SMITH ENGINEERING
Queen's University

Reimagining Engineering Education

2024-2025 Pilots

We are excited to introduce the first pilot projects in our initiative to reimagine engineering education at Smith Engineering. These pilots embody our commitment to preparing students for the future through innovation in teaching and learning. They integrate themes of problem-solving, hands-on learning, and real-world impact, ensuring that our graduates are equipped with the skills needed to tackle complex global challenges.

Reimagining Client-Based Design Projects (APSC 103)

The APSC 103 pilot aligns with the vision of reimagining engineering education by integrating empathy, creativity, and interdisciplinary collaboration into the team design process. New content on empathy and an updated evaluation rubric will enhance students' ability to design with a human-centric approach. Through open-ended, real-world projects, enriched by a systematic review on community-based engineering projects, students will tackle broader societal challenges. The course will also emphasize ethical reasoning and societal impact, fostering a new generation of engineers equipped to address global challenges.

CEAB Attributes to Competency Tracking through onQ

This pilot leverages the data already collected through onQ, the faculty's Learning Management System, to track student performance against the 12 CEAB graduate attributes—translated into competencies. Rather than focusing on aggregated data for program improvement, this initiative will deliver individual reports outlining each student's mastery of key skills as they progress through their courses. The approach provides a clear, personalized understanding of competencies, empowering students to articulate their strengths. The pilot also aims to refine the curriculum by identifying gaps in student learning and adjusting instruction accordingly. This competency-based assessment system sets the foundation for a future in which engineering education is directly aligned with the practical, adaptable skills required in the profession.

Civil Week 2.0

Civil Week 2.0 offers an immersive hands-on experience for second-year Civil Engineering students, building on the foundational concepts of teamwork and design introduced in their first year. In this one-week intensive challenge, small teams will apply their knowledge from key courses to develop and refine prototype solutions. Through faculty mentorship, brainstorming sessions, and an open-ended problem-solving approach, students will deepen their understanding of engineering principles while addressing real-world challenges. The week culminates in a presentation of their designs to a panel of experts, who will assess solutions based on innovation, technical soundness, and their broader societal impact. This intensive learning experience not only reinforces academic concepts but also fosters the competencies needed for engineering for humanity.

AI and Engineering through Autonomous Driving (ELEC 390)
The ELEC 390 pilot reimagines the course by using autonomous driving as a framework to teach artificial intelligence (AI), robotics, and ethical decision-making. Students will work in interdisciplinary teams to design and implement autonomous vehicles, navigating a miniature city while considering societal impacts and ethical considerations. Through open-ended problems students will gain practical experience in AI and robotics, while also developing a deeper understanding of the human and societal implications of emerging technologies. This redesign reinforces the core competencies of modern engineering practice and aligns with the broader goal of preparing engineers to solve complex global challenges.

Redesign of Technical Communications (APSC 101/199)
This pilot enhances first-year engineering communication skills by embedding real-world, humanity-focused projects into the curriculum. By redesigning APSC 199 and integrating it with APSC 101, students gain multiple opportunities to practice and receive feedback on their communication. Students will conceive, design, implement and test a water filtration system based on the UN Sustainable Development goal of clean water highlighting the importance of societal and ethical considerations in engineering. The competency-based assessment approach will track their progress toward proficiency in technical communication, bridging the gap between coursework and the human-centric realities of engineering practice. This initiative also aims to assess how students' written communication develops over their degree, providing insights for further curriculum improvements.

Distributed Systems (ELEC 477)
ELEC 477 introduces students to the complexities of collaboration in large, distributed systems, mirroring the teamwork dynamics they will encounter in industry. This pilot project involves a multi-phase group assignment where students must design and implement components of a larger system, negotiating with other teams to clarify interactions between various subsystems. The course will include lectures on negotiation skills, and teaching assistants will facilitate initial group meetings to ensure productive collaboration. By working on open-ended, real-world challenges, students will enhance their problem-solving abilities and develop the collaboration skills necessary for interdisciplinary teamwork in engineering practice.

Server as a Service (MECH 302)
Recognizing the importance of equal access to technology, this pilot transitions MECH 302 students from using personal laptops to a cloud-based platform for computational work. This shift eliminates hardware disparities, ensuring all students have access to the same resources, and enables seamless collaboration. By using cloud computing, the course enhances the learning experience, allowing students to focus on applying advanced methods to real-world data sets without technical barriers. This shift will also enable students to demonstrate their skills within a consistent, managed environment, facilitating better monitoring of tests, exams, and projects for fair use and academic integrity. This change not only enhances the learning experience but also sets the stage for integrating programming earlier in the curriculum. As computational skills are

critical for modern engineering, this shift provides a platform for students in all courses to tackle complex real-world problems.

Adapting Electronics I to Problem Based Learning (ELEC 252)
Today's engineering graduates need to have a well-established skill set and experience to approach real-world problem solving with the latest technology resources. ELEC 252 introduces students to modern electronics, including diodes and transistors, focusing on the design and analysis of fundamental circuits. This pilot aims to enhance students' ability to select, design, simulate, build, and test electronic circuits by integrating a complete design process into the course. Previously, these elements were included but not in a cohesive manner. The course will feature two team-based projects, giving students the opportunity to apply their theoretical knowledge to real-world design challenges from conception to testing. By incorporating competency-based assessments, students will receive targeted feedback on their progress. Industry examples and global challenges relevant to electronics will be woven into the course, allowing students to see the societal relevance of their work. Optional activities will also offer deeper engagement, including opportunities to fabricate printed circuit boards.

Integrating Problem Based Learning and Adaptable Assessments (MINE 272)
This pilot introduces a real-world data science problem in collaboration with mining companies to enhance the learning experience in MINE 272. Students will be presented with a real engineering data science problem in liaison with mining companies at the beginning of the semester. Throughout the term, students will tackle the problem in stages, learning new material as needed to complete the project. The adaptable assessment portion of the pilot will utilize an intelligent tutoring system to offer personalized feedback and targeted learning opportunities. This ensures that students master each learning objective efficiently, while aligning with the broader goals of competency-based education. By integrating industry-relevant challenges into the curriculum, this pilot fosters problem-solving and critical thinking skills essential for modern engineering practice.

Problem-Based Learning in Musculoskeletal Biomechanics (MECH 496)
This pilot enhances MECH 496 by expanding its problem-based learning component, offering students opportunities to collect and work with real-world data and cutting-edge technologies in musculoskeletal biomechanics. Students will use wearable sensors and their phones to capture and analyze motion data for applications ranging from sports to clinical diagnostics. By partnering with local and international organizations, the course will provide a global perspective on engineering challenges in research and industry. This allows students to address issues in both developed and developing contexts. This project-based approach develops not only technical skills, but also cross-disciplinary communication, teamwork, and project management abilities, reinforcing the value of engineering for humanity.

Mining for Humanity: Designing Sustainable Prosperity (APSC 200 and MINE 201)
This project empowers students to explore how mineral resource extraction can drive long-term sustainable development. Students will assess the human, industrial, climate, and geoscience potential of Canadian regions to propose innovative systems that emphasize waste reduction,

recycling, and renewable resources. These sustainable systems will be designed collaboratively, bringing together local communities, investors, industry experts, and government. By fostering design thinking and systems-based problem-solving, this initiative encourages students to push the boundaries of traditional mining engineering, inspiring them to develop creative solutions for a prosperous and sustainable future.

Capstone Living Bank of Projects (CHEE 472)
This dynamic platform links undergraduate chemical engineering students with cutting-edge departmental research, allowing them to engage in process design projects grounded in current technological advancements. Through this collaboration, students contribute to real-world engineering solutions while gaining hands-on experience with innovative technologies. The project fosters interdisciplinary collaboration, offering the potential to expand beyond chemical engineering and tackle complex societal challenges. It engages the students in the most relevant topics of engineering they are passionate about and allows them to contribute to solving current problems facing society. By bridging the gap between research and education, this initiative prepares students to use engineering in service of society, ensuring they graduate with the skills and mindset to address today's most pressing global challenges.

Printed Circuit Board Full Cycle Design (ELEC 353)
ELEC 353 offers students the opportunity to design, fabricate, and test their own printed circuit board (PCB) in a comprehensive, hands-on project. Building on their skills from previous courses, students will complete the full design cycle, from initial conception through to fabrication and testing. This experience is critical for developing the practical, real-world skills that are often required in industry, particularly as students progress to more advanced design projects in their senior year. Individualized design specifications allow for a more personalized assessment of student competencies at each stage of the process, ensuring a robust evaluation of their ability to apply learned concepts to a tangible outcome.

Professional Development and Responsible Engineering (MTHE 494)
This course is designed to enhance communication skills, deepen students' understanding of professional engineering practice and responsibilities, and critically analyze the role of engineers in society in the context of major design disasters. Through a rigorous investigative process, students will analyze disasters, proposing strategies for future prevention while developing empathy by stepping into the shoes of the engineers involved. Guest lecturers will share invaluable real-world insights, enriching the learning experience and reinforcing the ethical responsibilities of engineers. A significant portion of the course is dedicated to disaster analysis, where students lead seminar-style investigations of notable engineering failures. The technical writing component, integrated into key lectures, equips students with the skills to deliver polished case study presentations on real-world engineering disasters or related topics. These presentations demonstrate how technical communication plays a crucial role in addressing complex engineering challenges and preparing students for their future careers. By broadening perspectives and reinforcing the practical, societal, and ethical impacts of engineering, this course

ensures that students graduate with the skills and mindset necessary to practice responsible and impactful engineering.

MECHMania 2.0
MECHMania 2.0 is an intensive, week-long challenge that will take place in week 12 of the winter term and pushes second-year Mechanical and Mechatronics Engineering students to apply their course knowledge to tackle real-world challenges. Students will work in teams to design, build, test, and present engineering solutions to technical constraints drawn from their coursework. With guidance from faculty, students will integrate key concepts from design, communications, kinematics and dynamics, fluid dynamics, math and numerical methods, and mechatronics to address open-ended challenges. Culminating in a final showcase, this experience reinforces academic learning and fosters the collaboration, creativity, and problem-solving skills necessary for professional engineering practice.

Northern Communities Partnership
This long-term pilot project aims to connect engineering students with an Indigenous community in northern Canada to collaborate on sustainability-focused projects addressing issues like climate change, energy, and food security. Through this experiential learning initiative, students will gain a deeper understanding of the unique challenges faced by remote communities, while applying engineering solutions that are respectful of local contexts and traditions. The project aims to broaden students' perspectives, fostering cultural awareness and empathy in the engineering process and ultimately provide the community with valuable solutions. The goal in the 2024-2025 academic year is to form a working group to establish procedures for engaging Indigenous communities, identify a partner Indigenous organization, and explore ways to integrate into the undergraduate engineering curriculum. Once a partnership is established, the program will be incorporated into our curriculum, with insights used to refine a broader strategic project.

Safety-Critical Software Engineering (ELEC 471)
The pilot for ELEC 471 introduces safety-critical software engineering with a focus on how engineering decisions impact human lives. Students will work on real-world problems where failure could impact human safety or the environment. They will apply industry standards to build and review safety cases alongside software solutions. This hands-on, problem-based learning approach ensures students gain the core competencies needed for industries such as automotive, aerospace, and medical devices. By focusing on engineering for humanity, this course emphasizes the ethical and societal implications of safety-critical systems, preparing students for the complex challenges they will face in professional practice.

The Virtual Reality Copper Concentrator (MINE 201 and MINE 331)
This pilot immerses students in a high-fidelity virtual environment, allowing them to diagnose and solve real-world engineering problems in a safe, interactive setting. The project sharpens practical problem-solving and design skills, preparing students for careers in mining and mineral

processing. By Fall 2024, more than 100 second- and third-year mining engineering students will participate in this fully immersive experience. Using a blend of pre- and post-activity assessments, the project aims to evaluate how virtual reality enhances student engagement and deepens understanding of critical course material.

Practical Cryogenic Engineering (ENPH 459)
This pilot will embrace Experiential Learning blending theoretical knowledge with real-world applications, drawing on examples from current research experiments, teaching upper year students the complexities of cryogenic system design. In addition to in-class instruction, the course offers experiential learning through lab tours, where students will engage with existing cryogenic installations in the department like the helium recovery and liquefier system, dilution refrigerators, and optical cryostats. Through these various projects, students will explore critical engineering considerations that went into component and instrument designs. The students will engage in multiple Problem Based Learning activities working through research-inspired problems which introduce them to practical engineering evaluation methods, and peer design review. The course prepares students to solve open-ended design challenges, ensuring they are industry-ready to tackle the demands of modern engineering.

Beyond the Books
This proposal enhances the first-year engineering experience by embedding weekly 2–3-minute videos into APSC courses, connecting students with key campus resources like Student Academic Success Services, Design Clubs, and Career Services. Each video will feature an interview between an undergraduate student and a campus expert, focusing on topics relevant to first-year challenges. These will be followed by links for further engagement. Topics will align with the academic calendar, such as study skills before exams and discipline selection in January. Promoted in lectures and embedded in course content, this initiative offers a low-cost, high-impact way to increase cultural competence, promote self-directed learning, and lower barriers to campus resources, encouraging students to engage more fully in their academic and personal development.

TEEAM: Tutorial Enhanced Engagement in Applied Mechanics (APSC 182)
In the reimagined APSC 182 Applied Mechanics tutorials, Problem Based Learning will be used to better reinforce the concepts being taught. Each of the five APSC 182 tutorial sections will have its own unique problem to explore throughout the term (e.g. design of shelter for post disaster relief). Each individual tutorial session will feature a problem to solve related to Applied Mechanics (e.g. draw the shear force and bending moment diagram for the roof beams in your shelter) to ensure students practice fundamental concepts. Additionally, there will be a broader open-ended impact problem relating to either design or engineering for humanity (e.g. when sourcing materials to construct the beams for your shelter, which supplier would you choose and why). The groups will solve all problems within the tutorial period with the support of Competency-based Education as instructors and teaching assistants will work with groups throughout the tutorial to develop, assess, and reinforce concepts.

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Programming Skills (APSC 142)

This pilot improves first-year programming skills by refocusing the curriculum on the core competencies students need to succeed in the various engineering disciplines. This redesign of APSC 142 will give students more practice with the concepts they need to master for any engineering degree at Queen's. Students will complete assignments and projects that focus on human-centred problems and have multiple opportunities to be assessed on their progress mastering the most important competencies. This will better prepare students to use programming to solve real-world problems beyond their degrees.