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Makerspaces as Learning Sites at the Intersection of Engineering and Entrepreneurship Education*

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Makerspaces have become an important intersection between engineering and entrepreneurship. Drawing from data on a team-based engineering entrepreneurship program that included peer-reviews and faculty/advisor assessments, we examine how prototyping in combination with team process and composition variables affect entrepreneurial performance. Using a three-step hierarchical regression model, we found that team compositional variables such as gender, entrepreneurial and prototyping experience, had a positive effect on entrepreneurial performance. We also found that team process variables such as prototyping efficacy and communication frequency were positively linked with entrepreneurial performance. We conclude our study with a discussion of the implications of our findings for engineering entrepreneurship education.

Keywords: makerspaces; entrepreneurship; gender; prototyping

1. Introduction

Over the years, makerspaces have transformed from simple workspaces such as basements, garages, sheds, or machine shops to sites of user-driven innovation and entrepreneurship. These spaces connect users with tools, skills, resources, as well as a variety of for- and non-profit organizations in a single physical location. Specifically, the addition of advanced tools such as laser cutters, CNC machines, and 3-D printers, is enabling prospective makerspace users to create and test complex and innovate prototypes at a comparably low cost [1, 2]. Makerspaces have also had a profound impact on engineering education. Participation in makerspaces promises to keep students engaged, facilitate collaborative and iterative projects, enhance technological literacy [3], but most importantly make difficult technological subjects more approachable to students who traditionally might have not enrolled in engineering courses [4]. The makerspace environment also encourages students to think more entrepreneurially, work in teams and develop prototypes that are marketable [5]. This intersection of engineering and entrepreneurship, however, is still under researched.

We address this shortcoming by examining the effect of team composition variables such as gender, communication frequency, and entrepreneurial experience as well as makerspace-specific variables such as prototyping efficacy and experience on entrepreneurial performance. This paper is structured as follows. We start with a brief theoretical discussion covering the main strands of literature that we interlace in our paper: makerspaces in engineering and entrepreneurship education, prototyping and cooperative learning in engineering entrepreneurship education. Second, we will describe the methodology applied, present our key findings as well as their implications for theory and practice. The paper will close with a discussion of future research directions.

2. Related Literature

2.1 Makerspaces in Engineering and Entrepreneurship Education

Makerspaces, specified as the physical venue where individuals can develop physical and digital prototypes of all varieties, have found a prominent place in engineering education. Due to various factors, one of which is the adoption of human-centered design principles, many engineering design programs have started transforming traditional machine shops into prototyping sites for students who want to collaboratively create and develop their ideas. Examples include MIT's Pappalardo lab, Stanford University's d-school, Northwestern University's Segal Design Institute, Georgia Tech's Invention Studio or Rice University's Oshman Engineering Design Kitchen. Each of these academic makerspaces offers collaboration and/or meeting spaces as well as access to a variety of design and manufacturing equipment such as CNC mills and lathes, laser cutters, welding stations, paint booths, or 3D printers. Depending on

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the level of curricular integration and objectives, makerspaces might be open to specific courses and programs or also include the wider campus community [6]. Academic makerspaces have become central in teaching user-driven innovation, one of the major sources of product improvements and new products in established industries [7]. Community-run makerspaces, on the other hand, offer members of local communities with little building experience access to a safe space to experiment with new fabrication technologies and get advice as well as social support from experienced builders to prototype their ideas and engage in entrepreneurial activities. This is especially relevant for individuals that belong to underrepresented groups such as women or people that have disabilities or live in poverty that lack access to fabrication tools [8–10]. Recognizing the potential to enable previously underserved groups to engage in product development, many public institutions such as libraries, schools, and universities as well as businesses have added makerspaces to their portfolio [6]. The characteristics of makerspaces can also vary significantly with respect to size, equipment, support, and accessibility [7], thereby creating different conditions based on geography and resources. Despite the apparent utility that makerspaces can provide early-stage research on entrepreneurship programs utilizing makerspaces is still scarce [11] and deserves more attention.

2.2 Prototyping

The ability to use fabrication technology to rapidly prototype ideas is a key tenet to successfully utilize a makerspace. Researchers distinguish between low- and high-fidelity prototyping [12]. In the context of prototyping, fidelity describes the simplicity of the medium (e.g., sketches) that is being used to prototype, but also how easily a user can substantially change and distinguish said prototype from the final product. Low-fidelity prototypes have many advantages. First, their ease of manipulation allows the user to experiment with different (potentially unrelated) ideas. They also allow a quick exchange between different members of a team, without committing significant resources and therefore lowering users' resistance to (radically) change their ideas [13, 14]. Low-fidelity prototyping has also been found to reduce anxiety and fear of failure when developing new, potentially complex ideas [15]. In contrast, the use of high-fidelity prototyping offers a more realistic interaction between potential customers and the different functional and design aspects of the prototype. Furthermore, depending on the type of customer – business versus consumer – high-fidelity prototypes might be an indicator of professionalism and therefore required [16].

With respect to entrepreneurship, the ability to prototype can offer entrepreneurs a competitive advantage, enabling them to quickly respond to competitors' new offerings, new customer demands, or developments in technology. Prototypes can help define an idea's role, implementation, look and feel [17]; they can build an understanding of target users [18]; they establish a communication link to potential clients, users, and other stakeholders [19]. Entrepreneurs can test both their business and product-related hypotheses, then observe the outcome [20]. Successful prototyping requires iterative oscillation between creation and feedback, meaning that generation of hypotheses will lead to open questions, observations of failures, new ideas, and thus a variety of prototypes. Therefore, developing prototyping expertise can be the difference between thriving and going out of business [21]. Developing functional prototypes can be resource-intensive. Prototyping requires resources such as time, money, or personnel, but cost estimates can change over time as contingencies appear. Also, in fast-moving industries, development times for products can be short and therefore impose a time-constraint. Therefore, organizations are tempted to avoid prototyping or significantly reduce the number of iterations because they believe the cost/investment will be significant and the return will be minimal. This in turn can affect the quality and impact of the prototyping outcomes. However, research shows that additional iterations often cost less than a flawed product [22, 23].

Prototyping can also pose some challenges on the team level. In order to successfully prototype in a team environment, prototyping sessions have to be well structured and objectives have to be set. Team members have to find ways to communicate with each other verbally and visually in order to iterate effectively. The use of low-fidelity prototypes, for example, is a reasonable starting point that would reduce the need for fabrication expertise, and offer an easy gateway for everyone to participate in the prototyping process. At the same time, a process has to be developed in order to purposefully increase the fidelity of the prototype to meet customer usability thresholds.

2.3 Cooperative Learning in Engineering (Entrepreneurship) Education

Cooperative learning, the practice of grouping students together in teams to work on complex tasks, has become a common educational tool in most engineering (entrepreneurship) curricula [24, 25]. Such educational settings allow students to understand the importance of collaboration and bring awareness to a shared understanding of resources, relationships, and opportunities for becoming enterprising when they work in a team [26]. Examples include Brown University's course on technology-based entrepreneurship offered by the Division of Engineering [27], Northwestern University's NUVention program [28], the engineer-entrepreneur program at Shamoon College of Engineering in Israel [29], the Pennsylvania State University's Engineering Entrepreneurship minor [30], or the Engineering Entrepreneurs Program at North Carolina State University. These educational programs aim to build "teams [that] are truly multidisciplinary, with members that bring in a wide variety of experiences and expertise" [8, p. 187], which is a characteristic that participants consider an essential feature to their learning process. While more and more programs aim to add an interdisciplinary team experience, scholarly work on team-based engineering entrepreneurship education is underdeveloped.

Few notable exceptions exist. Work by Bodnar et al. [31], and Eberhardt et al. [32] has show that team-based hands-on learning activities positively contribute to student's development of entrepreneurial skills. Engineering innovation and entrepreneurship boot camp environments where students work in teams have been found to provide a setting for learning entrepreneurship related abilities and innovation concepts [31]. A multidisciplinary, team-based undergraduate and graduate engineering curriculum focused on medical device design, including teams of biomedical engineering and business students, showed high levels of success in student learning outcomes and student satisfaction [32].

Among the many factors that affect teamwork performance, are gender, relevant experience (entrepreneurship and prototyping), and educational attainment. With respect to teams in engineering (education), several studies suggest that the share of females in a team can positively contribute to a team's performance. For example, examining engineering and science teams, researchers found that teams with a higher proportion of women are more productive if they are operating in disciplines where female faculty representation is high [33]. A study on gender composition, team process, and team performance conducted in an introductory engineering course found mixed results. In one of the courses, majority male teams produced more high-quality final reports than majority female teams. This effect was reversed in the other course, where majority female teams produced higher quality reports [34]. In entrepreneurship (education), gender composition has been found to have positive effects on team performance. In a study on entrepreneurial student teams, majority female teams were found to perform better than their male counterparts [25]. With respect to how team members' previous experience in entrepreneurship and/or prototyping affect their team's performance, studies have found mixed results. In a study on serial entrepreneurs, researchers found that the positive experience-performance relationship can lead to increasingly worse outcomes for novice entrepreneurs, as they are unable to generalize their experiential knowledge and thus learn from their previous mistakes [35]. In another study, entrepreneurial teams with homogenous start-up experiences show positive effects in a short term, but perform lower in the long term than teams with more heterogeneous start-up experiences [36]. In contrast, Delmar and Shane found that venture experience has positive effects on venture survival and sales. However, the effects are nonlinear and vary with venture age [37].

Successful teamwork also requires communication. Entrepreneurial environments are characterized by high levels of uncertainty, ambiguity, and time constraints. Whether it is the coordination between different members of the team or the creation of procedures to communicate and discuss new content, communication is critical for entrepreneurial performance. Studies on entrepreneurial venture teams have shown that communication can build cognitive social capital as well as enhance social interaction, which in turn leads to higher venture performance outcomes [38, 39].

In summary, we propose to test an empirical model that incorporates a variety of team-based variables such as composition, communication frequency, entrepreneurial and prototyping performance and assess their influence on entrepreneurial performance, trying to answer the following research question: How do team compositional variables as well as the team's ability to prototype affect its entrepreneurial performance?

3. Method

The data was collected from a team-based entrepreneurship program at a large research university in the Midwest of the United States, during 2010, 2011, and 2012, totaling 30 teams. Each team consisted of 5–9 students. The sample was comprised of a total of 180 students (53% of the students were male and 47% female) with majors ranging from business to engineering (28% majoring in engineering, 26% in business, 24% in law, and 22% in others as medicine, arts and science). The composition of the teams did not change during the program, and each student was assigned to a team by the program director based on individual background, interests and strengths. Part of the program was to develop a prototype of the team's business idea that was subsequently rated by judges (six per team).

3.1 Measures

Our conceptual model included the following measures:

Educational attainment. Measured by educational level: (a) junior, (b) senior, (c) master, and (d) doctoral. The individual levels were subsequently averaged on the team level.

Gender composition. Measured by the proportion of women in the team and ranges from 0 to 1.

Team communication frequency. Measured by the question: "How often do you communicate with your team members every week?" referring to each member of the team. The individual student answers on this item were averaged at the team level, generating a score for the team communication frequency.

Prototyping efficacy. The teams' prototyping efficacy was assessed using the following questions: (1) to what extent is this prototype likely to be effective in achieving what the team wants to achieve?; (2) To what extent is this prototype likely to be feasible in the real world?; (3) To what extent is this prototype likely to be viable in the current context (economic, political, social, etc.)? (4) To what extent is this prototype likely to be supported by key stakeholders?; (5) To what extent is this prototype scalable for bigger impact? Judges rated each team on a ten-point scale, ranging from (0) unlikely to (10) very likely. The scores of each judge were averaged at the team level.

Prototyping experience. Measured by the average level of prototyping experience students on the team have. The three levels are as follows: (a) less than one year, (b) between one and two years, and (c) more than two years.

Entrepreneurial experience. Measured by the average level of entrepreneurial experience students on the team have. The three levels are as follows: (a) less than one year, (b) between one and two years, and (c) more than two years.

Entrepreneurial performance. The team's entrepreneurial performance was measured by judges' answers on six main criteria: (A) Value Created by the New Product or Service; (B) Attractiveness of the Market Opportunity; (C) Competitive Advantage of the Proposed Venture; (D) Operational and Technological Viability; (E) Capability of Management Team; and (F) Capital Requirements and Financial Forecast. Judges rated each team on a ten-point scale, ranging from (0) poor / inexistent to (10) excellent. The scores of each judge were averaged at the team level.

4. Results

To further examine the effects of gender and educational composition, team communication frequency, prototyping efficacy and experience, as well as entrepreneurial experience on entrepreneurial performance we conducted a hierarchical regression. Table 1 summarizes the descriptive statistics and variable correlations. The results indicate a strong statistically significant correlation between educational attainment and entrepreneurial experience (r = 0.41, p < 0.001) as well as prototyping experience (r = 0.35, p < 0.001). With respect to gender composition, we found a strong negative statistically significant correlation with entrepreneurial experience (r = –0.22, p < 0.01) and prototyping experience (r = –0.18, p < 0.05), as well as a positive statistically significant correlation with communication frequency (r = 0.19, p < 0.05). Furthermore, we found statistically significant correlations between entrepreneurial performance and entrepreneurial experience (r = 0.27, p < 0.01), communication frequency (r = 0.18, p < 0.05), and prototyping efficacy (r = 0.15, p < 0.05).

A hierarchical regression analysis was conducted to determine which team composition and process variables predict their entrepreneurial performance. To that purpose we tested three regression models (see Table 2). The first model tested to what extent general team composition variables such as gender, educational attainment, and entrepreneurial experience can predict entrepreneurial perfor-

Table 1. Descriptive statistics and variable correlations

Variables	**Mean**	**SD**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Educational attainment	3.1	0.6	1						
2. Entrepreneurial experience	1.37	1.1	0.41***	1					
3. Gender composition	0.43	0.36	0.01	–0.22**	1				
4. Prototyping experience	2.1	1.4	0.35***	0.05	–0.18*	1			
5. Communication frequency	4.7	2.8	0.08	0.15*	0.19*	0.05	1		
6. Prototyping efficacy	38.3	16.8	–0.06	0.09	0.11	0.28**	0.17*	1	
7. Entrepreneurial performance	34.8	13.5	0.03	0.27**	0.2	0.1	0.18*	0.15*	1

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 2. Hierarchical Regression Analysis of Predictors of Entrepreneurial Performance

Predictor variables	**M1**	**M2**	**M3**
Gender composition (prop. of women in a team)	0.15*	0.14*	0.14*
Educational attainment	0.08	0.07	0.07
Entrepreneurial experience	0.23**	0.22**	0.22**
Prototyping experience		0.11	0.11
Prototyping efficacy		0.27**	0.26**
Communication frequency			0.18*
R^2	0.07	0.13	0.17
R^2 change	–	0.06	0.04

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ Note: Team Level: N = 30.

mance. We found that gender composition (β = 0.15, p < 0.05) and entrepreneurial experience (β = 0.23, p < 0.05) have a statistically significant positive effect on entrepreneurial performance. In the second model we added prototyping experience and efficacy and found that prototyping efficacy had a statistically significant positive effect on entrepreneurial performance (β = 0.27, p < 0.01). When adding these two predictors, the R-change is 6% after controlling for gender composition, educational attainment, and entrepreneurial performance. In model 3, communication frequency was added and it had a positive statistically significant effect on entrepreneurial performance (β = 0.18, p < 0.05). When adding communication frequency as a predictor, the R-change is 4% after controlling for prototyping experience and efficacy, gender composition, educational attainment, and entrepreneurial experience.

5. Discussion and Future Work

This study makes two main contributions. First, it expands conceptual and empirical work on the role that makerspaces play, specifically prototyping, in the context of engineering (entrepreneurship) education [40]. Our results show that prototyping experience and efficacy in combination with team compositional variables affect entrepreneurial performance. Makerspaces provide teams comprised of engineering and business students an opportunity to develop shared principles with respect to their prospective product(s). They can collectively shape their product based on not only technical specifications, but also include entrepreneurial aspects such as customer preferences as well as the competition. Makerspaces can also play a significant, but understudied, role in the development of team entrepreneurial competencies [41]. In order to successfully prototype, teams have to develop fabrication skills, but also understand how and when to transition from low- to high-fidelity prototypes.

Finally, our study also has implications for the formation and design of entrepreneurial ecosystems. Makerspaces are an important development hub on both a university and community level. Students from different disciplines can gather at makerspaces to ideate and develop new ideas, without a large financial commitment. Similarly, community-run makerspaces can enable historically underserved populations such as poverty, female or sustainable entrepreneurs [42–46] to test and create new products for the marketplace and access expert advice previously unattainable. This in turn can enhance the portfolio of an entrepreneurial ecosystem and foster economic development [47].

Although our results were encouraging, several limitations need to be discussed. One major area of improvement is the measurement of prototyping efficacy. We recognize that using faculty/advisor assessments does not fully capture the complexity of building a new prototype in a team environment. Therefore, future studies need to put more emphasis on understanding the process of prototyping from a micro point of view, identifying the different stages, specific challenges, and potential interventions. Secondly, some of our results were based on self-report surveys which come with some inherent constraints on information depth. Future studies need to include more observational data in order to better model the social interactions and team dynamics. Although our survey data was somewhat limited in depth, we recognize the importance of studying unexplored constructs such as technology and digital literacy [48]. Future studies need to further examine this construct and its importance for entrepreneurial performance. Finally, the question of leadership when iterating through different prototypes requires more attention.

6. Conclusion

Makerspaces as learning sites combining engineering and entrepreneurship education are still underdeveloped in the literature. Part of the challenge stems from the ability to balance the learning content and goals of both of these disciplines. Our research showed that prototyping is a central tenet in addressing this challenge. More specifically, the positive influence of prototyping efficacy on entrepreneurial performance leads us several conclusions. Firstly, prototyping can be a meaningful communication tool between students from different backgrounds, giving them the opportunity to iterative through different product ideas and subsequently invite more feedback from a broad set of stakeholders such as entrepreneurs, investors, or subject experts. To be effective, however, prototyping experiences need to be designed to include students with a wide variety of prototyping expertise. This might initially require the use of low-fidelity prototypes in order to establish common ground. Secondly, colleges and universities need to design makerspaces such that they fit the specific goals of their engineering entrepreneurship programs, but also leave space for other entrepreneurial users from across campus, creating a fix point in the university-based entrepreneurial ecosystem.

References

1. H. E. Aldrich and T. Yang, Lost in translation: Cultural codes are not blueprints, *Strategic Entrepreneurship Journal*, **6**(1), pp. 1–17, 2012.
2. Y.-T. Cheng and A. H. Van de Ven, Learning the innovation journey: order out of chaos?, *Organization science*, **7**(6), pp. 593–614, 1996.
3. P. Blikstein, Z. Kabayadondo, A. Martin and D. Fields, An assessment instrument of technological literacies in makerspaces and FabLabs, *Journal of Engineering Education*, **106**(1), pp. 149–175, 2017.
4. S. L. Martinez and G. S. Stager, Invent to learn: Makers in the classroom, *The Education Digest*, **79**(4), p. 11, 2013.
5. J. S. Hui and E. M. Gerber, Developing makerspaces as sites of entrepreneurship, in *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*, 2017, pp. 2023–2038.
6. V. Wilczynski, Academic Maker Spaces and Engineering Design, presented at the *ASEE Annual Conference & Exposition*, Seattle, WA, 2015.
7. E. von Hippel, *Democratizing Innovation*. Cambridge, MA: MIT Press, 2005.
8. L. Buechley and B. M. Hill, LilyPad in the wild: how hardware's long tail is supporting new engineering and design communities, in *Proceedings of the 8th ACM conference on designing interactive systems*, pp. 199–207, 2010.
9. J. Hook, S. Verbaan, A. Durrant, P. Olivier and P. Wright, A study of the challenges related to DIY assistive technology in the context of children with disabilities, in *Proceedings of the 2014 conference on Designing interactive systems*, pp. 597–606, 2014.
10. M. H. Morris, S. C. Santos and X. Neumeyer, 8. Building supportive infrastructure for low-income entrepreneurs, in *Poverty and Entrepreneurship in developed economies*, Northampton, MA: Edward Elgar Publishing, pp. 132–153, 2018.
11. V. Bill and A.-L. Fayard, Building an entrepreneurial and innovative culture in a university makerspace, in *ASEE Annual Conference and Exposition, Conference Proceedings*, **2017**, 2017.
12. M. Walker, L. Takayama and J. A. Landay, High-fidelity or low-fidelity, paper or computer? Choosing attributes when testing web prototypes, in *Proceedings of the human factors and ergonomics society annual meeting*, **46**, pp. 661–665, 2002.
13. M. Schrage, *Serious play: How the world's best companies simulate to innovate*, Harvard Business Press, 1999.
14. T. Kelley, *The art of innovation: Lessons in creativity from IDEO, America's leading design firm*, **10**, Broadway Business, 2001.
15. E. Gerber and M. Carroll, The psychological experience of prototyping, *Design Studies*, **33**(1), pp. 64–84, 2012.
16. M. W. Newman and J. A. Landay, Sitemaps, storyboards, and specifications: a sketch of Web site design practice, in *Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques*, pp. 263–274, 2000.
17. S. Houde and C. Hill, What do prototypes prototype?, in *Handbook of human-computer interaction*, Elsevier, pp. 367–381, 1997.
18. M. Buchenau and J. F. Suri, Experience prototyping, in *Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques*, pp. 424–433, 2000.
19. A. Warr and E. O'Neill, Understanding design as a social creative process, in *Proceedings of the 5th conference on Creativity & cognition*, pp. 118–127, 2005.
20. T. Kelley, *The ten faces of innovation: IDEO's strategies for beating the devil's advocate & driving creativity throughout your organization*, Crown Business, 2005.
21. L. E. Carlson and J. F. Sullivan, Exploring entrepreneurship through product development: a hands-on approach, in *Symposium conducted at the American Society for Engineering Education Annual Conference and Exposition*, 2002.
22. H. Erdogmus, The economic impact of learning and flexibility on process decisions, *IEEE software*, **22**(6), pp. 76–83, 2005.
23. C.-M. Karat, Cost-benefit analysis of usability engineering techniques, in *Proceedings of the Human Factors Society Annual Meeting*, **34**, pp. 839–843, 1990.
24. J. E. Froyd, The engineering education coalitions program, *Educating the engineer of 2020: Adapting engineering education to the new century*, pp. 81–93, 2005.
25. X. Neumeyer and S. C. Santos, A lot of different flowers make a bouquet: The effect of gender composition on technology-based entrepreneurial student teams, *International Entrepreneurship and Management Journal*, pp. 1–22, 2019.
26. J. P. Warhuus, L. Tanggaard, S. Robinson and S. M. Ernø, From I to We: collaboration in entrepreneurship education and learning?, *Education+ Training*, **59**(3), pp. 234–249, 2017.
27. C. J. Creed, E. M. Suuberg and G. P. Crawford, Engineering entrepreneurship: An example of a paradigm shift in engineering education, *Journal of Engineering Education*, **91**(2), pp. 185–195, 2002.
28. X. Neumeyer and A. McKenna, Entrepreneurial Thinking in Interdisciplinary Student Teams, *Advances in Engineering Education*, **5**(1), p. n1, 2016.
29. M. Yemini and J. Haddad, Engineer-entrepreneur: Combining technical knowledge with entrepreneurship education – The Israeli case study, *International Journal of Engineering Education*, **26**(5), p. 1220, 2010.
30. S. G. Bilán, E. C. Kisenwether, S. E. Rzasa and J. C. Wise, Developing and assessing students' entrepreneurial skills and mind-set, *Journal of Engineering Education*, **94**(2), pp. 233–243, 2005.
31. C. A. Bodnar, R. M. Clark and M. Besterfield-Sacre, Lessons learned through sequential offerings of an innovation and entrepreneurship boot camp for sophomore engineering students, *The Journal of Engineering Entrepreneurship*, **6**(1), pp. 52–67, 2015.
32. A. W. Eberhardt, O. L. Johnson, W. B. Kirkland, J. H. Dobbs and L. G. Moradi, Team-based development of medical devices: an engineering–business collaborative, *Journal of biomechanical engineering*, **138**(7), p. 070803, 2016.

33. A. Joshi, By Whom and When Is Women's Expertise Recognized? The Interactive Effects of Gender and Education in Science and Engineering Teams, *Administrative Science Quarterly*, **59**(2), pp. 202–239, 2014.
34. M. Laeser, B. M. Moskal, R. Knecht and D. Lasich, Engineering design: Examining the impact of gender and the team's gender composition, *Journal of Engineering Education*, **92**(1), pp. 49–56, 2003.
35. R. Toft-Kehler, K. Wennberg and P. H. Kim, Practice makes perfect: Entrepreneurial-experience curves and venture performance, *Journal of Business Venturing*, **29**(4), pp. 453–470, 2014.
36. P. Steffens, S. Terjesen and P. Davidsson, Birds of a feather get lost together: new venture team composition and performance, *Small Business Economics*, **39**(3), pp. 727–743, 2012.
37. F. Delmar and S. Shane, Does experience matter? The effect of founding team experience on the survival and sales of newly founded ventures, *Strategic Organization*, **4**(3), pp. 215–247, 2006.
38. T. Lechler, Social interaction: A determinant of entrepreneurial team venture success, *Small Business Economics*, **16**(4), pp. 263–278, 2001.
39. R. Lee and O. Jones, Networks, communication and learning during business start-up: the creation of cognitive social capital, *International Small Business Journal*, **26**(5), pp. 559–594, 2008.
40. H. E. Aldrich, The democratization of entrepreneurship? Hackers, makerspaces, and crowdfunding, in *Annual Meeting of the Academy of Management*, 2014.
41. S. C. Santos, M. H. Morris, A. Caetano, S. F. Costa and X. Neumeyer, Team entrepreneurial competence: multilevel effects on individual cognitive strategies, *International Journal of Entrepreneurial Behavior & Research*, 2019.
42. S. C. Santos, X. Neumeyer and M. H. Morris, Entrepreneurship education in a poverty context: An empowerment perspective, *Journal of Small Business Management*, 2019.
43. X. Neumeyer, S. C. Santos and M. H. Morris, Who is left out: exploring social boundaries in entrepreneurial ecosystems, *The Journal of Technology Transfer*, pp. 1–23, 2018.
44. X. Neumeyer and S. C. Santos, Sustainable business models, venture typologies, and entrepreneurial ecosystems: A social network perspective, *Journal of Cleaner Production*, **172**, pp. 4565–4579, 2018.
45. X. Neumeyer and A. C. Corbett, Entrepreneurial Ecosystems: Weak Metaphor or Genuine Concept?, in *The Great Debates in Entrepreneurship*, Emerald Publishing Limited, pp. 35–45, 2017.
46. M. Morris, S. Santos and X. Neumeyer, *Poverty and Entrepreneurship in Developed Economies*, Edward Elgar Publishing, 2018.
47. M. H. Morris, X. Neumeyer and D. F. Kuratko, A portfolio perspective on entrepreneurship and economic development, *Small Business Economics*, **45**(4), pp. 713–728, 2015.
48. X. Neumeyer, S. C. Santos and M. H. Morris, Overcoming Barriers to Technology Adoption When Fostering Entrepreneurship Among the Poor: The Role of Technology and Digital Literacy, *IEEE Transactions on Engineering Management*, pp. 1–14, 2020, doi: 10.1109/TEM.2020.2989740.

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