Gender differences in academic entrepreneurship: experience, attitudes and outcomes among NSF I-CORPS participants

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Abstract

Purpose – Expanding access to entrepreneurship training programs can be a method to increase female involvement in technology commercialization only if these programs adequately address the specific challenges facing female faculty and graduate students. In the context of the US National Science Foundation's Innovation Corps (NSF I-Corps) program, this study examines gender differences in prior experience and attitudes towards the training in order to propose improvements to the program design.

Design/methodology/approach – This quantitative study uses Pearson's Chi-Square and ANOVA tests on survey data from the I-Corps national program (n = 2,195), which enrolls faculty members, graduate students, postdoctoral researchers and industry experts.

Findings – In comparison to male participants, female I-Corps participants reported less entrepreneurial experience prior to the program, poorer team relationships during the program and lower entrepreneurial intention and technology commercialization readiness at both the beginning and the end of the program. However, no gender differences were found in positive or negative perceptions of the instructional climate or perceptions of program usefulness.

Originality/value – This study is unique as it is based on a large-scale dataset drawn from sites across the United States. The results support potential changes to I-Corps and similar programs, including providing more explicit instructions for tasks with which female participants have less prior experience than males (e.g. in applying for patents), offering guidance for team interactions, and providing mentorship to assess whether low self-efficacy is leading women to underestimate the potential success of their projects.

Keywords Gender, Academic entrepreneurship, Entrepreneurship education, Technology commercialization, NSF I-Corps, Survey research, Evaluation, Assessment, Entrepreneurial intention, Faculty professional development, Graduate education

Paper type Research paper

Introduction

Academic entrepreneurship, or the process of commercializing university research through activities such as patenting, licensing and spin-off formation (Grimaldi *et al.*, 2011; Siegel and Wright, 2015b), is increasingly considered to be an important influence on both regional and national economies (Bekkers and Freitas, 2010). Although many universities have taken steps to encourage academic entrepreneurship (Rasmussen and Wright, 2015), implementing

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additional measures to grow commercialization activity continues to be a priority for both institutions and policymakers (Harrison and Leitch, 2010; Siegel and Wright, 2015a). In light of this movement, the development of successful growth strategies represents an active and expanding area of research (Guerrero and Urbano, 2012; Perkmann *et al.*, 2013). One important avenue that has been proposed in the US is expanding faculty and graduate student access to entrepreneurship education and training. This is the purpose of the National Science Foundation's Innovation-Corps (NSF I-Corps) program (Nnakwe *et al.*, 2018), which offers scientific researchers funding and training to address two primary challenges associated with academic entrepreneurship: evaluating product-market fit and building the social networks necessary for commercialization activity.

It is well documented that fewer female than male scientists engage in a range of academic entrepreneurship activities, paralleling the underrepresentation of women in entrepreneurship more generally (Goel *et al.*, 2015; Kelley *et al.*, 2012; Marlow and Mcadam, 2012). For example, women in academia are less likely than men to obtain patents as primary inventors (Abreu and Grinevich, 2017; Ding and Choi, 2011), engage in collaborations with the private sector (Perkmann *et al.*, 2013), or found startup companies related to their research (Abreu and Grinevich, 2017). Gendered differences exist in beliefs as well as behaviors, with male scientists reporting more positive attitudes than women towards research commercialization (Goel *et al.*, 2015; Miranda *et al.*, 2017a; Sugimoto *et al.*, 2015). Given these disparities, scholars have called for additional research in this area (Hughes *et al.*, 2012; Miranda *et al.*, 2017a; Poggesi *et al.*, 2020).

Although entrepreneurship education has been proposed as an avenue to improve women's attitudes towards and participation in entrepreneurship activities, women enroll in these programs at far lower rates than men (Robb *et al.*, 2014; Thébaud, 2015). Given the significant and expanding investments being made in academic entrepreneurship training (National Science Foundation, 2019), it is important to understand women's experiences to identify problems and potential improvements to engage more diverse participants.

The purpose of this study is to examine gender differences within the NSF I-Corps entrepreneurship training program, with a focus on participants' prior entrepreneurial experience, attitudes toward the program, and intention to become entrepreneurs. Specifically, drawing from a "capital framework" of proposed barriers to women's participation in entrepreneurship, we hypothesize that: (1) Women may enter the program with less prior entrepreneurial experience than their male colleagues ("human capital"); (2) Women may perceive their experiences in I-Corps training more negatively than men due to the male-stereotyped nature of the field and an instructional style that promotes competition ("cognitive capital"); (3) Women may perceive social interactions in the program more negatively than men ("social capital"); (4) Fewer female than male participants may achieve desired instructional outcomes. Our results suggest that opportunities exist to recruit and retain more women by facilitating more positive experiences in the course and addressing disparities in prior knowledge.

Theoretical Background

A substantial body of literature has analyzed barriers to women's participation in entrepreneurship activities broadly, however, research related to gender disparities specifically in the field of academic entrepreneurship is more limited (Hughes *et al.*, 2012; Miranda *et al.*, 2017b; Poggesi *et al.*, 2020). Wheadon and Duval-Couetil (2019) classified gendered issues related to technology entrepreneurship into a "capital framework", which synthesizes human, cognitive, social, and financial capital barriers to participation, as described below. In this study, we will examine the application of this general framework to female academic entrepreneurs by determining the extent to which they report facing these barriers within the context of the I-Corps training program.

Human capital

Human capital refers to resources represented by skills and abilities that are developed through education, training and other accumulated experience such as employment. Individuals who start businesses usually have prior work experience in a related field (Millan *et al.*, 2014; Klyver and Schenkel, 2013), and research has found that academics have more positive attitudes towards entrepreneurship if they have had prior business experience (Miranda *et al.*, 2017a). Therefore, gender differences in education and early career experiences are often proposed as contributing factors to overall gender disparities in entrepreneurship engagement (Goel *et al.*, 2015; Zolin *et al.*, 2013). For example, a qualitative study conducted in Germany found that female academic entrepreneurs were more likely than men to report "a lack of human resources, knowledge, and exchange with peers" (Sinell *et al.*, 2018, p. 21).

Implications for entrepreneurship education. Previous research results suggest that within the context of academic entrepreneurship, educational programs could diminish human capital disparities through instruction in key areas. For example, where gender differences exist, content could be tailored to reflect prior entrepreneurship or business-related experiences that female participants lack. To examine this topic in the present study, we tested for gender differences in entrepreneurship-related experiences prior to I-Corps participation.

Cognitive capital

Cognitive capital describes psychological resources beyond skills that influence task success, including confidence and motivation. In fields where women are underrepresented or experience negative stereotypes, they often have lower self-efficacy than men (Chen and Latham, 2014; Dohrman, 2010; Fox and Xiao, 2013), even when they demonstrate high levels of achievement or performance (Kay and Shipman, 2014). In entrepreneurship, women usually report lower self-efficacy than men (Dempsey and Jennings, 2014), which also relates to lower entrepreneurial intention (Westhead and Solesvik, 2016). For example, Shinnar *et al.* (2012) found that women with low entrepreneurial self-efficacy were more likely than men to have low entrepreneurial intention.

Implications for entrepreneurship education. Prior research has suggested that entrepreneurship education can positively influence elements of cognitive capital, but results have been mixed. For example, among MBA students, one study found that entrepreneurship education had greater self-efficacy benefits for women than men (Wilson *et al.*, 2007). Similarly, studies have found that female participants show increases in outcomes such as self-esteem (Cooney, 2009) and networking skills (Tynan *et al.*, 2009). However, in other work, self-efficacy was observed to improve for men but not women (Shinnar *et al.*, 2014).

Entrepreneurship education may also influence the entrepreneurial intention of men and women differently. Studies of entrepreneurial intention are often based on Shapero's (1982) entrepreneurial event model or Ajzen's (1991) theory of planned behavior, and research has shown that self-reported entrepreneurial intention is a strong predictor of later entrepreneurial behavior (Krueger *et al.*, 2000). However, prior research has found mixed results with regards to the impact of entrepreneurship education on entrepreneurial intention generally, and with regards to gender differences in these effects specifically. While some confirm the claim that entrepreneurship education leads to increases in intention (Souitaris *et al.*, 2007; Vaizler, 2011; Yar Hamidi *et al.*, 2008), others find no effect (Fayolle *et al.*, 2006; Wu and Wu, 2008) or even declines in entrepreneurial intention (von Graevenitz *et al.*, 2010). With respect to gender differences, while some prior research has found declines in entrepreneurial intention that were greater for women than men (Joensuu *et al.*, 2013), a meta-

analysis alternatively found that changes in entrepreneurial intention did not differ by gender (Bae *et al.*, 2014).

In our study, we included four variables in the category of *cognitive capital*, all of which relate to participants' emotional or motivational attitudes towards their experiences in the course: (1) perceptions of a negative (e.g. "harsh") instructional climate, (2) perceptions of a positive (e.g. "collegial") instructional climate, (3) perceptions of the usefulness of their participation in the program to their research and (4) perceptions of the usefulness of their participation in the program to their careers. If female participants report more negative attitudes in relation to these topics, this pattern would support the proposition that disparities in cognitive capital are a significant challenge for female academic entrepreneurs. Further, this result could imply that the curriculum of I-Corps, as well as similar entrepreneurship training programs, should be carefully analyzed to determine whether elements of the course materials or pedagogical style contribute to more negative experiences for women.

Social capital

Social capital refers to resources and assistance that individuals gain through their interpersonal connections, including their number of contacts, the extent to which assistance may be withheld due to bias, and the climate of the immediate social context.

Social networks. Multiple studies of academic entrepreneurship find that women have fewer relevant business and industry contacts than do men (Stephan and El-Ganainy, 2007). This factor may contribute to the trend that women faculty seek more help from university technology transfer offices (Goel *et al.*, 2015). In addition, the lack of women in a field may decrease feelings of belonging and thus, negatively affect cognitive capital (Sekaquaptewa and Thompson, 2002; Thompson and Sekaquaptewa, 2002). Given that same-gender mentoring relationships may be more effective for professional development than cross-gender mentoring (Marlow and Mcadam, 2015), females have reported that a lack of potential female mentors is a major challenge in technology entrepreneurship (Robb *et al.*, 2014). Similarly, Thompson and Sekaquaptewa (2002) researched "solo status", the state of being the only representative of one's demographic group in a team, and found that it has several negative effects. For example, stereotype threat more negatively affected women in a public performance setting if they had solo status in the group, and solo status women have more negative views of workplace climate, which can affect job satisfaction and retention (King *et al.*, 2010).

Stereotyping and biased treatment. Stereotyping and bias exert an influence on women's social capital in that resources are intentionally or unintentionally withheld in the context of social interactions. In the field of entrepreneurship, stereotypes are so prevalent that it has been proposed that men biologically possess certain relevant skills, or even a greater "basic talent" for these activities (Lazear, 2004; Obschonka *et al.*, 2011). Faced with these stereotypes, women are considered to be less likely to succeed as entrepreneurs than men due to personality traits like risk-aversion (Fox and Xiao, 2013; Henry *et al.*, 2005; Klein and Bullock, 2006), and "feminine" management techniques (Ahl, 2006). Stereotypes also favor men in relation to technology skills (Bury, 2011) as well as technology entrepreneurship specifically (Brush *et al.*, 2012). The misconception that such skills are biologically innate to men exerts a discouraging effect on women's cognitive capital (Agnete Alsos *et al.*, 2013; Sullivan and Meek, 2012; Sweida and Reichard, 2013). Conversely, the effects of stereotyping are multifaceted, and women's self-efficacy for some entrepreneurial activities could be positively influenced by the stereotype that women possess greater social and relational skills compared to men (Czopp *et al.*, 2015).

Social interactions. There is some evidence suggesting that competitive environments may negatively affect task performance for women to a greater extent than for men. For

example, one study found that women viewed public performances as more risky than men (Larkin and Pines, 2003). Similarly, Niederle and Vesterlund (2007) reported that women have more negative attitudes about competitive activities and that men are more confident about competitive performances. Similarly, in relation to social interactions within teams, women students in STEM fields often have more negative experiences (Meadows *et al.*, 2015). For example, studies have found that men speak for a disproportionate amount of time (Meadows and Sekaquaptewa, 2011), and that women more often take less technical and more female-stereotyped roles, such as organizer or note taker (Hirshfield, 2015; Meadows and Sekaquaptewa, 2013).

Implications for entrepreneurship education. Previous research findings suggest that entrepreneurship education can influence participants' views of gender stereotypes. For example, poorly designed curricula can perpetuate the stereotype that entrepreneurship is a male pursuit (Joensuu *et al.*, 2013; Westhead and Solesvik, 2016) or even exacerbate it (Achtenhagen and Welter, 2011). For example, Ulvenblad *et al.* (2011) performed a qualitative study of entrepreneurship education programs in Sweden, and observed that men were not only overrepresented among instructors and students, but also in the course materials. If not moderated, the presence of such stereotypes can have a harmful effect on female participants especially if gender differences in self-efficacy are ignored (Wilson *et al.*, 2007). However, well-designed entrepreneurship training could have the potential to counteract stereotypes as well as raise awareness of structural barriers (Byrne and Fayolle, 2010; Liñán *et al.*, 2011).

In this study, information about the social networks of participants, as well as direct measures of stereotyping, bias and discrimination were not available. Therefore, the extent to which access to social capital represents a barrier for female academic entrepreneurs in I-Corps is assessed using questions that relate to the perceived quality of participants' project team relationship. If female I-Corps participants report poorer team relationships than men, this pattern could imply that academic entrepreneurship training curricula could better address the needs of women participants by incorporating additional support to develop social capital.

Financial capital

Finally, financial resources represent an essential form of capital in technology entrepreneurship. For many of the reasons described above, women face problems accessing funding (Holmquist and Wetter, 2010; Klotz *et al.*, 2014); for example, female entrepreneurs tend to receive less private investment than male entrepreneurs with equal levels of previous experience (Tinkler *et al.*, 2015), and begin companies with less initial capital overall (Robb *et al.*, 2014). Whether or not this disparity in investment is the result of explicit discrimination has been debated (Kenney and Patton, 2015; Marlow and McAdam, 2013; Robb *et al.*, 2014), given that women are more likely than men to start companies that are smaller (Avnimelech and Teubal, 2006; Loscocco and Bird, 2012) or in the service sector (Hughes *et al.*, 2012), traits that are less attractive to investors (Marlow *et al.*, 2012; Sappleton, 2009). However, even in the absence of demonstrable lending discrimination, the anticipation of potential bias exerts an influence. As a result, female entrepreneurs ask for less capital from investors (Wheadon and Duval-Couetil, 2019), apply for fewer loans (Freel *et al.*, 2012; Treichel and Scott, 2006) and are less confident than men about obtaining investment (Holmquist and Wetter, 2010; Roper and Scott, 2009).

Implications for entrepreneurship education. These findings suggest that barriers to obtaining financial capital could be addressed by linking female entrepreneurs to grants or funding sources, or indirectly influenced through improvements in the three other forms of capital described above. Although financial information about participants' projects after leaving the course was not available in this study, the impact of I-Corps participation on

financial success could be implied by the presence or absence of gender differences in each of the other forms of capital resources.

The NSF I-Corps program

Scholars have called for more investigation of gender differences in academic entrepreneurship, and research examining the influence of entrepreneurship training on these activities is currently limited (Colyvas *et al.*, 2012; Goel *et al.*, 2015). Women's involvement is difficult to examine using quantitative methods given the low number of female faculty and graduate students involved in both entrepreneurship training and technology commercialization at universities. Furthermore, large-scale analyses of entrepreneurship education programs across universities are complicated by the fact that they vary dramatically in structure, context, culture and incentives, thereby limiting generalizability (Duval-Couetil, 2013). Therefore, a national initiative such as the NSF I-Corps program offers a unique opportunity to explore women's experiences in a large-scale program which uses a standardized curriculum.

The NSF I-Corps program is a nationwide entrepreneurship training program available to faculty and graduate students from engineering and technology disciplines, most of whom have received prior NSF research funding. Launched in 2011 (Nnakwe *et al.*, 2018), the program originated from the Lean LaunchPad approach to startups developed at Stanford by Steve Blank with the "support of Tom Byers, Tina Seelig, Kathy Eisenhardt, Ritta Katilla, Bob Sutton and Chuck Eesly at Stanford Technology Ventures Program" (Blank, 2021; VentureWell, 2019). The I-Corps curriculum centers around a process known as "customer discovery", which requires participants to interview 100 potential customers and stakeholders (Nnakwe *et al.*, 2018) to assess the product-market fit of their technologies (National Science Foundation, 2019; VentureWell, 2019). Participants apply to the program in teams of three (VentureWell, 2019): the Technical Lead (TL) is usually a faculty member, who provides the technical expertise necessary for the project; the Entrepreneurial Lead (EL) is the full-time leader of the project and is usually a graduate student or postdoctoral researcher; finally, the I-Corps Mentor (IM) is a volunteer advisor recruited from a business or industry relevant to the project (Blank and Engel, 2016; National Science Foundation, 2019; VentureWell, 2019). During the time period we studied, the program involved seven weeks of online instruction, with in-person classes at the beginning and end of the course (future classes are expected to be exclusively remote). Teams accepted into the program also receive $50,000 grants to use for travel associated with these interviews and some "short-term, modest" salary support for the EL (National Science Foundation, 2021).

With respect to the pedagogical style of the course, recent research has documented concerns about a "shark-tank culture" and "male-dominated experience, with female participants expressing a sense of discomfort and alienation" (Semcow and Morrison, 2018, p. 259). For example, participant impressions of the program have included descriptions such as "drill sergeant, boot camp mentality", "cutthroat intensity", "aggressive attitude", and "very testosterone-driven, male-style organization" (Duval-Couetil *et al.*, 2020, p. 18). While this past research was based on small numbers of participants, and there have since been efforts to improve the instructional climate, these reports indicate the need for further study of gender-related consequences of the program design.

Research questions

I-Corps offers a unique opportunity to examine gender issues within technology and academic entrepreneurship at scale. The program involves a large number of highly engaged and diverse participants, representing many industry sectors, universities and regions of the

country. In this study, we examined gender differences across several variables drawn from the capital framework described above.

H1. Human Capital: Based on previous research establishing low participation by women in a range of entrepreneurial activities (Kelley *et al.*, 2012; Marlow and Mcadam, 2012), we hypothesize that female participants will report less prior entrepreneurial experience than their male colleagues.

H2. Cognitive Capital: Based on previous research indicating that women generally report lower entrepreneurial self-efficacy than men (Dempsey and Jennings, 2014), that women who feel isolated in male-dominated settings may perceive more negative instructional experiences (Niederle and Vesterlund, 2007; Thompson and Sekaquaptewa, 2002), and that female participants have reported perceptions of a "male-dominated experience" (Duval-Couetil *et al.*, 2020; Semcow and Morrison, 2018, p. 259) in I-Corps specifically, we hypothesize that female participants will have more negative attitudes towards their experiences in the course. Specifically, we predict that female participants will report a more negative instructional climate and lower perceived usefulness of participation in the course.

H3. Social Capital: Based on research demonstrating that women may experience differential treatment in group projects due to stereotyping (van Veelen *et al.*, 2019), we hypothesize that women will report more negative perceptions of the relationships among their project team members.

H4. Outcomes: Based on previous research showing that women report lower entrepreneurial intention in entrepreneurship training programs (Haus *et al.*, 2013; Miranda *et al.*, 2017b; Santos *et al.*, 2016), we hypothesize that we will find the same pattern in the present study. Similarly, we predict that women will be less likely to report that the technology involved in their project is ready for commercialization. However, given mixed findings from prior research about longitudinal changes in entrepreneurial intention that occur during training programs (Azam Roomi and Harrison, 2010; Joensuu *et al.*, 2013), we do not hypothesize on whether intent will increase, decrease or remain stable. Finally, again based on the lower overall participation in entrepreneurial behavior of female academics than male academics, we predict that female participants will be less likely than male participants to report founding a company (Kelley *et al.*, 2012; Marlow *et al.*, 2012).

Methods

Data source

The data for our analyses is drawn from surveys administered to 39 cohorts of the national I-Corps training program between spring 2012 and fall 2016. The surveys were distributed by the nonprofit organization VentureWell in collaboration with the NSF (VentureWell, 2019). The data was obtained through a memorandum of understanding between the authors and VentureWell and is consistent with the de-identified VentureWell 2.0 public use data release, with the addition of gender data. The dataset includes 2,589 participants, including 843 Technical Leads (TL), 912 Entrepreneurial Leads (EL) and 834 I-Corps Mentors (IM).

Sample

The sample includes 2,195 participants for whom gender data is available. It comprises 409 women (19%), and 1,786 men (81%); their roles are 763 ELs, 705 IMs and 727 TLs. More specifically, the sample consists of 156 (7%) female ELs, 607 (28%) male ELs, 108 (5%) female IMs, 596 (27%) male IMs, 145 (7%) female TLs and, 582 (27%) male TLs. It is notable that there

are significantly fewer women who participate in I-Corps across all roles, at a ratio of approximately four or more male participants for every one female participant. Furthermore, a Pearson's Chi-Square test (χ^2 [2, 2,195] = 7.58, p = 0.023) demonstrates that women were most likely to be in the EL team role (Adjusted Standardized Residual [ASR] = 1.6) and least likely to be in the IM role (ASR = −2.7). In a check-all-that-apply racial/ethnic identification survey item, 26% of participants identified as Asian or Asian American, 3% as Black or African American, 67% as White, 7% as Hispanic, Latino or Spanish origin, and 5% as "Other".

Survey instruments

Participants completed three online surveys distributed via email: one prior to the course ("pre-course survey"), one immediately following the seven-week course ("post-course survey"), and one 9–16 months after completion of the course ("longitudinal follow-up survey"). The longitudinal surveys were administered in September of each year to all team members who participated in the prior year, with an average length of time since taking the course of 13 months. Response rates were 96% for the pre-course survey, 74% for the post-course survey and 60% for the longitudinal follow-up survey (VentureWell, 2019). VentureWell reports that the survey instruments were developed internally (VentureWell, 2019), and therefore information such as convergent and discriminant validity is not available for the scales used in this study.

Independent and dependent variables

In all analyses, gender served as the independent variable. The ten dependent variables in this analysis are divided into four conceptual categories (Table 1): human capital (one variable), cognitive capital (four variables), social capital (one variable) and course outcomes (four variables). Questions relating to financial capital were included in the survey but were not made available in order to maintain participant confidentiality. The survey items are described below.

Human capital. Human capital was represented in the analysis by a single variable, *prior experience*. *Prior experience* consists of 14 questions from the pre-course survey that asked participants to indicate the number of times they had participated in 14 types of entrepreneurship or commercialization activities prior to participation in the I-Corps program (Table 2). To address the extreme skew of these variables, the numeric responses were recoded into a dichotomous variable representing whether the participant had indicated any experience or none for each question.

Cognitive capital. Four variables were used to explore cognitive capital: *negative climate*, *positive climate*, *usefulness to research* and *usefulness to career*. The *negative climate* and

Table 1. Dependent variables

Conceptual category	Variable	Number of survey questions	Categorical/ Continuous	Time points
Human capital	Prior experience	14	Categorical	Pre
Cognitive capital	Negative climate	3	Continuous	Post
	Positive climate	5	Continuous	Post
	Usefulness to research	1	Continuous	Post
	Usefulness to career	1	Continuous	Post
Social capital	Team relationship	4	Continuous	Post
Course outcomes	Entrepreneurial intent	4	Continuous	Pre and post
	Commercialization readiness	5	Continuous	Pre and post
	Company founding	1	Categorical	Longitudinal
	Go or No-Go	1	Categorical	Post

Category	Variable name	Survey questions
Human capital	Prior experience	Indicate how many times you have participated in the following experiences prior to your involvement in the I-Corps program: (1) Presented a business idea to investors (2) Served on a corporate advisory board (3) Founded or co-founded a venture based on your research (4) Disclosed an invention to the university (5) Applied for a patent as an inventor or co-inventor (6) Issued a patent (7) Conducted market research (8) Interviewed potential customers about a product, service, or technology (9) Generated trade secrets (10) Licensed your research/technology (11) Participated in the technology transfer process at your university (12) Contributed ideas utilized by a company to improve a product, service, or process (13) Received royalties for your work (14) Participated in industry-funded research Response: Open-ended
Cognitive capital	Usefulness to career	I will use the information and ideas from the I-Corps course in my career Response choices: 1 "Totally disagree", 2 "Disagree", 3 "Unsure", 4 "Agree", 5 "Totally agree"
	Usefulness to research	I will use the information and ideas from the I-Corps course in my research program Response choices: 1 "Totally disagree", 2 "Disagree", 3 "Unsure", 4 "Agree", 5 "Totally agree"
Course outcomes	"Go" or "No-Go" decision	Which of the following best describes the current status of your project? Response choices: (1) Our research has commercial potential ("Go" decision) (2) Our research is not yet ready for commercialization ("No-go" decision) (3) We are not yet sure whether our research is commercializable (Uncertain)
	Company founding	To your knowledge, has a company been incorporated based on this I-Corps project? Response choices: "Yes", "No" When was the company incorporated? Please enter a date (mm/dd/yyyy)

Table 2.
Variables analyzed as single questions

positive climate variables were treated as scales, averaging responses to three survey questions ($\alpha = 0.74$) and five survey questions ($\alpha = 0.84$), respectively (Table 3). *Usefulness to research* and *usefulness to career* were individual survey questions (Table 2). To correct extreme skew for the course usefulness variables (Osborne, 2013), values of one ("Strongly disagree") and two ("Disagree") on the original five-point scale were converted (Windsorized) to values of three (Career, $n = 19$; Research, $n = 35$).

Social capital. In this study, social capital was studied using the variable *team relationships*. The *team relationships* variable was treated as a scale ($\alpha = 0.85$), averaging responses to five survey questions that relate to participant's perceptions of the quality of the interaction and cooperation in their project teams (Table 3).

Table 3.
Variables averaged for analysis

Conceptual category	Scale	Cronbach's alpha	Items
Cognitive capital	Negative climate	0.74	Overall, how would you describe the learning environment created during the course: (1) Stressful (2) Harsh (3) Exhausting Response choices: 1 "Not at all", 2 "A little", 3 "Somewhat", 4 "Very", 5 "Extremely"
	Positive climate	0.84	Overall, how would you describe the learning environment created during the course: (1) Collegial (2) Motivating (3) Productive (4) Innovative (5) Challenging (positively) Response choices: 1 "Not at all", 2 "A little", 3 "Somewhat", 4 "Very", 5 "Extremely"
Social capital	Team relationship	0.85	Describe the extent to which your team did the following: (1) Collaborated effectively (2) Had a clear leadership structure (3) Distributed the workload equitably (4) Shared decision making (5) Made good decisions Response choices: 1 "Never", 2 "Seldom", 3 "Sometimes", 4 "Most of the time", 5 "Always"
Course outcomes	Commercialization readiness	Pre – 0.81; Post – 0.83	Indicate your level of agreement with the following statements about the current status of your technology and future plans (1) I have adequately assessed my technology's readiness for commercialization (2) I have identified a viable commercialization path for my technology (3) I have developed a scalable business model (4) I have defined a minimum viable prototype for my product (5) I have identified and validated the market for a product based on my technology Response choices: 1 Totally disagree; 2 Disagree; 3 Unsure; 4 Agree; 5 Totally agree
	Entrepreneurial intention	Pre – 0.68; Post – 0.72	Indicate your level of agreement with the following statements about the current status of your technology and future plans (1) I will apply for SBIR funding for my technology in the next 12 months (2) I will seek other funding or investment for my technology within the next 12 months (3) I am interested in starting my own company (4) I am interested in working in a technology-based start up Response choices: 1 Totally disagree; 2 Disagree; 3 Unsure; 4 Agree; 5 Totally agree

Course outcomes. Four variables were used to examine course outcomes: *entrepreneurial intention, commercialization readiness, go or no-go decision,* and *company founding* (Tables 2 and 3). *Entrepreneurial intention* describes participants' plans to pursue commercialization or entrepreneurship activities. This variable consisted of 4 survey questions and was treated as a scale ($\alpha = 0.72$). *Commercialization readiness* reflects participants' beliefs that important steps towards commercialization of their technology had been completed and consisted of five survey questions averaged together ($\alpha = 0.83$). Both of these variables, *entrepreneurial intention* and *commercialization readiness,* were measured in the pre- and post-course surveys. The *go or no-go decision* binary variable represents participants' overall assessment of the commercialization potential of their technology and was measured only one time, during the post-course survey. Finally, the *company founding* variable was a single survey question included only in the longitudinal follow-up survey. This question asked participants to report whether a company had been founded, and if so, the date of the incorporation of the company.

Data analysis

All analyses were conducted using SPSS statistical software. Three types of statistical tests were used, Pearson's Chi-Square, Two-Way Univariate Analyses of Variance (ANOVA) and Two-Way Repeated Measures Analyses of Variance, depending on whether each dependent variable was categorical, continuous, measured at one time point or measured at multiple time points. In addition, a participant's role on the project team (Technical Lead, Entrepreneurial Lead, and I-Corps Mentor) was included as a control variable in all ANOVA analyses to account for differences between these groups that may otherwise interfere with the ability to detect gender differences. Similarly, to account for the effect of team role in the Chi-Square analyses, the tests were conducted separately for each role when allowed by sample size.

Results

Hypothesis 1, human capital

In our first hypothesis, we predicted that female I-Corps participants would report lower levels of human capital than male participants. To investigate this, the proportion of men and women who had engaged in 14 types of entrepreneurship activities prior to the I-Corps course was compared using Pearson's Chi-Square tests. The results (see Tables 4 and 5) showed that a significantly lower proportion of women ELs reported engagement in four types of entrepreneurship activities, IMs in one type of activity and TLs in eight types of activity. Supporting our hypothesis, no type of prior entrepreneurship experience was reported more often by women than men.

In addition to these single-item measures, we calculated a variable to represent the total amount of previous entrepreneurial experience by adding the individual items together. To examine gender differences in total prior experience while controlling for team role, we performed a two-way univariate ANOVA (see Tables 6 and 7). For the control variable of team role, the main effect was significant, with ELs reporting the least prior experience ($M = 4.26$, $SD = 2.97$), IMs reporting the most prior experience ($M = 8.25$, $SD = 2.80$) and TLs reporting an intermediate level of prior experience ($M = 7.24$, $SD = 3.26$). In support of our hypothesis about gender, the main effect of gender was significant with men ($M = 6.67$, $SD = 3.47$) reporting a greater amount of prior experience than women ($M = 5.48$, $SD = 3.29$). No gender by team role interaction was present, showing that this gender difference was present among all team roles.

Hypothesis 2, cognitive capital

In our second hypothesis, we predicted that women would report lower levels of cognitive capital than male participants, represented by perceptions related to four variables: positive

	EL			IM			TL		
	n	χ^2	*p*	*n*	χ^2	*p*	*n*	χ^2	*p*
Presented a business idea to investors	607	7.33**	0.007				575	2.76	0.097
Served on a corporate advisory board	608	0.02	0.891	491	2.41	0.121	574	3.71	0.054
Founded or co-founded a venture based on your research	609	0.37	0.543	492	11.02**	0.001	573	4.04*	0.044
Disclosed an invention to the university	611	5.48**	0.019	489	0.23	0.633	576	7.42**	0.006
Applied for a patent as an inventor or co-inventor	611	10.42**	0.001	487	2.72	0.099	576	9.67**	0.002
Issued a patent				484	2.01	0.156	574	11.48**	0.001
Conducted market research	610	1.82	0.177				571	0.37	0.543
Interviewed potential customers about a product, service, or technology	610	0.41	0.524				574	0.10	0.751
Generated trade secrets				458	1.15	0.284	567	8.00**	0.005
Licensed your research/ technology	608	0.89	0.346	483	1.93	0.164	575	9.31**	0.002
Participated in the technology transfer process at your university	608	1.17	0.280	461	0.01	0.925	573	1.14	0.286
Contributed ideas utilized by a company to improve a product, service, or process	606	0.28	0.599				570	3.21	0.073
Received royalties for your work							572	7.91**	0.005
Participated in industry-funded research	610	4.78*	0.029	485	1.58	0.208	575	9.78**	0.002

Table 4.
Results of chi-square analyses of prior entrepreneurial experience

Note(s): The degrees of freedom for all above analyses was one. Blank cells indicate that a Pearson's chi Square analysis could not be performed due to sample size of 15 or less in at least one subgroup. For all variables with significant differences, fewer women than men reported having the prior entrepreneurial experience; *$p < 0.05$, **$p < 0.01$

climate, negative climate, usefulness to career and usefulness to research. To investigate this question while controlling for team role, we performed a two-way univariate ANOVA for each dependent variable with gender and team role as the independent variables (see Tables 6 and 7). For all of these the variables, we found no significant gender differences for any team role. However, significant differences were present for the control variable of team role in relation to negative climate and to usefulness to career. Compared to TLs, ELs perceived negative climate to be greater (for ELs, $M = 3.76$, $SD = 0.79$; for IMs, $M = 3.16$, $SD = 0.88$; for TLs, $M = 3.32$, $SD = 0.86$) and the course to be more useful to their careers (for ELs, $M = 4.72$, $SD = 0.50$; for IMs, $M = 4.68$, $SD = 0.56$; for TLs, $M = 4.60$, $SD = 0.57$). In summary, contrary to our hypotheses, we found no gender differences in any of the cognitive capital variables including positive climate, negative climate, usefulness to career or usefulness to research.

Hypothesis 3, social capital

In our third hypothesis, we predicted that women would report lower levels of social capital than did men, which was represented by their perceptions of the quality of their team relationship. To test for this gender difference while controlling for team role, we used a two-way univariate ANOVA (see Tables 6 and 7). In this analysis, both the main effects of role and

Table 5. Frequency statistics for categorical variables by gender and role

		EL		M		TL		Item total *N*
		Women	Men	Women	Men	Women	Men	
Presented a business idea to investors	No	94 (6%)	311 (19%)	9 (1%)	50 (3%)	65 (4%)	231 (14%)	
	Yes	28 (2%)	174 (11%)	58 (4%)	320 (20%)	46 (3%)	233 (14%)	1619
Served on a corporate advisory board	No	119 (7%)	468 (28%)	31 (2%)	136 (8%)	92 (5%)	348 (21%)	
	Yes	4 (<1%)	17 (1%)	43 (3%)	281 (17%)	18 (1%)	116 (7%)	1673
Founded or co-founded a venture based on your research	No	106 (6%)	408 (24%)	36 (2%)	124 (7%)	79 (5%)	285 (17%)	
	Yes	17 (1%)	78 (5%)	37 (2%)	295 (18%)	31 (2%)	178 (11%)	1674
Disclosed an invention to the university	No	77 (5%)	248 (15%)	56 (3%)	303 (18%)	26 (2%)	61 (4%)	
	Yes	46 (3%)	240 (14%)	18 (1%)	112 (7%)	85 (5%)	404 (24%)	1676
Applied for a patent as an inventor or co-inventor	No	80 (5%)	238 (14%)	43 (3%)	197 (12%)	33 (2%)	79 (5%)	
	Yes	43 (3%)	250 (15%)	31 (2%)	216 (13%)	77 (5%)	387 (23%)	1674
Issued a patent	No	111 (7%)	394 (24%)	48 (3%)	238 (14%)	66 (4%)	198 (12%)	
	Yes	12 (1%)	91 (5%)	24 (1%)	174 (10%)	43 (3%)	267 (16%)	1666
Conducted market research	No	76 (5%)	268 (16%)	5 (<1%)	35 (2%)	64 (4%)	289 (17%)	
	Yes	47 (3%)	219 (13%)	66 (4%)	372 (22%)	44 (3%)	174 (10%)	1659
Interviewed potential customers about a product, service, or technology	No	59 (4%)	218 (13%)	3 (0%)	18 (1%)	47 (3%)	206 (12%)	
	Yes	64 (4%)	269 (16%)	69 (4%)	375 (23%)	63 (4%)	258 (16%)	1649
Generated trade secrets	No	108 (7%)	395 (24%)	30 (2%)	133 (8%)	88 (5%)	315 (19%)	
	Yes	15 (1%)	90 (6%)	43 (3%)	252 (15%)	19 (1%)	145 (9%)	1633
Licensed your research/technology	No	112 (7%)	427 (26%)	50 (3%)	250 (15%)	83 (5%)	282 (17%)	
	Yes	11 (1%)	58 (3%)	22 (1%)	161 (10%)	26 (2%)	184 (11%)	1666
Participated in the technology transfer process at your university	No	86 (5%)	314 (19%)	36 (2%)	189 (12%)	44 (3%)	162 (10%)	
	Yes	37 (2%)	171 (10%)	37 (2%)	199 (12%)	65 (4%)	302 (18%)	1642
Contributed ideas utilized by a company to improve a product, service, or process	No	64 (4%)	241 (15%)	1 (<1%)	16 (1%)	40 (2%)	129 (8%)	
	Yes	58 (4%)	243 (15%)	68 (4%)	390 (24%)	69 (4%)	332 (20%)	1651
Received royalties for your work	No	114 (7%)	451 (27%)	62 (4%)	312 (19%)	87 (5%)	301 (18%)	
	Yes	8 (0%)	35 (2%)	11 (1%)	102 (6%)	23 (1%)	161 (10%)	1667
Participated in industry-funded research	No	73 (4%)	238 (14%)	30 (2%)	138 (8%)	39 (2%)	99 (6%)	
	Yes	49 (3%)	250 (15%)	43 (3%)	274 (16%)	71 (4%)	366 (22%)	1670
"Go" or "No-Go" Decision	Our research has commercial potential (Go decision)	60 (4%)	223 (16%)	40 (3%)	205 (15%)	53 (4%)	230 (17%)	
	Our research is not yet ready for commercialization (No-go decision)	33 (2%)	103 (7%)	27 (2%)	111 (8%)	27 (2%)	104 (8%)	
	We are not yet sure whether our research is commercializable (Uncertain)	9 (1%)	44 (3%)	10 (1%)	58 (4%)	10 (1%)	29 (2%)	1376
Company founding	No company was founded	52 (6%)	130 (14%)	25 (3%)	159 (17%)	42 (5%)	140 (15%)	
	Before course	2 (<1%)	38 (4%)	1 (<1%)	18 (2%)	7 (1%)	43 (5%)	
	During or after course	16 (2%)	84 (9%)	11 (1%)	43 (5%)	16 (2%)	88 (10%)	915

Note(s): Percentages displayed are in relation to the item total *N*

		Df	*F*	*p*
Prior experience	Gender	1683, 1	25.10	<0.001
	Team role	1683, 2	157.46	<0.001
	Interaction	1683, 2	1.26	0.284
Positive climate	Gender	1369, 1	0.94	0.332
	Team role	1369, 2	0.79	0.452
	Interaction	1369, 2	0.35	0.700
Negative climate	Gender	1365, 1	0.64	0.421
	Team role	1365, 2	34.84	<0.001
	Interaction	1365, 2	0.64	0.525
Usefulness to career	Gender	1537, 1	0.22	0.421
	Team role	1537, 2	5.41	0.005
	Interaction	1537, 2	0.77	0.462
Usefulness to research	Gender	1219, 1	0.34	0.557
	Team role	1219, 2	2.35	0.095
	Interaction	1219, 2	0.22	0.800
Team relationship	Gender	1351, 2	9.62	0.002
	Team role	1351, 2	15.00	<0.001
	Interaction	1351, 2	0.72	0.483

Table 6.
Results of two-way univariate ANOVA analyses

gender were significant, but not the interaction. For the control variable of team role, ELs (M = 3.78, SD = 0.76) reported poorer quality team relationships than IMs (M = 3.94, SD = 0.72) or TLs (M = 4.07, SD = 0.64). In support of our hypothesis, women (M = 3.79, SD = 0.79) reported significantly poorer perceptions of team relationships than did men (M = 3.96, SD = 0.78).

Hypothesis 4, outcomes

In our fourth hypothesis, we expected that women would be less likely than men to achieve four desired course outcomes, represented by entrepreneurial intention, commercialization readiness, founding a company and overall go or no-go assessment of their technology.

Commercialization readiness. To examine differences between commercialization readiness on the pre and post survey by gender and role, we used a two-way repeated measures ANOVA (see Table 7). Consistent with our hypothesis, the effect of gender was significant, $F(1, 1{,}433) = 9.37$, $p = 0.002$, with women (pre-course, $M = 3.03$, $SD = 0.74$; post-course, $M = 3.65$, $SD = 0.78$) reporting lower commercialization readiness than men (pre-course, $M = 3.11$, $SD = 0.71$; post-course, $M = 3.76$, $SD = 0.74$) at both time points. The gender by team role interaction, $F(2, 1{,}433) = 1.06$, $p = 0.346$, the gender by time interaction, $F(2, 1{,}433) = 1.29$, $p = 0.256$ and the gender by time by team role interaction, $F(2, 1{,}433) = 2.16$, $p = 0.116$, were not significant, showing that this gender effect was similar across all team roles and time points. For the control variable of team role, the between-subjects effect was significant, $F(2, 1{,}433) = 26.26$, $p < 0.001$, with ELs reporting the highest commercialization readiness (pre-course, $M = 3.22$, $SD = 0.71$; post-course, $M = 3.88$, $SD = 0.69$), IMs reporting the lowest (pre-course, $M = 2.97$, $SD = 0.74$; post-course, $M = 3.51$, $SD = 0.80$) and TLs reporting an intermediate level (pre-course, $M = 3.07$, $SD = 0.69$; post-course, $M = 3.82$, $SD = 0.71$). For the within-subjects effect of time, commercialization readiness increased significantly from pre to post survey, $F(1, 1{,}433) = 462.49$, $p < 0.001$, with a significant interaction effect between team role and time, $F(2, 1{,}433) = 9.10$, $p < 0.001$. Post-hoc tests showed that while this increase was significant for all team roles (for ELs, $f[1, 501] = 209.27$, $p < 0.001$; for IMs, $f[1, 437] = 62.36$, $p < 0.001$; for TLs, $f[1, 495] = 254.77$, $p < 0.001$), the increase in commercialization readiness was lower

		Women			Men			
		N	*M*	*SD*	*N*	*M*	*SD*	Role total *N*
EL	Prior experience Sum	123	3.57	2.68	492	4.44	3.01	615
	Positive climate	100	3.98	0.66	377	4.01	0.68	477
	Negative climate	100	3.76	0.75	376	3.76	0.79	476
	Usefulness to career	110	4.68	0.54	419	4.73	0.49	529
	Usefulness to research	95	4.57	0.63	378	4.55	0.64	473
	Team relationship	98	3.61	0.8	370	3.83	0.75	468
	Pre-course commercialization readiness	148	3.18	0.69	565	3.23	0.71	713
	Post-course commercialization readiness	110	3.83	0.65	421	3.88	0.71	531
	Pre-course entrepreneurial intention	147	4.12	0.62	563	4.25	0.6	710
	Post-course entrepreneurial intention	110	4.14	0.72	420	4.22	0.74	530
IM	Prior experience Sum	74	7.7	2.68	422	8.35	2.82	496
	Positive climate	76	3.97	0.72	375	3.97	0.69	451
	Negative climate	75	3.28	0.98	374	3.14	0.86	449
	Usefulness to career	81	4.73	0.45	413	4.68	0.58	494
	Usefulness to research	30	4.4	0.67	205	4.4	0.76	235
	Team relationship	75	3.81	0.74	370	3.97	0.72	445
	Pre-course commercialization readiness	92	2.88	0.8	520	2.98	0.75	612
	Post-course commercialization readiness	76	3.31	0.89	413	3.55	0.79	489
	Pre-course entrepreneurial intention	90	3.91	0.59	515	4.02	0.69	605
	Post-course entrepreneurial intention	68	4.05	0.66	406	4.09	0.79	474
TL	Prior experience Sum	111	6.13	3.13	467	7.51	3.24	578
	Positive climate	83	3.87	0.8	364	3.97	0.7	447
	Negative climate	83	3.32	0.94	363	3.32	0.84	446
	Usefulness to career	100	4.56	0.59	420	4.61	0.56	520
	Usefulness to research	101	4.57	0.62	416	4.5	0.67	517
	Team relationship	83	4.01	0.76	361	4.09	0.61	444
	Pre-course commercialization readiness	134	3.03	0.68	556	3.09	0.68	690
	Post-course commercialization readiness	100	3.75	0.75	423	3.83	0.71	523
	Pre-course entrepreneurial intention	134	3.94	0.75	555	4.08	0.68	689
	Post-course entrepreneurial intention	100	3.89	0.92	422	4.16	0.74	522

Table 7. Descriptive statistics for continuous variables by gender and role

(using the Scheffe correction, $t[1,438] = 3.85$, $p = 0.001$) for IMs ($M = 0.53$) than for TLs ($M = 0.74$), with ELs reporting an intermediate increase ($M = 0.66$).

Entrepreneurial intention. To examine differences between entrepreneurial intention on the pre and post survey by gender and role, we used a two-way repeated measures ANOVA (see Table 7). Consistent with our hypothesis, the effect of gender was significant, $F(1, 1,410) = 10.13$, $p < 0.001$, with women (pre-course, $M = 4.01$, $SD = 0.67$; post-course, $M = 4.02$, $SD = 0.78$) reporting lower entrepreneurial intention than men (pre-course, $M = 4.13$, $SD = 0.67$; post-course, $M = 4.17$, $SD = 0.74$) at both time points. No interactions were present for gender by team role, $F(2, 1,410) = 1.32$, $p = 0.268$, gender by time, $F(1, 1,410) = 0.41$, $p = 0.522$ or gender by team role by time $F(2, 1,410) = 1.19$, $p = 0.302$, demonstrating that this gender effect was similar across all team roles and time points. The effect of the control variable of team role was significant, $F(2, 1,410) = 8.52$, $p < 0.001$, with ELs reporting the highest entrepreneurial intention (pre-course, $M = 4.22$, $SD = 0.61$; post-course, $M = 4.22$, $SD = 0.72$), IMs reporting the lowest (pre-course, $M = 4.00$, $SD = 0.69$; post-course, $M = 4.07$, $SD = 0.77$) and TLs reporting an intermediate level (pre-course, $M = 4.09$, $SD = 0.67$; post-course, $M =$, $SD = 0.78$). In within-subjects tests, entrepreneurial intention did not increase from the pre to post survey, $F(1, 1,410) = 0.51$, $p = 0.474$, with no interactions present with team role, $F(2, 1,410) = 0.23$, $p = 0.798$, gender (see above) or gender by team role (see above). The finding that commercialization readiness increased over the course while

intent did not may be due to a ceiling effect, because entrepreneurial intention was very high on the pre course survey.

"Go" or "No-Go" decision. To determine whether men and women differed in their likelihood of reporting that their technology was ready to commercialize on the post survey ("go" decision vs. "no go" decision vs. "unsure"), we used a Pearson's chi-square test (see Table 4). No gender differences on this variable were found for any team role (for ELs, $\chi^2[2, n = 472] = 1.29$, $p = 0.532$; for IMs, $\chi^2[2, n = 451] = 0.971$, $p = 0.615$; for TLs, $\chi^2[2, n = 453] = 1.09$, $p = 0.579$).

Company founding. To determine whether men and women differed in their likelihood of reporting founding a company on the longitudinal follow-up survey, we used a Pearson's chi-square test (see Table 4). The responses to this question were analyzed by comparing three categories: whether a company was never founded, founded before the course or founded either during or after the course. Due to the smaller sample size of responses to the longitudinal survey, we conducted this analysis with team roles combined. The results demonstrated a significant gender difference, χ^2 $(2, n = 915) = 10.437$, $p = 0.005$. Compared to men, women were more likely to report never founding a company (Adjusted Standardized Residual [ASR] = 2.8) and less likely to report founding a company before the course (ASR = −2.7), but no gender difference was evident in founding a company during or after course (ASR = −1.0).

In summary, our hypothesis was supported for the variables of commercialization readiness, entrepreneurial intention and company founding. Women reported lower levels of perceived commercialization readiness and entrepreneurial intention, and were also less likely to report founding a company than men. However, contrary to our hypothesis, men and women did not differ in their overall "go, no-go, or unsure" decision assessment of their technology.

Discussion

The purpose of this study was to explore gender differences in participants' experiences of a large-scale academic entrepreneurship education program. Using data from the US National Science Foundation's National I-Corps program, we examined several variables that have been identified in the literature as barriers to women's engagement in technology entrepreneurship. The dataset we examined included individuals affiliated with universities across the United States and from many disciplines. Unique to this study was the ability to examine women serving in various roles within entrepreneurial project teams, since I-Corps teams include not only faculty members, but also postdocs, graduate students and expert industry mentors. Our purpose was to explore if these findings could be useful in the design of entrepreneurship education and training programs targeting women, and how these educational interventions might influence entrepreneurial intention.

For our first hypothesis, we expected that female participants would report less prior entrepreneurial experience than their male colleagues. Consistent with this hypothesis, we found that women on average reported lower total engagement than men on a checklist of 14 types of entrepreneurship activities prior to enrolling in the course. In follow-up analyses of each individual type of experience, the results differed by project team role. Among participants who were in the EL role, comprising primarily graduate students, women were less likely than men to have presented a business idea to investors. Among participants who were in the TL role, comprising primarily faculty members, women were less likely than men to have founded or co-founded a venture, issued a patent, generated trade secrets, licensed technology or received royalties based on their research. In a shared pattern across both the EL and the TL team roles, women were less likely than men to previously disclose an invention to the university, apply for or receiving a patent or participate in industry-funded research. Finally, among participants in the IM team role, comprising primarily industry

experts, the only significant difference found was that women were less likely than men to report previously founding or co-founding a venture.

For our second hypothesis, we expected that female participants would have more negative perceptions of, and attitudes towards, the I-Corps program in relation to: perceived positive climate (e.g. "collegial"), negative climate (e.g. "harsh"), usefulness to career and usefulness to research. However, in contrast to previous findings (van Veelen *et al.*, 2019), this hypothesis was not confirmed for any of these four variables. As described below, the potential reasons for the lack of gender differences in this analysis warrant further study.

For our third hypothesis, we predicted that women would report lower levels of social capital than did men, based on their perceptions of the quality of their project team relationship. In support of our hypothesis and consistent with prior research (Niederle and Vesterlund, 2007), women reported significantly poorer perceptions of team relationships than did men. Therefore, despite the result that women did not view I-Corps training as more generally harsh, social interactions remain a potential problem for female participants.

Our fourth hypothesis focused on variables considered to be course outcomes. We expected that women would be less likely than men to report high entrepreneurial intention, commercialization readiness of their project, achieving a "go" decision on moving forward with their venture at the end of the course, and founding a company during or after the course. Our hypotheses were supported for both entrepreneurial intention and commercialization readiness. However, contrary to our hypothesis, men and women did not differ either in reporting project "go or no-go" decisions or founding a company during or after the course. Instead, men were significantly more likely than women to enter I-Corps with a company already founded. We also examined longitudinal trends in entrepreneurial intention and commercialization readiness and found no gender differences. For both men and women, entrepreneurial intention remained stable while perceptions of commercialization readiness significantly improved during the course.

These gender differences in entrepreneurial intention and commercialization readiness are consistent with existing literature showing that women report lower entrepreneurial self-efficacy (Dempsey and Jennings, 2014), entrepreneurial intention (Kickul and D'Intino, 2005) and ultimately entrepreneurial behavior (Marlow and Mcadam, 2012). It is possible that female participants in I-Corps were less confident about their projects and therefore gave more cautious assessments. However, self-efficacy was not directly measured in this study, representing another topic for future research. In addition, future studies could examine the extent to which differences in project or venture characteristics, such as size, sector or funding expectations, could account for apparent gender differences (Marlow *et al.*, 2012).

The results of this study could have implications for curricula as well as research methodology in relation to academic entrepreneurship training. First, it is clear that significantly fewer females than males participate in I-Corps, a finding which warrants further investigation. Women make up just 1/5 of participants across all I-Corps team roles and the gender discrepancy is even more pronounced for industry mentors. It is likely that this discrepancy is partly due to the smaller population of female scientists in STEM fields, making fewer eligible to participate. In the case of industry mentors, it is possible that women business leaders are not part of the networks to which I-Corps administrators typically reach out. What is unclear is the extent to which there are other personal, professional, contextual or programmatic barriers or issues associated with I-Corps that further limit women's participation.

Given previous research and concerns that women have more negative experiences than men in STEM education and entrepreneurship training, the lack of a gender difference in perceptions of I-Corps instructional climate could relate to several factors that merit further study. First, I-Corps participants represent a unique population which could result in self-selection bias. Many come from STEM fields, where they may be accustomed to gender gaps

in representation as well as male-stereotyped or "chilly" climates (Hall and Sandier, 1982). Similarly, participants may have been aware of the competitive "boot-camp" (Duval-Couetil *et al.*, 2020, p. 18) or "shark tank" (Semcow and Morrison, 2018, p. 259) nature of the I-Corps instructional style prior to enrolling, either from colleagues or through their own participation in regional programs that are often a prerequisite for participating in the national program (National Science Foundation, 2019). Therefore, additional research is needed to help determine whether the instructional style could present an obstacle to the initial recruitment of female participants, exacerbating the self-selection bias.

Other factors that could explain the lack of gender differences in attitudes include the assessment method and survey items used. For example, the survey used general descriptors such as "harsh", "stressful", "collegial" and "productive", which do not specifically capture experiences of bias, stereotyping, or exclusion. In the future, researchers and evaluators could consider using survey questions that address these issues more specifically. Further, the inclusion of qualitative methods as well as classroom observations on this topic may be critical to determining the extent to which gender bias in entrepreneurship training is accurately captured by these self-reported survey questions. Similarly, social desirability bias may also play a role in responses, given that the identity of survey participants was known to NSF, which is an influential funding agency. Therefore, participants may have been reluctant to report experiences of bias, suggesting that program evaluators could consider using anonymous assessment tools to examine these topics. Yet another factor that could contribute to these null findings is that incidents of bias could vary dramatically between course instructors and class cohorts, indicating that future research would benefit from multilevel analysis that links participants with specific instructors.

With respect to the design of course curricula, results related to prior entrepreneurial experience suggest that women may benefit from additional training and resources associated with specific activities, separate from or prior to, participating in I-Corps. In addition, the gender disparity in quality of team relationships implies that support and mentoring to ensure an equitable division of labor may be a particularly effective method to create a better experience for female participants (Sekaquaptewa and Thompson, 2002). This result is consistent with prior research on the benefits of female mentorship (Riebe, 2012), which could provide specific guidance on the role of gender in resolution of project team conflicts. Further, pedagogical strategies related to gender dynamics in team interactions represents an active area of research in the field of STEM education. While some studies indicate that all-female project teams result in benefits to women's self-efficacy and performance (Meadows and Sekaquaptewa, 2013; Shi *et al.*, 2015), others show that mixed gender teams have learning benefits (Hansen *et al.*, 2015; Takeda and Homberg, 2014).

In summary, our analysis found that in comparison to male participants, female I-Corps participants reported less prior entrepreneurial experience, poorer team relationships during the program and lower entrepreneurial intention and technology commercialization readiness at both the beginning and the end of the program. However, no gender differences were found in perceptions of positive instructional climate (e.g. "collegial"), negative instructional climate (e.g. "harsh") or usefulness of participating in the course. Notably, results were similar across I-Corps team roles, meaning that gender differences were similarly evident among faculty, graduate students, as well as industry mentors. Therefore, female participants may benefit from curricular changes that address inequalities in prior entrepreneurial experience, team relationships and perceptions of commercialization readiness. We propose that in conjunction with other strategies to foster the participation of women in entrepreneurship, such as female-focused fundraising training (Leitch *et al.*, 2018), the continued development and improvement of entrepreneurship training programs such as I-Corps could contribute to equalizing the human, cognitive, social and ultimately, the financial capital available to potential academic entrepreneurs.

Limitations

In addition to the limitations discussed above, the study of gender using a dichotomous measure is a simplification of the way that gender identification and gender role expression can affect beliefs and behaviors. For this reason, follow-up research on this topic should include a range of measures of gender identification, such as continuous scales or qualitative data. In addition, datasets with larger sample sizes are necessary to examine the influence of Racial/Ethnic identification on gender differences in these variables. Furthermore, the results reported here could vary based on contextual variables such as the technology sector of the project and the institutional norms towards entrepreneurship at each participant's employing institution, information which was not available in this study. For example, female participation in the biological and health sectors may be greater, with fewer perceived barriers.

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