by experts, the appropriation of them by children is a didactical problem. That is why I also rely on research that tries to build bridges between students' representations of the meso-space, that is, the space they can cover through their daily activities, and the scientific maps; from the didactics of mathematics point of view (Salin, 2004). That is how I consider the pertinence of the study of maps in school, an interdisciplinary curricular content, given its presence in the traditional subjects of mathematics, history, and geography.

I articulate these cultural and didactical approaches with a view on socio-environmental education that highlights the political dimension of ecological problems (González-Gaudiano, Meira-Cartea & Gutiérrez-Pérez, 2020).

References

González-Gaudiano, E.J., Meira-Cartea, P.A., & Gutiérrez-Pérez, J. (2020). ¿Cómo educar sobre la complejidad de la crisis climática? Hacia un currículum de emergencia. *Revista Mexicana de Investigación Educativa, 25* (87), 843-872.

Pinxten, R. (1991). Some remarks on Navajo geometry and Piagetian genetic theory. *Infancia y Aprendizaje*, *14*(54), 41-52. https://doi.org/10.1080/02103702.1991.10822292

Salin, M.H. (2004). La enseñanza del espacio y la geometría en la enseñanza elemental. In C. Chamorro (Ed.) *Números, formas y volúmenes en el entorno del niño*. Ministerio de Educación y Ciencia.

Velasco Santos, P. (2017). *Ríos de contradicción. Contaminación, ecología política y sujetos rurales en Natívitas, Tlaxcala*. Instituto de Investigaciones Antropológicas, Universidad Nacional Autónoma de México.

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USING MIDDLE SCHOOL MATH TO MANAGE RAINWATER

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In the field of mathematics education, there is an almost universal interest in ensuring that students can use mathematics in both school and out-of-school contexts. For example, Smith and Morgan (2016) conducted a study that examined eleven jurisdictions in different countries that pursue the goal of connecting mathematics to the "real world." Mathematics Education (the field of research) has responded to this interest. For example: Realistic Mathematics uses non-mathematical contexts to make mathematical concepts meaningful (Smith & Morgan, 2016). The Modeling and Models perspective (Blomhøj, 2019) takes real contexts as a starting point so that meanings are constructed in the modeling process.

Nevertheless, the purpose of these theoretical frameworks is that students acquire and master (scientificity) specific mathematical objects. However, Cordero et al. (2015) point out that in the school environment, "people who learn in school and in life, who are not scientists a priori, are involved; their attitudes to knowledge are different and therefore derive from justifications that are also different" (p. 19).

In contrast to previous approaches, the Socioepistemological Theory recognizes that the focus on mathematical objects and the emphasis on scientificity in school mathematics are not accidental, but the result of a problematic called the *mathematical school discourse*. This discourse establishes a single system of reason that "breaks with human nature in the construction of mathematical knowledge. Therefore, meanings are socially imposed and legitimized causing the *opacity* of other epistemologies of mathematical knowledge (Cordero, et al., 2015).

In other to confront this mathematical school discourse, Socioepistemology, especially the Forgotten Subject and Transversality of Knowledge Program (SOLTSA for acronym in Spanish) has created *Designs of Socialization School Situation.* These designs intend to transform the *mathematical school discourse* because their epistemological base is the use of mathematics that has emerged from specific situations of communities, where the center is its functionality and not the acquisition of concepts and definitions of objects. These designs treat the opacity of other epistemologies through the *Socialization of Knowledge,* which makes visible current realities where mathematical knowledge is resignified (Cordero, et al., 2015).

The Sustainable Development Goals (SDG) expose some of those realities such as the degradation of our world, and they exhort us to manage natural resources to

stop it (ONU, 2017). SOLTSA sees, in these realities, situations where the use of mathematical knowledge of different communities (school, work, and city) can emerge. Thus, Designs of Socialization School Situation will be structured by those situations and will allow to rescue epistemological plurality and the interdisciplinarity of mathematical knowledge that are absent in the *mathematical school discourse*. (Cordero, et al., 2022)

This research project is looking for a functional mathematics in basic education, in Mexican middle school, where its uses are oriented to the conservation of the planet and the sustainable development of the student community. This objective leads us to ask the following research question: What is the functional mathematics that third year secondary school students build when they face a learning situation about improving rainwater management?

References

Blomhøj, M. (2019). Towards Integration of Modelling in Secondary Mathematics Teaching. En A. Stillman y J. Brown (Eds), Lines of inquiry in mathematical modelling research in education. (pp. 259). Springer Nature.

Cordero, F., Gómez, K., Silva-Crocci, H., y Soto, D. (2015). El discurso matemático escolar: la adherencia, la exclusión y la opacidad. Barcelona, España: Gedisa.

Cordero, F., Mendoza-Higuera, J., Pérez-Oxté, I., Huincahue, J., y Mena-Lorca, J. (2022). A Category of Modelling: The Uses of Mathematical Knowledge in Different Scenarios and the Learning of Mathematics. En M. Rosa, F. Cordero, D. Clark, y P. Carranza (Eds), Mathematical Modelling Programs in Latin America. (pp. 247-267). Springer

Organización de las Naciones Unidas (ONU) (2017). Transformar nuestro mundo: la Agenda 2030 para el Desarrollo Sostenible. Recuperado en:

https://www.gob.mx/agenda2030/documentos/resolucion-de-las-naciones-unidas-para-la-adopcion-de-la-agenda-2030-para-el-desarrollo-sostenible?state=published

Smith, C. y Morgan, C. (2016). Curricular orientations to real-world contexts in mathematics. The Curriculum Journal, 27(1), 24-45.

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ETHNOMODELlING OF A DANCE PALO DE MAYO IN COSTA RICA

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The importance of this study is related to the search for the appreciation and respect for mathematical knowledge that was developed in Costa Rican by the members of traditional dances through their systems of symbols and artifacts. The members of this cultural group developed their own internal logic and decision-making process based on their own cultural elements. The elaboration of the ethnomodels were related to the choreography of the traditional Afro-descendant dance of Palo de Mayo, which represents the province of Limón, in Costa Rica. In this qualitative research, the collected data were analyzed and the results were interpreted to find an answer to the research question: *How does ethnomodeling, specifically, through its ethnomodels, that may be present in the Caribbean dance of Palo de Mayo manage to contribute to the development of a pedagogical action from the*

perspective of Ethnomathematics? Through an adaptation of the Grounded Theory preliminary codes were identified in the open coding process, which were grouped by similarities of conceptions into four conceptual categories through axial coding: a) Emic Approach (Local) of the Traditional Dance of Palo de Mayo, b) Etic Approach (Global) of the Traditional Dance of Palo de Mayo, c) Dialogical Approach (Glocal) of the Traditional Dance of Palo de Mayo and d) Pedagogical Action for Traditional Dances.

Ethnomathematics is recognized as a valid pedagogical action that reinforces creativity, effort, and cultural respect by offering a broad vision of humanity, which increasingly tends towards multiculturalism and cultural plurality. Ethnomodelling is conceived as the translation of local and global mathematical ideas that seek to recognize, value, and respect mathematical knowledge of members of distinct cultural groups (Rosa & Orey, 2010), which, in this case, is the group of traditional dancers, specifically, Palo de Mayo.

In this context, the interest of this project focuses on a proposal related to aspects of anthropological and cultural character from an internal perspective at the culture of traditional dances in Costa Rica. Thus, in order to characterize cultural mathematical knowledge, in the regional perspective of traditional dances, it is intended, in this way, to disseminate aspects related to cultural knowledge and its relation with mathematical knowledge developed in schools.

With respect to the dances of Costa Rica, Vargas (2003) emphasizes that "as in other manifestations of its culture, elements of its environment were used in it" (p. 197). In addition, Valencia, Garcia and Monestel (2010) state that the dance of Palo de Mayo is executed to the rhythm of Calypso limonense, which has its origin in the Antilles, especially in Trinidad, where its antecedents are contemplated in the

colonial period in the framework of slave exploitations. Thus, the calypsonian arose from the urbanization processes that were subsequent to emancipation.

On the other hand, during the session time the thoughts, meanings, context, ethnomodels and opinions of the members of the traditional dances of Costa Rica considered a cultural group will be shared, after knowing this vision of the world from them, this knowledge was related to mathematical knowledge in order to create a pedagogical action that value both kind of knowledge (emic and etic) through the generation of a dialogue that seeks total peace and social justice.

References

Monestel, M. (2010) Nowhere like Limón, Limón is the land of Freedom. La música afrodescendiente en la región caribeña de Costa Rica. En: Monestel, M. (Coord.). Expresiones musicales de la población afrodescendiente de la costa Caribe de Centroamérica, República Dominicana y Haití. Madrid: España: en clave AfroCaribe. pp. 126-163.

Rosa, M. & Orey, D. C. (2010). Ethnomodelling: a pedagogical action for uncovering ethnomathematical practices. Journal of Mathematical Modelling and Application, 1(3), 58-67

Vargas, G. C.(2003) Panorama etnológico de las danzas indígenas. Danzas Regionales - Costa Rica. En: Vargas, G. C. et al. (Coords.). Nuestra música y danzas tradicionales. Libro 5. Serie: Culturas Populares Centroamericanas. San José, Costa Rica: Coordinación Educativa y Cultural Centroamericana, pp. 197-203.

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HOW THIRSTY IS OUR FOOD? EXPERIENCES OF A HIGH SCHOOL TEACHER DEALING WITH ENVIRONMENTAL TOPICS IN THE MATHEMATICS CLASSROOM

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Major local or global issues like climate change, economic crisis, or social justice need consideration from multiple perspectives to find appropriate responses and concern all (school) subjects. Considering mathematics' important role in describing, modeling, predicting, and solving societal challenges and its special importance in legitimizing political decisions, it seems especially important to integrate such topics into the mathematics classroom. The Austrian curriculum explicitly emphasizes the development of an understanding of "political, economic, legal, social, ecological, and cultural" contexts and calls for orientation towards

guiding values such as humanity, tolerance, or environmental awareness (BMBWF, 2022). These goals are to be reached in every school subject. However, within mathematics teaching, the focus still often lies on teaching inner-mathematical knowledge, rules, and procedures without connecting these to real-world contexts.

The presenting researcher and teacher worked together in a year-long workshop with six other teachers. We collaboratively elaborated on the concept of critical mathematics education and possible practical realizations. Thereby the teacher designed a task that dealt with the topic of water consumption of food. A main goal was to use math to question myths about environmental impacts of food production and consumption and uncover the sometimes misleading headlines in newspapers. This allowed students to reflect on their consumption behavior and see how their choices can impact the environment. While the provided data gave them a scientific foundation for their discussion, every student could come up with individual solutions that connected to their personal life, and they experienced using math to understand environmental topics that need to concern all of us. As this doesn't usually happen in math classrooms in Austria, the teacher will report about experienced struggles and benefits and give an outlook on how this experience influenced her way of teaching mathematics. It became apparent that it is a necessity to touch on such topics in the math classroom as some students have never been confronted with such issues before and weren't aware of the role that math plays in describing and analyzing these. Such a way of teaching can contribute to preparing our students to be critical, reflective, and mindful members of our society and might be the much-needed impulse for at least some of them to start acting more environmentally aware.

Session plan:

Interactive introduction to the topic: Facts and Myth related to food and environment

collecting ideas/statements from audience, comparing to headlines from media

How can math help to make sense of these headlines?

Description of CME project/context/task

The teachers' perspective: Struggles and benefits of bringing socio-ecological topics into the mathematics classroom

Outlook: What can we learn from these experiences? What might that mean for future teaching?

Discussion

References

BMBWF (Bundesministerium für Bildung, Wissenschaft und Forschung) Verordnung des Bundesministers für Unterricht und Kunst vom 14. November 1984 über die Lehrpläne der allgemeinbildenden höheren Schulen, BGBl. Nr. 88/1985.

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A PHENOMENOLOGICAL SYSTEMS APPROACH TO THE SOCIO-ECOLOGICAL IN MATHEMATICS EDUCATION

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The aim of this paper is to prompt philosophical discussion in relation to the social, environmental and cognitive aspects of mathematics education to get at a foundational understanding of what socio-ecological might mean in the context of mathematics education. Mathematics education, at least the conceptualization of it, was forged within mathematics itself, and within the discipline of psychology. This is not unsurprising if one ventures back to a nascent system of mathematics in antiquity, and where it was reflected upon in ancient Greece; the relationship between thought, reason, mathematics, and the learning of such abstraction and abstractive processes were inextricably intertwined then. It is in the latter part of

the 20th century that the role of *the social* and *communication* takes a legitimate place in institutional academic discourse. What Lerman characterizes as the social turn in mathematics education. Yet we approach the socio-ecological, in mathematics education research, from a field of study embedded in the dichotomies of the psychological and the sociological. Moreover, sociology regards itself as in and of the social, and where the ecological (and what I refer to here as the environment and the ecological as systems/environment distinctions) is external. Therefore, a socio-ecological comprehension of mathematics and mathematics education requires some philosophical treatment to conceptualize the distinctions between the cognitive and the social and the ecological (and the environmental). A line of philosophical thought that has engaged with the nature of distinctions or dichotomies is phenomenology with a major contribution by Husserl (1900–1901/2001). Phenomenology's gaze is on the distinction rather than awarding ascendancy to either side whether it is a distinction between subject and object or between idealism and realism. The point for Husserl is that one side of a distinction is precipitated from the other side of a distinction that is unknowable but contains all possibilities also. This is a considerable challenge to the aspiration of completeness after the Enlightenment and as an ontology that underpins European modernity. Luhmann (1989)simplifies and generalizes distinction as the distinction between system and environment. Systems theory posits a system as something that is distinct from its environment, phenomenologically. Consciousness is a system that is distinct from an environment, an externality – the distinction between abstraction and reality – and in that external reality there is the social and communication and there is a material world. Similarly, in the environment of the 'social' are systems of consciousness, which in modern society are characterized as 'individual', and the material and physical world. It is from this phenomenological and systemic interpretation of the relationship between consciousness, society and a material world that there is the most productive and potentially viable way to

investigate the socio-ecological in relation to mathematics education. A key contribution of systems theory to phenomenology is an understanding of the role of social and cognitive structures and relationships in 'representing' and even simplifying the external world. The difference system-environment is where uncertainty is crystallized and where structures form, endure deform and disintegrate. An overarching question that is comprehended abstractly by systems theory is how can social systems like, for example, mathematics education, while embedded and implicated within society's impact on the environment also contribute to insights into the problem even if it recognizes the limits of its own self-referentiality?

References

Husserl, E. (2001). *Logical investigations* (D. Moran, Trans.). Routledge. (Original work published 1900–1901)

Luhmann, N. (1989). *Ecological communication*. University of Chicago Press.