



WIP: An Undergraduate Theory and Methods of Research Class for Honors Students

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Work in Progress: An Undergraduate Theory and Methods of Research Class for Honors Students

In an effort to improve recruiting and retention, our institution has focused on expanding the Honor's College experience. The Honors College is working with each of the individual colleges to develop honors experiences specific to that college's needs. Within the College of Engineering and Applied Science, the goal is to focus the Honors experience on undergraduate research with an aim of broadening research opportunities and competitiveness of student applications for summer research programs, NSF REUs, internal/external research funding applications, participation in undergraduate research conferences, and preparing the students for graduate school. Historically, many students (inside and outside of the honors program) have received credit for completing undergraduate research, but this is often a "stand-alone" course with no additional preparation and ill-defined outcomes. While this approach may provide a laboratory experience, the research experience is greatly dependent on the research laboratory and the research advisor. The significant increase in expected students performing undergraduate honors research also suggests that a group mentoring approach may be required in order not to require additional time from the research mentors. In an effort to improve the undergraduate research experience, we will be initiating an Engineering Honors Research Methods course for the undergraduate Honors students during the Spring 2020 semester as a prerequisite for subsequent undergraduate research.

The Research Methods course will be broadly focused by providing a general approach to research and graduate school preparation appropriate for all majors in the Engineering College. Alternative approaches from the literature that are used to teach students how to conduct research will be compared and contrasted. Course topics will include: finding a research mentor, literature search skills, using the scientific method for approaching a research problem, developing a research methodology, writing a funding proposal, delivering a research presentation, and selecting and applying for graduate school. The motivation for this work, course details, learning objectives, course schedule, and course assignments will be presented. Assessments and student outcome tracking for the course will be discussed. Experiences, outcomes, feedback, and lessons learned from the initial offering of this course will be presented.

Introduction

Recently, the Honor's program in our college has been revised to focus on undergraduate research. Undergraduate research experiences are considered High Impact Practices (HIP)[1] and are broadly used to improve recruiting and retention. As a result, all students will be required to take 3 credits of undergraduate research, complete a senior thesis, and deliver a research presentation.[2] The goal of this change is to increase the number of students conducting undergraduate research and to also increase the number of students applying for graduate school, NSF REUs and other research funding, and regional and national conference presentations. To achieve these goals, the undergraduate research will be paired with a Research Methods course. The broad goals of this research methods course are to improve the productivity of the subsequent undergraduate laboratory research course while providing the skills to apply for and receive competitive funding, admissions, and conferences.

In the social sciences, undergraduate research methods courses are fairly common.[3-5] These courses usually focus on developing, using, and interpreting surveys along with statistical analysis techniques. While these courses are less common in the hard sciences and engineering, some similar courses are offered.[6-8] In contrast with undergraduate courses, research methods courses for graduate students are becoming more common.[9-11] Compared to the social sciences courses, the graduate engineering courses include such content as delivering presentations, scientific methods, research ethics, proposal writing, literature searches, and reading the literature. Since these topics match up well with the research requirements of undergraduate students, many similar topics would also complement an undergraduate research course in engineering and hard sciences. In the current apprenticeship model of undergraduate research, the student simply goes to work in the laboratory. The strength of this model is the traditional reliance on one-on-one mentoring between the faculty and student. However, without this mentoring, the student is often on their own to obtain the research methods knowledge. To address this shortcoming, combined research and methods courses are offered where students are mentored on research methods while simultaneously conducting research.[12, 13]

As the demand for undergraduate research grows, is the current apprenticeship model of sending students directly into the lab without additional skills still viable? Even if these students receive additional research methods mentorship in the lab, the demands on the faculty time becomes evident.[14] Others have asked "What skills do students need to participate in undergraduate research?" and "Where in the curriculum do students develop these skills?"[15] This indicates an additional solution: a common course providing an introduction to research methods for undergraduates covering topics applicable to the goals above. In this way, multiple students can be group mentored in an efficient way to make progress towards the desired outcomes in the subsequent laboratory research course.

Methods

The initial offering of Introduction to Research Methods is being taught during the Spring Semester, 2020. Enrollment for this offering is two students. The course is being taught under the ES (Engineering Science) label and is cross listed under the label of each program in the college. While listed as a 3XXX level course (to help students meet upper division course requirements) the course is targeted at sophomore level students. Engineering Honors students are required to take three engineering honors course. This course is not required for Engineering Honors,

however, it will count as one of the three required. The course meets for 50 minutes three times per week for a total of 42 class periods. For the course, two required textbooks will be used: The Craft of research by Booth, Colomb, and Williams[16] and the Craft of Scientific Presentation by Alley.[17] For the research ethics discussion, On Being a Scientist: Responsible Conduct of Research [18] will be used. All assignments, lecture materials, and assessment tools will be posted at: https://uwyo.libguides.com/honors_research_methods_es3890

Assessment will fall into two categories: 1) course elements designed to improve the research experience and 2) feedback to develop the initial offering of the course and to refine future offerings. To measure impact on the research experience, the previously developed and validated Classroom Undergraduate Research Experience (CURE) survey will be used.[19] The longer goal is to then also perform student self-assessment before and after the subsequent laboratory experience using the Survey of Undergraduate Research experience (SURE III) survey.[20] For course development, pre- and post-course feedback will be obtained by a self-reported survey of the course topics.

Discussion

The general goals for the course are: (1) provide a general approach to scientific research and graduate school preparation, and (2) prepare the students for the subsequent laboratory research course. While focused on students in Engineering Honors, the course is available to all students across campus. The broad goals were then separated into individual learning objectives as discussed below. The class schedule for the initial offering is shown in Table 1.

Table 1: Course Outline

Week	Class	Topic	Week	Class	Topic
1	1	Introduction/Syllabus	9	1	Research Ethics
	2	Why Undergrad Research		2	Research Ethics
	3	Finding a Mentor		3	Research Ethics
2	1	Finding a mentor	10	1	Instructor out of town/guest
	2	Oral Presentations		2	lectures/to be determined
	3	Oral Presentations		3	
3	1	Literature Searches	11	1	What is graduate School?
	2	Reading the Literature		2	Finding a Graduate School
	3	Poster Presentations		3	Applying for Graduate School
4	1	Scientific Method	12	1	Careers with Graduate Degrees
	2	Scientific Method		2	Safety
	3	Scientific Method		3	Safety
5	1	Student Presentation	13	1	Research Notebooks
	2	Student Presentation		2	Research Notebooks
	3	Student Presentation		3	Citation Management Software
6	1	Student Presentation	14	1	Student Led Ethics Discussions
	2	Student Presentation		2	Student Led Ethics Discussions
	3	Student Presentation		3	Student Led Ethics Discussions
7	1	Undergraduate Research Opportunities	15		Final Exam week
	2	Proposal Writing			
	3	Proposal Writing			
8	1	Proposal Writing			
	2	Paper Writing			
	3	Paper Writing			

Lectures and topics fall into several categories: (1) finding your research interest and finding a mentor, (2) reading papers and writing papers and proposals, (3), scientific methods for developing a hypothesis and research plan, (4) research ethics, (5) graduate school familiarity and applying for graduate school, (6) presenting your research plan, and (7) professional skills.

To complement the lectures, assignments for the course are shown in Table 2. The skills and concepts to be reinforced by each assignment are also shown in Table 2. Assignments fall into the same seven areas as listed above for course topics/lectures.

Table 2: Course Assignments

	Topic	Skills/Concepts Reinforced
1	Finding a Mentor	Faculty/Student Interaction
	Research Interests	Self-Reflection
	Identifying Potential Mentors	Web research
	Meeting Mentors	Oral and Written Communication
2	Literature Search	Library, Written Communication, Literature Comprehension
	Find Relevant Papers	Library, Searching Skills
	Insert Into Reference Manager	Practical Skills
	Literature Synopsis	Written Communication
3	Presentation	Oral Communication, Research Methods, Scientific Method
4	Ethics Discussion	Oral Presentation, Research Methods, Library Skills
5	Seminar/Proposal/Defense	Written communication, Research Integration, Exposure to Graduate Expectations
6	Hypothesis and Research Plan	Scientific Method, Research Integrations, Written Communication
7	Laboratory Safety	Safe laboratory practices
8	Proposal	Library, Scientific Method, Written communication
9	Poster Presentation	Oral Communication, Scientific Methods, Literature Skills, Research Integration

To initiate the course, three lectures are devoted to discussing the outcomes and benefits of undergraduate research and finding a mentor for research. Finding a mentor is complemented by three assignments: identifying the student's research interests, identifying potential mentors, and meeting mentors. A reflective statement will be used by the students to self-focus their research interests. Next, web and other resources will be used for the students to identify potential mentors across campus. Finally, the students will meet with potential mentors to discuss research opportunities and then write a synopsis of the meetings along with the positives and negatives of each opportunity. The goal is for the students to identify a mentor and start the process of integrating into their mentor's research lab.

Following lectures on literature searches and reading the literature, the student will locate journal articles of their mentors work and other related work. This assignment will also have them write a synopsis of the articles and how it is connected with the student's project. Later in the semester, the students will enter the manuscripts into a reference manager. The scientific methods will then be covered over three lectures. Future assignments to develop a research plan and hypothesis will build upon these lectures.

In parallel with the assignments to find a mentor, three lectures will cover oral and poster presentations. Practical examples of both types of presentations will be examined to assist the students in the upcoming assignments to prepare both types of presentations. The student presentation will be an oral presentation to present a synopsis of their literature search and how it contributes to and directs their research. This presentation combines the previous work on reading the literature, the literature synopsis, and provides presentation practice. Immediate feedback from the instructor and student peers will be used to improve presentation skills.

To complement the outcome of having students write and submit their own funding proposals, three lectures will discuss proposals and proposal writing. For the assignment, students will select a funded research opportunity (on campus or off) and complete a mock application. Hopefully, students will directly submit these applications or further improve them during the subsequent semester's research course under their research mentors guidance. Since personal statements are common for these types of applications, this area will be emphasized. To complete the writing portion of the course, two lectures will cover writing manuscripts for submission to journals. Clearly the students have not completed enough research to prepare a manuscript, however the goal is for thinking about writing papers and the structure of papers to contribute to learning about the research process and guiding their research hypothesis and plan.

Research ethics will be covered over three lectures with a subsequent assignment and student led research ethics discussion. The National Academies document "On Being a Scientist"[18] provides an effective approach for these lectures as it has a number vignettes for discussion. With this background, the students will lead class discussion on some historical research ethics examples. This will include, literature search, situation synopsis, and oral classroom discussion. Late semester topics will focus on professional development topics such as: What is Graduate School, Finding a Graduate School, Applying for Graduate School, and Careers with Graduate Degrees. These lectures are complemented with an assignment to attend a graduate seminar and either a proposal (preliminary exam) or a final defense and then reflect on the presentation and connect components with topics covered in the course. The students will also complete the on-line safety training during this time.

The poster presentation will conclude the semester and be held during the final examination period. The poster will be similar to a portfolio combining all of the work from the semester. This will include a short synopsis of their research mentor and their mentor's work. The main focus of the poster is to cover the research hypothesis and research plan together with contributions from the literature and how the literature influenced their plan.

This course builds from similar undergraduate courses in the social sciences and graduate courses in hard sciences and engineering. While the research mentoring is similar to combined mentoring/research courses, this course is set up for the students to have separate research mentors in a subsequent course. Perhaps the most similar course to this course is presented by Balster et al.[21] Many of the topics and goals are similar with their course actually being a two semester sequence of courses meeting for one hour per week each semester.

For assessment, the CURE survey compares self-reported learning benefits between course experiences and undergraduate research experiences in such areas as knowledge of the

“research process.” It measures progress in a number of areas valuable in scientific research. It also provides estimates of learning benefits that parallel questions in the SURE. An important comparison will be the starting and ending point SURE measurements as compared between students taking this course and not taking this course. Students will also be individually interviewed to obtain their perspectives on the course and any suggested course improvements.

Conclusions

As a work in progress, an undergraduate Introduction to Research Methods course is being developed and offered for the Honors Program in our college. The course is being offered for the first time during Spring Semester 2020.

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