Investing in Instructors: Creating Intelligent Feedback Loops in Large Foundational Courses for Undergraduate Engineering

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Introduction

The drive to encourage young people to pursue degrees and careers in engineering has led to an increase in student populations in engineering programs. For some institutions, such as large public research institutions, this has led to large class sizes for courses that are commonly taken across multiple programs [1], [2]. While this decision is reasonable from an operational and resource management perspective, research on large classes have shown that students suffer decreased academic engagement, motivation and achievement [3]–[5] . Instructors, on the other hand, report having difficulty establishing rapport with their students and a growing inability to monitor students' learning gains and provide quality individualized feedback [4]–[6]. To address these issues, our project draws from Lattuca and Stark's Academic Plan model [9], which incorporates a thorough consideration of factors influencing curricular activities that can be applied at the course, program, and institutional levels, and assumes that instructors are key actors in curriculum development and revision [9]. We aim to revitalize feedback loops by productively leveraging institutional data to help instructors and departments continuously improve [10].

Project overview

A fundamental characteristic of the learning organization theory of change is the need to understand both the individual and systems level perspectives [11]. We prioritize regular engagement between faculty and institutional support structures to collaboratively identify problems and systematically establish continuous improvement, a key strength of this theory of change. We strive to build a *learning organization ecosystem* which will transform the undergraduate engineering educational environment by: (1) engaging, as equal partners, the faculty responsible for teaching large foundational engineering courses; (2) recreating the broken feedback loop from the Academic Plan Model by infusing data back into the decision-making processes of faculty and departments; and (3) collaboratively defining problems with faculty and administrators within the system and iteratively intervene.

This *Exploration and Design Institutional and Community Transformation* IUSE project will prompt and study the behavioral shifts of instructors in their responsibilities to teach approximately 4800 undergraduate engineering students across three years (see Figure 1 for a visual overview of the project). Project activities will answer the following research questions at the intersection of *learning analytics* and *faculty change* to inform how to productively leverage institutional data to improve the STEM undergraduate education system, in particular at the stage during which students take foundational courses taught in large class sizes:

RQ1: What data do STEM faculty teaching large foundational classes for undergraduate engineering identify as being useful so that they may enhance students' experiences and outcomes a) within the classes they teach, and b) across students' multiple large classes?

RQ2: How can looking across data sets at different levels (i.e., within-course and across courses) change faculty members' attitudes or behaviors related to teaching undergraduate classes?

RQ3: How can looking across data sets at different levels produce insights related to systemic challenges that can be addressed by an academic program or institution?
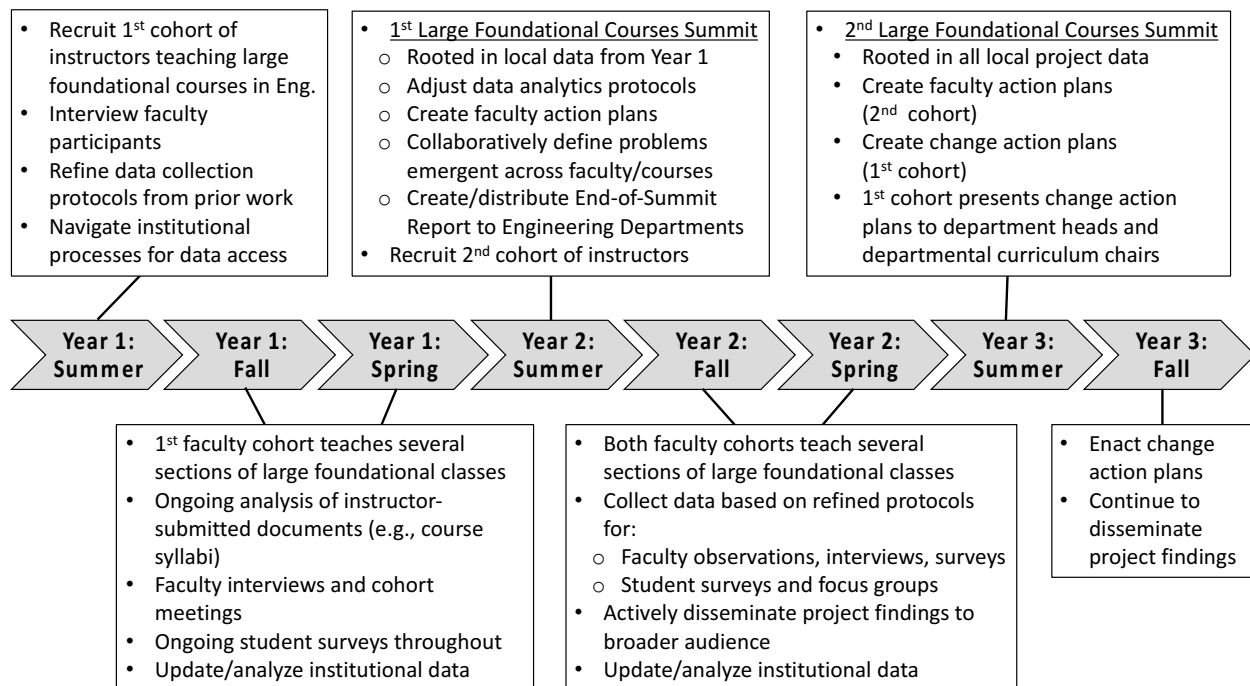
Year 1: Summer
- Recruit 1st cohort of instructors teaching large foundational courses in Eng.
- Interview faculty participants
- Refine data collection protocols from prior work
- Navigate institutional processes for data access

Year 1: Spring
- 1st Large Foundational Courses Summit
  - Rooted in local data from Year 1
  - Adjust data analytics protocols
  - Create faculty action plans
  - Collaboratively define problems emergent across faculty/courses
  - Create/distribute End-of-Summit Report to Engineering Departments
- Recruit 2nd cohort of instructors

Year 2: Spring
- 2nd Large Foundational Courses Summit
- Rooted in all local project data
- Create faculty action plans (2nd cohort)
- Create change action plans (1st cohort)
- 1st cohort presents change action plans to department heads and departmental curriculum chairs

Timeline: Year 1: Summer → Year 1: Fall → Year 1: Spring → Year 2: Summer → Year 2: Fall → Year 2: Spring → Year 3: Summer → Year 3: Fall

Year 1: Fall
- 1st faculty cohort teaches several sections of large foundational classes
- Ongoing analysis of instructor-submitted documents (e.g., course syllabi)
- Faculty interviews and cohort meetings
- Ongoing student surveys throughout
- Update/analyze institutional data

Year 2: Fall
- Both faculty cohorts teach several sections of large foundational classes
- Collect data based on refined protocols for:
  - Faculty observations, interviews, surveys
  - Student surveys and focus groups
- Actively disseminate project findings to broader audience
- Update/analyze institutional data

Year 3: Fall
- Enact change action plans
- Continue to disseminate project findings

Figure 1. Project at a glance: Investing in Instructors

Progress of Work

In Year 1 (see Figure 1) of this project, we focused on the experiences of instructors of foundational engineering courses usually taught in large class sizes. Project participants taught in 4 different departments at a large public research institution. We collected qualitative data (semi-structured interviews, course-related documents) and quantitative data (student surveys, institution-provided transcript data, department-provided evaluation data) to answer our research questions.

The preliminary data were used as a baseline to further refine data collection protocols, identify data that faculty consider meaningful and useful, and consider ways of productively leveraging data to improve the learning experience in large foundational engineering courses.

Participant interviews. We conducted semi-structured interviews with 8 instructors participating in Year 1, before the start of the Fall 2017 semester. The interviews, which lasted from approximately 40 minutes to one hour, were transcribed using a professional transcription service and analyzed using an online qualitative analysis software (www.dedoose.com).

Preliminary analysis on interview data was conducted concurrently by two members of the research team, in keeping with triangulation techniques [12]. First-cycle coding yielded 110 codes clustered around 17 themes, using *a priori*, *in vivo*, and descriptive coding techniques [13], [14]. The codebook was built iteratively, with the two investigators comparing coding decisions and making adjustments to code descriptions and clustering as part of the coding process. Themes included instructors' beliefs about students, challenges associated with the large class learning environment, and current practices and aspirations related to instructional processes and resources.

The participants were asked to identify data and resources that would help them facilitate the learning process more effectively. Based on participant responses, the most commonly-articulated aspiration is for interaction and collaboration with instructors from other departments. Participants sought opportunities to interact and collaborate with instructors from other departments who: 1) teach pre-requisite or prior courses that prepare students for the course/s that they are currently teaching, and 2) teach succeeding courses where the knowledge and skills gained in the course/s the participant is currently teaching are important and useful.

For example, a participant who teaches mathematics shared: "*As a resource that I would like, like from the department, from the university, is maybe to afford us some time to connect with colleagues outside of the department when we're teaching a class that services other departments, to get some input from those departments on why their students are in my room.*"

An instructor who teaches engineering mechanics courses expressed similar sentiments: "*The other thing that we don't really do and we haven't done this anywhere that I've worked and it would be really nice if we could is get these instructors of different courses together to talk about exactly what to cover, to even just look over the syllabus. What's covered, what they expect their students to know, and what they don't expect their students to know as well.*" This participant also shared: "*For all I know, whoever teaches next semester's course that follows [course], they might expect that their students understand one topic really very well and students are coming in with no idea how to do it because I don't spend any time on it because I don't think it's that important.*"

These statements are further supported by responses that talk about seeking discipline-specific applications of course concepts from participants teaching in non-engineering departments, such as: "*I also want to have the material I'm teaching somehow relevant to them, and that's something that I struggle with a little bit, because I don't have the engineering side.*"

Participant responses articulated data and resources that faculty consider valuable to the decision-making processes that shape the student learning experience in large foundational engineering courses. The information shared by our participants will allow us to identify strategies and facilitate opportunities to provide the instructors with the data that they need. Findings from the pre-semester interviews will inform activities and serve as catalyst for conversations during the Large Foundational Courses Summit, scheduled for Summer of Year 2.

Institutional and departmental data. We were provided access to institutional transcript data, from the Fall 2009 semester onwards. This data includes demographic information (e.g., gender, major), admissions data (e.g., SAT scores, high school GPA), and institutional academic information (e.g., course grades, cumulative GPA). The institutional transcript data provides such information as students' course-taking histories, major switching, degrees earned, and pre-college characteristics.

Participating departments provided access to data (e.g., departmental survey data) that may be merged with the institutional transcript data. Analysis of institutional and departmental data is ongoing. Initial findings on quantitative analysis performed on this data will be presented and help guide discussions during the Large Foundational Courses Summit.

Student Surveys. Surveys focused on students' study habits were administered to students in classes taught by project participants from one participating department. The survey asked students to indicate the amount of time they spent engaging with course material as they prepared for a high-stakes test. The instrument was adapted from a previous study that explored learner engagement in a statics course conducted by some members of the project team [15], [16].

Data collection was conducted through paper surveys included as an insert in a high-stakes test. A pilot run was conducted during the Fall 2017 semester; student responses and feedback from the instructor-participants were used to make adjustments to the survey. An updated version of the survey is being administered during the Spring 2018 semester.

Next steps

Year 2 will begin with the 1st Large Foundational Courses Summit. Participants to the first summit will include the first cohort of instructors who participated in the Year 1 activities.

Preliminary findings from data collection and analysis activities conducted during Year 1 will be presented and will be used as basis for action plans that will be collaboratively prepared by the participants and the project team. A report will be generated at the end of the Summit, for distribution to the participants' departments and college-level administrators.

The second cohort of instructors will be recruited. Instructors from departments not currently participating in the project will be considered; identification of these departments will be part of the Year 2 Summit.

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