Impact of an I-Corps Site Program on Engineering Students at a Large Southwestern University: Year 4

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Rodney Boehm is the Director of Engineering Entrepreneurship and an Associate Professor of Practice in the Texas A&M University College of Engineering. He has broad industry experiences, including over 35 years in all aspects of the telecommunications industry (sales, marketing, manufacturing, business development, and technical design), the creation of a telecommunications standard (SONET - Synchronous Optical Network) for the fiber optics industry that is still in use internationally over 30 years later, a wide variety of business experiences in international companies, and startup experiences. This has helped him lead a very successful industry career.

Currently he is using his technical business experiences to develop and run innovation and entrepreneurial programs for the Engineering Innovation Center, a 20,000 sq ft rapid prototyping facility. These include Aggies Invent, TAMU iSITE, Inventeer, and Pop Up Classes. In addition, he mentors multiple entrepreneurial teams.

Formerly he was a Senior Vice President of Fujitsu Network Communications, headquartered in Richardson, Texas. With over 30 years of experience in telecommunications, Rodney was responsible for developing partnerships with leading network technology providers and driving marketing efforts for optical, access and data products developed by Fujitsu. Rodney was Chairman of the T1X1 Technical Sub-Committee (the organization responsible for SONET standardization) from 1990 through 1994. He has been active in SONET's National and International Standardization since 1985. In addition, Rodney has published numerous papers and presentations on SONET.

Rodney began his career with Fujitsu Network Communications in 1989 as the Director of Strategic Planning. He also held the positions of Director of Transport Product Planning, Vice President of Business Management, Senior Vice President of Sales Management, Senior Vice President of Manufacturing, and

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Ms. Hannah Wehlmann

Impact of an I-Corps Site Program on Engineering Students at a Large Southwestern University: Year 4

I. Introduction

Per National Science Foundation, the I-Corps Sites program was launched to provide research groups with infrastructure, advice, resources, networking opportunities, entrepreneurship training, and modest funding that enable their technology to transition into the marketplace directly or guide them into becoming NSF I-Corps Team applicants [1, 2]. Furthermore, several of the close to 100 existing Sites also serve student participants working on student-owned intellectual property. We are currently operating on the fourth year of our I-Corps Site grant, which has supported 11 cohorts and more than one hundred teams at a larger Southwestern university. In previous work, using pre- and post-program surveys, we evaluated student changes in perceptions of interest in entrepreneurship, confidence in defining their value proposition, and self-efficacy in entrepreneurship, and lessons learned from practicing customer discovery after their participation of the I-Corps Sites program [3]. Furthermore, we investigated how these student perceptions of interest, confidence, and entrepreneurship are associated with their decision to GO/No GO with regards to student demographics and classification (undergraduate vs. graduate students) [4]. In this study, we added new findings on the effects of the program on students' learning to our previous work.

Background

The I-Corps Site at a large Southwestern university has been offered as a program since 2017 with a focus on mostly engineering undergraduate and graduate students. The I-Corps Site is dedicated to supporting teams with innovative ideas by offering them the relevant tools necessary to further develop their idea. It is offered three times (fall/spring/summer) per year as a six-week program and targets students pursuing innovations associated with faculty research or their own ideas. In Year 4, even under the COVID-19 pandemic, the program served the most teams, with a total of forty-two students, completing the virtual six-week program and an additional fifteen teams participating as part of a 14-week course on the lean startup offered at this institution. The demographics of Year 4 participants included 27% females, 22% Black or Hispanic, and 43%

Figure 1. Year 4 Participant Majors

undergraduates. Figure 1 shows the various majors represented by Year 4 participants while Figure 2 shows images related to the innovations pursued by these teams.
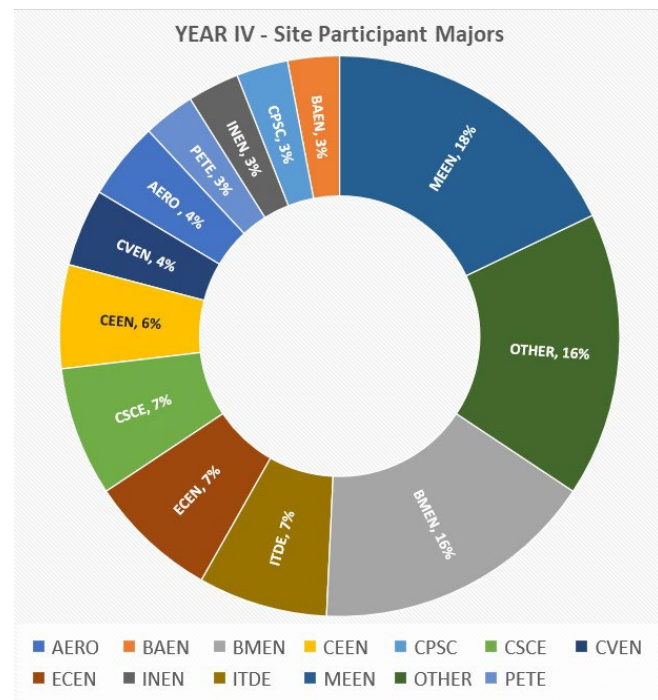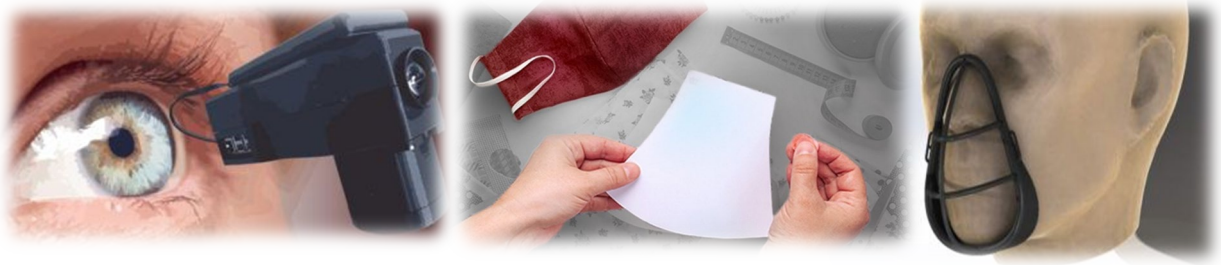
Figure 2. Year 4 Examples of Innovations

Overall, the program has grown every year as shown in Figure 3 and it has served more than 200 students since it was established. While the curriculum has remained the same, due to COVID-19, several recent cohorts (2020 Summer, 2020 Fall, 2021 Spring) participated in the program remotely. Seven Site teams have completed the National Teams program and additional teams are in the process of applying. In our efforts to reach more students, we have established a collaboration with the National Security Innovation Network and for the past three semesters and have offered a 3-credit hour course focused on applying principles of lean launch to solve challenging problems in the Department of Defense.
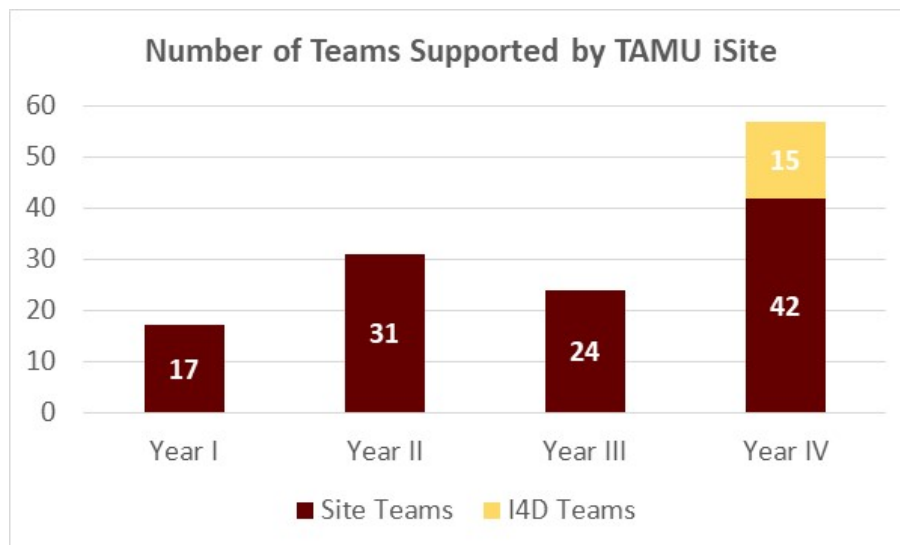

Figure 3. Number of Site Teams Per Year

Purpose of the Study

In this study, our focus is to investigate open-ended participant responses gathered in the pre- and post-program surveys and explore any association between participants' expectations of the Site program and their perceived value after completing the program. The study will focus mainly on two research questions:
- Question 1: What are students' expectations before they start the program?
- Question 2: What are students' perceived values of learning after the program completion?

II. Method

A. Participants

Participants of this study are students from six cohorts (cohorts 4, 5, 6, 7, 8, 10, and 11) between Summer 2018 and Fall 2020, who have responded to at least one of the pre- and post-program surveys. Due to the transition of the program format from in-person to online under the COVID-19 pandemic, the pre- and post-program surveys were not administered to cohort 9 participants during Spring 2020. While there were 153 program participants in the six cohorts, 106 (69%) responded to at least one of the pre- and post-program surveys. Table 1 shows the demographic characteristics of the 106 respondents of the surveys.

Table 1. *Demographic Characteristics of the Participants* ($N = 106$)

Category	Subgroup	n[a]	%
Gender	Female	25	23.6
	Male	72	67.9
Race/Ethnicity	Hispanic	18	17.0
	Asian	20	18.9
	Black	7	6.6
	White	36	34.0
	Multiracial	2	1.9
Track	Undergraduate	52	49.1
	Graduate	38	35.8
Engineering Major	Aerospace Engineering	7	6.6
	Biomedical Engineering	11	10.4
	Chemical Engineering	3	2.8
	Civil Engineering	4	3.8
	Computer Science	10	9.4
	Electrical and Computer Engineering	10	9.4
	Industrial and Systems Engineering	13	12.3
	Mechanical Engineering	15	14.2
	Engineering	82	77.4
Non-engineering Major		7	6.6
Total		106	100.0

Note. [a]Due to unspecified responses, the numbers are inconsistent with the total number of participants

B. Assessment

Since 2018, pre- and post-program surveys have been administered to evaluate the effects of the I-Corps Site program on students and adjust the program to ensure program goals are met. In detail, the online program evaluation consists of the pre-program survey with four sections and the post-program survey with five sections: (a) current knowledge, (b) a scale on perceptions of entrepreneurship, (c) practice, (d) team and business model, and (e) program evaluation (post-program survey only). The format of the assessment included both open-ended questions and

seven-point Likert scales, which ranged from 1 (strongly disagree) to 7 (strongly agree). The findings from quantitative data, published previously [3, 4], indicate that participants (a) maintained high interest on entrepreneurship throughout the program, (2) reported increased confidence in value proposition, self-efficacy in entrepreneurship, marketing /business planning, and customer interview skills, and (3) that the program affected students equally across diversity in gender, race/ethnicity, majors, and classifications. The focus of this study is to investigate participant responses to open-ended questions, shown in Table 2, and gain additional insights on their expectations from the program and perceived values after program completion.

Table 2. Open-ended questions used in this study.

Survey	#	Open-ended Questions
Pre-program	1	What do you hope to learn out of this program?
Post-program	2	Overall, how well did the Site course meet your expectations?
	3	If you intend to use the information and ideas from the program in other ways, please describe them here.
	4	What would be your biggest take-away from this program that you would like to share with others?

C. Data Analysis

In this study, we used an inductive thematic strategy to identify major themes in 106 students' reflections as they participated in the Site program [5]. The qualitative data analysis was completed by two authors of this study. The coding process to analyze the contents was completed in several ways using a conventional approach [6]. First, the two authors independently identified the themes that emerged in the open-ended responses and then independently coded the responses based on their identified themes. Repeated words and key groups were noted and put into preliminary codes. Second, in the initial meeting, the open-ended responses were reread and each author further refined their coding, separately. Then, they held weekly meetings to reach a consensus on their independently identified themes. Third, they coded the data independently again based on the consensus themes, and then compared, discussed, and recoded until they reached a consensus on all of the coding (i.e., inter-rater reliability coefficient = 1.00). Similarities were noted and differences in coding were discussed until each party was satisfied with the changes made. Some codes were integrated into another to form a sub-theme, while others were removed entirely [7]. Finally, they labeled and described the themes and calculated the frequency each theme appeared in students' open-ended responses. The frequency data were converted to the percentage of students who responded on each theme [8].

III. Results

Participant responses were analyzed for common themes using responses from the four pre- and post-program survey questions. Eight common themes were found across four survey questions, corresponding to one of the two categories: (a) expectations for learning and (b) perceived values of learning. The first category, "Expectations for Learning," encompasses what students expected to learn prior to starting the program. The second category, "Perceived Values of Learning" are the biggest take-aways that students perceived after the completion of the

program, including what information learned in the program they plan to use in the future. Seven themes, shown in Table 3 below, appeared on the pre-program survey question on students' expectations of the program.

Table 3. Descriptions of the Themes on "Expectations for Learning"

Theme	Description
Development of Innovation	Growth or expansion of an idea whose purpose is to meet the needs and requirements of the customer and of the market.
Learning of knowledge and Skills of Entrepreneurship	Learning the necessary skills that it takes to be a person who operates a business with an entrepreneurial mindset.
Customer Discovery	How to identify potential customers and how to discover what they desire from a product.
Commercialization	The process of developing a new product or business and introducing it into the market to make a financial gain.
Professional Growth	Professional growth refers to the skills identified by students to help them grow during the program. These skills refer to non-technical skills that are important in the business environment - such as communication skills (i.e., interview skills), networking, and teamwork.
Entrepreneurship Mindset	How to develop entrepreneurship mindset.
Mentoring Experience	Expectation about mentoring.

Table 4 describes the eight themes represented by participant responses after program completion. Seven of the eight themes are similar to the ones identified in the pre-program survey. However, we noted that student responses on the seven themes were specified with details on the post-program survey. The unique theme, which emerged in the post-program survey, is associated with the value that program participants see with respect to their engineering careers. The trend was expected since the topic of the entrepreneurial mindset and its value to potential employers is discussed frequently with program participants during the program.

Table 4. Descriptions of the Themes on Students' Perceived Values of Learning from the Program

Theme	Description
Development of Innovation	Students addressed the need to grow or expand an idea whose purpose is to meet the needs and requirements of the customer and of the market. In addition, some students addressed a systematic investigation into the research of a product or an idea for adjustment and improvement.

Entrepreneurship Knowledge and Skills	Students addressed their learning of the necessary skills that take to be a person who operates a business to apply for future endeavors.
Customer Discovery	Students valued the importance of how to identify potential customers and how to discover what they desire from a product.
Commercialization	Students expressed the importance of the development process for a new product or business model and introducing it into the market.
Professional Growth	Students acknowledged their professional growth, including the soft skills identified by students to help them grow, such as non-technical skills that are important in the business environment, including communication skills (i.e., interview skills), networking, and teamwork.
*Engineering Career	Students intended to use fundamental knowledge learned from the program for their future engineering careers.
Entrepreneurship Mindset	Students acknowledged the importance of an entrepreneurial mindset and expressed confidence gained from the program.
Mentoring and Peer Experiences	Students appreciated interactions with team members and mentors, utilizing their feedback to advance product ideas.

Note. *This theme only appeared on the post-program expectation question.

Figure 4 and Table 5 display the frequency with which student responses appear within each theme in Tables 3 and 4.
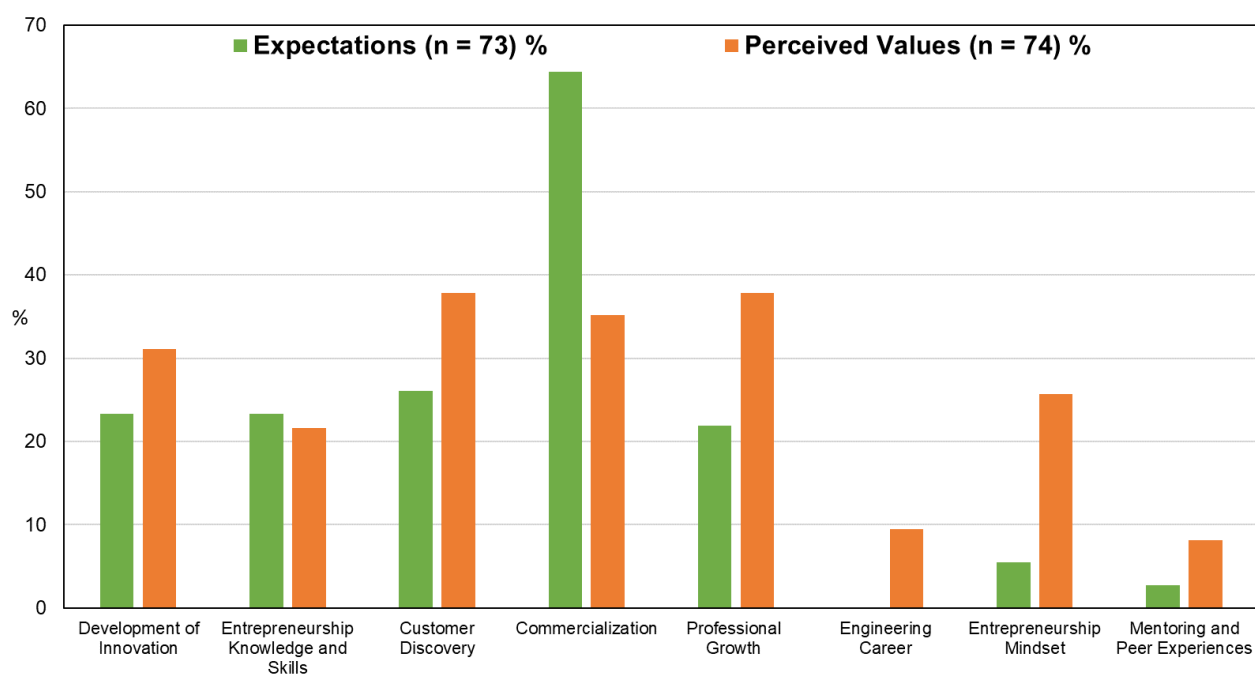

Figure 4. Students' expectation for learning outcomes prior to participating in the program as compared to the perceived values after program completion.

Development of Innovation - 23% of participants expected to learn more about the process of taking an idea and developing a new product or process. After program completion, 31% of participants valued the skills they learned under this theme which aligns with the program goals of raising awareness of the need to develop innovations which address specific market needs.

Entrepreneurship Knowledge and Skills - 23% of participants expressed interest to gain new skills and knowledge in entrepreneurship and that did not change significantly after the program with 22% of students indicating perceived value in this area. The reason for this could be that a number of students participating in the program already have a basic understanding of business model canvas [9] and lean launch methodology [10].

Customer Discovery - Significant change, from 26% in pre-program to 37.8% after program completion, was observed under this theme, which is expected since participants invest the majority of their time pursuing customer discovery – identifying potential markets, interviewing customers, and synthesizing received input.

Table 5. Themes on Students' Expectation for Learning and Perceived Values of Learning

Theme	Expectation for Learning ($n = 73$)		Perceived Values of Learning ($n = 74$)	
	n	*%*	*n*	*%*
Development of Innovation	17	23.3	23	31.1
Knowledge and Skills of Entrepreneurship	17	23.3	16	21.6
Customer Discovery	19	26.0	28	37.8
Commercialization	47	64.4	26	35.1
Professional Growth	16	21.9	28	37.8
Engineering Career	0	0.0	7	9.5
Entrepreneurship Mindset	4	5.5	19	25.7
Mentoring and Peer Experiences	2	2.7	6	8.1

Commercialization - This is the theme most participants (64%) expressed interest in the pre-program survey which is expected since most people associate entrepreneurship with the overall process of commercialization. However, the focus of the program is mainly in training and supporting students as they validate their hypothesis for market needs specific to their innovation which is an essential step in the overall process of commercialization. This may justify the lower number (35%) of participants mentioned commercialization in post-program responses.

Professional Growth - It shows an upward trend in relevancy to students from the beginning to the end of the program. 22% of students expected value in their professional growth as part of their participation in the program and more students (38%) recognized the value in the post-program survey. Participants seem to recognize the value of professional skills, such as communication, team collaboration and networking in further developing their innovations.

Engineering Career - While the impact of the program on the engineering careers of the

participants did not emerge as theme in the pre-program survey, 9.5% of the students mentioned utilizing the skills and knowledge they learned in the program in their future careers.

The last two themes – *Entrepreneurship Mindset and Mentoring and Peer Experience* - show similar trends. There was slight interest pre-program participation and an increased recognition of importance at the completion of the program. Students learned to better think like entrepreneurs and expressed more confidence in entrepreneurship. They also appreciated interactions with team members and mentors, utilizing their feedback to advance product ideas.

IV. Discussion

Overall, this study provided additional insight into what students expected from the Site program and what were the perceived values after program completion. The program leadership will consider this additional input and further improve the program to benefit our students.

To supplement the findings on Figure 4, we sampled quotes from the students' responses to the open-ended questions on the pre- and post-program surveys for discission.

A. Expectations for Learning before the Site Program

Below are some quotes from undergraduate female and male students. For example, an undergraduate female student addressed the expectation for learning from the program.

> *"A lot more knowledge on entrepreneurship, as going through this survey has allowed me to realize I have almost no experience or knowledge in that area. Additionally, I would be excited to learn how to market our idea into the real world and make it a reality."*

Another female student was motivated to gain skills in entrepreneurial mindset, with hope for the commercialization of her product.

> *"I hope to learn to think and be more like an entrepreneur. I would like to get a better grasp of what to look out for, how to devise and implement an effective plan for commercialization for my product, and how to effectively utilize the resources provided as well as the customer discovery ideals. I'd love to learn what makes a great interview and everything else I can apply to my life and the lives of others."*

Similarly, below are some quotes from undergraduate male students addressed on a pre-program survey.

> *"I hope to learn the basic skills that are expected from an entrepreneur and the incorporation between the business and engineering fields. Expanding my entrepreneurial mindset as much as possible is my main goal because taking entrepreneurial roles is something I wish to do in the far future."*

> *"While I do believe in our product, and while I have complete faith in my team, I know*

that I am personally weak in many critical areas needed in business due to my lack of education in the subject. I hope to improve myself in these areas and become a stronger leader and businessman."

One graduate male student addressed leaning of commercialization, customer discovery, and entrepreneurial mindset on a pre-program survey.

"I want to learn how to commercialize on-going research technology to a real-world product and find potential customer. And I also hope to learn how to be a entrepreneur and the right mindset for entrepreneur."

B. Perceived Values after the Site Program

Compared to student responses on the pre-program survey, which were understandably vague, student responses on the post-program survey were more specific and concrete with details. Undergraduate female students commented on the post-program survey as shown below.

"I feel so much more aware of what it takes to begin a company and sell a product through this program. I have gained interview skills and pushed myself more than I thought I was able to do. I knew how important the market was to selling a product, but through iSite, I learned how to do research over the market and how to interact with possible customers, both through lectures and experience with the interviews. "

"Researching ideas before jumping and investing in them is extremely important. Research will save you time and money in the long run and can improve your product/idea more than you would expect."

Some undergraduate male students addressed the importance of customer discovery on the post-program survey as below.

"As someone who already spent several months working through customer discovery, the iSite program allowed me the opportunity to go back and test my hypotheses on how I could have done a better job. Actually, having someone to talk with allowed me to question these hypotheses and drove my ability to refine my customer discovery approach."

"Conducting customer interviews before reaching out to any potential investors because: interviews establish whom your potential customers are, where the fields are that your product will perform the best, and what your selling points should be for the product."

Below is the remark from a graduate male student on the program impact on selecting his PhD thesis topic.

"Deciding on a topic for thesis for a Ph.D. student is a major task. I will use my experience to reshape my objectives of research and choose the topic and courses accordingly.; The interviews helped me in taking decisions on my Ph.D. topic selection. I

will choose my topic such that it is coherent with the customer needs.

C. Limitations of the Study and Suggestions for Future Research

There are several limitations on this study. First, the findings of this study conducted at a Southwestern university limits the generalization of the results beyond the university due to the differences in the learning environment and local entrepreneurial eco-system. Second, it will be important to compare these findings with previous findings based on quantitative data – Likert scale responses. Third, it will be interesting to see any variations between cohorts before COVID-19 where all meetings were face-to-face and cohorts 10 and 11 which were conducted virtually. Further research is necessary to overcome the limitations of this study.

D. Conclusion

The findings of this study provide additional insight into what Site participants value from the program and assists our efforts to further improve the program. We hope these data add value to the body of research on the areas of entrepreneurship targeting engineering students.

Acknowledgement

References

[1] National Science Foundation, NSF Innovation Corps (I-Corps™), 2019. Available: https://www.nsf.gov/news/special_reports/i-corps/index.jsp

[2] A. Huang-Saad, J. Fay, and L. Sheridan, "Closing the divide: Accelerating technology commercialization by catalyzing the university entrepreneurial ecosystem with I-Corps™," *The Journal of Technology Transfer,* vol. 42(6), pp. 1466-1486, 2017.

[3] Lagoudas, M. Z., Yoon, S. Y., and Bohem, R. (2019). The Implementation and assessment of an I-Corps site: Lessons learned. *Proceedings of the 126th American Society for Engineering Education (ASEE) Annual Conference and Exposition, Tampa, FL, USA.*

[4] Lagoudas, M. Z., Yoon, S. Y., Bohem, R., and Asbell, S. (2020). Impact of an I-Corps site program on engineering students at a large southwestern university: Year 3. *Proceedings of the 127th American Society for Engineering Education (ASEE) Annual Virtual Conference and Exposition, USA.*

[5] M. Q. Patton, "*Qualitative evaluation and research methods,"* (3rd ed.). Newbury Park, CA: Sage, 2002.

[6] Hsieh, H.-F. & Shannon, S. E. "Three approaches to qualitative content analysis." Qualitative Health Research, vol 15, no. 9, 2005, pp. 1277-1288. SAGE Publications

[7] Ryan, Gery W., and H. Russell Bernard. "Techniques to identify themes." Field Methods, vol 15, no. 1, 2003, pp. 85-109. SAGE Publications.

[8] St. Pierre, Elizabeth A., and Alecia Y. Jackson. "Qualitative data analysis after coding". Qualitative Inquiry, vol 20, no. 6, 2014, pp. 715-719. SAGE Publications.

[9] A. Osterwalder, and Y. Pigneur, *"Business model generation: A handbook for visionaries, game changers, and challengers".* Hoboken, NY: John Wiley & Sons, Inc, 2010.

[10] S. Blank, *"Why the Lean Start-Up changes everything, "* Harvard Business Review, May 2013 Issue. Available: https://hbr.org/2013/05/why-the-lean-start-up-changes-everything