Redesigning CEE courses to teach computational thinking and engineering in societal context

What is this project about?

This SIIP project was conceptualized to serve 3 goals:

1. Expand integration of computational thinking and student-centered learning in CEE 3xx level courses.
2. Teach CEE fundamentals in its engineering societal context.
3. Improved connectivity and cooperation among the participating community of practice (CoP) members.

What are the participating courses?

Instructors of the following courses currently participate in the project:

- CEE 201 Engineering Economics
- CEE 202 Engineering Risk & Uncertainty
- CEE 300 Behavior of Materials
- CEE 320 Construction Engineering
- CEE 330 Environmental Engineering
- CEE 340 Energy and Global Environment
- CEE 437 Water Quality Engineering

Even though this project targets primarily the 3xx level courses, courses at the 2xx and 4xx levels are also included to facilitate more effective scaffolding, through the communication and coordination of faculty who teach courses at different levels. We aim for continuation and continuous improvements, so that students keep learning and connecting with what they have learned earlier, thus gradually and continuously strengthening their backgrounds and skills. This SIIP project follows up on an earlier SIIP project that focused on integrating computational tools in CEE 201 and CEE 202.

How is goal 2 relevant to threading computation throughout the curriculum?

What we teach is important but how we teach it and how students perceive it is crucial for learning and retaining the information. As we know from experience and as the relevant educational literature informs us, we pay more attention, and thus we are bound to learn better, when we feel we have a stake in what we are taught. Seeing relevance to themselves as persons and as future CEE professionals, to society, and to their communities helps students learn and retain that knowledge. Therefore, computational assignments should not be dry drills but be presented in the CEE and societal context, where computational tools become parts of the problem-solving process for an interesting and relevant problem.

What is the Community of Practice mentioned in goal 3?

The CoP potentially includes all CEE faculty or all campus faculty, depending on scope and perspective. Placing a boundary based on scope, the CoP for this project includes the instructors of the participating courses and our Education Innovation Fellows (EIF) mentors from the Academy for Excellence in Engineering Education (AE3). The project CoP meet regularly to discuss, brainstorm and coordinate. A well-connected CoP not only helps with better designed courses but also with sustainability of the efforts and equity for students, as good coordination in course design helps with course been taught the same state of the art way no matter who the instructor is.

How does this project relate to CEE Educational Strategic Plan?
This CEE focused SIIP project aligns with the second thrust of CEE's Educational Strategic Plan for "of integrating and meaningfully infusing computation and data science content within the undergraduate and graduate curricula".

The project also aligns with the curriculum committee's pillars for curriculum innovation:

- Nurture professional skills (Leadership and team building, Communication, Innovation and Entrepreneurship)
- Promote emergent skills (CEE fundamentals, Design thinking, Computation and Data Science
- Engender broader identity (Global and Societal Context, Sustainability and Environmental Justice, Professional Practice and Ethics)

How is the project managed?
Curriculum innovation is anything but trivial. It requires a continuous, persistent effort and continuous evaluation and improvement. It takes a long list of tasks demanding considerable human time. With typical shortage in the latter, it all comes down to determination and planning. Small persistent steps can become important leaps.

In each of a maximum of 3 SIIP funded years, the grant provides support for two 50% TAs. For each course, the instructors set one or more realistic goals per semester for their courses. The TA help is allocated based on need with 3xx courses having priority in this project. Instructors are always in charge of their course. The broader CoP does not interfere in how courses are taught. This is decided through the coordination among instructors, who teach the same course. The broader project CoP acts as motivator, a forum for idea generation and exchange, a venue for communication and as the technical supporter for new material development, always as planned by the course instructors.

What are the accomplishments so far?
Following integration of computation in CEE 201 (python) and 202 (R) and adoption of Prairie Learn, supported by an earlier SIIP grant, the current project is supporting the following developments, currently under way:

CEE 201 and CEE 202: development continues with development of assignment problems to explicitly include CEE context and support development of the CEE engineering identity.

CEE 300: All 12 lab assignments of the course are redesigned as Python Jupyter workspaces on Google colab.

CEE 320: The integrated and semester-long Rockford project which contains 10 dependent assignments has been updated to contain optional/bonus complementary coding problems in python.

CEE 330: Assignment and exam coding problems in Python have been created on Prairie Learn.

CEE 340: The course has been redesigned with three main goals: a) teaching in a societal context, b) updating the computational components using R/RStudio, and c) becoming an advanced composition course.

CEE 437: Assignment and exam coding problems in Python have been created on Prairie Learn.

Is there an assessment plan for project outcomes?
Our assessment plan includes monitoring of student performance and collection of student feedback through two student surveys distributed at the beginning and at the end of a semester. Over the years we have seen a shift in the student culture toward acceptance of computational tools as essential in CEE. We use our observations and student feedback in an iterative process for continuous improvement of teaching materials and teaching approach (pedagogy).

Project co-PIs: Sotiria Koloutsou-Vakakis, Mani Golparvar Fard, Jacob Henschen, Hannah Horowitz, Eleftheria Kontou, Helen Nguyen, Megan Matthews, Hadi Meidani, John S. Popovics, Ashlynn Stillwell, Chris Tessum.

EIF Liaisons for the project: Andre Schleife (MATSE), Abdu Alawini (CS), Chandrasekhar Radhakrishnan (ECE)

Publicity

The following papers have been prepared for the 2025 ASEE annual conference:

- Sotiria Koloutsou-Vakakis, Megan L. Matthews, Cheryl Cohen, Jacob Henschen, John S. Popovics, Ashlynn S. Stillwell. Student attitudes toward integration of computing for problem solving and data analysis in civil engineering courses. Civil Engineering Division., 2025 ASEE Annual Conference & Exposition, Montreal, Canada.
- Megan L. Matthews, Sotiria Koloutsou-Vakakis, Ashlynn S. Stillwell. CASE STUDY: Integrating societal context with engineering communication and computational thinking in an upper-level civil and environmental engineering course. Civil Engineering Division., 2025 ASEE Annual Conference & Exposition, Montreal, Canada.
- John S. Popovics, Yiming Niu, Sotiria Koloutsou-Vakakis, Karthik Pattaje, Jacob Henschen. CASE STUDY: Integration of Python programming in a civil engineering laboratory course. Civil Engineering Division., 2025 ASEE Annual Conference & Exposition, Montreal, Canada.