

# An Innovative Graduate Education Course –

## Lean Canvas for Invention

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**Abstract**— The Lean Canvas for Invention (LCI): A Team Based Framework for Research Development and Mentoring is a bold, new, and transformative approach to STEM graduate education and training. In this project, we are piloting, testing, and validating the effectiveness and feasibility of the Lean Canvas for Invention framework, hosted within a course for research students within the College of Engineering at the University of Utah. This course is 1-3 credits, meant to be taken in the first year of a graduate student program. Content includes research development (including business-oriented evaluation of technology), career development, and mentor/network development. This paper describes our first year experience teaching the class twice, lessons learned, and plans for next year's developments.

### I. INTRODUCTION

The Lean Canvas for Invention (LCI): A Team Based Framework for Research Development and Mentoring is a bold, new, and transformative approach to STEM graduate education and training. In this project, we are piloting, testing, and validating the effectiveness and feasibility of the Lean Canvas for Invention (LCI) framework [1], [2], combined with career development and mentor/network development, in a course for research students within the John and Marcia Price College of Engineering at the University of Utah.

The LCI is a new framework to help research students identify and think through a key research problem and its *most valuable research questions*, and plan and implement both their research and career trajectories. Their exploration reaches beyond the traditional scientific literature and experience and will include innovation triggers such as patent literature, business reviews, and personal interactions with key stakeholders. In addition, students explore career development and mentor/network development through readings/video content, self-exploration, and interviews with stakeholders in their chosen industry.

We have recently piloted this as a 1-3 credit course in two semesters, and have gained a variety of lessons learned, in some cases pivoted our trajectory, and made plans for next year's course. Faculty have readily adopted this approach with their teams. In this project we propose to add mentoring and career development aspects to the LCI. Thus, the LCI can provide a framework that fits naturally with the way engineering research is typically done and provides a structure that enhances the team research experiences, and the quality of mentoring and career preparation.

We hypothesize that this novel framework will improve graduate education by: (a) helping students develop their research objectives and critical thinking and develop the skills and knowledge 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.

### II. THE LEAN CANVASES FOR BUSINESS AND INVENTION

The *Lean Canvas for Invention (LCI)* (Fig. 1 Bottom) is a new approach that we developed based on the *Lean Canvas for Business (LCB)* [3] (Fig. 1 Top) that has been taught at Stanford, Berkeley, Columbia, and Caltech and has been adopted by NSF [4] and NIH [5] (i-Corps). This framework (“canvas”) shortens (“leans”) product development cycles by adopting business-hypothesis-driven experimentation, iterative product releases, and validated learning [6], [7]. Entrepreneurs talk to key stakeholders (customers, partners, competitors, etc.) and encounter the chaos and uncertainty of commercializing innovations. The *LCB* has been adapted and leveraged extensively at the University of Utah, and is one of the key components of our innovation ecosystem. Applying this model after recently submitting invention disclosures, many researchers have said they wished they had gone through the stakeholder reviews at the beginning of their research process, and that it could have made their thinking even more innovative and more likely to be applicable in the real world. Where the *Lean Canvas for Business* identifies the Minimum Viable Product for a startup business, the *Lean Canvas for Invention* helps researchers at an early stage in the invention-innovation cycle identify their Most Valuable Research Questions.

In addition, through the *Lean Canvas* experience, a social network is formed that benefits both the research and the mentoring and career development of the individuals and the team. This framework formalizes the team-based research development process that is common in engineering and adds in three significant components that are typically ad hoc or missing entirely (1) Exploration of the full state of the art, including patent literature and business / market reviews (e.g. is this area growing, in what ways, what are the major barriers to growth, what regulations apply, what policies are in play?), (2) Two-way interaction with a wide variety of stakeholders

(e.g. rather than a traditional model of teaching students to speak to diverse audiences, this framework engages students in asking and listening to the perspectives of diverse audiences that interact with their field, also providing early opportunities for interaction and networking within their professional community), (3) A matrix mentoring model where multiple mentors provide support for the student.

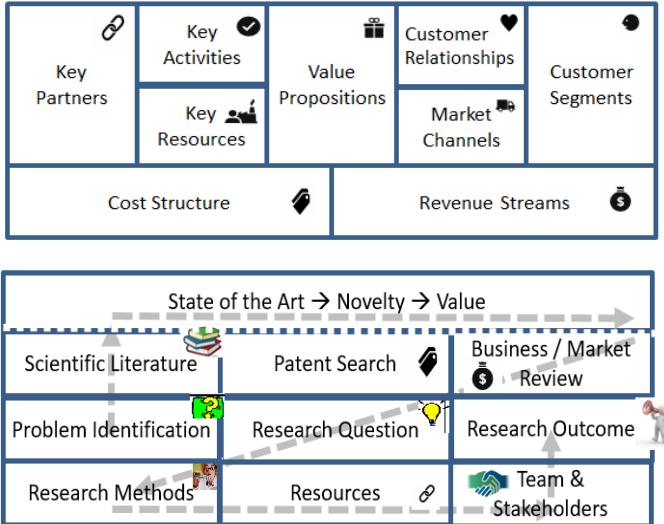


Figure 1. (Top) **The Lean Canvas for Business (LCB)** is used for I-Corps training by both NSF and NIH. Participants fill in the canvas information via in-person stakeholder interviews, pivot their business theories based on these interviews, and identify a minimum viable product (MVP) in a realistic market. The Canvas is stored, accessed, and assessed via a mature set of online tools. (Bottom) **The Lean Canvas for Invention (LCI)** framework follows (see the Z-shape) the full dynamic life of the research process from the earliest problem identification, through an evaluation of novelty and value to identify the most valuable research question, then through the research methods and resources (including the team and stakeholders) to a valuable research outcome, which would then lead into the LCB. A detailed version of the LCI framework can be found in [1], [2].

### III. FIRST YEAR PILOT COURSES

The LCI class has been developed on the Instructure Canvas our learning management system (not to be confused with the Lean Canvas). The course is designed to be variable credit (1-3 credits), and is intended for graduate students in their first year of study. It may be potentially valuable for students in later years, and undergraduate research students have joined the course, as well. We have taught this course two semesters and are assessing data from the student experiences to plan for the next course in fall 2023.

Content includes LCI research development, career development, and mentor/network development. Formal review of academic, patent, and business literature leads to problem identification, followed by stakeholder interviews. Prof. Bhutto has developed a series of video lectures and a textbook, which supports the LCI content. Formal career development and mentor/network development are also

included. Stakeholder interviews are used to evaluate technology and business needs, learn more about the industry in the area the student is interested in working, and establish some mentor/network opportunities within the context of the student's chosen research area. Content includes:

- Week 1: Introduction to the LCI and Research Problem Identification
- Week 2: Stakeholder Needs (Gaps and Interests)
- Week 3: Stakeholder Interview Preparation (Needs, Gaps, Values & Interests data collection)
- Week 4: Research Strategies & Information Seeking
- Week 5: Patent Searching Strategies
- Week 6: Preparing for Stakeholder Interviews
- Week 7: Business and Market Landscape Analysis
- Week 8-10: Stakeholder Interviews
- Week 11: School-Work-Life Balance
- Week 12: Leadership
- Week 13: Implicit Bias
- Week 14-15: Wrap up

### IV CONCLUSION

We have taught a pilot course and two semester-long LCI courses, and have several lessons learned. We initially planned that students would do 10-30 stakeholder interviews, similar to an NSF i-Corps program (which expects 100+). This has not proven to be feasible. We have found that 3-5 is more realistic. We thought students would be most engaged with the research development portion of the course, given the need to jump start their research programs. And although this was the case with some students, many seemed most hungry for career and mentor development support. We are assessing further data, which we will share at the conference.

All of these materials can be shared with other faculty interested in developing a similar course at their institution.

### ACKNOWLEDGMENT

This material is based upon work supported by the National Science Foundation under Grant No. 2105489.

### REFERENCES

- [1] C. Furse and A. Bhutto, "Entrepreneurship: Getting Your Research Off the Bench and Out Into the Real World [Young Professionals]," *IEEE Antennas and Propagation Magazine*, vol. 61, no. 1, pp. 139–142, 2019.
- [2] Bhutto, Arabella and Furse, Cynthia, "Bridging Academic Inventor-TTO Manager Schism: A Tool - the Lean Canvas for Invention," presented at the First International Triple Helix Summit on "The Role of Government / Academia / Industry in building Innovation-based Cities and Nations, Dubai, United Arab Emirates, Nov. 2018.
- [3] A. Osterwalder and Y. Pigneur, *Business model generation: a handbook for visionaries, game changers, and challengers*. John Wiley & Sons, 2010.
- [4] "I-Corps - NSF - National Science Foundation." [https://www.nsf.gov/news/special\\_reports/i-corps/](https://www.nsf.gov/news/special_reports/i-corps/) (accessed Nov. 24, 2018).
- [5] "I-Corps™ at NIH | NCI: SBIR & STTR." <https://sbir.cancer.gov/programs/education/icorps> (accessed Nov. 24, 2018).
- [6] H. Y. Ching and C. Fauvel, "CRITICISMS, VARIATIONS AND EXPERIENCES WITH BUSINESS MODEL CANVAS," p. 12, 2013.
- [7] M. N. Dudin, N. V. Lyasnikov, L. S. Leon'teva, K. J. Reshetov, and V. N. Sidorenko, "Business Model Canvas as a Basis for the Competitive Advantage of Enterprise structures in the Industrial Agriculture," *Biosciences Biotechnology Research Asia*, vol. 12, no. 1, pp. 887–894, Apr. 2015, doi: 10.13005/bbra/1736.

# An Innovative Graduate Education Course

## The Lean Canvas for Invention



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Design, and Heritages (Pakistan)**

# An Innovative Graduate Education Course

## The Lean Canvas for Invention



### Acknowledgement:

This material is based upon work supported by the National Science Foundation under Grant No. 2105489.

# The Project

- **The *Lean Canvas for Invention*:  
A Team-Based Program for Research Development,  
Mentoring, and Career Readiness**



# The Team

## ***The Lean Canvas for Invention: A Team-Based Program for Research Development, Mentoring, and Career Readiness***



[Cynthia Furse](#) ➔

Electrical and Computer  
Engineering, UofU



[Arabella Bhutto](#) ➔

Vice Chancellor, SABS  
University



[A.J. Metz](#) ➔

Educational Psychology,  
UofU



[Karen Tao](#) ➔

Educational Psychology,  
UofU

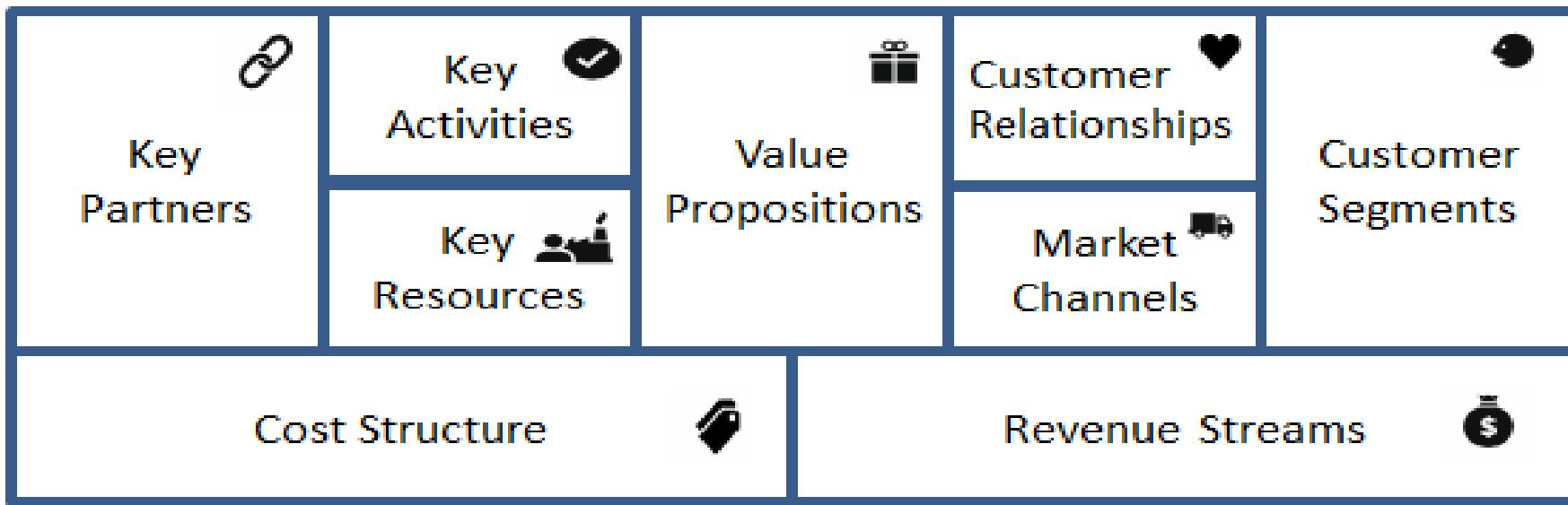


[Donna Ziegenfuss](#) ➔

Education Specialist,  
Marriott Library, UofU

# The Lean Canvas for Business

- A Tool to help early stage technology find the “Minimum Viable Product (MVP)”

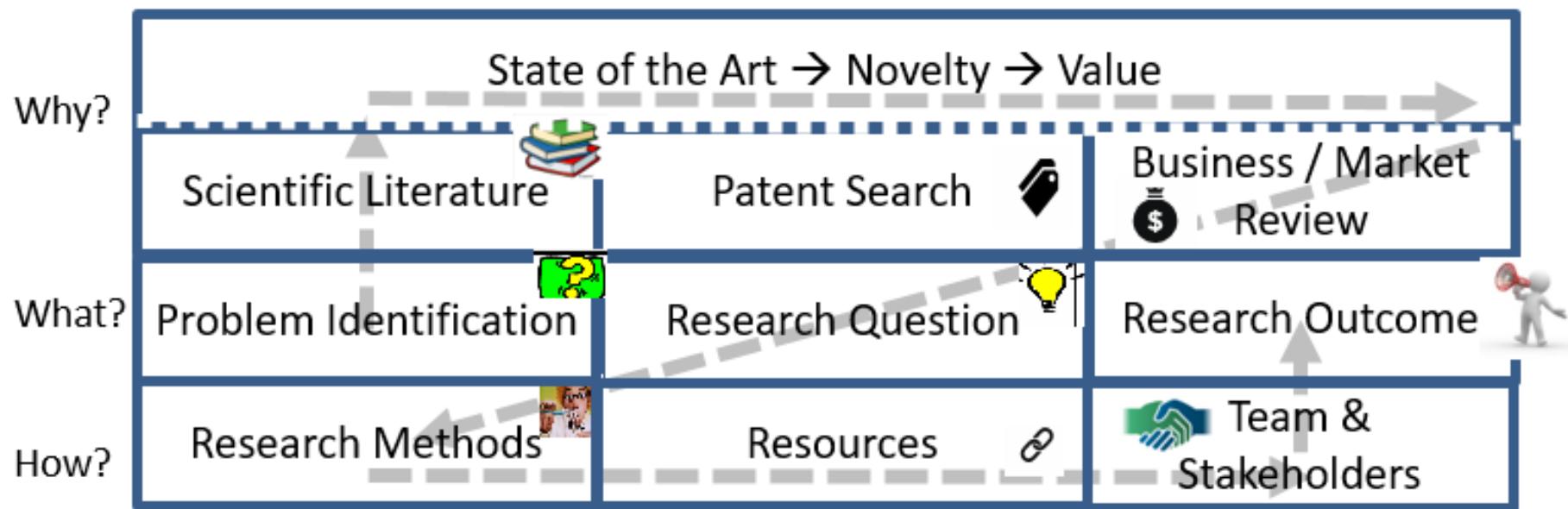


Osterwalder, A., Pigneur, Y., & Clark, T. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers*, Wiley, Hoboken, NJ. The *Lean Canvas for Business* is also known as the *Business Model Canvas* or *Lean Startup*.

# The Lean Canvas for Invention

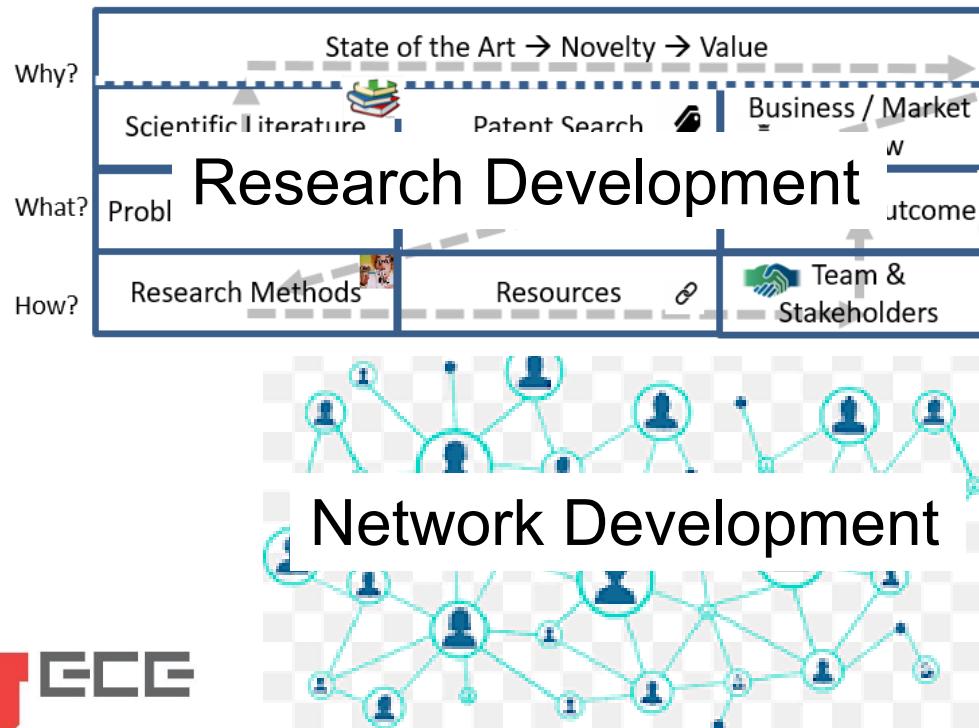
- **A Tool to help early stage research find the “Most Valuable Problem (MVP)”**

## Research Development



# The Lean Canvas for Invention ++

- **A Tool to help early stage research find the “Most Valuable Problem (MVP)”**
  - + Network / Mentor Development
  - + Career Development



# Network Development



- **Matrix Mentoring – Research Advisor**



# Network Development



- **Matrix Mentoring – Research Advisor, Other Faculty**



# Network Development



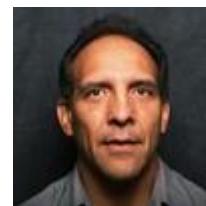
- **Matrix Mentoring – Research Advisor, Other Faculty, Peers**



# Network Development



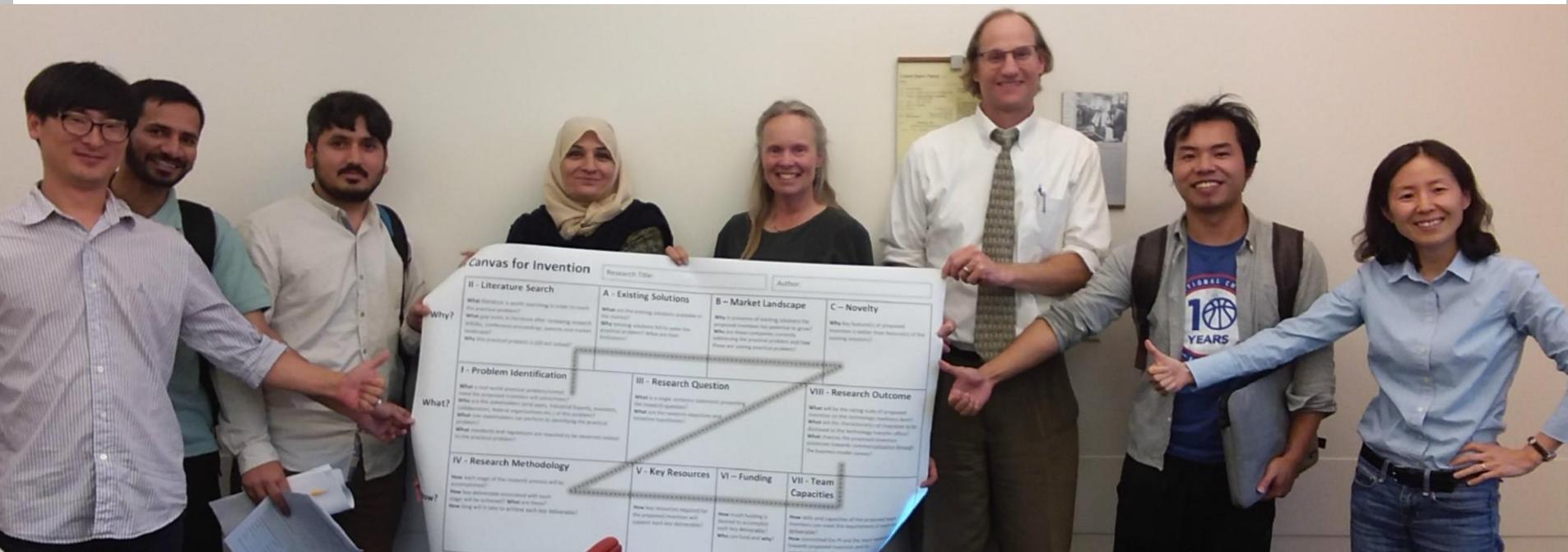
- **Matrix Mentoring – Research Advisor, Other Faculty, Peers, Business and Industry Experts**



# Network Development

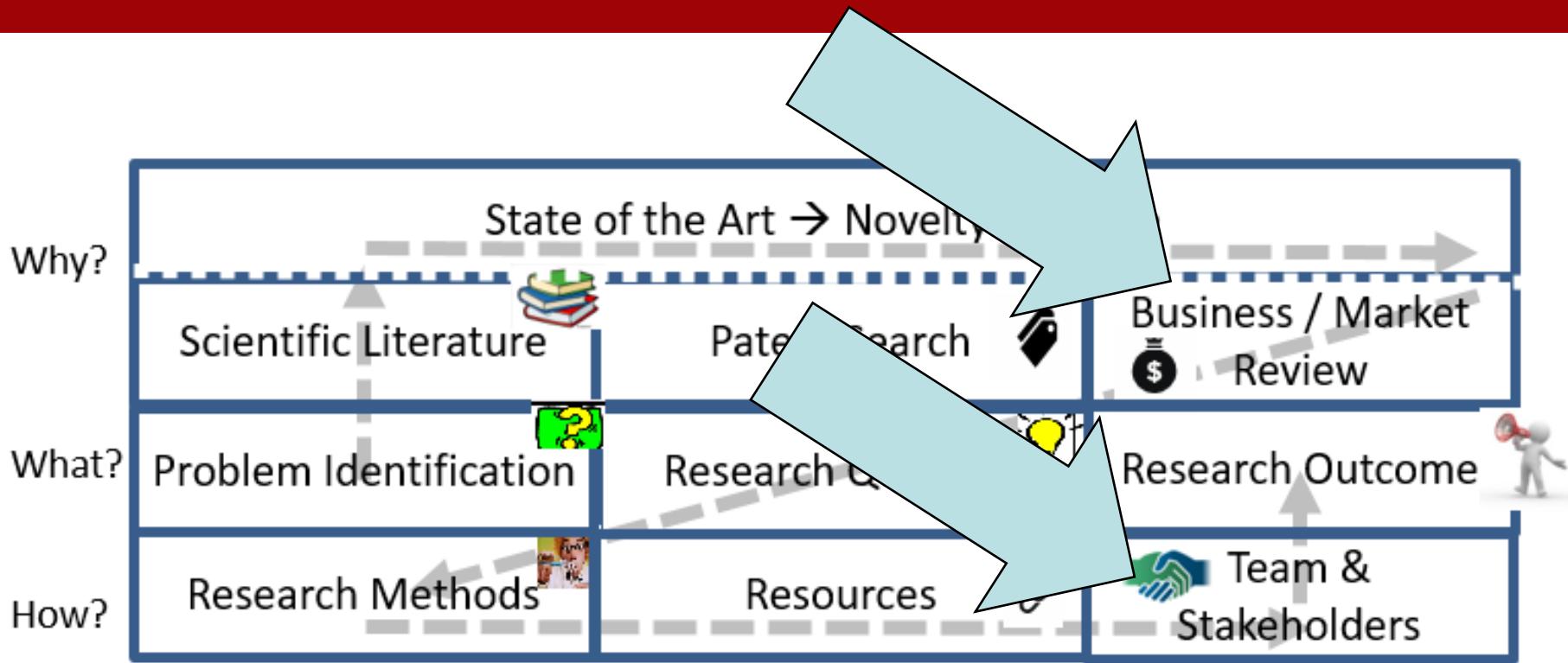


- **Matrix Mentoring – Research Advisor, Other Faculty, Peers, Business and Industry Experts**



A “Matrix of Mentors” and a PROCESS for building it

# Network Development



- Skills: Communication (interviews, difficult conversations, communication styles), Work Management (scheduling, work/life balance, meeting skills), Team (communication, bias, leadership), Mentoring (giving and receiving)

# Professional & Career Dvlpmnt.



- **Diverse career options (industry, academia, govt., policy, etc.)**
- **Skill identification, development plan, practice**
- **Individual Development Plan (IDP)**

# How the Class is Organized

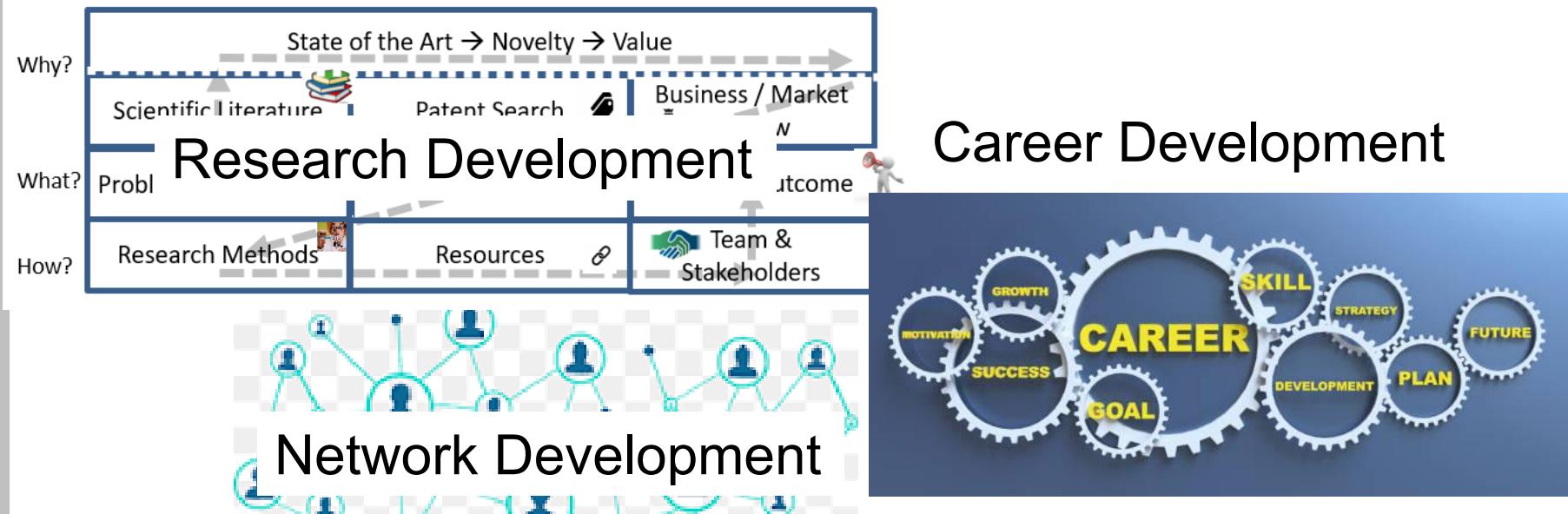


Table 3: The *Lean Canvas for Invention (LCI)* Curriculum:

(Colors are associated the research questions in Table 2)

Example of LCI-based Activities	Mentoring Skills	Professional & Career Competencies
<b>Pre-Class</b> Faculty member defines real-world problem (a funded project, or new project of interest), shares this with the team (some students may already be working on this, others are new to the group).	Students complete Individual Development Plan (IDP) ( <a href="http://MyIDP.sciencecareers.org">MyIDP.sciencecareers.org</a> )	Students and faculty identify possible career paths and competencies needed.

## STAKEHOLDER NEEDS (GAPS & INTERESTS)



### INTRODUCTION & EXPECTATIONS

The focus this week will be on preparation. In terms Research Development, you will be reading more about Lean Canvas including stakeholder identification. You will then complete a mapping of stakeholders and share it with your research mentor. With respect to Matrix Mentoring, you will reflect on how your personal characteristics and values might influence your mentoring relationships or work within a team. Finally, we'll set the stage for your Career Development by exploring the changing nature of work, "future of work" skills, and a model for understanding the importance of self-efficacy beliefs, goal setting, and feedback.

Dr. AJ Metz will be the facilitator for Week 2



### PRE-CLASS PREPARATION

The focus this week will be on career development. We'll start by taking a look at how the nature of work is changing, the need to develop "future work" skills, and the importance of building a protean career.

Dr. AJ Metz will be the facilitator



## LEARNING OBJECTIVES

- Understand how the nature of work is changing and the need to develop "future work" skills
- Identify ways to raise low self-efficacy beliefs
- Be able to articulate proximal influences to career decisions, goals, and actions
- Adopt a growth mindset and a "Not Yet" attitude towards feedback

## INTRODUCTION

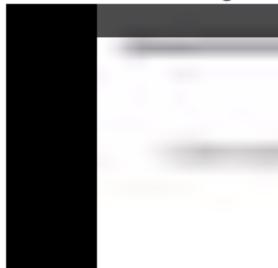
- The focus this week will be on career development. We'll start by taking a look at how the nature of work is changing, the need to develop "future work" skills, and how to build a protean career. We'll then take a look at a career development model that will help us understand the importance of self-efficacy beliefs, goal setting, feedback, and identifying barriers and supports.

## PRE-CLASS READINGS / ACTIVITIES

- Please take a look at this article. You don't have to read it word-for-word, but be able to identify one or two things you found interesting in class. [Coronavirus: How the World of Work May Change Forever](#)

## PRE-CLASS VIDEOS, TUTORIALS & CLASS RECORDINGS

- Please watch: [Understanding Career Development](#)



## OVERVIEW OF POST-CLASS ASSIGNMENTS

Throughout the semester, you will be accessing the myIDP website (<https://myidp.sciencecareers.org/>) to complete the self-assessment tools and see what career paths fit your interests and skills. You will then read about different career paths that interest you and learn about sources for gathering additional information. Small assignments based on the myIDP have been created to help you gather the information that will be integrated into your final Career Development project - crafting an Individual Development Plan (IDP).

This week, you'll be reading about interests in the myIDP portal and taking the interests assessment. The assignment will help you think about how you can create a S.M.A.R.T. goal for pursuing one of your interests while still in graduate school.

## SUPPORTING MATERIALS

-  [SMART Goal Template](#) ↓



## IN-CLASS ACTIVITIES

Wednesday 2-3 pm Please join us via Zoom

Link to Zoom Classroom: <https://utah.zoom.us/j/91285976417>

We will discuss:

- the career development activities you can select from this semester (See [attachment](#)
- the LCI Pre-Class Survey and informed consent
- Changes in the nature of work and how you may be impacted
- the Social Cognitive Career Theory
  - How to raise self-efficacy beliefs
  - How to interpret and use feedback
- My IDP



## POST-CLASS ASSIGNMENTS (HOMEWORK OUTSIDE OF CLASS)

Lean Canvas Topic

- [Stakeholder Mapping](#)
- [Week 2 Wrap Up Survey](#)

Mentoring Matrix Topic

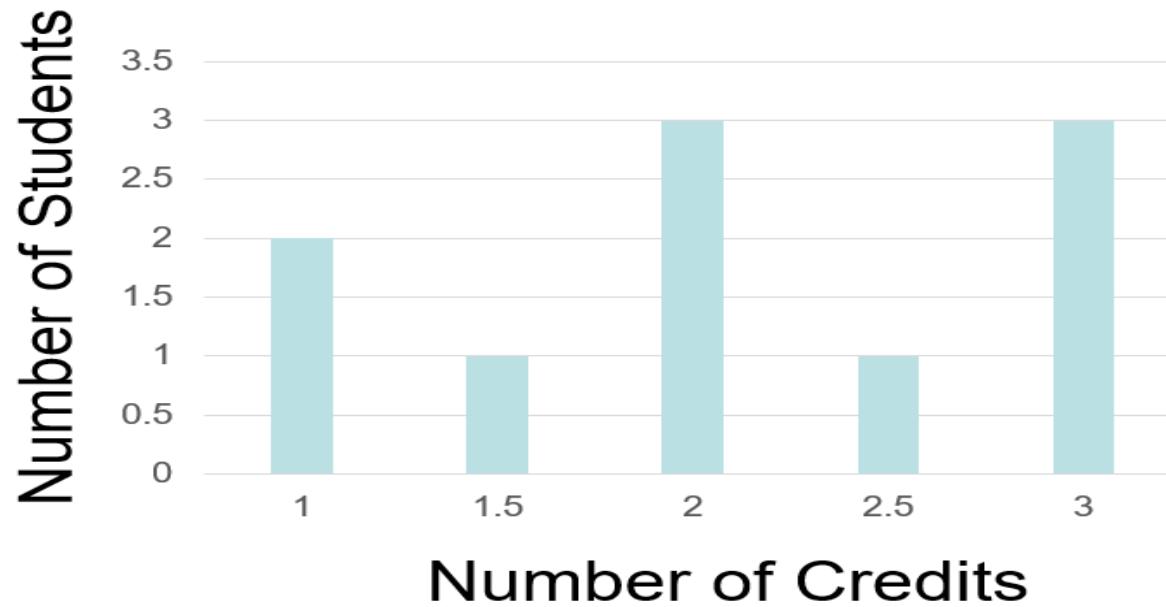
- [Via Character Strengths Survey](#)
- [SMART Goals for Your Mentoring Relationship](#)

Career Development Topic

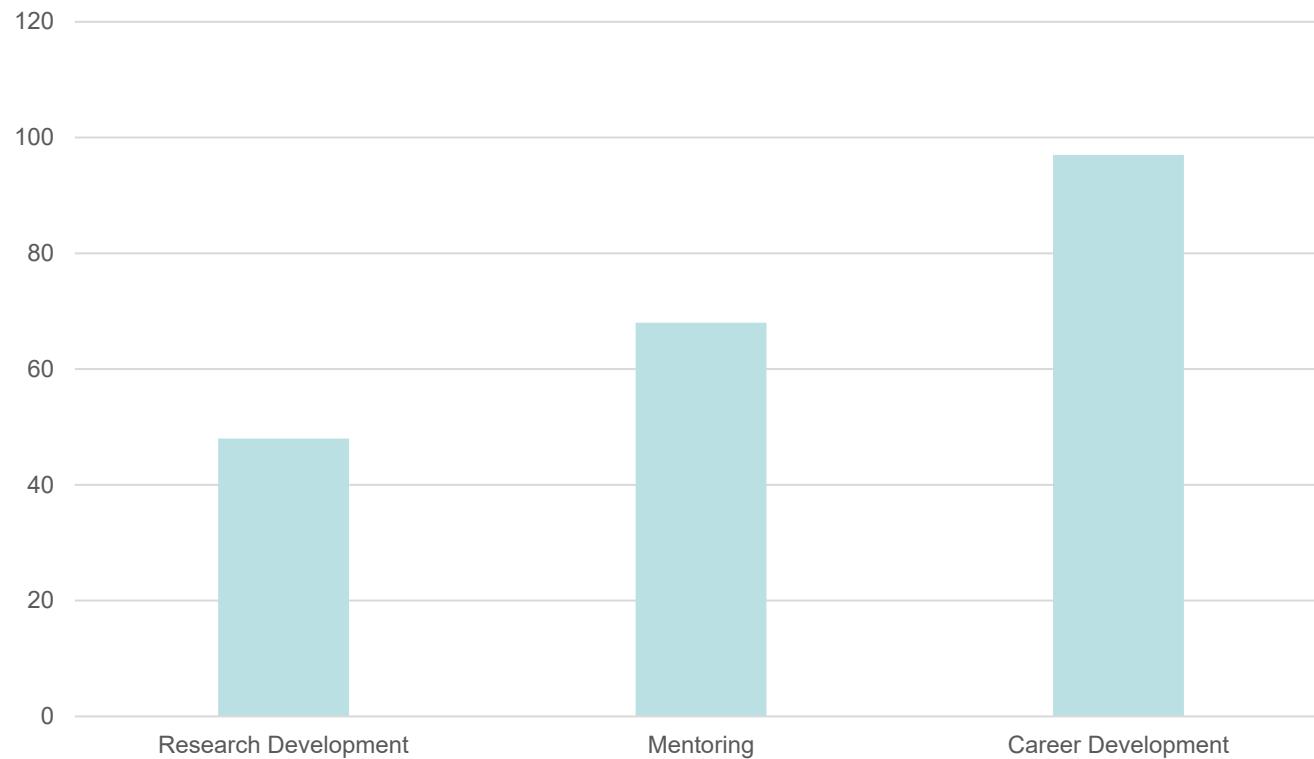
- [Individualized Development Plan \(IDP\) Interests \(CD4\)](#)
- [LCI Informed Consent \(CD5\)](#)

Turns out, There's a  
LOT of Material.

# How the Class is Organized: Variable Credit



# Variable Credit: Most Preferred Assignments

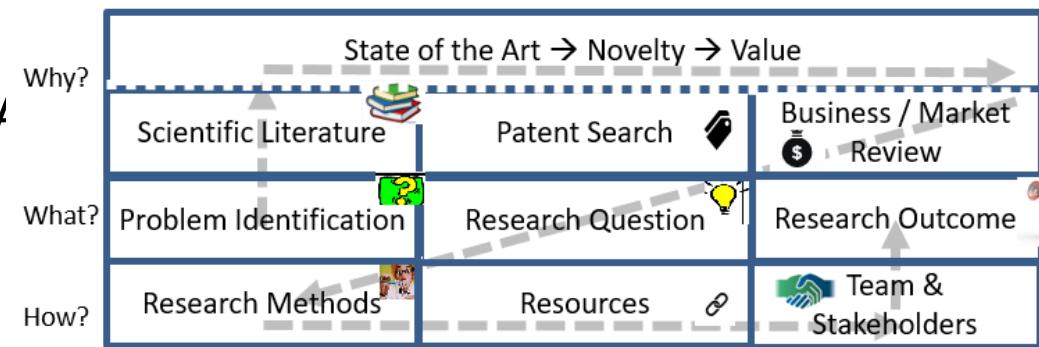


# Weekly Overview

- 1: Introduction to the Lean Canvas for Invention II & Problem Identification
- 2: Stakeholders' Needs (Gaps & Interests)
- 3: Stakeholder Interview Preparation (Needs, Gaps, Values & Interests data collection)
- 4: Research Strategies & Information Seeking
- 5: Patent Searching Strategies
- 6: Preparing for Interviews
- 7: Business & Market Landscape Analysis
- 8-9: Stakeholder Interviews
- 10: School-Work-Life Balance
- 11: Leadership
- 12: Implicit Bias
- 13-15: Work Weeks

# How this Fits the Lean Canvas for Invention

- 1: Introduction to the Lean Canvas for Invention II & Problem Identification
- 2: Stakeholders' Needs (Gaps & Interests)
- 3: Stakeholder Interview Preparation (Needs, Gaps, Values & Interests data collection)
- 4: Research Strategies & Information Seeking
- 5: Patent Searching Strategies
- 6: Preparing for Interviews
- 7: Business & Market Landscape /
- 8-9: Stakeholder Interviews
- 10: School-Work-Life Balance
- 11: Leadership
- 12: Implicit Bias
- 13-15: Work Weeks



# Example Module Assignments

## ▼ Module 1 (wks 1-3): Gearing Up to Collaborate & Problem Identification

 [Home Page](#)

 [Week 1: Introduction to the Lean Canvas for Invention II & Problem Identification](#)

Aug 30

 [LCI Pre-Class Survey \(CD1\)](#)

Sep 6 | 10 pts

 [Elevator Pitch \(CD2\)](#)

Aug 30 | 10 pts

 [Research Problem Identification and 5 Whys -- Identify and Understand the Problem.](#)

Aug 30 | 30 pts

 [Individualized Development Plan \(IDP\) Skills Assignment \(CD3\)](#)

Sep 6 | 10 pts

 [Mentee Readiness Assessment \(M1\)](#)

Aug 30 | 10 pts

 [Pre-Course CBAM survey assignment \(res dev\)](#)

Aug 30 | 10 pts

# Example Module Assignments



## Week 2: Stakeholders' Needs (Gaps & Interests)

Sep 6

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### Stakeholder Mapping

Sep 6 | 30 pts

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### VIA Character Strength Activity (M2)

Sep 6 | 10 pts

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### SMART Goals for Mentoring

Sep 6 | 10 pts

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### Individualized Development Plan (IDP) Interests Assignment (CD4)

Sep 13 | 10 pts

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### LCI Informed Consent (CD5)

# So What Happened?

2019: Pilot Course

2021: LCI Course Development (8 students)

- Didn't work to plan on research TEAMS, switch to individual
- Students struggled to complete 3 full credits, switch to Flex credits.

2022: LCI Course Second Run (14 students, Flex Credits)

- Students liked Flex Credits, did well.
- Most popular topic was Career Development, students suggest this as a substitute for Grad Seminar
- Still difficult to get good discussions going via Zoom, switch to in person
- Interdisciplinary, worked well (undergrads also benefitted)

2023: LCI Course Third Run

# So What Happened? Pre- Post-

- 16 students took the LCI pre-test in Spring 2022 and Fall 2022
- 6 students took the LCI post-test
  - Learning point: Require post-test
- Gender
  - 12.5% Female
  - 87.5% Male
- Race/Ethnicity
  - 43.75% Asian/Asian American
  - 37.5% White/Caucasian
  - 18.75% African American/African/Black
- Year in School
  - 1 undergraduate
  - 5 master's degree
  - 8 Ph.D.
  - 2 Did not report

# Engineering Interest (Scale of 1-7)

Item	Pretest Mean	SD	Post-test Mean	SD
Fascinating	6.23	.70	6.6	.49
Appealing	6.08	.73	6.2	.56
Interesting	6.8	1.28	6.93	.75
Exciting	6	.96	5.4	1.36
Means a Lot	6.36	1.67	6.8	.16

# Engineering Self-Efficacy (Scale of 1-7)

Item	Pretest Mean	SD	Post-test Mean	SD
I can master the content in engineering courses I am taking this semester.	5.73	1.44	6.2	.98
I can master the content in even the most challenging engineering courses if I try.	5.27	1.48	6.2	.40
I can do a good job on almost all of my engineering courses if I do not give up.	6	1.10	6.2	.75
I can do an excellent job on engineering related problems and tasks assigned this semester.	5.67	1.25	5.8	.75
I can learn the content taught in engineering-related courses.	6.2	.75	5.8	.98
I can earn a good grade in my engineering-related courses.	6.13	.62	5.6	1.02

# Engineering Persistence Intentions (Scale of 1-7)

Item	Pretest Mean	SD	Post-test Mean	SD
I intend to enroll in additional engineering courses.	5.27	1.8	5.4	1.62
I intend to complete all requirements for the engineering degree program.	6.8	.4	7.0	0
I intend to seek a job in engineering once I graduate.	6.33	1.0	6.6	.49
I see myself working in the field of engineering for at least 3 years after I graduate.	6.53	.81	6.8	.40
It is important for me to graduate from college with a degree in engineering.	6.67	.79	7.0	0

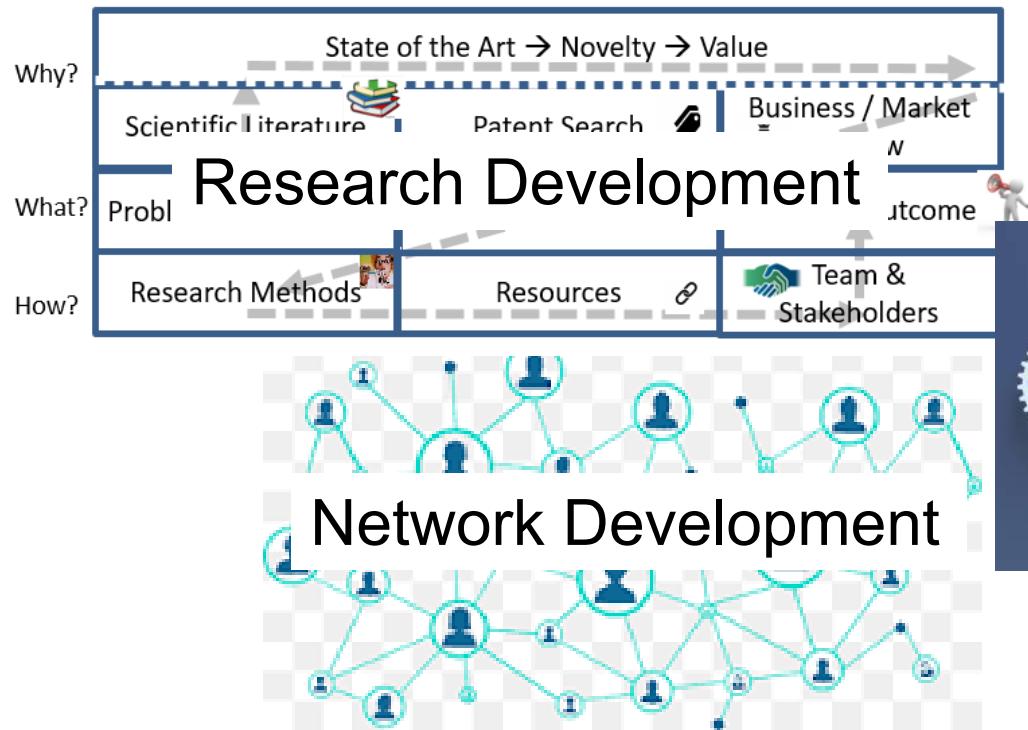
# STEM Self-Efficacy Beliefs (Scale of 1-7)

	Mean		Mean	
Acquire sufficient transdisciplinary literacy to solve complex problems	3.27	1	3.75	1.09
Identify an important problem and articulate an original research question	3.07	1.18	4	1.22
Design a research study to address the research question	3	1.26	3.75	.83
Acquire mastery of quantitative, analytical, technical, and technological skills	3	1.03	3.5	1.12
Understand and apply professional norms and practices to the engineering enterprise	3.13	1.15	4	.71
Learn ethical responsibilities and apply ethical principles and standards	4.13	.88	4.75	.43
Learn how to effectively lead teams and manage others	3.53	1.09	4.25	.83
Develop the ability to work in collaborative team settings	4	.82	4.25	.83
Acquire the capacity to communicate orally and in written form to STEM professionals and the public	3.47	1.15	3.5	1.12
Interpersonal communication	3.67	.94	4	.71
Multicultural competence	3.93	.85	3.75	.83
Develop deep specialized expertise in at least one STEM discipline	3.6	.8	3.25	1.3
Adopt rigorous standards of investigation	3.07	1.06	3.25	.83

# Barriers (Scale of 1-7)

Financial strain	3.2	1.33	4.0	.63
Lacking confidence in my academic skills	3.4	1.2	2.87	1.5
Test anxiety	2.6	1.31	3	1.67
Experiencing discrimination	1.93	1.34	1.4	.49
Uncertain of my career goals	2.93	1.06	2.4	1.74
Lacking support from my instructors	1.93	1.18	1.4	.49
Lacking support from my friends or family	1.53	.72	1.2	.4
Difficulty balancing all of my responsibilities	3.4	1.36	3.6	1.36
Depression	3.36	1.23	3.6	1.36
Not having a role model or mentor	2.07	1.39	1.6	1.20
Loss of interest in engineering	2.6	1.3	2.3	1.3
Feeling anxious or overwhelmed	3.6	1.54	3.2	1.83
Feeling bored	2.73	1.06	2.4	.8

# The Lean Canvas for Invention ++



# Resources

## Canvas-based Course

- (Available to share)
- EMLab.eng.Utah.edu  
(Click Education)

LEAN CANVAS FOR INVENTION AND CAREER DEVELOPMENT



The image shows a screenshot of a Canvas-based course interface. At the top, a red banner displays the title "LEAN CANVAS FOR INVENTION AND CAREER DEVELOPMENT". Below the banner is a large image of a red "U" logo on a grassy lawn with trees in the background. Below the image are four navigation links: "About this Course" (with a lightbulb icon), "Resources" (with a book icon), "Tech Help" (with a question mark icon), and "Contact your Instructors" (with an envelope icon). A circular navigation icon with a hand icon is at the bottom.

WELCOME TO ECE 5960 / 6960-028!



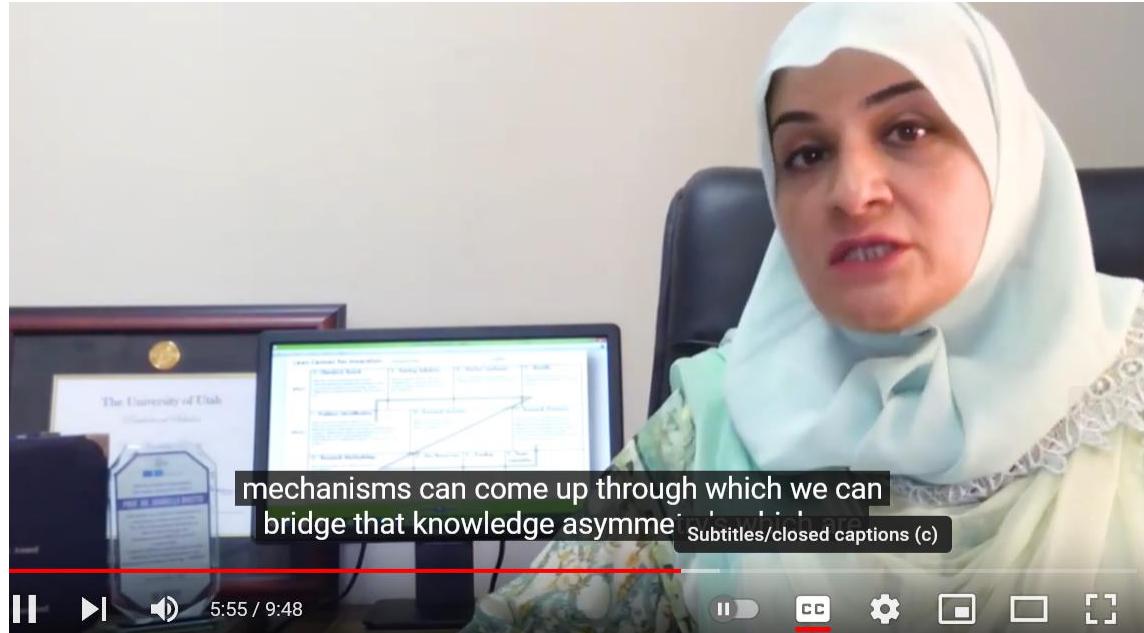
The image shows a video player interface. At the top, it says "Intro to LCI Course CMF". The main video frame shows a woman with blonde hair smiling, with a red "U" logo visible behind her. A play button icon is in the center of the video frame. At the bottom of the video frame, the date and time "2022-01-09 21:32:21" are displayed. A circular navigation icon with an info icon is at the top right of the video frame.

# Resources

## YouTube Lectures

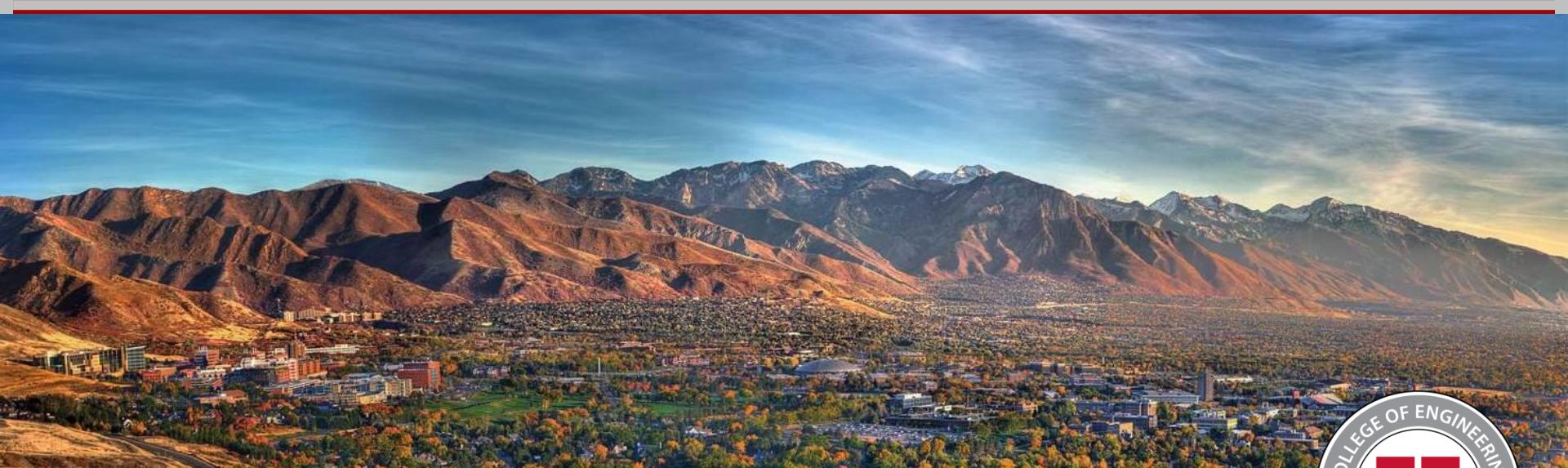
- Arabella Bhutto
- (and others)

Lean Canvas for  
Invention Book  
(coming soon!)



# An Innovative Graduate Education Course

## The Lean Canvas for Invention



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Ziegenfuss, Arabella Bhutto**  
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