Title

STEM Graduate Students' Development at the Intersection of Research, Leadership, and Innovation

Abstract:

Researcher innovation and leadership skills are fundamental to create implementable solutions to pressing societal- and market-based global problems. The Research to Innovation to Society (R2I2S) program is a transformative approach to graduate education, training students at the intersection of research, innovation, and leadership. We detail the design of the program, and a three-year exploratory investigation of its impact at one research university in the western United States. We found that, overall, students who participated in the program realized the value of thinking about their scientific research from a market-need perspective. Students perceived enhanced interest in and understanding of societal and market insights related to their own and other's research. As well, students developed professional skills in communication, team collaboration, innovation, and entrepreneurial skills. We situate our findings in frameworks concerning the development of emerging professionals and argue for programming for STEM graduate students that extends the deep discipline knowledge-based model of professional development into one inclusive of leadership, communication, and innovation goals.

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Introduction

While essential to advancing fundamental knowledge, basic research alone does not typically warrant solutions that address our most pressing societal challenges, such as offsetting the effects of climate change (Giordan et al., 2011; National Academies Press, 2007). Meaningful and timely solutions for modern problems necessitate researcher innovation (Demirkan & Spohrer, 2015). We define *innovation* as the translation of scientific discoveries into products or know-how for practical use and solving societal challenges, including (though not limited to) solutions with commercial potential. Innovation requires professionals with deep disciplinary knowledge coupled with the analytical, collaboration, and communication abilities needed to develop and implement entrepreneurial solutions (Demirkan & Spohrer, 2015).

While universities have historically prepared their graduates for employment realities (e.g. professional programs in teaching, nursing, and engineering), they continue to struggle to identify and integrate programs needed to develop student researchers who can translate disciplinary knowledge and research into innovations and marketable products. Traditional STEM education develops professionals around disciplinary knowledge and skills towards the creation of a discipline-focused workforce (Kruger, 2015). Yet, this privilege of disciplinary knowledge and expertise occurs at the expense of training well-rounded STEM innovators (Jain et al., 2009). Recent counts show only eight percent of STEM graduate students (masters and doctoral) assume positions at four-year academic institutions, while only six percent assume "other" educational positions (NRC, 2015). In comparison, industry welcomes almost 70 percent of these graduates (Langdon, 2011). A recent study showed that 44 percent of executives in manufacturing perceived today's university graduates, even those with graduate degrees, as lacking adequate skills in communication, collaboration, and entrepreneurship (US Chamber of

Commerce Foundation, 2014, p. 2). Employers have indicated a need for more optimal ways to develop professionals' 21st century skills (Langdon, 2011), critical thinking, teamwork, communication, and work ethic (Hora, 2019).

Given all of this, how might postsecondary programming better serve their students, specifically? Data from the National Academies report on the "Science of Team Science" (NRC, 2015) describes the need for early orientation of students towards *transdisciplinarity*. The National Science Foundation's calls for *convergence research* around problems that require integration across disciplines (NSF, 2019). Programs that promote transdisciplinarity may also help students recognize commonalities and connections among disciplines (NRC, 2015).

Yet, in the case of graduate education across STEM, integrating research within a broader understanding of other disciplines, as well as associated societal and market needs, is most often left to students without guidance from their graduate mentors or programs (Hayter et al., 2017). Many graduate faculty and programs do not see the development of students' knowledge and skills for innovation--including leadership, teamwork and entrepreneurial skills--to be their responsibility and any training that does exist consists of discrete professional development events not integrated with graduate students' program- and discipline-related training in research (Wendler et al., 2012).

We argue that an evolution in STEM graduate education is needed that promotes deep disciplinary knowledge and skills, and an ability and desire to apply that disciplinary understanding in different situations and in collaboration with different disciplines. We advocate for programs that educate students to experiment with emergent leadership roles towards positive societal changes (McIntosh & Taylor, 2013). In this paper, we detail the design and impact of

one university-based program that trains graduate students at the intersection of research, innovation, and entrepreneurialism.

The Research2Innovation2Society program: Goals and Structure

Research2Innovation2Society (hereafter, R2I2S) is an education model sponsored by the National Science Foundation Research Traineeship (NRT) Program that is designed to train STEM graduate students as innovators. The program guides students through the lenses of STEM research and markets that reflect societal needs. The program integrates training in basic research knowledge and skills, societal and market insights, and collaboration and communication to create professionals with the skills needed to advance economic development and to excel in academic, government, or private organizations.

R2I2S addresses the NRT Program goals by building on the Lens of the Market$^{(R)}$ (LoM) program (EcosVC, 2018), which was originally developed in an industrial science and engineering context. R2I2S goals seek to provide STEM graduate students with skills considered critical to career success in the ever-changing world of translating research into innovations: (a) awareness and ability to continuously inform and augment research with validated societal and market insights, and (b) expertise in critical research translational skills to communicate clearly, lead confidently, and work effectively in teams (EcosVC, 2018). The R2I2S program includes two stages. During Stage one, lasting one to three months, students are introduced to vocabulary, skills, and tools needed to engage in translating their research into innovations. During Stage two, lasting five to six months, students, in teams: (a) construct a market hypothesis, (b) collect data aligned with specific market-aligned questions, (c) develop a script and protocol to conduct interviews with market stakeholders, (d) analyze market-based data, and (e) conduct Star Market and Market Gap analyses. The delivery mode was a series of one-day, team-based workshops

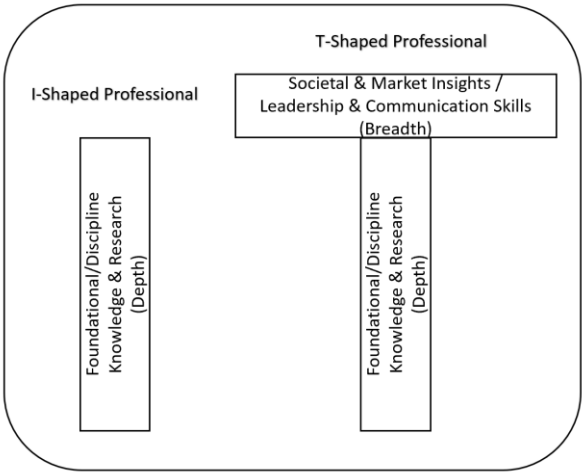
supported by regular check-ins on work progress and were subsequently adapted to a full academic-year course sequence offered in a hybrid mode.

The R2I2S program intends to develop innovation and professional skills by scaffolding students' science and engineering research frameworks via experiential learning. The program is delivered by instructors with advanced STEM degrees and demonstrated track records of STEM innovation and entrepreneurial success. The program platform encourages participation of faculty from students' home departments, and attending to faculty research interests, hopefully further eliminating potential barriers for graduate-student participation and helping to sync their program obligations.

Conceptual Framework

A typical goal of postsecondary education across the disciplines are what McIntosh and Taylor (2013) refer to as *I-shaped* professionals, or developing students' understanding, skills, and practices within a discipline (see Figure 1). Many educators, practitioners, and researchers expand this approach and promote the development of *T-shaped* professionals, able to also exhibit knowledge, skills, and abilities essential for solving complex problems (Demirkan & Spohrer, 2015). Figure 1 shows foundational research skills and depth of knowledge within a discipline as key components of successful t-shaped professionals. The horizontal leg represents the second component of the T-shaped professional, including leadership, and communication skills, along with insight into

Figure 1
I- & T- Shaped Professionals



societal and market skills. Ability for innovation is predicated on individuals possessing these numerous interacting skills (McIntosh & Taylor, 2013), who can work with others across multi-disciplinary, -functional, or -cultural contexts to allow faster adaptations of ideas (Demirkan & Spohrer, 2015). Development of T-shaped professionals within postsecondary environments can be conceptualized as "situated learning" in which the novice learner (e.g. graduate student) participates in a community of experts and professionals (e.g. experienced entrepreneurs). Situated learning "takes as its focus the relationship between learning and the social situations in which it occurs" (Lave & Wenger, 1991, p. 14). Through activities, often planned by educators, the learner moves through a process towards becoming a full participant in the socio-cultural activities of a community of practice (Lave & Wenger, 2015).

Methods

Participants

This exploratory study was conducted over a three-year period at one research university in the western United States and examined graduate students' experiences with the R2I2S program. Over the period of this grant, three cohorts of graduate students (pursuing masters/doctoral degrees in physical and natural sciences and engineering) participated in Stage One and/or Stage Two of the program. Forty-six students participated in at least one stage of the program and completed associated study surveys. A subset of six students in the year-three cohort also participated in one-to-one semi-structured interviews.

Research Focus

Our research adds to the very limited literature on graduate programming intended to help students develop collaboration, innovation, and entrepreneurial skills (Giordan et al., 2011).

Our research question is: *In what ways do graduate students perceive the R2I2S program developing collaboration, communication, innovation, and entrepreneurial skills?*

Data Collection

Data collection and analysis of findings were performed by two independent researchers who were not involved in program development, implementation of the program, or interactions with students.

Survey questions (quantitative and qualitative) focused on students' self-assessment of their level of knowledge about specific terminology and concepts before and after the stages, and their assessment of the value of the program. To heighten reliability, the same questions were asked for each of the cohorts at the same point in their program. Survey questions were built from existing Lens of the Market(R) program survey instruments used with more than 400 participating students over the course of multiple years. Content validity was established through question review by multiple experts in postsecondary entrepreneurial and STEM education. Surveys were conducted using Qualtrics. The survey instrument contained various questions on retrospective pre-post knowledge and ability, which were measured using a 5-point numeric scale (1, 2, 3 = low, 4, 5 = high) and open-ended qualitative questions to determine student learning and program quality (Dochy et al., 1999) (See Appendix A).

Semi-structured interviews were conducted with students in cohort three and lasted for 20-30 minutes (See Appendix B). Interviews were transcribed verbatim. Coding for interviews and survey items were done in two phases, an inductive followed by a deductive phase. The first analyst created inductive codes from a first read of the verbatim transcripts, drawing perspectives from participants' own words to determine emerging concepts and themes (Auerbach & Silverstein, 2003). The second deductive phase was performed in light of the T-shaped

conceptual framework to capture the experiences of students associated with the development of knowledge and skills related to innovating their program, gaining experience in collaborating, and communicating their research. Themes were considered salient when at least two participants mentioned the topic (see Appendix C). To increase confirmability of our methods, analysts reviewed transcripts to ensure reliability of coding and emerging themes based on their critical reflections of the data (Zhao et al., 2016).

Study Limitations

We acknowledge limitations of data collected at only one university over a three-year period. Findings are not transferable or generalizable beyond the experiences of participants. Also, assessing students' self-reported knowledge on surveys and via interviews may not determine the extent to which students actually gained the skills and abilities attributed to the program. Nevertheless, we contend that our exploratory study may still enlighten the emerging field concerning the development of innovation and entrepreneurial skills in graduate education and the benefits of fostering graduate student development as innovators and entrepreneurs via a novel and targeted program.

Findings

1. *Students perceived gains in understanding elements of market analysis*

Via engagement with the program, students perceived gains towards understanding the elements of the market analysis process and how to conduct interviews about market analysis. Specifically, they reported that the activities they engaged via the program challenged them to think beyond their research-centered perspectives and to consider how their research could translate science into social, economic, and environmental markets. Table 1 reflects students' felt

levels of knowledge in understanding the elements of the entire market analysis process and how to conduct interviews about market analysis before and after training.

Table 1
Self-assessment of Students' Knowledge and Understanding of Subject Matter

Understanding Elements of Market Analysis	Score[1]	(Low) 1		2		3		4		5 (High)	
		n	%	n	%	n	%	n	%	n	%
Understand the elements of the entire market analysis process.	*Before* the session	6	38	7	44	2	12	1	5	0	0
	After the session	0	0	0	0	4	25	10	63	2	12
Have a working knowledge of how to conduct market analysis interviews.	*Before* the session	5	31	5	31	4	25	1	6	0	0
	After the session	0	0	0	0	3	19	7	44	6	38

Note. N=16. [1]We consider 1-3 as "low" scores and 4-5 as "high."

Students reported gains in understanding the elements of the entire market analysis process. Student responses showed how this knowledge might help them communicate their research perspectives to a larger audience outside of their research area. One student said "learning how to navigate, understanding how a market works and finding meaningful information … I had absolutely no idea where to even start and was surprised to learn it wasn't as arduous of a task as it seemed initially." Another student stated: "Describing a value chain is a skill that helps to pin down the addressable market of an offering. I believe this narrows the focus of a team of innovators, making the process of bringing an offering to market less overwhelming."

Students also reported gains towards having a working knowledge of how they conduct interviews with professionals in the field related to their research innovations. One activity in stage two of the program required students to interview experts in relevant fields about the marketability of their potential research innovation. One student said: "The mock interviews were by far the most valuable. It forced us to get over the fear, angst, whatever you want to call it, when it comes to contacting people and doing interviews."

2. *Students perceived gains in innovation and entrepreneurial knowledge and skills*

Reflecting on their realities before and after training, students claimed an increased knowledge of terminology and methodology, the value of conducting a market analysis, developing value propositions and value chains, and how to apply market analysis to their research. Table 2 reflects students' self-reporting in a post-program survey in which students claimed increased knowledge across all other categories, with the greatest gains in 'having a working knowledge of the value of conducting a market analysis.' Students acknowledged that after engaging in the program activities, they "have a sense of how to do market research." They

Table 2
Self-assessment of Students' Knowledge and Understanding of Subject Matter

Innovation and Entrepreneurial Skills	Score[3]	(Low) 1		2		3		4		5 (High)	
		n	%	n	%	n	%	n	%	n	%
Knowledge of terminology & methodology[1]	*Before* the session	15	34.9	13	30.2	10	23.3	2	4.6	3	7.0
	After the session	1	2.3	2	4.7	9	21.0	21	48.8	10	23.2
Understand the value of conducting a market analysis[2]	*Before* the session	6	37.5	6	37.5	4	25.0	0	0	0	0
	After the session	0	0	0	0	3	18.8	7	43.8	6	37.5
Understand how to work in a team-based process[2]	*Before* the session	0	0	2	12.5	1	6.3	12	75.0	1	6.3
	After the session	0	0	1	6.3	0	0	5	31.3	10	62.5
Develop sample value propositions and value chains for specific market applications[2]	*Before* the session	5	31.3	5	31.3	5	31.3	1	6.3	0	0
	After the session	0	0	0	0	2	12.5	9	56.3	5	31.3
Understand how to apply market analysis to applications derived from innovations[2]	*Before* the session	9	56.3	3	18.8	3	18.8	1	6.3	0	0
	After the session	0	0	1	6.3	4	25.0	7	43.8	4	25.0

Note. [1]N=43; [2]N=16. [3]We consider 1-3 as "low" scores and 4-5 as "high."

saw the content building a "bridge" from their research to a business or market perspective, and the class activities provided a "tool set" that helped them think about the process. One student reported:

> I definitely lacked a tool set for how to apply certain things as far as the business aspect of it. So, it was awesome taking this class and coming up with how you can methodically go through this business problem and create this business use case from research.

Students claimed the least growth in their 'knowledge of terminology and methodology' concerning vocabulary, concepts, and processes related to market analysis and applications. As well, students indicated more limited growth concerning how to apply that analysis to applications derived from innovation.

Students' relative difficulty with gaining knowledge of terminology and methodology emerged within interviews as well. Students reported that conducting basic research, informed by market and societal needs, required them to develop technical vocabulary. For one student, "understanding language like 'value proposition' and 'differentiators' and applying these concepts to my field" were challenging. Another student noted the challenge of "learning the nomenclature of market analytics as well as how to take a step back and critically analyze our areas of research and how they can be applied to specific areas outside of science and academic settings."

Students' perceived challenges did not seem to lessen the value they saw in thinking about their scientific research through a lens of innovation and entrepreneurship. The distinctive approach to innovating research through a market and societal-need lens motivated them to consider how their research might be valuable to people outside their discipline or research area.

3. *Students perceived the value of recognizing diverse types of research and work*

Students stated the program promoted the value of thinking differently about their research and hearing diverse perspectives about their and others' research interests. Students

claimed they were encouraged to listen to alternative ways of thinking about their and others' research and it challenged their inculcated ways of thinking about scientific research. One student said:

> It was definitely challenging to get out of the engineering mindset of, 'I'm just going to build this thing and it's going to work.' But then having to step back and see the big picture of how we break out of this just mechanical engineering or just civil engineering and think about a business use case and people who actually use that tool.

Another stated: "It was almost exhaustingly tough to get out of the 'R & D' mentality and into a market analytics mentality. It was humbling to fully realize the level of bias that can arise when trying to put one's own area of research into a market-driven environment."

Students reported that the program helped them to recognize their research was developed in a scientific, academic setting within their discipline's perspective which is different from a market research perspective. One student stated:

> My work is very isolated and narrow in a small field and it is only people in [my research area] who would be interested in my work, but when I presented to my classmates and professors, they directed me in how to make it appealing and interesting to other people and with the potential to turn it into a business.

4. *Students perceived gains in understanding how to work in teams and how it benefited them individually*

Students perceived modest growth in understanding how to work in a team-based environment. Even though the gains in this objective were smaller than self-reported gains in other areas (13 percentage point increase), students recognized the value in working with peers

and with discipline-specific faculty towards improving their collaboration skills, as seen in this comment: "Being able to interact with our team members and familiarizing [ourselves] with each other's personalities." Another student said, "Different types of people working as a team, it is good for me to learn not only cooperation, but new ways of thinking about my research."

Generally, students realize the potential for expanding their research capabilities through working effectively with team members and communicating with others to gain greater perspective on their own research and innovation potentials.

5. *Students perceived value in the program*

The two reasons students cited most for participating in the R2I2S program were a) to gain collaboration and communication skills that will help with a career outside academia in the private, non-profit, or government sector and b) to gain skills in determining the potential for market and societal impact of their research. Overall, we found that students' interactions and responses to the program were positive, in both helping to meet these goals, and with respect to other skills and knowledge.

In post-stage surveys, students claimed heightened interest towards innovating their own research as well as understanding others' research and perspectives. Students were asked to rate the value of the program for helping them understand the significance of their research towards innovation and entrepreneurship. Seventy-five percent of students (n=40) indicated a "high" score of 4 or 5 when asked if the program was valuable in helping them consider how their research can translate to innovation, and 90 percent (n= 40) indicated, with a "high" score of 4 or 5, a personal interest in translating their research into innovations in the future.

Discussion and Implications

Postsecondary STEM programming that provides graduate students experience in taking their research through a market analysis and calculating the value of their innovations is rare, and potentially needed given the complexity and realities of modern problems that necessitate more than just deep research skills and knowledge (Jain et al., 2009). Graduates are faced with entering careers that demand more leadership and communication skills along with insight into societal and market skills (National Research Council, 2015). Employers demand workers that can synergistically navigate in multidisciplinary, multifunctional, and multicultural contexts and are able to make faster adaptations of their research (US Chamber of Commerce Foundation, 2014).

In this paper, we described a program that aims to attend to these concerns, by introducing graduate students to the language of innovation and the process of validating their research as marketable solutions and studied student participants' perceptions of it. Students in this study indicated their interest and need for this kind of curriculum. We also found that students claimed to develop knowledge and skills that should make them better T-shaped professionals and innovators. We found that students recognized the value and influence of innovation training and market awareness on their research and the benefits that this knowledge would bring to their future careers, whether in academe or industry. Students were particularly challenged with thinking about their research from a market-analysis perspective. Students found especially valuable their new understandings of the language and know-how of market analysis, the experiences of teamwork, communicating their research to diverse audiences, and seeing the limitations of their own research and the benefits of understanding others' work, which was recognized by students as important towards expanding and translating their research beyond traditional programmatic and disciplinary goals.

We acknowledge that these conclusions may not seem particularly groundbreaking, given the realities of graduate programming and the novelty of the program of focus. Yet this does not negate the promise of the curriculum that revised typical programming towards a more enhanced research, innovation, and entrepreneurial focus and seemingly successfully. We argue that novel programs like the one we detailed above can help students build the bridge between more basic, disciplinary research knowledge typical of I-shaped professional within a discipline, and an awareness of market and societal needs as characterized by the T-shaped professional that develops professional and entrepreneurial skills, including leadership and communication skills and the ability to work in diverse environments.

Yet creating and developing such programs, that requires students' situated learning, takes resources and care. Our research findings inform those wanting to attempt these programs, and our own institution as we work to improve and expand them. For one, graduate students need intentional and supportive programs that help them develop the unfamiliar nomenclature, skills, and knowledge in innovation and entrepreneurship that broadens and strengthens their ability to inform their research, and if desired, develop it into market required solutions. At this institution, we are currently working to offer this program to more students. This has important implications for programs across the postsecondary spectrum, including at the undergraduate level, to design and develop programming that situate learners in communities of future and expert professionals with disciplinary knowledge intertwined with 21st century leadership, communication, and entrepreneurial skills. Specifically, developing and implementing successful programs for postsecondary students will likely require training of program faculty who could otherwise serve as barriers for students' participation, perhaps led by faculty who can draw from expertise and experiences in translating their research activity into innovation and entrepreneurialism. At this

institution, we are explicitly fostering faculty training to better do this. These faculty who understand the research-to-innovation (and potentially innovation-to- entrepreneurialism) trajectory, can take a central role in helping students develop such understanding. Successful programming will also likely require the support of higher education leaders and administrators, in departmental, college, and university leadership roles, who can provide resources and motivations for faculty support and participation (Bouwma-Gearhart, Carter, et al., 2021; Bouwma-Gearhart, Lenhart, et al., 2021). At this institution, we are implementing recommendations from a national effort[1] that will encourage institutional leaders and faculty to recognize the worth of, foster, and evaluate innovation and entrepreneurialism throughout institutional processes and structures (including those related to tenure considerations and graduate programming) (Bouwma-Gearhart et al., 2020). Lastly, successful programs may also need the support of high-status and high -demand STEM-related industries and employers in providing affordances for real-life experiences and helping to inform/improve such programs towards students' and faculty members' efforts as marketable.

This study adds to the very limited knowledge base of postsecondary programming intended to help students develop skills beyond research and teaching, with heightened focus on translating research to innovation and entrepreneurial activity. Future research is needed to determine how program participants in similar programs represent the desires of students writ large, to inform the need for such programming in addition to more typical programmatic focus. In addition, more research is needed to assess the knowledge and skills acquired by students (beyond self-reported data) engaged in similar programs, including longitudinal research to

[1] The Promotion and Tenure - Innovation and Entrepreneurship (PTIE) consortium is a national network of universities working to foster innovation and entrepreneurship in promotion and tenure practices. More information at www.ptie.org.

ascertain students' career trajectories. Lastly, research is needed to better understand how such novel programming "fits" within postsecondary education, including the norms of graduate education and how faculty and organizations effectively (and not) justify, build, and offer such novel programming.

Conclusion

Society needs postsecondary STEM graduates who can translate basic and applied research to address the needs of markets and society. Simply being effective at doing research does not go far enough in tackling the complex problems associated with climate change and global societal needs. To innovate, graduates must develop deep knowledge in their discipline and the skills to validate research and market alignment. To be effective in this work and to translate innovations to practical use, they must possess teamwork, leadership, and communication skills that allow them to effectively coordinate efforts within a broader innovation ecosystem of universities, government, corporations, mentors, and investors. We advocate for the design and implementation of programs that emphasize the skills and knowledge that support the development and relevance of graduate-student research and provide a mechanism for graduate education to share in the responsibility of meeting the needs of students entering the workforce.

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Appendix A

R2S2I Survey Protocol

1. What did you find most valuable about the first session overall? Please mention specific activities or exercises if appropriate.

2. Based on your experience with Lens of the Market Stage 2: Innovation2Market so far, what improvements do you suggest? Please describe specific activities, lectures, or other aspects of Lens of the Market Stage 2: Innovation2Market that could be refined or improved.

3. For each area, indicate your knowledge of the subject matter before and at the end of the session (circle one number):

- Gaining a working knowledge of the value of conducting a market analysis
  - o BEFORE the session: Low (1) (2) (3) (4) (5) High
  - o AFTER the session: Low (1) (2) (3) (4) (5) High

- Understanding how to work in a team-based process
  - o BEFORE the session: Low (1) (2) (3) (4) (5) High
  - o AFTER the session: Low (1) (2) (3) (4) (5) High

- Gaining a working knowledge of how to conduct market analysis interviews
  - o BEFORE the session: Low (1) (2) (3) (4) (5) High
  - o AFTER the session: Low (1) (2) (3) (4) (5) High

- Understanding the elements of the entire market analysis process
  - o BEFORE the session: Low (1) (2) (3) (4) (5) High
  - o AFTER the session: Low (1) (2) (3) (4) (5) High

- Developing sample value propositions and value chains for specific applications

o BEFORE the session: Low (1) (2) (3) (4) (5) High

o AFTER the session: Low (1) (2) (3) (4) (5) High

• Understanding how to apply market analysis to applications derived from your center's innovations

o BEFORE the session: Low (1) (2) (3) (4) (5) High

o AFTER the session: Low (1) (2) (3) (4) (5) High

Appendix B

Interview Protocol, R2I2S Project

1. Tell me about your experience in this R2I2S program.
2. What did you most appreciate about the experience?
3. What was the most challenging about the experience?
4. Please reflect on the delivery of the experience and duration [term-length in-person class or online], in terms of its usefulness and efficacy.
7. What would you change about the program to improve or make more meaningful the experience for you or others?
8. Would you like to share anything else with us today?

Appendix C

Table of codes and excerpts for each finding	
Parent Code: *Impacted understanding elements of market analysis*	
Source/ question	**Examples of Student Excerpts**
Childcode: Elements of Market analysis:	It [the program] provided the entire framework of how to perform a market analysis, with examples and assistance.
	The structure provided to us to analyze the possibility of bringing our basic research to a commercially viable product is fantastic. Without the structure, entering into the market world is overwhelming and seems impenetrable. With the structure, although it is a lot of work and there are still situations in which we must make critical decisions, it feels much more feasible.
	Learning how to navigate, understanding how a market works, and finding meaningful information on it. Going into this, I had absolutely no idea of where to even start on this, and was surprised to learn it wasn't as arduous of a task as it seemed initially. The exercises also helped quite a bit with learning how to apply it.
	At several points I felt as if I was starting to gain some deeper understanding in market analytics.
Childcode: Interviews	Confirmation of thought process and skills over "mock" interviews.
	The mock interviews were by far the most valuable. It forced us to get over the fear, angst, whatever you want to call it, when it comes to contacting people and doing interviews.
	That you have to phrase your question very carefully to get the answers that you want.
	Phone interviews are difficult and having "scripts" are important!
	Further explanation about market segments and how to interview people efficiently to gather information was the most valuable.

	Many but especially realizing how much difference it makes to phrase questions differently for the interviews.
Childcode: Value Chain	Describing a value chain is a skill that helps to pin down the addressable market of an offering. I believe this narrows the focus of a team of innovators, making the process of bringing an offering to market less overwhelming
	It is amazing how valuable a good value chain is for the understanding of the market. Without it you have very little direction when it comes to asking the right questions of your data sources.
	Once we made the value chains everything came together and made sense. It was a great feeling.
Parent Code: *Impact innovation and entrepreneurial knowledge/skills*	
Child code: Value of Market analysis:	Diving deeper into market analysis and understanding the importance of turning research into innovation through the lens of the market was the most valuable.
	I definitely lacked a tool set for how to apply certain things as far as the business aspect of it. So, it was really awesome taking this class and coming up with seeing this kind of, 'Here's how you can methodically go through this business problem and create this business use case for business. It's a good idea to build this research tool or build this thing. Does the market need something like that?
	As stated previously, the market world seemed impenetrable. Now, the structure provided for these concepts makes the work seem much more possible.
Childcode: Terms & Knowledge Gained	Understanding language like 'value proposition' and 'differentiators' and applying these concepts to my field.
	Learning the nomenclature of market analytics as well as how to take a step back and critically analyze our areas of research and how they can be applied to specific areas outside of science and academic settings
	Marketing language, approaches to do marketing research
	I understand my risks pretty well. But when I explain my research to other people who have literally no experience…that is a big question mark. How do I

	explain this well, so it is easily understood using a very simple planning grid to describe a complicated scientific question?
	I can say that it [terminology] was a challenging part of the experience, because I'm still having a hard time understanding the value chain in terms of the market that I'm in currently.
	Still lacking some confidence about the terminology, but that will become more comfortable over time.
	Coming in I had no idea what ANY of these terms meant. I do not feel completely comfortable with these topics just yet, but I just need more practice.
Parent Code: *Perceptions of applicable research/work*	
Childcode: Diverse perspectives/ research	It was definitely challenging to get out of the engineering mindset of, "I'm just going to build this thing and it's going to work." But then having to step back and see the big picture and like, 'Well, now, how do we kind of break out of this just mechanical engineering or just civil engineering and think about business use cases and people who actually use that tool?' And provide some value to that.
	It was almost exhaustingly tough to get out of the 'R & D' mentality and into a market analytics mentality. It was humbling to fully realize the level of bias that can arise when trying to put one's own area of research into a market-driven environment.
	Yeah, the way they [people] think in market research is very different.
	My work is very isolated and narrow in a small field and it is only people in [my research area] who would be interested in my work, but when I presented to my classmates and professors, they directed me in how to make it very appealing and interesting to other people and with the potential to turn it into a business
Parent Code: *Impact teamwork*	

Childcode: Teamwork	Being able to interact with our team members and familiarizing [ourselves] with each other's personalities
	Different types of people working as a team, it is good for me to learn not only cooperation, but new ways of thinking about my research.
Parent Code: *Students perceived value in the program*	
Childcode: Program value	I've learned a lot of things regarding the commercialization process of products we do in the laboratory. It's pragmatic.
Childcode: career	Learning the language of business and how it connects to the importance of marketing a scientific idea. Also giving a clear understanding of business in general, of which I knew nothing about.
	To sculpture the process to convert the research into innovation.
	Exposure to market concepts and how they apply to / constrain each industry was certainly useful to me and will inform much of my professional life moving forward.
	A reminder about business lifestyle. Probability of producing something valuable.
Childcode: Societal impact	Gaining a deeper understanding and appreciation for the process of transforming basic research into successful products. Not only do I think I could do a better job, I think I am now better equipped to *hire* someone to do this work for me in the future.
	The most valuable aspects of the workshop were real-life examples and the ability of the facilitator to enforce the perspective of the market.
	Understanding the market framework and how decisions concerning innovations should take place in a business context.