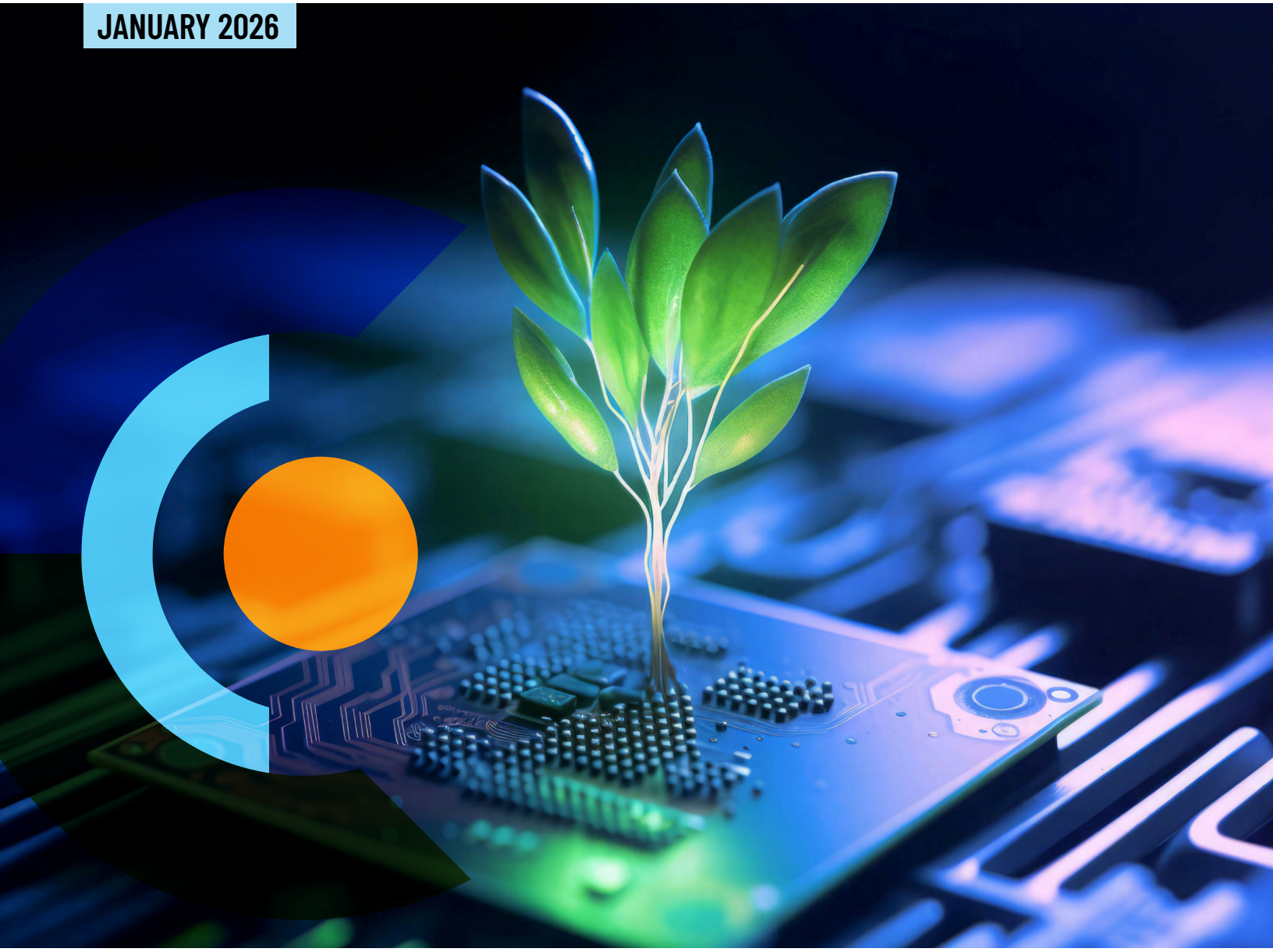
Integrating Climate Change into Engineering Programs

Accelerating Climate Education (ACE) Curriculum Brief

JANUARY 2026



UNIVERSITY OF WATERLOO | WATERLOO Climate Institute

ACKNOWLEDGEMENTS

CONTRIBUTORS

WRITING AND EDITING

MICHELE MARTIN, Waterloo Climate Institute

NADINE IBRAHIM, University of Waterloo, Civil and Environmental Engineering

BRUCE MACVICAR, University of Waterloo, Civil and Environmental Engineering

LAUREL PIERROZ-WONG, University of Waterloo, Civil and Environmental Engineering

DESIGN AND LAYOUT

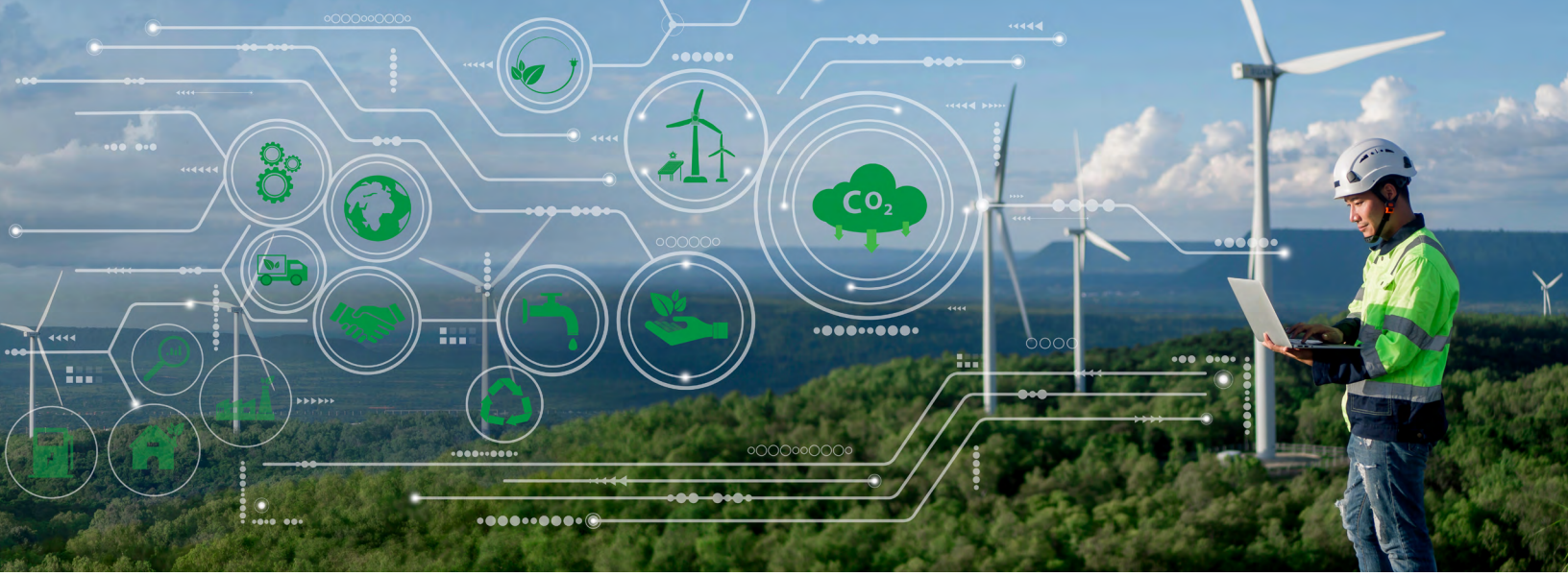
NATALIE SMITH, Waterloo Climate Institute

ANUSHKA KSHIRSAGAR, Waterloo Climate Institute

This brief was produced as part of the Accelerating Climate Education for the Next Generation of Professionals (ACE) project being implemented by the University of Waterloo Climate Institute, with funding support from Natural Resources Canada's Climate Change Adaptation Program.

Natural Resources Canada | Ressources naturelles Canada

Canada



OVERVIEW

The Waterloo Climate Institute's Accelerating Climate Education (ACE) project is a three-year initiative (2024-2026) to support the rapid integration of climate change adaptation knowledge and skills into professional degree programs at universities and colleges across Canada. The ACE project focuses primarily on accounting, architecture, engineering and planning programs and is intended to contribute to the implementation of Canada's National Adaptation Strategy: Building resilient communities and a strong economy. The project creates opportunities for dialogue, networking and collaboration with other higher education institutions across Canada to support and share efforts and to engage with professional accreditation bodies to support broader integration of climate adaptation competencies into these professions. Visit the ACE project website for more information.

Integrating climate adaptation into the curriculum creates opportunities to embed justice, decolonization, and reconciliation perspectives within existing programs and courses, while also strengthening and connecting to ongoing climate, biodiversity and sustainability education initiatives across Canadian post-secondary institutions.

This curriculum brief is not prescriptive. It is intended to provide a catalyst for dialogue about curriculum revisions in engineering programs in Canada, with a special emphasis on civil and environmental engineering. It can be used as a starting point to consider possible content and pedagogical approaches. The brief is organised into four sections:

1. **The Curriculum Challenge** - an overview of the relevance of climate change to engineering education
2. **Climate Change Competencies** - a list of competencies based on current accreditation guidance and Canada's Climate Action Competency Framework (CACFv2)
3. **Further Reading** - a bibliography of current literature on climate change and engineering education
4. **Resources** - websites, toolkits, guidebooks and other resources that can be used to develop teaching/learning activities for engineering courses

1 - The Curriculum Challenge

Canada's National Adaptation Strategy asserts the hope that by 2027, 70% of all practicing engineers will have "the capacity to apply climate change adaptation tools and information and communicate the business case for adaptation measures to their clients or target audiences." To meet this target, it is critical that undergraduate engineering programs work on the integration of climate education (alongside sustainability education) into the curriculum and existing competencies required by accreditation bodies.

Like many professional degree programs, the engineering curriculum is governed by competencies defined by a professional body, Engineers Canada, through their Canadian Engineering Accreditation Board. Engineers Canada's competency assessment guidelines do not specifically name climate change in any of the core competencies, but sustainability is covered under the core competency area 6, "Social, Economic, Environmental and Sustainability". Under competency 6.1 (Demonstrate an understanding of the safeguards required to protect the public and the methods of mitigating adverse impacts), one of the suggested indicators (understand potential effects of climate change), provides some insight on how this might be assessed.

Despite the lack of guidance in core competencies for engineering schools, the impetus for engineering to address climate considerations is quite clear:

- Engineering schools across Canada recognize that this is a priority and are making progress to incorporate climate change in expected competencies as well as the curriculum (Liu et al. 2024).
- Engineers Canada and provincial professional associations recognize the need for engineers to have the knowledge and skills needed to be successful in a climate-changing world and contribute to a just, sustainable and low carbon future. Their advocacy work in both climate adaptation and mitigation to the Government of Canada highlights the urgency of the climate crisis, how engineers can help, and federal government actions needed to support this work.
- Engineers Canada published a public guideline in 2018: Principles of Climate Adaptation and Mitigation for Engineers. This document responds to the assertion that climate impacts can "adversely affect the integrity of the design, operation, and management of engineered systems" and that engineers need to plan for this, but also that they are "central to the development and implementation of strategies and technologies that will lower carbon emissions". This document can provide an excellent resource for climate change curriculum development for engineers, as can Engineers Canada's earlier publication, "Principles of Climate Change Adaptation for Engineers" published in 2014.
- A national survey undertaken by the University of Waterloo's Climate Institute of climate change in accounting, engineering, planning and architecture programs at Canadian universities found that the integration of climate competencies into engineering programs in Canada is not common. However, over 80% of engineering program respondents (directors and faculty) indicated that climate change knowledge and skills are very relevant to their students' careers. See Figure 1 for more information about the survey findings.

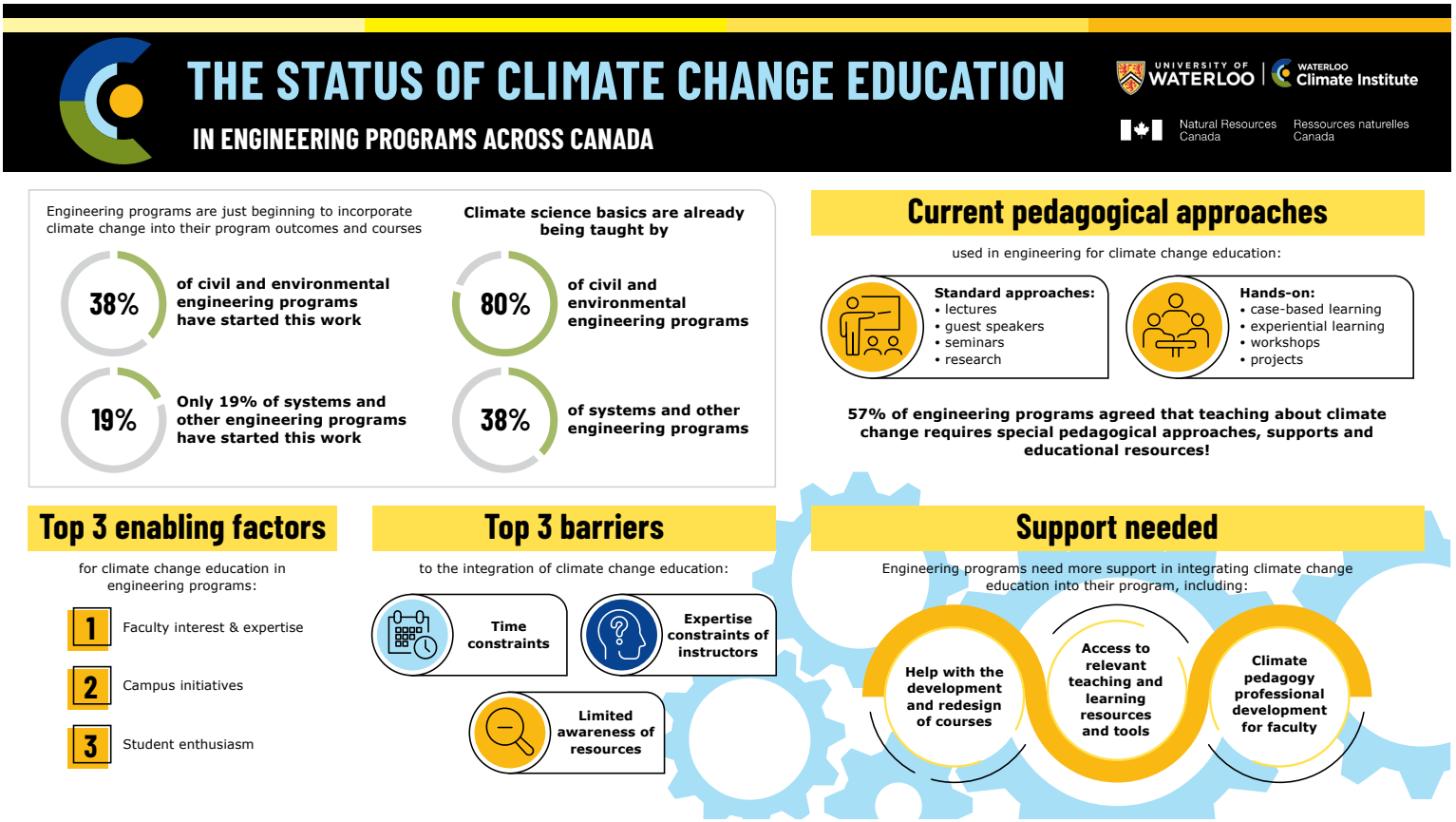


Figure 1. The status of climate change education in engineering programs across Canada

Clearly, the engineering profession is aware of the need to consider climate change in all aspects of work. The task ahead now is to build on and improve climate change education offerings in engineering undergraduate and graduate programs so that students have the necessary skills to respond to climate change. Integrating climate change into the curriculum could be done in different ways including:

1. Requiring an early core/mandatory course on climate change and sustainability to provide foundational knowledge related to engineering.
2. Integrating climate change content competencies into existing courses as relevant
3. Collaborating with other faculties to develop new interdisciplinary courses and other learning opportunities, and/or encouraging students to take climate courses offered by other faculties.
4. Looking at ways to incorporate extra-curricular climate learning opportunities on campus into existing core engineering courses, e.g. recognizing participation in design teams, hack-a-thons, case competitions etc. especially in design courses and capstones.

2 - Climate Change Competencies for Engineers

What climate change knowledge and skills should Engineers have?

Natural Resources Canada suggests using the Climate Action Competency Framework (CACFv2). This framework was developed by the Resilience by Design Lab at Royal Roads University in collaboration with many partners from academic, industry and government. The framework is organised under 6 themes: 1) Working Together; 2) Climate Action Leadership; 3) Capacity Building; 4) Climate Risk Assessment; 5) Solution Design; and 6) Effecting Change.

Some key climate change competencies for Canadian engineering programs that align with the CACFv2 might include the following (See Table 1):

Table 1. Climate change competencies for engineering programs

Theme	Climate change competencies	Engineers Canada related competencies
Climate science literacy	Understand the physical basis of climate change, drivers, trends, projections, and key metrics (e.g., GHG budgets, temperature/rainfall extremes, sea-level rise) and how to read/interpret climate model outputs for decision-making.	• Apply fundamental scientific knowledge to engineering problems. • Protect the public by understanding hazard drivers.
Climate risk assessment & vulnerability analysis	Identify, assess and quantify climate hazards, exposure, sensitivity and adaptive capacity for infrastructure, communities and systems; translate projections into design loads or service-level implications.	• Risk-informed design, due diligence and protecting public safety. • Canadian environment competencies.
Adaptation & resilient design (technical solutions)	Design, evaluate and specify engineering solutions that increase resilience (e.g., nature-based options, retrofit, redundancy, robust design under uncertainty), while considering life-cycle and performance trade-offs.	• Apply engineering tools & methods. • Engineering design under uncertainty. • Professional responsibility.
Mitigation & low-carbon systems thinking	Integrate greenhouse-gas mitigation into engineering design and system planning (energy efficiency, decarbonization pathways, materials choices, whole-system emissions accounting).	• Systems-level application of engineering knowledge and sustainability principles.
Policy, governance & regulatory literacy	Interpret and apply climate-related policy, codes, standards and procurement rules; advise on how regulatory context shapes technical decisions and constraints.	• Professional practice within legal and regulatory frameworks. • Record-keeping and documentation of climate considerations.
Climate aware financial and economic appraisal	Incorporate climate risks and mitigation/adaptation costs into business cases, cost–benefit or life-cycle analyses, and procurement decisions (including climate finance mechanisms).	• Economic and project management competency.

Uncertainty management & decision making under deep uncertainty	Apply approaches for working with uncertainty (scenario analysis, robust decision-making, adaptive pathways, safety factors) and clearly communicate implications for design and policy.	• Sound professional judgement, record of decisions and assumptions.
Interdisciplinary collaboration	Work effectively across disciplines (planners, ecologists, social scientists, Indigenous knowledge holders) and with stakeholders to co-produce climate solutions.	• Communication, leadership and teamwork competencies.
Stakeholder engagement & communication	Facilitate inclusive engagement, communicate climate risks/uncertainties to non-technical audiences, and document rationale for decisions (transparency & traceability).	• Communicate effectively and protect public interest.
Ethics, equity & climate justice	Recognize and evaluate distributional impacts of climate decisions (vulnerable populations, intergenerational equity), and integrate ethical reasoning into engineering recommendations.	• Professional ethics and public welfare mandate.
Monitoring, evaluation & adaptive management	Design monitoring programs, set indicators and feedback loops so interventions can be evaluated and adapted as climate knowledge and conditions change.	• Lifecycle stewardship and ongoing professional responsibility.
Lifelong learning & professional development	Commit to continuous updating of climate knowledge and skills (professional development, maintenance of competency as climate science and policy evolve).	• Ongoing competence, continuing professional development.
Documentation, accountability & traceability	Keep clear records of climate-related assessments, assumptions, decisions and rationale to support accountability, permitting and future review.	• Record-keeping and professional practice expectations.

(NOTE: this list was generated by ChatGPT on December 11, 2025, in response to the prompt: "Please list the climate change competencies for Canadian engineering education programs based on the climate action competency framework V2 and Engineers Canada competency requirements")

3 - Further Reading on Climate Change in Engineering Education

Axelithioti, P., Fisher, R. S., Ferranti, E. J., Foss, H. J., & Quinn, A. D. (2023). What are We teaching engineers about climate change? Presenting the MACC evaluation of climate change education. Education Sciences, 13(2), 153.

Broo, D. G., Kaynak, O., & Sait, S. M. (2022). Rethinking engineering education at the age of industry 5.0. Journal of Industrial Information Integration, 25, 100311.

Caeiro-Rodríguez, M., Manso-Vázquez, M., Mikic-Fonte, F. A., Llamas-Nistal, M., Fernández-Iglesias, M. J., Tsalapatas, H., ... & Sørensen, L. T. (2021). Teaching soft skills in engineering education: An European perspective. IEEE Access, 9, 29222-29242.

Hadgraft, R. G., & Kolmos, A. (2020). Emerging learning environments in engineering education. Australasian Journal of Engineering Education, 25(1), 3-16.

Higgs, B. J., & Patil, U. D. (2024, October). Integrating Climate Change Into Engineering Education. In 2024 Fall ASEE Mid-Atlantic Section Conference.

Ibell, T., & Russell, N. (2022). The climate is right for a fundamental change in civil engineering education. Proceedings of the Institution of Civil Engineers-Structures and Buildings, 176(12), 967-971.

Kamp, A. (2023). Engineering Education in the Rapidly Changing World: Rethinking the Vision for Higher Engineering Education|. TU Delft OPEN Publishing.

Lantada, A. D. (2020). Engineering education 5.0: Continuously evolving engineering education. International Journal of Engineering Education, 36(6), 1814-1832.

Linow, S. (2019). Integrating climate change competencies into mechanical engineering education. In Climate Change and the Role of Education (pp. 33-51). Cham: Springer International Publishing.

Liu, P., Lovegrove, G. R., & Nehdi, M. L. (2024). Climate Change in Canadian Civil Engineering Curricula: Gaps and Best Practices. Canadian Journal of Civil Engineering, (ja).https://doi.org/10.1139/cjce-2024-0141

Liu, S. C. (2023). Examining undergraduate students' systems thinking competency through a problem scenario in the context of climate change education. Environmental Education Research, 29(12), 1780-1795.

Kennedy, C., Byer, P., Pressnail, K., Touchie, M., Bentz, E., Roorda, M., & Vanderburg, W. (2011). Enhancing the sustainability content of a civil engineering undergraduate curriculum. Proceedings of the Canadian Engineering Education Association (CEEA). https://doi.org/10.24908/pceea.v0i0.3671 https://ojs.library.queensu.ca/index.php/PCEEA/article/view/3671

MacVicar, B., Ibrahim, N., Martin, M., Sanderson, J., Diouri, M., Wijeweera, P., Wang, H. & Zheng, E. (2025). Accelerating Climate Change Adaptation (CCA) Education for the Next Generation of Engineering Professionals. Proceedings of the Canadian Engineering Education Association (CEEA).

Mann, L., Chang, R., Chandrasekaran, S., Coddington, A., Daniel, S., Cook, E., ... & Smith, T. D. (2021). From problem-based learning to practice-based education: A framework for shaping future engineers. European Journal of Engineering Education, 46(1), 27-47.

Martin, M., Sanderson, J. and Diouri, M. (2025). The Status of Climate Change Education in Canadian Accounting, Architecture, Planning and Engineering Programs. University of Waterloo Climate Institute.

Martin, M. J., Diem, S. J., Karwat, D. M., Krieger, E. M., Rittschof, C. C., Bayon, B., ... & Mahmoud, H. (2022). The climate is changing. Engineering education needs to change as well. Journal of Engineering Education, 111(4).

Milovanovic, J., Shealy, T., & Godwin, A. (2022). Senior engineering students in the USA carry misconceptions about climate change: Implications for engineering education. Journal of Cleaner Production, 345, 131129.

Nyka, L. (2019). Bridging the gap between architectural and environmental engineering education in the context of climate change. World Transactions on Engineering and Technology Education, 17, 204-209.

Qadir, J., Yau, K. L. A., Imran, M. A., & Al-Fuqaha, A. (2020, October). Engineering education, moving into 2020s: Essential competencies for effective 21st century electrical & computer engineers. In 2020 IEEE Frontiers in Education Conference (FIE) (pp. 1-9). IEEE.

Reynante, B., & Marimuthu, G. (2023). Decolonizing Climate Change Imagination: An "Engineering Fiction" Learning Experience. In Proceedings of the 17th International Conference of the Learning Sciences-ICLS 2023, pp. 942-945. International Society of the Learning Sciences.

Semerikov, S., Striuk, A., Striuk, L., Striuk, M., & Shalatska, H. (2020). Sustainability in Software Engineering Education: a case of general professional competencies.

Shealy, T., Katz, A., Godwin, A., & Bell, M. (2021). Civil engineering students' beliefs about global warming and misconceptions about climate science. Journal of Civil Engineering Education, 147(4), 04021011.

4 - Resources

Engineers Canada:

- Principles of Climate Adaptation for Engineers.
- Preparing for the Impact of Climate Change: The Importance of Improving Infrastructure Climate Resiliency - The Engineering Perspective.
- Principles of Climate Adaptation and Mitigation for Engineers.
- Climate Change and Extreme Events.
- Engineering a sustainable future: role of engineers in helping Canada achieve net-zero emissions by 2050.

Government of Canada:

- Canada's Climate Adaptation Platform.
- Canada's National Adaptation Strategy: Building resilient communities and a strong economy. (2023) https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/national-adaptation-strategy.html.
- 2030 Emissions Reduction Plan: Canada's Next Steps for Clean Air and a Strong Economy (2022). https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030.html.
- Climate Change Strategies and Initiatives.
- Infrastructure Canada's Climate Lens.
- Canada in a Changing Climate Reports.
- Canada's Fourth Biennial Report on Climate Change to the UNFF (2022).

Useful tools and websites:

- Climate Framework: A cross-industry action group initiative - list of topics and skills to integrate into civil engineering.
- Engineers & Geoscientists British Columbia's climate change information portal.
- Climate Atlas of Canada Interactive Map of climate impacts. Available at: https://climateatlas.ca/planning-climate-change.
- Envision V3 – Sustainable Infrastructure Framework (2018) or visit the Envision Canada site to download the Canadian version.
- Climate Insight – platform for climate ready housing and infrastructure in Canada.
- ClimateData.ca - high-resolution climate data to help build a more resilient Canada.
- CanAdapt - a collective of Canadian professionals, organizations, and networks working to help Canadian communities and industries adapt to climate change and become more sustainable.
- Natural Infrastructure: Online Canadian community of practice for nature based climate adaptation.
- Housing and Infrastructure Communities Canada HICC: Climate Toolkit for Housing and Infrastructure.
- Climate Risk Institute courses for engineers.
- Federation of Canadian Municipalities. Climate and Sustainability.
- UNCCe-Learn: Free online module: Cities and Climate Change.
- World Bank. (2021). A catalogue of nature-based solutions for urban resilience. Available here.
- Engineers for One Planet.