The student experience in an integrative, project-based course on quantitative engineering analysis

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I. Goals

Quantitative Engineering Analysis is an eight-credit, two-semester, experiential project-based course at F. W. Olin College of Engineering, for second and third semester engineering students. The course is designed to improve students facility and confidence in choosing and using the power tools of analysis in solving engineering problems. The goal of this workshop is to expose faculty from other institutions to the student experience in the first semester of this class, where participants will work through a number of activities based on activities done by students in the course. These goals align with the goals of FIE as we aim to expose participants to innovative teaching practice on multiple fronts including experiential, project-based learning of fundamental mathematics, physics and engineering material, approaches to teaming for students as well as interdisciplinary faculty, and scaffolding self-directed learning. Additionally, we will work with participants to initiate designs of activities which draw on these ideas that are adapted to the contexts of their home institutions.

II. Description

In this workshop, participants will engage with a number of activities based on the experimental course: Quantitative Engineering Analysis offered to first year students at our college. This 8-credit, two-semester course was designed to help improve student confidence and competence in choosing and using the power tools of engineering in solving real world problems. This course is taught by an multidisciplinary team of faculty at our institution and utilizes a number of innovative approaches to experiential and self-directed learning, and project based learning of fundamental mathematics, physics and engineering content.

In the spirit of learning by doing, participants will engage in a set of activities based on a subset of activities done by students in the class. These activities draw on three modules from the course: boat design, facial recognition, and computational robotics. Activities from these modules will illustrate approaches we took to teaching problem decomposition, learning quantitative tools, and bridging theory to practice. As such, these activities will develop approaches for analyzing and solving engineering problems, as well as fundamental concepts in mathematics, physics, and engineering at the first-year college level.

Additionally, we will share the approaches and frameworks we took for teaming - both for students and instructors, appropriate scaffolding for self-directed learning, assessment using a constructive engagement rubric, and creating an engaging, student-centered learning environment.

Earlier versions of this workshop have been presented by the facilitators and colleagues as part of the Olin College Summer Institute on Designing Student-Centered Learning Experiences in 2017 and in June 2018, and the Davis Workshop Series at Olin College in 2017. Presentation slides for the June 2018 edition can be found at: QEA Workshop 2018 at Olin College. This workshop will follow a similar set of activities.

Participants at the workshop will participate in the following activities

- In order to give participants a flavor of what an in-class activity might look like, participants will do an experimental activity on boat stability.
- In order to better understand the written assignments in this class, which are the primary guide for students in scaffolding their learning, we will have an activity where participants will explore a set of assignments in detail.
- Participants will be involved in an activity where they will design some aspect of a course using the approaches highlighted in the workshop, for their home institutions. This could be anything from an outline of an assignment, to a month-long module in a class, depending on participant's interests.

III. Qualifications of Presenters

Rebecca Christianson, Associate Professor of Applied Physics at Olin College of Engineering. B.S., B.A. Stanford University (1995), Ph. D. Massachusetts Institute of Technology (2001). 13 years of experience designing and teaching project based physics, mathematics and engineering classes at Olin College. Facilitator of several workshops on curriculum design and experiential learning such as:

1) Project based learning in Materials Science.Rebecca Christianson. ETH, Zurich Switzerland. January 2018.

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2) Entrepreneurial Thinking in Quantitative Course Design. Rebecca Christianson and John Geddes. KEEN National Conference, Dallas, TX. January 2018.
3) Team Teaching. Rebecca Christianson and John Geddes. Purdue Polytechnic, School of Construction Management Technology. August 2017.
4) Experience Matters: Quantitative Engineering Analysis. Rebecca Christianson, John Geddes, Paul Ruvolo, Sam Michalka, Siddhartan Govindasamy, Chris Lee. Olin College Summer Institute. June 2017.
5) Capstones as the Culmination of a Curriculum. Alisha Sarang-Sieminski and Rebecca Christianson. Olin College Summer Institute. June 2017.
6) Quantitative Engineering Analysis. Rebecca Christianson, John Geddes, Paul Ruvolo, Sam Michalka, Siddhartan Govindasamy, Chris Lee. Olin College Davis Foundation Workshop. May 2017.
7) Optics Taught Through Practical Microscopy. Rebecca Christianson. Olin College Davis Foundation Workshop. June 2011.
8) Creation of an energy focused engineering program within the physics department. Rebecca Christianson, Jon Stolk and Rob Martello. Creighton University. August 2010.

Siddhartan Govindasamy, Associate Professor of Electrical and Computer Engineering at Olin College of Engineering. S.B (1999), M.Eng (2000), Ph. D. (2008), Massachusetts Institute of Technology. 9.5 years of experience in designing and teaching project-based engineering classes at Olin College. Facilitator of a number of workshops on student-centered and project-based learning such as:

1) Faculty Development Workshop on Experiential and Project-based Learning, by Siddhartan Govindasamy. JK Lakshmipat University, Jaipur, India. March 2018.
2) Intrinsic Motivation Across Cultures, by Jonathan Stolk, Rob Martello, Siddhartan Govindasamy, Paulina Achurra. Olin College Collaboratory Summer Institute, June 2017.
3) Quantitative Engineering Classes: Experience Matters! by Rebecca Christianson, Siddhartan Govindasamy, John Geddes, Christopher Lee, Samantha Michalka, Paul Ruvolo. Olin College Collaboratory Summer Institute, June 2017.
4) Quantitative Engineering Analysis Faculty Development Workshop by Rebecca Christianson, Siddhartan Govindasamy, John Geddes, Samantha Michalka, Paul Ruvolo. Davis Foundation Workshop series at Olin College, May 2017.
5) Master class on Project-based Learning: A project-based introduction to Orthogonal Frequency Division Multiplexing (OFDM), by Siddhartan Govindasamy. Independent Studies Period, Ahmedabad University, India. December 2016.
6) Student-centered Approaches to Designing Advanced Technical Courses, by Siddhartan Govindasamy and Alexandra Coso-Strong. Olin College Collaboratory Summer Focus Workshop Series, July 2016.

John Geddes, Professor of Applied Mathematics. Dr. Geddes joined Olin in 2003, and has been fully engaged in building and sustaining this new engineering school. He has focused his attention on transforming mathematics education for engineers, and the development and mentorship of a diverse faculty body.

Dr. Geddes applies the tools and techniques of applied mathematics to a variety of problems in science and engineering. Over the years, he has worked with numerous collaborators on projects in fields like nonlinear optics and mathematical biology. His expertise is in mathematical and computational modeling, nonlinear dynamics and chaos. More recently, he is working with a group of faculty and students to develop and deploy navigation technology for blind sailors. He has received funding from the NSF and the NIH to support his work.

Dr. Geddes also brings his passion for applied mathematics to the classroom. He has developed and taught courses at all levels of the undergraduate curriculum, but he has focused on courses for first- and second-year students. Many of the courses that he has been involved with are inter-disciplinary, and co-taught with a range of faculty from across the disciplines. Dr. Geddes believes that undergraduate students have enormous potential for growth, and his courses usually emphasize self-directed learning and intrinsic motivation. Dr. Geddes has a B.Sc. in Computational Physics from Heriot-Watt University in Scotland, and a Ph.D. in Applied Mathematics from the University of Arizona. Prior to joining Olin College of Engineering, Dr. Geddes served on the faculty at the University of New Hampshire and Ramapo College of New Jersey.

IV. Agenda

1) Overview of course (10 mins)
2) Introduction to Boat Design module (45 mins)
   - Boat balancing exercise. Participants will work in small groups and conduct a boat-balancing and cargo maximization challenge which helps participants understand what student activities are like in the class.
3) Introduction to Face Recognition module (30 mins)
   - Activity on approaches to learning quantitative tools based on face recognition module. Participants will work in small groups to analyze approaches we took for students in the course to learn quantitative tools, as well as propose other approaches.
4) Break (5 mins)
5) Introduction to computational robotics module (10 mins)
6) Descriptions of subsequent modules (15 mins)
   - Facilitators will describe the 4 modules that students were assigned in the subsequent semester of the class namely, controlled heating, motion sensing, a balancing robot, and a student-designed module.

7) Design an activity/module (45 mins). Working in groups, participants will perform a high-level design of an activity pr module for an existing or planned class at their home institution based on ideas discussed in the workshop.
8) Discussion and wrap up (20 mins).
    - Facilitators will discuss observations and learnings from running this course including approaches to self-directed learning, faculty teaming, student motivation and ability in using analytical tools in solving engineering challenges.

V. Anticipated Audience

This workshop would be suitable for engineering and other technical faculty or others interested in project based learning of fundamental mathematics, physics and engineering. Maximum attendance of 40 participants. Specific domain knowledge in the example modules is not required.

VI. Take away skills, knowledge and material

Participants will learn approaches to designing project-based courses for teaching fundamental mathematics, physics and engineering concepts. Attendees will also learn about methods we used to teach engineering process, including problem breakdown, structuring self directed learning and bridging theory to applications.This includes guidelines for selecting appropriate projects, creating assignments that blend theory and application as well as developing students ability in problem framing. Additionally, participants will learn approaches for scaffolding self-directed learning. This includes approaches to designing assignments, in-class activities, and other course material which promote self-directed learning. In addition, attendees will learn our approaches to creating teams, organizing group work and in-class activities, and creating a classroom environment which promote peer learning.

VII. Resources and Fees

Any special requirements for electricity, audio-visual equipment, or materials? Projector.

Anticipated fee for attendees to cover materials and supplies? None beyond standard FIE fee for workshops