

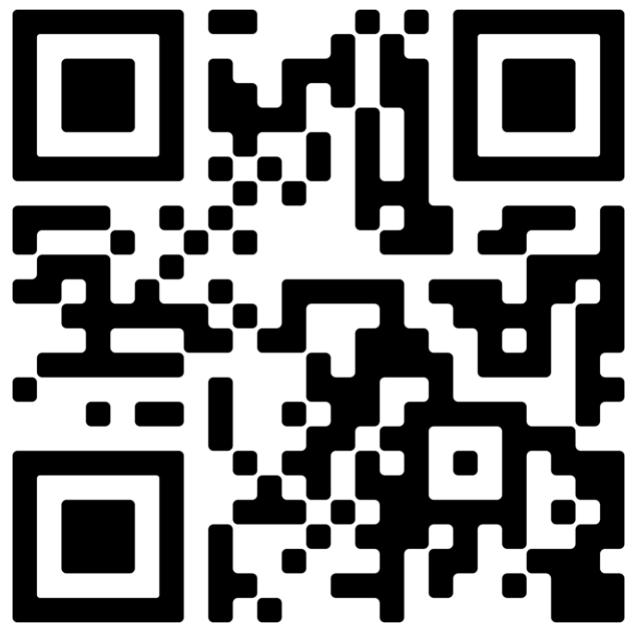
Project Overview

Introduction to the Fall 2023 - Winter 2024 Undergraduate Research Award Project

The goal of this research project is to create innovative lesson plans and activities to teach secondary students the application of mathematical concepts in the use of big data to inquire about real-world issues in connection with the United Nations’ (UN) Sustainable Development Goals (SDGs) and social justice. While there are many online resources offering lesson plans pertaining to the SDGs, most are situated in the context of primary education and very few approach the issues from a mathematical perspective, opting instead for more social studies or humanities perspectives. This project is unique in that it examines SDG related issues through a secondary mathematical lens, using age-appropriate concepts from the Alberta curriculum and open source emerging digital tools.

The resources developed for this project also aim to foster the development of critical consciousness in students. Critical consciousness is the ability to recognize and analyze systems of inequality and the commitment to take action against these systems (El-Amin et Al., 2017), and was a concept developed by the Brazilian educator Paulo Freire. Although Freire’s area of expertise was in literacy and not mathematics, the principles of recognizing, analyzing, and taking action to change inequitable systems remain relevant to mathematics education (Gutstein, 2006). By incorporating activities to position students as agents of social change, this study aims to:

- [Support high school mathematics teachers](#) to create activities or tasks using big data to develop students’ data literacy skills in a context of real-world issues as part of interdisciplinary STEM-related projects.
- [Involve students in the exploration of real data](#) from UN databases and other credible big data sources to increase their understanding of global issues related to SDGs.
- [Empower students in taking actions](#) to resolve issues relating to sustainability based on data science and mathematical modelling.



Teaching & Learning Mathematics for Sustainable Development
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Sustainability

Sustainable Development and the United Nations

This project’s lessons are guided by the “2030 Agenda for Sustainable Development”, a framework developed by the United Nations (UN) and adopted by all of the Member States in 2015 (United Nations, 2015). In this Agenda, the UN defines seventeen sustainable development goals (SDGs) which are intended to end poverty, promote equality, and protect the planet (United Nations, 2015).

Each of the tasks and lessons developed by the research team featured one of the seventeen goals, and explored the roles that mathematics and data play in monitoring and evaluating the success of the measures put in place to address those goals.



Big Data in Mathematics

Big Data Sources and the Alberta Math Curriculum

In order to track the progress of the SDGs as the target deadline of 2030 approaches, the UN utilizes enormous amounts of data that are recorded by governments, private companies, and charities around the world. In this study we conceptualize big data as online resources that have access to large data sets, with tools to help the user organize or visualize data in a manner that is accessible to secondary mathematics students in Alberta.

One of the four main strands in the Kindergarten to Grade 9 Mathematics Program of Studies is “Statistics and Probability (Data Analysis)”, which focuses on the skills required to “collect, display and analyze data to solve problems” (Alberta Education, 2016). Those skills are developed further in high school through topics such as patterns, relationships, and uncertainty (Alberta Education, 2008).

These “big data” sources, then, offer opportunities to build on the mathematics fundamentals that students learn about in the isolated environment of the classroom, giving them an opportunity to see how those same principles apply to data collection and analysis in the context of the real world.

- Some of the online tools that were used in this project included:
- Worldometer - live numerical data on population and resource metrics;
 - Gapminder - interactive graphs and maps;
 - Statistics Canada - data, articles, and tools designed specifically for Canadian citizens, using information from federal agencies.

Critical Education

Teaching Mathematics Through a Social Justice Lens

If mathematics is treated like a language, students can establish critical consciousness through deliberate mathematics instruction. The study draws on the ideas proposed by Eric Gutstein (2006) for teaching mathematics for social justice based on Freire’s principles of critical education. For this project, the lesson plans focus on three critical pedagogical goals outlined in Gutstein’s framework:

1. **Reading the mathematical word** - establishing a solid foundational knowledge of pure mathematics, so that the students have the technical ability to access and understand the concepts when situated in new contexts.
2. **Reading the world with mathematics** - understanding the socio-political and cultural-historic contexts of how mathematics is used in society, from local communities to the international political landscape, and how that affects different social groups.
3. **Writing the world with mathematics** - practicing reflecting on the systems that create social inequities, developing a sense of social agency, and taking meaningful action to correct the inequities in the learners’ communities.

These lessons are intended to build on learners’ understanding of mathematics (i.e. their ability to read the word) by introducing new contexts in which those mathematical concepts are used and providing opportunities to analyze and question those applications (i.e. reading the world), and finally offering suggestions for the students to enact meaningful change in their communities (i.e. writing the world). Encouraging action from the learners is also an important feature of this project: while there are many online lesson plans that teach about the UN’s SDGs, only some incorporate elements of mathematics and even fewer, if any, encourage the learners to take direct action.

Implementation

Bringing Critical Mathematics for Social Justice into the Classroom

Several lesson plans have been developed for use in secondary mathematics classrooms in Alberta. Each lesson plan:

- Features one of the United Nations’ seventeen SDGs
- Incorporates commonly available big data resources and tools
- Targets outcomes from the Alberta Mathematics programs of study.
 - “Statistics and Probability (Data Analysis)” strand in Kindergarten to Grade 9
 - “Relations and Functions” or “Statistics” topics in Grades 10-12

These lesson plans were developed by members of the research team, and then given to a small group of volunteer teachers and pre-service teachers to trial in their classrooms. The lesson plans are also freely available online, published by the University of Alberta, and will be updated with new lesson plans as the project progresses.

Qualitative Results

Based on observations conducted during the delivery of the lessons, the research team gained some valuable insights into what parts of the tasks could potentially be explored further for implementation in the future.

- Students were very engaged when exploring the features and capabilities of digital tools like Gapminder. Several students finished the assigned work for the class, then continued to experiment with the graphing and plotting tools.
- These lessons are meant to inspire students to develop social agency, which is difficult to cultivate during a single one-hour lesson in a classroom setting. In the future, these lessons would likely be more impactful if several classes could be dedicated to the project: this would allow students to better understand the stakes of the SDGs and the issues’ connections to the Alberta mathematics curriculum.
- Observing teachers expressed their appreciation for the fact that these lessons explored real-world applications of mathematics, rather than simply presenting the abstract and sometimes difficult to follow “pure math” to the students.

References

1. Alberta Education. (2008). *Mathematics grades 10-12* [Program of studies]. <https://education.alberta.ca/media/564028/math10to12.pdf>
2. Alberta Education. (2016). *Mathematics kindergarten to grade 9* [Program of studies]. https://education.alberta.ca/media/3115252/2016_k_to_9_math_pos.pdf
3. El-Amin, A., Seider, S., Graves, D., Tamerat, J., Clark, S., Soutter, M., Johannsen, J., & Malhotra, S. (2017). Critical consciousness: A key to student achievement. *Phi Delta Kappan*, 98(5), 18–23. <https://doi.org/10.1177/0031721717690360>
4. Frankenstein, M. (1983). Critical Mathematics Education: An Application of Paulo Freire’s Epistemology. *Journal of Education*, 165(4), 315-339. <https://doi.org/10.1177/002205748316500403>
5. Gutstein, E. (2006). *Reading and Writing the World with Mathematics Toward a Pedagogy for Social Justice* (pp. 21–38). Routledge. <https://eds.p.ebscohost.com/eds/detail/detail?vid=1&sid=4c94d9f2-265b-4cd3-a073-c7c65eccc1687%40redis&bdata=JnNpdGU9ZWRzLWxpdmUmc2NvcGU9c2l0ZQ%3d%3d#AN=alb.9962491&db=cat03710a>
6. United Nations. (n.d.). Sustainable Development Goals Poster [Online image]. In *United Nations*. Retrieved September 21, 2024, from <https://www.un.org/en/file/57285>
7. United Nations. (2015). *The 17 Sustainable Development Goals*. United Nations Department of Economic and Social Affairs: Sustainable Development; United Nations. <https://sdgs.un.org/goals>