A SYSTEMS APPROACH TO GLOBAL ENGINEERING

CVEN 4837/CVEN 5837

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Instructor
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Prerequisites
Senior or graduate level

Credits
3 credit hours

Course Description

The purpose of this course is to introduce engineering students to the global context in which engineers are asked to operate in the 21st century. The course also aims at introducing students to system dynamics tools and other decision-making tools (network analysis, agent based modeling, etc.) necessary to analyze the uncertainty and complexity inherent in global projects. At the end of this course, students should be able to:

• Have the ability to identify the multiple dimensions of engineering projects in a developed or developing country context;
• Be aware of the role non-technical issues may play in their technical decision-making;
• Appreciate the multi-cultural, social, and economic dimensions of practicing engineering;
• Understand the global interconnectedness of issues at different scales from the local to the global and why a systems approach can complement a more traditional linear approach;
• Formulate problems and their solutions in a more systemic and integrated way;
• Be able to approach a wide range of simple, complicated, and complex problems often characterized by different levels of uncertainty; and
• Be familiar with a range of decision making tools.

These seven goals will be met through a combination of lectures, seminars, and term projects. Students will be exposed to a variety of large and small scale projects in the developed and developing world. In each project, students will be shown how technical and non-technical issues have helped shaped the project outcome.

Throughout this course, students will be presented the importance of depth and breadth in their education and the need for balance between specialization (depth) and a broader understanding of the inter- and intra-disciplinary nature of engineering and society.
This course serves as the last course in the Undergraduate Certificate in Global Engineering at CU Boulder. It is offered as a technical elective at the senior and graduate level.

Expected Learning Outcomes

By the end of the course, students should have attained competency in the following areas:\(^1\)

- participatory decision making between many parties (ABET 3d)
- creation and administration of a community needs assessment (ABET 3c,e,h)
- creating and analyzing multiple design alternatives (ABET 3c,e)
- determining appropriate technology choices based on the existing knowledge within a partner community (ABET 3c,e,f,h)
- determining metrics for a project design (ABET 3c)
- determining metrics for project success vs. failure (ABET 3c,e,h)
- understanding of general construction and safety practices within the partner community (ABET 3k)
- objective monitoring and evaluation of a built system (ABET 3b,e)
- creation of long-term communication strategies between in-country partners, partner communities, and project teams (ABET 3d)

Class Hours: Two 75 min lectures per week.

Course Readings:

Students are responsible for all the required readings. These readings aim to set the context for the class, allow students to engage lecturers, to generate questions for discussions, and to deepen students’ knowledge of topics. A mandatory reading list will be provided for each class period. Textbooks used in class:


\(^1\)These expected learning outcomes have been mapped to ABET Criteria 3 Student Outcomes: http://www.abet.org/eac-criteria-2014-2015/. Also reference to ABET Learning Outcomes Rubric courtesy of the Harvard School Engineering and Applied Sciences.
The web and the literature are rich in articles, videos, and web sites that cover the topics mentioned below. Students will be asked to read three to four articles (or book chapters) before each class, work and learn with their peers, and present their findings in class.

**Course Content (30 lectures)**

1. **Introduction: A Systems View of the World (2 lectures)**
   - Looking at the world as systems of systems
   - Systems science and complexity science
   - System thinking
   - Methods of decision making
   - Simple, complicated and complex systems
2. **Using STELLA as a tool- Part I (3 lectures)**
   - Introduction to system dynamics 1
   - Introduction to system dynamics 2
3. **A Systems Approach to Development Engineering (4 lectures)**
   - Human and economic development
   - Development challenges in the developed and developing world
   - The Millennium and Sustainable Development Goals
   - Sustainability and sustainable development
   - Integrating a systems approach to the MDGs an SDGs
   - The ENVISION project sustainability framework
   - importance of context and scale
   - from villages to megacities
   - capacity and vulnerabilities
   - critical infrastructure
   - response to hazards, adverse events, and human migrations
   - resilience and security
   - communities as systems of systems
5. **Project Management in Complex and Uncertain Conditions (5 lectures)**
   - stages of project management
   - role of non-technical issues in all stages of project management
   - the non-technical dimensions of engineering innovation. Who benefits?
   - right projects, done right, and for the right reasons. Who decides and participates?
   - case study of large projects: Panama Canal extension, Three Gorges Dam, etc.
   - case study of small projects: Examples of EWB type projects
6. **Mid-term exam (Take home)**
7. **Using STELLA as a tool- Part II (3 lectures)**
   - Intermediate system dynamics 1
   - Intermediate system dynamics 2
8. A Systems Approach to Project Failure (2 lectures)
   - failure and the engineering mindset
   - deciding when facing complexity and uncertainty
   - the ethical dimensions of failure

9. Group Decision Making Dynamics (2 lectures)
   - the different dimensions of leadership
   - teamwork
   - dealing with conflict (internal and external)

10. A Systems Approach to Relief and Recovery Work (3 lectures)
    - Post-Katrina reconstruction
    - What did we learn from the 2004 Asian Tsunami, hurricane Katrina, and super storm Sandy?
    - Rebuilding Nepal following the 2015 earthquakes: who decides?
    - Developing solutions for an uncertain future

    - Future trend “what if” models
    - Scenario planning models at different scales

Assignments and Grades

Student grades will be determined based on in-class participation (10%), homework assignments, and quizzes (30%), a mid-term take home exam (30%), and a term project (30%).

Taking the Class at the Graduate Level

Students interested in taking the course at the graduate level will be given additional reading assignments. They will be asked to work on more extensive term projects and at time serve as mentors to the undergraduate students.