

# WIP: The Lean Canvas for Invention (LCI): An Integrated Framework for Research Development, Matrix Mentoring, and Career Development Training

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**Abstract**—This research-to-practice WIP paper describes a novel framework for research development in a graduate course that integrates career preparation and mentoring. The Lean Canvas for Invention (LCI) framework aims to help students identify a research problem through exploration of scientific, patent, and business literature, as well as stakeholder interviews. The stakeholder interviews and synchronous class interactions provide career and early mentor/network development. The 15-week variable credit (0.5-3) course is designed for first-year graduate students.

**Keywords**—professional development, research development, mentoring, career development, network development

## I. INTRODUCTION

This paper describes three years of a pilot curriculum experience with intent to improve graduate student professional development in the Department of Electrical and Computer Engineering at the University of Utah. We used the Lean Canvas for Invention (LCI) framework [1], [2], integrated with the additional topics of career and mentor/network development. This new framework is designed to help graduate students find and think through a key research or technical problem of their choosing and its *most valuable research problems*. This problem is explored through the innovative scientific, patent, and business literatures. Student conduct a series of stakeholder interviews to further refine the problem. This LCI framework provides support for technical exploration as well as career exploration and mentor/network development. We found that interactions within the class and reaching out to stakeholders naturally leads to enhanced career exploration and early development of the students' mentor/network for the industry of choice. In this paper, we describe pilots for a variable (0.5-3 credit semester course (15 weeks), and the lessons learned through these pilot experiences.

Our goals were to improve graduate education by: (a) helping students develop their research objectives and critical thinking to be successful in their discipline, (b) enhance the quality and effectiveness of peer and faculty mentoring relationships to create a more inclusive and supportive research environment, and (c) facilitate graduate students professional competencies, vocational literacy, career identity, workforce readiness, and lifelong career management for a broad range of STEM careers. The course includes:

**Research Development:** Students apply the LCI framework process to an engineering research problem of their choosing. They evaluate journal literature, patents, and business literature to find a novel idea/question of interest, and its value proposition. Students also find and interview stakeholders.

**Mentor/Network Development:** Students reflect on what makes a high-quality mentor/mentee relationship through discussion with other classmates and their advisor. They learn about the structures at universities and companies that can help facilitate mentoring, and how to adapt to change and provide criticism as needed. They develop strategies for tough conversations, learn about bias, and how to lead diverse professional teams. Students also learn how to improve their mentor network.

**Career Development:** Students reflect on their strengths and weaknesses and complete an (IDP), individual professional development plan, to learn about a variety of career options for graduate students. When they interview stakeholders related to their research problem of interest, they also ask about the career options and expectations of the companies represented. Students attend the career fair (resumes in hand) and host an industry career panel to learn about several types of careers open to them.

The course materials are available for sharing with other faculty/institutions via Canvas [3], and a textbook has been created [4]. Please contact the authors.

## II. COURSE DEVELOPMENT

The *Lean Canvas for Invention (LCI)* [2], [4] shown in Fig. 1 (bottom) is a new approach based on the *Lean Canvas for Business (LCB)* (Fig. 1 top) (also called the Lean Startup) [5], [6]. The Canvas refers to a visual process that lays out the essential elements for success shown in Fig. 1. Lean refers to being efficient and effective. The LCB has been taught at Stanford, Berkeley, Columbia, and Caltech and adopted by NSF [7] and NIH [8] (i-Corps) to improve business development through hypothesis-driven experimentation, iterative product releases, and validated learning [9], [10]. Stakeholder interviews with customers, partners, competitors, etc. are a key feature of this approach. The LCB identifies the *Minimum Viable Product (MVP)* for a startup business. The LCI helps researchers at an early stage in the invention-innovation cycle identify their *Most Valuable Problems (mvp)* to address in their research. The professional network that is formed helps the LCB entrepreneur and the LCI researcher with initial connections and early feedback. The challenge when applying the LCB to academic research is that it starts at the stage a startup can be conceptualized, typically after much of the early research and innovation has been completed, and a patent has been or soon will be filed. But most academic research starts earlier than this when questions are being explored. The LCI canvas shown in Fig. 1 has different key elements than the LCB. The dashed “Z” on the LCI shows the route of exploration for (example) a PhD project. Beginning with Problem Identification (the big picture problem of interest), the state of art, novelty and potential value are explored through scientific, patent, and business literature to find the most valuable research question or problem (mvp), which is as far as we get in the LCI course described in this paper. The early stakeholder interviews provide specific technical and societal impact information, and they also provide a social network for the LCI researcher and a first professional network for career development and exploration.

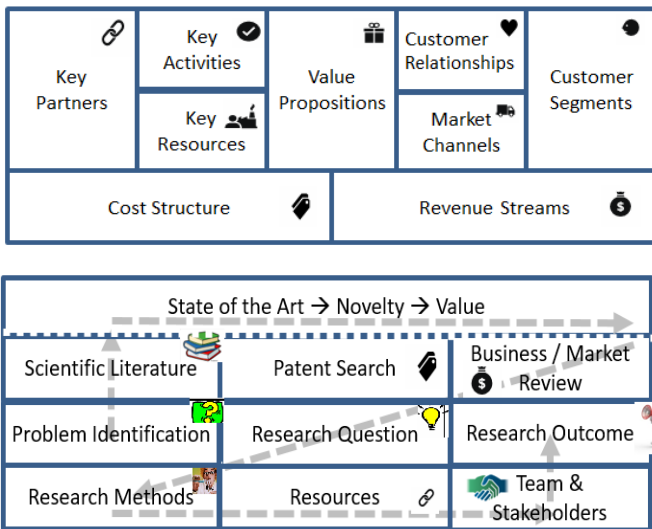


Fig. 1. (Top) The Lean Canvas for Business (LCB), and (Bottom) The Lean Canvas for Invention (LCI) [1], [2]

### A. Course Pilot History

The Lean Canvas research development content of the course was originally piloted at the University of Utah as a 6-week not-for-credit experiment. Research groups joined together along with their professors, rather than as individual students, and considerable progress was made in research development. Since then, Prof. Bhutto has been teaching this content both in person and online in Pakistan and seeing substantial improvement in the student research and entrepreneurship experience, based on review of content included in their theses.

In 2021, we taught the course as a 3-credit semester-long graduate course. The course was team-taught by an electrical engineering professor (Furse), two educational psychology faculty (Metz and Tao), and librarians (Ziegenfuss and colleagues, who led content on patent and literature surveys). Although students liked and took part actively in the course, they seemed to struggle keeping up with the homework, and nearly half took an incomplete, and finished it over the summer.

In 2022, we taught the course as variable credit, where students could take anywhere between 0.5 and 3.0 credits. We required them to attend at least one weekly session, which gave them at least an introduction to each of the three course areas - research development, network/mentoring development, and career development. We also further refined course content, based on earlier feedback. The distribution of credits selected by the students is shown in Fig. 2, and student feedback on the variable credit option was very strong.

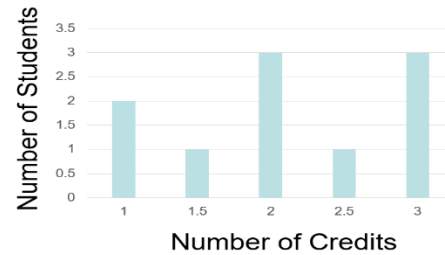


Fig. 2. Student credit choices for Fall 2022

In 2023, we did an informal survey in our graduate seminar. Students requested an online course in professional development, so we adapted the content for a fully online asynchronous format. We kept the (popular) variable credit option developed in 2022, allowing students to select assignments from any of the topics in the course, choosing those that best fit their interests and needs. The distribution of assignments students selected is shown in Fig. 33. We also kept the weekly live discussions but made them optional. Students requested these to be via Zoom. This format of the course was much more popular than previous years. Thirty students enrolled. About ~ 1/3 of the students normally attended the discussions, which were used for items that benefit from interaction such as practicing presentations -- Elevator Pitch, Interview questions (what are your strengths and weaknesses), patent searching, etc. In 2023, we also changed the course title from *Lean Canvas* to *Professional Development for Graduate Students*, which improved the marketing for the course.

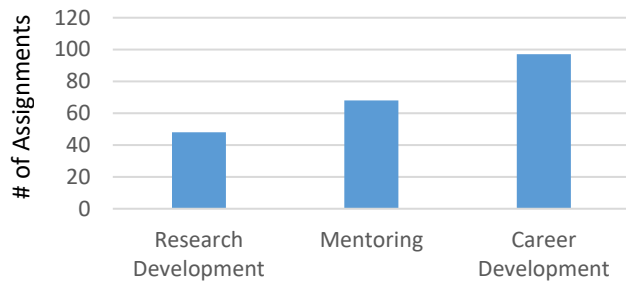


Fig. 3. Assignment choices (#) in each category in fall 2022

### III. ASSESSMENT

To find out more about the confidence of our overall student population (not just those in our course, we surveyed the students in our graduate seminar course (most of the first-year students) about their confidence in various career development tasks. The results are given in Table 1. Example career-related questions and concerns are given below:

"Get my CV past the hiring algorithm."

"Improve communication to perform better in interviews."

"Understanding scope of growth in a particular role."

"I know I am the best, but I don't believe it. It seems confusing but I don't know why! I need to learn how to have more confidence."

"How to stand out in a crowd of talent?"

Post-course interviews were completed by Dr. Ziegenfuss after the 2021/2022 course. Students reported they developed confidence in their abilities to be a successful engineer, conduct research, realized the value they bring to the profession and learned about subjects traditionally outside of engineering such as business practices. They reported appreciating having the time to reflect on their career path and professional strengths and weaknesses as something they had not done before. One student also commented on feeling much better about the skill sets that he brings to the engineering profession.

### IV. RESULTS:

We evaluated the effectiveness of the work in progress in several ways. After each assignment, we asked students to rank the value of the assignment, how much time it took, and any feedback on improving the assignment. Although students ranked all three of the course elements well, the highest rankings were in the Lean Canvas research assignments, particularly finding the research problem, citation formatting, and conducting stakeholder interviews. The second strongest rankings were for career development, where the highest valued assignments were completing and reflecting on the individual development plan, doing an elevator pitch, and learning about interviewing. In the mentoring development section, the highest scoring assignments were those that focused on setting mentoring SMART goals, setting up mentoring expectations and boundaries and learning about culturally responsive mentoring. One student commented, "we talked about the soft skills you need as an engineer but aren't talked about in other classes." This topic of valued-added course topics kept

recurring over and over. Although students felt overwhelmed with the number of assignments (which greatly improved when we went to a variable credit option), they felt all three topic areas (research, career development, and mentoring skills) were all important. One student reported that they were sharing what they learned with their peers and research team members.

TABLE 1: CAREER DEVELOPMENT QUESTIONNAIRE, GRADUATE SEMINAR FALL 2023 (N = 33). SCALE: NOT AT ALL CONFIDENT = 1, A LITTLE CONFIDENT = 2, CONFIDENT = 3, VERY CONFIDENT = 4, EXTREMELY CONFIDENT = 5

|     | How confident do you feel that you could:   | Mean | SD   | % who responded not at all or a little |
|-----|---|------|------|--|
| 1.  | Write a resume or CV that highlights your skills  | 3.58 | .94  | 15.2%                                  |
| 2.  | Read a job description and understand what the employer is looking for in an applicant (needed versus preferred qualifications) | 3.64 | .90  | 9.1%                                   |
| 3.  | Write a compelling cover letter that explains how you are a great fit for a specific job  | 2.91 | .98  | 33.4%                                  |
| 4.  | Attend a career fair and make small talk with recruiters  | 3.79 | 1.08 | 15.2%                                  |
| 5.  | Attend a career fair and gain information about internships and jobs  | 4.06 | .93  | 6.1%                                   |
| 6.  | Design a LinkedIn account that will represent you well to recruiters and companies  | 3.09 | 1.26 | 30.3%                                  |
| 7.  | Search for internships or jobs on company websites  | 3.55 | 1.00 | 15.2%                                  |
| 8.  | Apply for internships or jobs on company websites   | 3.7  | 1.10 | 18.2%                                  |
| 9.  | Talk about your skills and abilities in an interview  | 3.73 | 1.10 | 21.2%                                  |
| 10. | Talk about a weakness in an interview   | 3.39 | 1.06 | 21.2%                                  |
| 11. | Ask relevant questions in an interview  | 3.34 | 1.18 | 28.1%                                  |
| 12. | Negotiate a job offer   | 2.48 | 1.28 | 69.7%                                  |
| 13. | Build a network of professional contacts from peers to faculty, to people in industry   | 2.88 | .99  | 36.4%                                  |
| 14. | Learn about careers outside of academia   | 3.16 | 1.32 | 40.7%                                  |
| 15. | Stay up to date with the latest trends in your field  | 3.15 | 1.23 | 39.4%                                  |

#### A. Career Development and Mentoring Reflections

Part of each assignment was a reflection, which we evaluated with a qualitative analysis to better understand students' mentoring and career development needs. In total, 118 individual responses from 11 students selecting amongst the twenty assignments were uploaded to NVivo, a qualitative analysis tool. The average number of responses per assignment was 6. Two of the assignments, Communication Ideas and the Implicit Attitudes Test, only had one response each. The assignments with the largest student responses (at 8 and 9 students each) were: Individual Plan Interests, Individual Plan Skills, Psychosociocultural Factors, Strengths and Weaknesses, Strengths Profile, and Stress Strategies. In total, 526 code instances (or coding frequencies) were identified and coded using a recursive inductive process of open coding, and then

categorization into themes. Six themes were identified with the percentage of coding:

- Dealing with self-care and stress (33.5%)
- Aspiring to learn and do more (23%)
- Connecting and interacting with others (14.7%)
- Managing mentoring boundaries/ expectations (13.2%)
- Identifying work values (10.7%)
- Developing plans and commitments (4.9%)

The largest themes within the *Dealing with Self-Care and Stress* theme, were identifying strengths and weaknesses, barriers to self-care, coping strategies, and the different types of self-care related to family and friends, work-related, body, spiritual and relationship self-care. One student summed up similar responses of others by saying, “Instead of trying to make huge changes, work on simple, tiny improvements ... don’t have to spend a lot of time or money on self-care... [and] start with the most important task.” The coding in the second largest theme, *Aspiring to Learn and Do More*, centered on discussion of having to be more assertive and take initiative and how they could contribute to the research teams. Students reflected on lessons learned and the importance of perseverance and the continuous improvement when in graduate school. The third highest numbers of codes were in the theme, *Connecting and Interacting with Others*. Assignments helped students think through and reflect on having difficult conversations, confronting peers, asking questions and requesting help from others. The topic of impostor syndrome was also associated with this theme and how they needed time and experience to rise above feeling inadequate when interacting with others. One student said, “One of the main reasons people experience the imposter phenomenon is when other people, like peers, mentors, and relatives, criticize them.” Although the last three themes were really the focus and purpose of these assignments, the student reflections and assignment responses about the mentoring experience and career planning coding crossed boundaries about what they aspired for the future, how they need to learn to work as a productive research team member, and how all this graduate student activity was influenced by their work life balance and interacting with others.

### B. Additional observed outcomes

In at least one case, the student reflected that he was working directly with the rest of his (more senior) research team members on the research development tasks, and he provided specific feedback to his team about the business and patent literature from the class. Three of the five students were interviewed after the completion of the Spring 2022 semester. Two of the three reported the value of the course that integrated research, career and mentoring development and talked about recommending the course to their peers.

Originally this course was designed for graduate student teams nearing completion of their graduate studies but most of the students who took this course were just beginning graduate studies and felt this should be offered for beginning graduate students. Based on the qualitative data analysis, it is recommended to introduce this type of curriculum earlier in the graduate student experience so that students can learn how to

reflect and become more self-aware of the challenges, issues and opportunities that are also important for impacting their graduate student career and into the future.

We found that the students clearly liked the variable credit option. They also liked being able to choose between research, network, career assignments. We continue to feel that in person or zoom conversations are often stilted, although some of the more candid conversions illuminated areas of angst within the department. One concern was the rising cost of student housing on campus. We helped students from our class reach out to administration and join a rising set of voices on this issue. As a result, our graduate student advisory committee (SAC) was reinvigorated, and steps have been taken to raise student stipends and limit housing cost rises.

### ACKNOWLEDGEMENT

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