A SYSTEMS APPROACH TO GLOBAL ENGINEERING

CVEN 4157/CVEN 5157 (3 credit hours)

Spring 2021

Instructor
Bernard Amadei Ph.D., NAE
Professor of Civil Engineering, ECOT 546
E-mail: amadei@colorado.edu; Tel: 303-929-8167 (cell)

Prerequisites Senior or graduate level

Course website:
https://www.colorado.edu/center/mortenson/education/mortenson-center-courses/cven-41575157-001-systems-approach-global-engineering

Course Description

This course aims to introduce engineering students to the global context in which engineers are asked to operate in the 21st century. The course also introduces students to system dynamics tools and other decision-making tools (network analysis, agent-based modeling, etc.) 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 goals will be met through a combination of lectures, seminars, and projects. Students will be exposed to a variety of projects in the developed and developing world. In each project, students will be shown how technical and non-technical issues have helped shape the project outcome.

Throughout this course, students will be presented with the importance of depth and breadth in their education and the need for a balance between specialization and a broader understanding of the linkages between engineering and society.

This course 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 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: Tu and Th from 8:00-9:15 am; Online

Office Hours: By appointment.

Course Readings:

Students are responsible for all the required readings. These readings aim to (i) set the context for the class, (ii) generate questions for discussions, and (iii) deepen students' knowledge of topics. A mandatory reading list will be provided for each class period. Textbooks used in class include:

- Amadei, B. (2019) *A systems approach to modeling the Water-Energy-Land-Food Nexus, Vol. II,* ISBN 9781947083547, Momentum Press (required).
- Laszlo, E. (2001). *The systems view of the world: A holistic vision for our time*. Hampton Press, Cresskill, NJ. (distributed in class)
- Meadows, D. (2008). *Thinking in systems*. Chelsea Green Publishing, White River Junction, VT. (optional)
- Richmond, B. (2004). *An introduction to systems thinking, STELLA software*. isee Systems, Inc., Lebanon, NH (web link mentioned in class).

The web and the literature are rich in articles, videos, and web sites covering the topics mentioned below. Students are expected to read three to four articles (or book chapters) before each class, work and learn with their peers, and present their findings in class.

Software:

You are asked to purchase the student version of the ***STELLA Architect*** software (version 2.0.3) from https://www.iseesystems.com/store/education.aspx. Several student licenses are available. Select the one that fits your needs.

[1]These expected learning outcomes have been mapped to ABET Criteria 3 Student Outcomes: http://www.abet.org/eac-criteria-2014-2015/.

Course Content (30 lectures)

Below is a list of topics that will be addressed during the semester. They are listed in no specific order**.**

1. Course Overview and Introduction. Introduction to Systems Thinking
2. A Systems View of the World
   - Looking at the world as a system of systems
   - Systems science and complexity science
   - System thinking and methods of decision making
3. Introduction to System Dynamics
   - Components of system dynamics
   - System dynamics qualitative and quantitative modeling
   - Stella Architect software
4. A Systems Approach to Human Development- Part 1
   - Concepts and models of development
   - Development challenges in the developed and developing world
   - A systems approach to the MDGs and SDGs
   - Scenario planning models at different scales
5. The Water-Energy-Land-Food Nexus
   - The Water of Ayole case study
   - Analyzing and modeling the components of a case study
6. A Systems Approach to Human Development- Part 2
   - Modeling population dynamics
   - System archetypes
7. Systems Approach to the Management of Development Projects
   - Stages of project management
   - Role of non-technical issues in all stages of project management
   - Right projects, done right, and for the right reasons. Who decides and participates?
   - Collecting and analyzing data for systems modeling
   - Defining issues and their dynamic hypotheses
   - Social network analysis and GIS
   - Methods of decision making and the importance of perspective (Zoom)
   - Capacity, vulnerability, and risk analysis
   - Developing an implementation plan
   - Failure and the engineering mindset
   - Deciding when faced with uncertainty and complexity
   - Biases and cross-cultural communication
8. Sustainability and Sustainable Development
   - Definitions
   - Integrating sustainability in engineering projects
9. Systems Approach to Community Resilience and Security
   - Importance of context and scale
   - Capacity and vulnerability
   - Critical infrastructure
   - Response to hazards, adverse events, and human migrations
10. Combining methods of analysis
    - Network analysis (UCINET software)
    - Agent-based and discrete modeling (AnyLogic software)

- GIS (Esri ArcMap software)
- Causal Analysis and Multi-Criteria Decision Analysis (MCDA)

11. Case studies

Assignments and Grades

Student grades will be determined based on in-class participation (20%), homework assignments, and possible quizzes (40%), and multiple projects (40%).

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 advanced projects and serve as mentors to undergraduate students.

Team Work

All homework assignments and projects will be done in teams of undergraduate and graduate students.

Accommodations for Disability
If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

Religious Holidays
Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments, or required attendance. See the campus policy regarding religious observances for full details.

Classroom Behavior
Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation, or political philosophy. For more information, see the policies on classroom behavior and the Student Code of Conduct.

Preferred Student Names and Pronouns
CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation
The University of Colorado Boulder (CU Boulder) is committed to fostering inclusive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or cureport@colorado.edu. Information about the OIEC, university policies, anonymous reporting, and campus resources can be found on the OIEC website. Please know that faculty and graduate instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, dating, and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

Honor Code
All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the policy may include plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code

(honor@colorado.edu); 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the Honor Code Office website.

Requirements for COVID-19

As a matter of public health and safety due to the pandemic, all members of the CU Boulder community and all visitors to campus must follow university, department, building requirements, and public health orders in place to reduce the risk of spreading infectious disease. Required safety measures at CU Boulder relevant to the classroom setting include:

- maintain 6-foot distancing when possible,
- wear a face-covering in public indoor spaces and outdoors while on campus consistent with state and county health orders,
- clean local work area,
- practice hand hygiene,
- follow public health orders, and
- if sick and you live off-campus, do not come onto campus (unless instructed by a CU Healthcare professional), or if you live on-campus, please alert CU Boulder Medical Services.

Students who fail to adhere to these requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, see the policies on COVID-19 Health and Safety and classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please see the "Accommodation for Disabilities" statement on this syllabus. All students who are new to campus must complete the COVID-19 Student Health and Expectations Course. Before coming to campus each day, all students are required to complete the Buff Pass.

Students who have tested positive for COVID-19, have symptoms of COVID-19 or have had close contact with someone who has tested positive for or had symptoms of COVID-19 must stay home. Please let me know if you are sick or quarantined. Because of FERPA student privacy laws, students are not required to state the nature of their illness when alerting me. Also, they do not need "doctor's notes" for classes missed due to illness; campus health services no longer provide "doctor's notes" or appointment verifications.

Spring Pause

The week of March 22-26 will be used in this class as a spring pause to provide us all with a safe and supportive way to promote health, wellness, and learning without leaving campus. During this week, we will not have any exams or assignments due. We will still have classes with interactive class activities that will require your attendance and be part of your final course grade. While March 25 is a wellness day, attendance is still required for all other class sessions that week. I wish we could take a regular spring break, but public health concerns prevent us from doing so. I want to emphasize that it is still essential for you all to behave responsibly. Please do not use the week to travel or engage in risky behavior that could result in an outbreak on campus after we all return.