TROC-IMAC: Towards the development of a framework for designing big data and sustainability-inspired mathematics tasks

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The emergence of global interconnectivity has opened up numerous opportunities to explore and understand the complexities of social phenomena (Pauwels, 2019). Engaging with global problems can be challenging because of their multidimensional and multidirectional nature, thus requiring multidisciplinary approaches. Leveraging the power of big data allows for more efficient problem-solving approaches in addressing complex global issues that necessitate sustainable solutions. By harnessing the potential of mathematics and data analysis, we not only unlock the ability to visualize information but also equip ourselves with the tools to analyze global challenges critically and suggest responses that yield sustainable outcomes (Barwell, 2013). Furthermore, teaching mathematics for sustainable development offers an opportunity to prepare students to both read (understand) and write (transform) the world through mathematics (Gutstein, 2006), while developing critical thinking, ethical awareness, and social responsibility (Ananiadou & Claro, 2009).

Adopted in 2015 as part of the United Nations' 2030 agenda towards a better and transformative world, the Sustainable Development Goals (SDG) framework represents 17 goals based on pressing needs that require attention, urging all nations to plan, act and measure progress such as *SDG1 No poverty*; *SDG 2 Zero hunger*; *SDG 3 Good health and wellbeing* (Williams, 2021). The integration of sustainability into mathematics education is an emerging and rapidly evolving field. As of now, there is no universally accepted model guiding this integration. However, scholars such as Silveira and Petrini (2018) argue that mathematics, due to its inherently interdisciplinary nature, offers unique opportunities to explore real-life and environment-related contexts. Technology, particularly digital tools and big data, play a key role in helping students connect mathematical thinking to pressing global challenges.

Over the past few years, there has been a shift in educational priorities from national initiatives that promote lifelong learning and technological integration. Notably, in October 2022, Edmonton, Alberta, became Canada's first city to be recognized as a UNESCO Learning City. Furthermore, provincial education standards reflect this evolution. For example, Alberta's Teacher Quality Standard (TQS) mandates the integration of Information and Communication Technology (ICT) across all K–12 curricula, including Mathematics and Science. Similarly, New Brunswick's curriculum reform, aligned with its 10-Year Education Plan, prioritizes the development of numeracy and STEM competencies while promoting career-readiness. Objective 8 of the plan specifically highlights the importance of equipping students with mathematical and financial literacy skills. This objective also recognizes the relevance of real-world learning contexts, particularly those aligned with the United Nations Sustainable Development Goals (SDGs).

The SDGs offer a compelling framework for education by addressing urgent global challenges such as poverty, climate change, and inequality. Williams (2021) notes that incorporating SDGs into classroom practice allows educators to present subject matter within relevant contexts, enabling students to apply their learning to both local and global issues. In Alberta, for instance, the Science, Technology, and Society (STS) curriculum aims to build STS literacy through a blend of knowledge, skills, and attitudes—ranging from inquiry and data analysis to collaboration and environmental stewardship. A dedicated section in the Grade 9 curriculum bridges mathematics with STS themes, reinforcing the interdisciplinary nature of real-world problem solving.

New Brunswick's science curriculum echoes these goals by emphasizing the development of scientific literacy. Through investigative processes, students engage in activities such as interpreting data, modeling trends, and evaluating quantitative information. These practices naturally align with mathematical thinking and support the integration of sustainability themes into mathematics education. However, as Silveira and Petrini (2018) argue, a universally accepted model for teaching sustainability through mathematics is still emerging. They stress the importance of incorporating global and environmental contexts to foster students' awareness and capacity to address contemporary planetary challenges.

Since a wide range of big data and open data platforms are now publicly available and accessible for educational use, teachers can draw from both global and local sources to create meaningful tasks. Resources such as *Callysto*, *Cartogram*, *Gapminder, Statistics Canada*, enable students to analyze authentic data sets, make predictions, and engage in discussions about sustainability from a mathematical modeling perspective. For instance, learners might use the Gapminder interactive tools to graph CO_2 emissions across different countries, calculate population growth rates, or model the relationship between education levels and income inequality for further questioning and search for solutions.

Grounded in the theoretical perspectives of critical mathematics education and sustainable development, our ongoing study (Yaro et al., 2024) examines the following research question:

How might critical mathematics education and sustainability inform and guide the development of a framework for teaching big data and sustainability-inspired mathematics tasks?

Drawing on Chiasson and Freiman (2022), a collaborative study we conducted with teachers, in-service and pre-service from grades 7-12 since 2023, explores the potential of integrating data science into mathematics teaching and learning. Our aim is not to propose data science as a standalone subject in schools, but rather to reimagine its integration into mathematics education to create a space for sustainability education—leveraging big data to create meaningful, real-world learning opportunities. Through this lens, big data becomes a potential bridge to connect students with global challenges and local realities. The mathematics classroom thus becomes a critical space for exploring equity, environmental responsibility, and systems thinking. It is yet not clear how this space would look like and what kind of activities would foster interdisciplinary connections. How to design and implement them with students?

Based on the first results from our work with teachers, as well as synthesis of literature from key studies such as UNESCO (2017) T*extbooks for sustainable development,* Gutstein (2006), Yaro et al (2020), Geiger et al's (2023) work on STEM Capabilities Set (SCS) for teachers, we propose a framework—TROC-IMAC. This framework identifies eight essential dimensions for designing big data-inspired mathematics tasks aligned with sustainable development goals such as deforestation awareness (*SDG 15 Life on land*), hunger (*SDG 2 Zero hunger*) and so on. These elements include tools: **R**eal and reliable data, **O**pen dialogue/participation, **C**ritical orientation, **I**nterdisciplinary connections to SDGs, **M**athematical literacy experience, **A**ction, and **C**ollaboration. In this presentation, we will provide examples of how these elements can serve as a model for educators interested in designing mathematics tasks that are meaningful, socially relevant, and driven by real-world data. Engaging in such tasks with students not only contributes to building their number sense, statistical reasoning (data visualization and analysis), and modelling skills, but also feeds the discussions about real-life issues that are global in nature within the context of mathematics learning. While the pedagogical value of using real-world data is well-documented, little is known about how mathematics teachers can effectively incorporate big data sources to support education around Sustainable Development Goals (SDGs). This concern was further reinforced in the work of Alsina and Vásquez (2024), as teachers expressed a strong need for targeted training and resources to effectively integrate sustainability concepts into mathematics. The TROC-IMAC model proposed in this paper highlights the importance of providing sustained support to empower educators to use big data in ways that advance social justice and sustainability goals based on its essential dimensions.

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