



# Interdisciplinary Capstone Symposium

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UNIVERSITY OF  
**WATERLOO**





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Engineering



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Environment



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Mathematics

## Associate Deans' Message

Welcome to the Interdisciplinary Capstone Design Symposium! A pilot from the Faculties of Engineering, Environment, and Mathematics — expanding to other faculties in years to come. In line with Waterloo@100, this symposium brings together a selection of projects primarily related to the Global Future theme of sustainability, from across multiple faculties.

Participating students are from Environment and Business, Computer Science, and a variety of Engineering disciplines including: Chemical, Civil, Computer, Electrical, Management, Mechanical, Mechatronics, Software, and Systems Design Engineering. All students, instructors, and TAs, were co-located in the Ideas Clinic, creating opportunities for multidisciplinary and interdisciplinary interaction and collaboration at all levels.

Capstone is the culmination of the undergraduate student experience, providing a critical opportunity for students to showcase their ingenuity and design skills — in the classroom and beyond. Capstone encourages teams to engage with real-world problems outside the classroom, as a transitional educational experience to the larger scopes and longer timelines (even longer than co-op!) that they can expect to see in their careers.

Opportunity/problem identification, background research, ideation, empirical work, and evaluation are universal elements of capstone. These elements can have varied realizations in different disciplines, with some common threads. For example, some teams from all three faculties took TCPS2 training and engaged with some form of human subject interaction. Engineering learned PESTLE analysis from Environment. CS students got help building physical devices from Engineering. Environment/Business students connected Engineering projects to broader scopes and real deployment contexts. CS students were inspired by Environment students to choose sustainability-oriented projects. All teams benefited from presenting to and hearing from more diverse audiences.

Thank you to capstone clients, project sponsors, expert advisors, TAs, support staff, W Print, and the Ideas Clinic. Capstone is truly a team effort at every level. Your contributions are essential to and have enriched the educational experience of the students. Your leading examples of caring and commitment have helped to launch the students into their careers as compassionate and knowledgeable professionals. Thank you.

Students: Congratulations on your hard work and accomplishments! We are proud of you and your inspiring projects. We are confident that you will do great things after graduation. Best wishes on your next adventures!

Jason Grove, Engineering  
Johanna Wandel, Environment  
Cecilia Cotton, Mathematics



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# 1 Turbopumps for student rockets

## Team TurboPump

Turbopumps for use in rocket engines were developed during the second world war, and are a requirement for rockets to leave Earth's atmosphere. For a rocket engine to operate efficiently, the propellants must be at a high pressure when entering the combustion chamber. To store propellants at high pressure, heavy tanks must be used. By using turbopumps between a rocket's propellant tank and engine, propellants can be stored at low pressures resulting in significant weight savings. A turbopump consists of a pump driven by a hot gas turbine at very high speeds.<sup>1,2</sup>

Turbopumps are generally considered one of the most complex parts of rocket engine development, and as of yet, have not been used in any student team rockets. By developing this technology, we can pave the way for student design team turbopump development, and open the gates for a new age of Canadian rocket engine development.

The goal of this project is to develop the technology and knowledge at the student team level for future students to use turbopumps on liquid propellant rockets. By creating this technology with our available resources, we are paving a path for future students, and industry partners to follow. Turbopumps are challenging because they require very precise and careful integration between the mechanical, hydraulic, and electrical components within.

The scope of the project is not to develop a "flight-ready" system, but rather to demonstrate the feasibility of the small-scale pump-fed engine concept by building a working prototype. The goal is that the technology developed, and lessons learned from this project could be used in future work done by the Waterloo Rocketry Team.

By the end of our project, we intend to test of all components demonstrating the capability of the technology to operate without significant faults, and meet specified design goals in a full test using water as the operating fluid. Our goal specifications are to design a turbopump that produces a total power of 64 kW (86 HP), spins at 35000 rpm, and produces a pressure rise of 580 psi in fuel flowing at 10.7 lb/s.



ABM Hussein, Roman Kobets,  
Artem Sotnikov, Aaron Leszkowiat,  
Lana Tomlin

## 2 Hydroponics for Toronto foodbanks Team HydroBud



Jiayu Li, Alexis Windatt,  
Katie Franken, Laura Menezes,  
Rumaisha Qadar

HydroBud envisions utilizing advanced hydroponics technology and evolving automation to implement vertical hydroponics units within Toronto food banks and community organizations. This initiative aims to alleviate the food insecurity crisis low-income communities face by addressing the current food supply challenge.

### 3 Safe milk supply chain in East Africa Team Safi

East Africa has the highest global incidence of milk-borne disease,<sup>3</sup> with 30% of deaths in children under 5.<sup>4</sup> This is due to a lack of access to safe and quality milk, with up to 90% of milk in East Africa being sold by small scale milk sellers in the informal, unregulated market.<sup>5</sup> The challenges of the current dairy supply chain are burdened by many factors, but most importantly the lack of adequate traceability and tools to ensure safety.



Martin Turuta<sup>δ</sup>, Daria Margarit<sup>δ</sup>,  
Miraal Kabir

To address this problem, we founded Safi in March of 2021.

We have patented the world's first, small-scale pasteurization control unit targeted towards small-scale dairy farmers and vendors. The device kills milk-borne diseases all while retaining the key nutrients of milk. It is affordable, powered by renewable energy sources, and allows farmers to easily pasteurize their differentiating daily yields.

After travelling to Rwanda, Kenya and Uganda in September of 2023 to pilot test the device, our team realized that our hardware solution needs to be combined with a software solution to address inadequate traceability and to track pasteurization data from the device so that farmers can prove to regulators that they used it.

This project has focused on adding a digital tracking system to the core of the product that remotely records milk pasteurization data and centralizes production information for regulators. This data is stored in our devices ESP-32, sent via bluetooth to our app on a farmers phone and then sent to our database when they have wifi or data connection on their phones.

The software has been tested in our lab in Waterloo by imitating different use and edge cases that would occur by using our software. Although the initial tests had to be conducted in Canada and not in Africa due to travel constraints, after demonstrating the efficacy of our lab tests, we are working in collaboration with the Rwandan and Kenyan ministry of agricultures to pilot our software this April with 100s of farmers.

<https://www.safi.world/>

## 4 A DIY in-home aeroponics system

### Team Aeroculture



Darby Smyth, Frederick Kwan,  
Leon Han, Edna To

An aeroponic system is a method of growing produce that suspends plants in an enclosed container, allowing their roots to grow without a growing medium. The roots of each plant hang in the container where they are exposed to atomizer nozzles that mist a nutrient solution directly onto the roots. Aeroponic systems are used to grow plants up to 3x faster according to NASA<sup>6</sup> and with 90% less water according to the World Economic Forum<sup>7</sup> than conventional soil growing, making them ideal for communities in remote areas

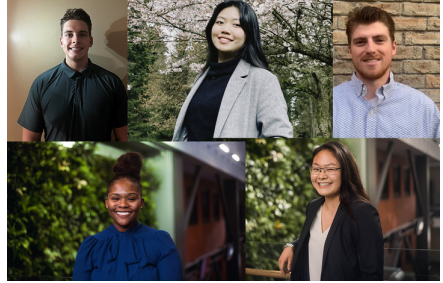
like Northern Ontario where land is infertile, sparse, and groceries are more expensive.<sup>8</sup> However, already-built systems are costly,<sup>9</sup> and constructing one from scratch can require a strong background in plant biology and engineering.

Our solution was a DIY aeroponic system that can be put together like IKEA furniture which required no technical background and helped make improve food security. This system targeted users in remote, Northern Ontario communities who spend higher proportions of their income on groceries and offer an investment in a product that, in the long run, will save them money.

Due to time constraints, our system was limited to growing beans and leafy greens (i.e. crops that grow fast); root vegetables like potatoes and carrots were not viable with the MVP. We gauged success with two main questions: “Is our system easy to put together?”, and “Does our system grow crops faster than conventional soil growing?”. To test ease to put together, potential users in the appropriate demographic were given an instruction manual to assemble our product; metrics included assembly time, number of questions asked, and mean scores from the System Usability Scale (SUS). To test if crops grew faster in our aeroponic system compared to conventional planting, two groups of crops were grown simultaneously – one control group (aeroponics) and one conventional soil grown group – and each day, plant height was measured. After 2 weeks, the means will be compared to determine any significant differences in growth.

## 5 Aeroponics/Hydroponics recommendation framework Team How to Grow It

"Food insecurity is a widespread problem where individuals or communities lack consistent access to enough affordable and nutritious food to support a healthy and active life. We aim to provide a solution to this issue through the use of aeroponics. Our research will explore different aeroponic systems to create a framework that gives recommendations and information to users on which system to get/build and which product should be grown. We aim to support the development of food sovereignty and resilience in community-led food systems in Canada. "



James Torrance-Perks, Karen Chen,  
Sharlene Nguy, Kayla Wickham,  
Dominik Kerekes

## 6 Naturalizing campus spaces

### Team Naturalized Spaces



Muyang Li, Jonathan Ho, Ruiyang Ai,  
Charlotte Zhang, Junhong Huang,  
Ikkshita Vinaya

The project titled "Developing a business case for naturalization" analyzes the potential values of the University of Waterloo campus naturalization. It aims to address social barriers to sustainable landscaping, this initiative involves reviewing landscaping standards, examining naturalized spaces, and conducting stakeholder analysis. The project aligns with UN Sustainable Development Goals, focusing on enhancing biodiversity, improving student well-being, and promoting sustainable urban development. Recommendations will be

based on the economic, environmental, and societal benefits of naturalized landscaping.



## 7 Invasive plant species detection with AI Team ATARRA

Our project is an invasive plant species identifier which leverages AI to identify *Phragmites australis* from aerial satellite imagery. *Phragmites australis* is a major invasive species in bogs and wetlands throughout Ontario. In fact, it is one of Ontario's worst invasive species, and it out-competes native wetlands plants, depriving frogs and turtles of their vital habitat.<sup>10</sup>

Our project is an artificial intelligence tool which identifies regions of likely *Phragmites australis* infestation, along with an application for viewing these results. Users can upload satellite images and shape files containing location information to the application, and they receive a heat map showing the likelihood of *Phragmites* being present in that region.

At the time we began the project, there were no commercially available software products focused on the detection of invasive plant species using satellite images. There were some research groups with similar projects centred around detecting *Phragmites australis* as well as other invasive species.<sup>11</sup> However, the most common solution for invasive species identification was "Ground Truthing", where landowners and park rangers trek over large properties to check whether or not the invasive species is present. We hope that conservationists can use our tool to optimise this existing labour-heavy method. Ground truthing can be more targeted and less frequent if they can predict where invasive *Phragmites* is likely to be

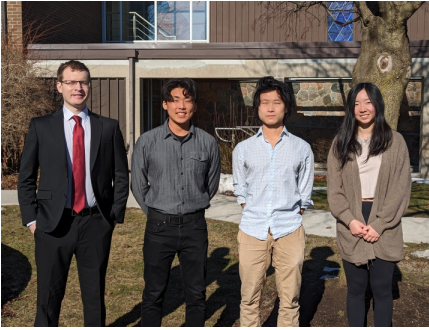
We divided our data into training and testing splits, which allowed us to evaluate the accuracy of our AI model after training. This method allowed us to predict its performance on unseen data. We also used several metrics to quantify and track the accuracy of our machine learning model during development, including intersection over union, precision, and recall. These are commonly used in image segmentation problems like ours.<sup>12</sup>



Ryan Dancy, Amir Roshankar,  
Alex Van De Wiele, Aariana Singh,  
Raymond Zhou, Taya Davison

## 8 A vibration-detecting bike lock system with alerts

### Team BikeLogs



William Ancich, Jerry Xing,  
Gavin Dan, Veronica Leong

Bike theft is a prevalent problem in modern developed societies. It is of particular concern in high-traffic areas, such as dense cities and school campuses.

The overwhelming majority of stolen bikes are never recovered, and many bike thefts go unreported to the police at all. We aim to solve this problem by providing a reliable way to detect bike theft when it is being conducted.

Bike theft can be generalized into two phases: deterrence (before theft) and recovery (after theft). Readily available market options for deterrence are steel U-locks. These locks are easily defeated in minutes using battery-powered angle grinders, which are portable enough to be carried by thieves. For recovery, many popular market options include some GPS location-tracked tag. This functionality provides little use when the stolen bike is moved far away, when the battery dies, and may put the owner in danger by incentivizing a dangerous confrontation.

Our team focused on the deterrence phase since recovery is difficult even with law enforcement, who typically ignores small property theft. Our team designed a vibration-sensing attachment that fits onto existing market U-locks. This attachment sends an alert to the owner's phone when it detects an angle grinder attack, which typically produces characteristic vibration patterns in the metal of the lock.

The technical functions of the attachment are straightforward - to accurately detect vibrations, and to alert the owner properly. For the first, an accurate yet power-efficient signal processing algorithm was used, as well as ensuring the detection covered different angle grinder disc speeds and lock metal compositions. For the second, a notification with a large range and fast delivery was implemented.

Results are measured using the metrics of missed detections rate, false alarm rate, and device lifetime on a full battery charge.

## 9 Encouraging transit use in the City of Waterloo Team Transport for Waterloo

The City of Waterloo has several sustainable transportation options including buses, trains, and an electric bike scooter rental program. Yet, emissions from transportation account for about 50% of greenhouse gas emissions in the city. Despite the infrastructural improvements to the public transit system, there is still significant private vehicle use. Our capstone project aims to identify barriers that prevent residents from using public transit and develop solutions that could encourage them to use public transit more frequently based on the results of local surveys.



Muhammad Aziz, Preet Bhamrah,  
Enakeno Isaac-Onwah, Samuel Kumi,  
Kosisochukwu Adaobi Nwagbara

## 10 Proposed transit loop for London Team Transport for London



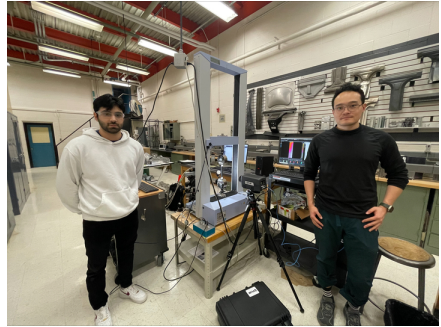
Samson Walsom, Ben Loates,  
Ishaq Mian, George Handal

Our capstone project focuses on encouraging public transit use in London, Ontario. We're assessing ridership demand and evaluating the benefits of a new Transit Loop System for major employers in the area. Through various means of primary research, we've analyzed prominent business hours and have identified strategic points between London and St. Thomas for transit development. By understanding demand and points of interest, we're confident in our ability to improve transit accessibility and efficiency in the area.

# 11 Damage Detection in Fiber Reinforced Polymeric Composite Materials

## Team Composite Damage

The use of continuous fiber reinforced polymeric composite materials is becoming more prevalent in different manufacturing applications due to its favourable high stiffness and lightweight characteristics. It is particularly useful in aerospace and automotive industries where durable lightweight structures are preferred due to their superior aerodynamic performance.



Hamad Qazi

Having said this, it is important for stress analysts and engineers to be able to predict the behaviour of this material and to determine how the material behaves under fatigue loading. This involves an in depth understanding of crack propagation theory in composite materials.

The crack propagation sequence in composite materials is very different to that of metallic alloys and can not be predicted through the use of traditional Linear Elastic Fracture Mechanics (LEFM). Unlike metallic alloys, composite materials are brittle and will not deform before reaching ultimate failure. This highlights the importance of early detection of micro cracks in the composite material prior to the onset of failure. The focus of this project will be to investigate and further develop the use of a thermographic technique that will be used to monitor the fatigue damage induced within composite materials. The release of heat energy within the composite material matrix upon crack initiation is a key indicator for damage detection. The Infrared Thermography (IRT) technique will involve using an infrared camera to analyze the temperature variation within the composite material as it is being subject to fatigue loading.

The overall aim of this project will be to establish a connection between the thermographic imaging of the material under fatigue load and the resulting failure of the material that will ultimately serve as a pro active damage detection tool.

## 12 Circular economy for drinking cups

### Team Circular Cups



Kayla Chutter, Eman Khan,  
Virginia Xu, Aedan Bell

Society's insatiable consumption of single-use plastics and their waste mismanagement have devastating impacts on our environment, marine life, air quality, and more (UNEP, 2018). One promising, long-term, systemic solution that will have even broader cultural impacts, is transitioning all possible industries to a circular economy model (USEPA, 2023). The purpose of this study is to examine and analyze current perceptions, barriers, and opportunities that event spaces in Vancouver have

in regards to the prospect of switching from single-use to reusable cups and containers.

## 13 EV3 Café carbon calculator Team Café Carbon

Our team aimed to develop a carbon calculator and collaborated with the marketing team to create and promote a food label on carbon footprints, using EV3 Café as an example. The scope of our calculator focuses on the transportation of food products, and the final calculator is intended to be presented in Excel format.



Yihan Lu, Jia Qin, Qi Qi,  
Xiangyun Wang, Xinya Zhou

## 14 EV3 Café sustainability food labels Team Smart Labellers



Chelsi Li, Xiaowen Li, Esther Zhou

The sustainable food service at the University of Waterloo lacks sustainable labelling. The key issue is that the cafe's food labelling lacks sufficient sustainability information to help customers make more sustainable food choices. Therefore, we are attempting to solve the issue of growing and designing sustainable information on food labels in ev3rcafe. Overall, we expect that our research can assist the University of Waterloo

in developing a sustainable campus and reducing food-related emissions.



## 15 Improving waste diversion on campus Team Waste Warriors

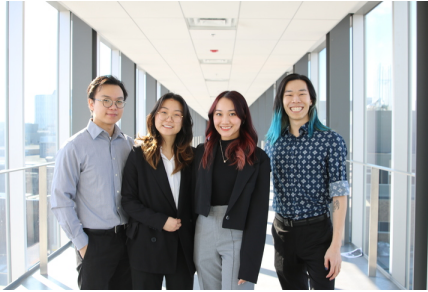
Facing the issue of low waste diversion rates on Waterloo's campus, Waste Warriors is here to identify the gaps and barriers students face in addressing this problem. To close these gaps, we are collecting information to better understand student behaviours, beliefs, and values around sustainability, as well as accessibility barriers to waste sorting. In doing so, we are able to use student feedback in an effort to better sustainability efforts on campus and improve waste diversion rates in residence.



Cooper Murphy, William Nguyen,  
Ryan Vetere, Lindsey Sutton,  
Virginia Li

## 16 Making Campus Navigation Inclusive and Accessible

### Team AccessiLoo



Jonathan Lanson, Jessica Zhang, Carina Chiu, Evan Cheer

Accessiloo is a mobile app developed to address campus navigation challenges, particularly for individuals with accessibility needs, at the University of Waterloo. Our team conducted user studies by interviewing stakeholders from a diverse range of perspectives including the University of Waterloo Faculty of Engineering Associate Dean of Outreach, Equity, and Diversity; Conference on Diversity in Engineering organizers; a professor with accessible mobility requirements; the Office of Equity, Diversity, Inclusion, and Anti-Racism; and the Plant Operations Department.

The user studies<sup>13</sup> conducted discovered that the primary limitation users encountered were related to mobility issues. Users expressed difficulty navigating across the campus due to inaccessible pathways and insufficient signage. Users also highlighted the importance of having real-time information on the location of accessible features such as washrooms, elevators, and ramps to facilitate navigation.

To address these challenges, Accessiloo was designed to meet user requirements, prioritizing essential features for inclusive access. This includes ensuring AODA compliance<sup>14</sup> to meet accessibility standards, providing the ability to locate various types of washrooms (including gender-neutral, universal, male, female, and wheelchair accessible), offering accessible navigation across elevations (via elevators, ramps, or stairs), and protecting user privacy to prevent identification through app usage patterns.

Moreover, our app incorporates insights from the WCAG mobile app/web-site accessibility guidelines.<sup>15</sup> By adhering to these guidelines, Accessiloo aims to provide a seamless and inclusive campus navigation experience for all users, regardless of their mobility needs.

In summary, Accessiloo transforms campus accessibility by providing real-time navigation tailored to the varied needs of individuals at the University of Waterloo. Through user-centric design and adherence to accessibility standards, Accessiloo enhances the overall campus experience and fosters inclusivity for all students and visitors.

## 17 EEG To Image Reconstruction Team All Joined

Inspired by the advancements in image reconstruction,<sup>16,17,18</sup> All Joined wanted to further explore the possibility of reconstructing images from electroencephalogram (EEG) signals. Despite the state-of-the-art (SOTA) achievements, such as those reported by DreamDiffusion<sup>17</sup> which purportedly reconstructed images from EEGs, the limitation to 40 image classes suggested a functionality closer to that of a classifier rather than a generative model. Our objective was to develop an EEG-to-image model capable of handling a broader



Ricky Mao, Daekun Kim,  
Jonathan Xu, Charles Liu

spectrum of stimuli, and to demonstrate the model's capability by reconstructing visual imagery from EEG signals in real-time. This achievement could lead to further innovations in medical diagnosis and neurotherapy, brain computer interfaces, AR/VR integration, neuroeducation and learning, and more.

Our methodology consists of three parts: 1) stimulus & data collection, where we collect EEG data from participants; 2) preprocessing, where we clean the data and restructure it into a format amenable for model training; and 3) model training, during which an autoencoder and diffusion model were trained to reconstruct images from the processed EEG data.

In total, we collected over 16,000 trials of EEG-image pairs over 8 participants, which enabled us to build a dataset with a significantly broader range of image stimuli than previously reported. We also innovated our ML model to be able to perform cross-dataset learning by segmenting the EEG signals into EEG channel patches, which allows our model to be more robust and adaptable.

Despite achieving image reconstruction capabilities, the model's performance was constrained by its limited ability to represent the extensive variety of objects in the real world. Additionally, the model was also dependent on a comprehensive preprocessing procedure to mitigate noise in the EEG data which necessitated manual oversight. Future directions will focus on enlarging the dataset to encompass a more extensive variety of classes and refining the preprocessing pipeline to remove the need for human inspection. These improvements aim to facilitate real-time inference capabilities as was originally intended.

## 18 Device to promote bloodflow and mitigate bed sores Team TurnCare



Lily Tao, Adam Iantorno,  
Vansh Dhingra, Rishi Vimalendran,  
Noah Coutinho, Joshua Sewerynek

Pressure ulcers, also known as bed sores, affect more than 3 million adults in the US. Bedsores inhibit people by causing pain, limited mobility, infection risks, and extended hospitalization, and is promoted by lack of blood and air flow to a region of skin.<sup>19</sup> The primary method to prevent bed sores is having two or more nurses manually turn the patient to relieve pressure, which is recommended to happen every two hours. This is extremely labour and resource intensive, often resulting in patients not being turned as frequently as needed.

Our team has developed a prototype mattress topper that intelligently re-distributes pressure over a patients' body to increase blood flow and prevent the formation of bed sores. Feedback from a set of pressure sensors paired with specific patient data are used to detect high risk zones along the body. Pneumatically controlled air pockets along the mattress inflate and deflate to alleviate these targeted regions while maintaining comfort. The mattress topper is compatible with mattresses in hospitals, long term care facilities, and at home.

All patient data and mattress states can be monitored and controlled using a mobile app which receives live feedback from the device, making the task of caregiving easy and intuitive. The mobile application will also be able to control the inflation of individual cells of the mattress topper for specific use-cases.

We controlled the air pocket inflation states and evaluated the pressure reduction of targeted regions on 15 test patients, yielding a (expected) 30% reduction in loading while maintaining patient comfort. Ultrasonic blood flow meter measurements during the test cases showed an (expected) increase in flow by 15%.

## 19 Mercury: The industrial instrument tracker

### Team Mercury

As climate change and international conflicts threaten global energy infrastructure, companies like Tesla are ramping up their energy solutions production. For example, in Q1 2023, Tesla's energy storage deployments increased by 360% YoY with the ramp up of their new Megapack factory in California.<sup>20</sup> With increased production, servicing these energy solutions will require more heavy-industrial instruments like battery lifters or battery management system testers to maintain them.



Braden Mah, Eli Vlahos,  
Nicolas Quintana, Kyle Dyck

Manually tracking and maintaining these instruments is expensive, complex, and inefficient with a growing fleet of globally deployed energy solutions. Mercury provides status updates on your fleet by attaching a small, wireless printed circuit board to each instrument, relaying state information to a remote database, and displaying the status of all instruments on an interactive online dashboard.

Mercury provides various kinds of information to create an accurate status report and provides control features for the user to remotely interact with their instruments. An instrument's location and battery level is transmitted by default and there are optional GPIO ports that can be connected. There is also a slot for an SD card if the user wishes to store information locally. Further, Mercury allows a user to toggle the GPS module and remotely control a relay for powering their own devices.

Hardware prototyping and software development began in October 2023 with initial implementation and testing of the Mercury device and dashboard. First, the GPS module provided accurate location data when verified against other localization methods. Second, the analog and digital GPIO ports produced accurate output voltages and correctly read input voltages when verified against a multimeter. Third, Mercury successfully captured logging information on a removable SD card that was verified with a computer. Lastly, the dashboard went through user acceptance testing to ensure users could view device information and customize the dashboard to their needs.

## 20 A UI for Sensitive Document Redaction Team NewBloom



Wendi Yu, Emily Lin, Richard Sun

Canada's immigration system provides asylum to politically persecuted refugees. In 2022, the Immigration and Refugee board received 94,246 applications for asylum, and granted 68% of these requests.<sup>21</sup> After the application process, the application's supporting documents are released to the public for the sake of transparency. Because these documents contain personally identifying information (PII) that could endanger these applicants, they must be

redacted before release.

The Canadian government employs court redactors who comb through each of these documents and manually redact personally identifying information. This manual redaction is time-consuming and tedious, and thus error-prone. Though each redaction goes through initial redaction and secondary review, high-stakes uncertainty about quality increases mental load for redactors and contributes to high turnover.

We leverage an ML model to create redaction suggestions, streamlining the redaction process. Machine learning can automate the redaction of not only straightforward PII, but contextual details as well. We integrate these model suggestions into an ergonomic UI that streamlines the entire end-to-end redaction and review process. Our UI provides views and abstractions in addition to a traditional text editor layout to combat user biases. It centralizes audit records of changes and reviews. This UI provides us leverage points to (1) improve redaction speed and ergonomics,<sup>22</sup> (2) assure redactor confidence in output, (3) Combat user biases, eg for automation and repetition<sup>23</sup> (4) provide transparency and accountability for the role of AI in government processes<sup>24</sup>

Initial testing of NewBloom was performed with student volunteers. We found that our approach improved speed and accuracy over existing manual methods. Furthermore, redactor confidence and satisfaction also improved. Our UI's redaction abstractions were also effective in improving ML model error detection, compared to the traditional approach.

## 21 Tensions in Redaction of Refugee Court Files Team Sorry, That's Classified

In 2022, 17.23% of permanent residents admitted to Canada were refugees.<sup>25</sup> In accordance with the UN SDG for peaceful and inclusive societies and accessible judicial systems, refugee-related legal datasets should be publicly available, while preserving the privacy of refugee claimants.<sup>26</sup> Our team worked with Osgoode Hall Law School's Refugee Law Lab to develop a framework to evaluate how redaction algorithms address this privacy-transparency tradeoff, and applied it to an ML algorithm for the Canadian context which had high technical accuracy while addressing stakeholder obligations.



Areena Akhter, Benn McGregor<sup>δ</sup>,  
Kate Granstrom<sup>δ</sup>

Our “technical desiderata for a redaction algorithm” requires that it must (a) protect the privacy of the refugee applicant, (b) enforce transparency for the public and researchers, and (c) provide accountability for the governmental organization building it. In building such an algorithm, we found that despite the technical feasibility of applying a Transformer-based approach to ‘learn the language’ of redacted documents, applying this technique to refugee law was not straightforward, due to the absence of high-quality training data available in open-source datasets. To overcome this difficulty, we demonstrated the benefits of using an inverted labeling technique that leveraged open source data and legal domain expert labellers to generate semi-synthetic data suitable for training our model.

To holistically evaluate the algorithm’s capacity to address our desiderata, we evaluated both its technical accuracy against the existing human annotation process, and its benefits against alternative redaction approaches. We found that our algorithm is 95% accurate against human annotators, while providing higher accountability and transparency for governments and the public than private third-parties. Ultimately, this project suggests a way forward for civil servants to leverage ML algorithms for the public benefit while acting as responsible data stewards and maintaining obligations to the public.



## 22 Framework for costing climate change impacts in Waterloo

### Team Costing Climate Change

The project is to create a framework that the City of Waterloo can adopt to measure the cost of climate change impacts within the city.



Zhengqi Kuang, Yifei Wang,  
Aranjot Tutt, Mahwash Kargel,  
Simran Sampat



## 23 A guide for quantifying Category 1 emissions Team Emission Impossible

Our project aimed to propose recommendations for reporting Category 1: Purchased Goods and Services under the Scope 3 emissions for the University of Waterloo (UWaterloo). We addressed key gaps, including defining collection boundaries, identified data requirements, and assessed resource viability. By researching case studies and best practices, we not only aimed to create a framework that provided the university with a guide for quantifying Category 1 emissions, but also to identify opportunities for emission reduction.



Emily Everest, Sanjay Ketheeswaran,  
Rowan Perry, Hugo Andre, Asser  
Sigmund Ang, Abdullah Atekulla

## 24 Green procurement analysis for City of Waterloo Team Green Procurement

Our team compared the environmental impacts of a range of products by creating a green purchasing framework applicable to the City of Waterloo. This project will contribute to the promotion of sustainable development in the City of Waterloo.



Xinxin Huang, Hanlin Gao,  
Mingjuan Jiang, Siyang Ding

## 25 Analysis of Propel Impact Investing Fellowship Team Impact Investing

Impact Investing refers to investments made with the intention to generate positive, measurable social and environmental impact alongside a financial return. The problem area we are working within encompasses the identified gap in funding and support for social entrepreneurs in KW, as well as strategic plan fulfilment by educational institutions. By examining the Impact Investing space at UW, we hope to answer the question of if a Propel Impact Investing Fellowship program could be implemented as an experiential learning opportunity for students.



Willow Glicksohn, Liam O'Rourke,  
Trisha Duza, Emma Cheung,  
Jonah Barkey, Michelle Angkasa

## 26 Sustainable biochar alternative to peat Team Biochar



Ethan Surian, Ryan Ertel,  
Braydon Hamilton

Canada's north.

Working with Walker Industries, our team is assessing the feasibility of using biochar as a sustainable alternative to sphagnum/peat in soil amendment products. The team is exploring deriving biochar from textile waste and forestry byproducts. While biochar not new in the soil amendment space - the team believes that incorporating textile waste into the feedstock can promote closed-loop-supply-chains at the industry level while avoiding GHG emissions associated with stripping surficial peat in

## 27 Towards supply chain carbon neutrality

### Team Carbon Neutralizers

Our group is working with Walker Industries to help make their current supply chain more carbon-neutral. Focusing on their supply chain and procurement, our group is analyzing their emulsion and landscaping divisions to optimize their supply chain and enable sustainable practices to make it more carbon-friendly. Based on their current sustainability goals and operating procedures, our team is committed to finding the most cost-effective and optimal solution. We aim to create a customized vendor selection framework that aligns with their company values and enables them to reach their sustainability goals.



Jeeya Doshi, Tanisha Lakhani,  
Felicia Daryonoputri, Ayman Gostar,  
Garrett Duncan, Eian Lim

## 28 Circular Economy Framework across Walker Industries

### Team Walker Zero-Waste



Ava Henderson, Avery Sudsbury,  
Clara Lau, Joy Gu, Ruby Hong,  
Chloe Fan

The Walker Zero-Waste Team is developing a circular economy framework across Walker Industries' operating divisions. The focus is on identifying and optimizing waste streams through the principles of reduce, reuse, and recycle, with the ultimate objective of establishing a robust Zero Waste Strategy. The Walker Zero Waste initiative aims to elevate sustainability through promoting industrial symbiosis within the company's operations.

## 29 Market segmentation for Scope 3 emissions & EPR Team Reverse Logistics

Our capstone project delves into Scope 3 emissions reporting and Extended Producer Responsibility (EPR) in the environmental consulting industry. Addressing challenges like government mandates and reporting standardization, our project aims to identify roadblocks and tailor service offerings to incentivize reporting and EPR compliance. It seeks to enhance RevLogic's ability to encourage reporting among clients by incorporating end-of-life emissions and assessing EPR regulations' impact on environmental, social, and governance (ESG) reporting. Our project also explores diverse industry personas to craft compelling a business case to varying businesses.



Nanda Abbas, Romona Choonilall,  
Mila Jokovic, Uswa Zafar

## 30 Engaging students in sustainability Team Engagement



Caver Zhou, Qianyi Wang, Yating Luo,  
Tian Jiang, Xin Li, Xinyu Jin

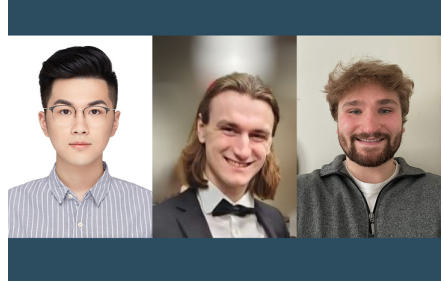
We are hoping that our research will provide valuable insights and analysis toward the goal of enhancing the engagement of undergraduate students in sustainability conversations and activities, particularly the significance of leveraging social media to encourage young people to create, communicate, and share about sustainability issues. More specifically, we will continue to understand the preferences of students in use of social

media and explore how to optimize the output of social media content by analyzing the effectiveness and outcomes of existing channels.



## 31 Analyzing domestic enrollment in SEED programmes Team Future Leaders

Our project is focused on exploring why the enrollment numbers for domestic students have declined in SEED programs at the University of Waterloo. As well we are going to conduct research to help find a successful strategy to bring enrollment numbers back to where they were and hopefully bring a consistent improvement in domestic enrollment.



Maximilian LeDuc, Caelen Fraser,  
Sergio Wang

## 32 EV battery lifecycle: recycling and disposal

### Team EV Battery Recycling



Colin Pederson, Jessica Waddell,  
Larissa Coulas, Naomi Olivotti,  
Olivia Penhall, David Kozak

The purpose of our capstone project is to explore the current state of EV battery recycling and disposal practices. Through quantitative and qualitative research methods such as interviews and data analysis, we aim to demonstrate the economic and ecological importance of recycling EV batteries. In doing so, we hope to promote both environmental responsibility and opportunities for sustainable resource management.

## 33 ElectricityMaps.com open source contributions Team Three

Electricity Maps is a small start-up who provides vital data that tells the world how electricity is produced and used. The data is used commercially by companies and other large organizations to help achieve their objectives, while individuals and governments also make use of the data for academic or policy initiatives. Some of Electricity Maps most well known clients include Google and Microsoft.

Our team has contributed over the course of our capstone project to this environmental endeavour. Over the course of a year, our work has touched upon the vast majority of the project's pipeline: In the data collection phase, we patched the parsing of data sources, scraped additional publicly available venues for more data and identified and addressed security risks for certain methods of data collection. In the API and display phase of the application, we ameliorated the visual effects for meteorological layers.

This term, our team focused on the development of a package that allowed users to calculate temporal and locality schedules for their data jobs that maximized the effectiveness of the energy being used. Data centres are heavy consumers of electricity - where just one data centre could consumer one million megawatt hours in a single year. This package and its subsequent integration with existing tools such as Kubernetes have completed internal testing and have been passed onto the Electricity maps team to tailor to their specific business needs.

When we flick on a switch or plug in an appliance, it often feels like the electricity we use is just an afterthought. But when a country or a corporation turns on or off their processes, the effect and sources of energy use are no longer trivial - and they depend on easy, dependable sources to make the right decisions.



Willard Ma, Helen Zhang,  
Wanda Song, Frank Chen

## 34 Hydrogen markets analysis for Sault Ste. Marie Team Hydrogen SSM



Elizabeth Schnurr, Eavan Kennah,  
Noah Enns-Le Doare,  
Yatharth Chandhok,  
Evan Palmer-Charrette, Ellie Wolfe

tion via the local port.

Canadian regions rich in feedstock are poised to benefit from the increasing demand for low-carbon hydrogen. The industry is anticipated to reach a value of \$11 trillion by 2050 and achieve cost competitiveness by 2030, supporting net-zero goals. This study for the City of Sault Ste. Marie (SSM) focuses on overcoming barriers for SSM's entry into the hydrogen market, identifying funding opportunities and necessary capital infrastructure investments, including those for natural gas blending and hydrogen exportation.

## 35 Hydrogen generation from curtailed renewable sources Team GreenMachine

Renewable energy plants generate AC electricity, which cannot be easily stored when generation is higher than demand. So, when energy is not needed, they turn them off. This is called curtailment. Electrolysis is one way to store curtailed energy, converting the excess electricity into hydrogen. Sault Ste. Marie has plenty of renewable energy generation but lacks the supporting infrastructure to fully utilize it, with bottlenecks from both a lack of local demand and over saturation of transmission lines.

Hydrogen is an industry leader in green energy potential with projections of increased future demand and applications. It can generate power in fuel cells or via replacing natural gas combustion, as well as its use in industries such as steel, mining, gas, etc.<sup>27</sup> There exists a market demand for hydrogen as a fuel source or manufacturing aid, making it a safe investment for Sault Ste. Marie.

The adoption of hydrogen production and distribution was a significant challenge with integration into the existing infrastructure. Financial considerations were multi-faceted: contractual, infrastructural, technological, startup, and delivery costs to name a few. As well, this option required comparison with proposed solutions to ensure that hydrogen generation was the best option for Sault Ste. Marie. From a technical lens, location-specific challenges for infrastructure, curtailment modelling, maintenance, equipment logistics, and current technologies were all unknowns to address when proving viability.

An engineering analysis revealed hydrogen generation as the most effective means of curtailed renewable energy storage and utilization in Sault Ste. Marie. Current and future government programs incentivizing the use and resale of renewable energy, and particularly hydrogen, proved profitability. The most effective configuration was a combination of PEM electrolysis and short-range pipeline power transmission to dilute existing natural gas networks through the nearby Great Lakes pipeline.<sup>28,29</sup> This will ultimately offset emissions and better utilize existing green energy infrastructure around Sault Ste. Marie.



Dafydd Banfield, Manvir Banwait,  
Jillian Lee, Shivam Abhi, Milind Jain,  
Ben Hosseinian

[linktr.ee/GreenMachine2024](https://linktr.ee/GreenMachine2024)

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