Perceived Barriers and Costs Associated with Participation in Student Innovation Competitions

Sadan Kulturel-Konak
Division of Engineering, Business, and Computing
Penn State Berks
Reading, PA, USA
sxk70@psu.edu

Ada Leung
Division of Engineering, Business, and Computing
Penn State Berks
Reading, PA, USA
cxl51@psu.edu

Abdullah Konak
Division of Engineering, Business, and Computing
Penn State Berks
Reading, PA, USA
auk3@psu.edu

***Abstract*—Student innovation competitions and programs, hereafter called ICPs, such as hackathons, start-up incubator competitions, design challenges, boot camps, and customer discovery labs, have emerged as pipeline-builders and transformative for higher education entrepreneurial ecosystems. Moreover, ICPs foster students' STEM-based experiences and serve as a gateway for career readiness. There is a disparity in ICP participation of students underrepresented in Science, Technology, Engineering, and Math (STEM) compared to student groups dominating STEM fields. While research supports the importance and benefits of STEM students' participation in these programs, literature discussing the students' perceptions of these programs remains limited. In order to increase diverse students' motivations for participating in ICPs and make ICPs more inclusive learning experiences for all students, this paper will answer two research questions: (i) what are the barriers that discourage student participation in ICPs, and (ii) what are the costs that associate with participation in ICPs? The primary research methodology in this paper is semi-structured interviews. Thirty-eight students (25 females vs. 13 males and 21 participants vs. 17 non-participants) were interviewed after a recruitment survey. The interview questions were crafted and analyzed based on the known scales and theories in the literature, namely the Expectancy-Value-Cost Scale and the Theory of Planned Behavior. Through student interviews, student perceptions of fitting in these co-curricular activities, i.e., ICPs, were explored, with a particular interest being students who are underrepresented in STEM. The complete recordings of the interviewee responses to interview questions were transcribed into text and analyzed using a grounded theory approach. The research findings will contribute to making the innovation ecosystem more inclusive and diverse by uncovering factors that discourage students from engaging in ICPs. Two levels of barriers were identified, institutional and individual. Institutional-level barriers include "low program awareness" and "lack of diversity and inclusiveness," whereas individual barriers include "not matching self-identity" and "low expectancy of success." As for costs, apart from "opportunity cost," "teamwork cost" has emerged to be another important cost dimension that associates with ICP participation. The ongoing research direction is to share the findings with the STEM educators and ICP organizers so that they are aware of these barriers and costs of participating in ICPs, which might be a basis for designing and testing interventions.**

***Index Terms*—student competitions, design competitions, inclusivity, innovation, underrepresented students, entrepreneurship, extracurricular**

I. Introduction and Background

Extracurricular and co-curricular activities play an increasingly crucial role in educating well-rounded engineers. A meta-analysis by Shulruf [1] found a significant relationship between extracurricular activities and educational outcomes. In addition to supporting students' academic development, extracurricular activities help students develop their 21st Century skills, provide opportunities to apply their classroom learning in real-life settings, expose them to new areas and interests, and support them in making more informed decisions about their career choices. While the industry seeks to hire engineering students with extracurricular experiences, many do not regularly participate in those experiences [2]. This paper focuses on innovation competitions and programs (ICPs), such as hackathons, start-up incubator competitions, design challenges, boot camps, and customer discovery labs, which are special extracurricular activities that aim to increase students' innovation mindset. In the recent decade, engineering programs have increased their emphasis on innovation and entrepreneurship to better prepare students for the complex problems posed by the global economy and climate change [3]–[5]. Innovation competitions play important roles in universities' innovation and entrepreneurship ecosystems by serving as a recruitment ground for many other co-curricular programs and exposing students to entrepreneurship and innovation [6].

In the literature, a limited number of studies investigated the obstacles that discourage students, especially underrepresented students, from participating in ICPs. To make ICPs more inclusive and equitable learning experiences, there is a need for

This material is based upon work partially supported by the Penn State Social Science Research Institute (SSRI) seed grant and the National Science Foundation (NSF) grant (DUE 2120936). Any opinions, findings, and conclusions expressed in this material are of the authors and do not necessarily reflect the views of the Penn State SSRI and NSF.

a systematic investigation of the barriers that underrepresented students face. In this paper, we use semi-structured interviews to answer two main research questions: (i) what are the barriers that discourage student participation in ICPs, and (ii) what are the costs associated with ICP participation? This paper is a preliminary study, to develop a theoretical framework to explore the factors that influence the participation of fewer underrepresented students in ICPs.

Several authors indicate a lack of diversity in ICPs [7]–[11], yet the reasons for why some students avoid participating in these events have not been discussed based on theoretical models. The disproportionately large number of white and Asian male participants in hackathons make marginalized student groups feel unwelcome at the events [12]. For example, hackathon environments implicitly exclude women [13]. Dang and Nguyen Viet [14] used the theory of planned behavior to examine the factors influencing students' intention to participate in extracurricular activities and noted that students with part-time jobs were less likely to join these activities as such involvements take away students' time to engage in ICPs. Kulturel-Konak et al. [15] used a survey based on the Expectancy-Value-Cost theory [16] and Self-Determination Theory [17] to gain insight into students' motivation for participating in ICPs and to identify possible barriers to their participation. Their findings identified the time demand of ICPs, low awareness of ICPs, a lack of understanding of how participating ICPs can help students attain their academic and professional goals, and a preconceived notion about how ICPs relate to their majors. For example, Art/Sciences students did not consider participating in ICPs essential to their identity. Interestingly, the authors noted that students with entrepreneurial family backgrounds valued ICPs more than others [15].

II. Research Methodology

A. Interview Procedure

The primary research methodology in this paper is semi-structured interview to gather responses from students enrolled in various programs at a land-grant university in the Northeastern United States. Recruitment survey links were emailed to targeted academic programs and clubs. Then, 249 students responded to the survey, and 38 students were invited to participate in the interviews. Interviews were conducted remotely via video conferencing by two research team members, who were trained with uniform interview objectives and skills. Interviews were conducted independently at scheduled times and varied from 20-40 minutes in length. Questions touched on several areas, including barriers to participating in ICPs and challenges experienced among the ICP participants.

Thirty-eight students (25 females vs. 13 males, 21 ICP participants vs. 17 non-participants, and 9 whites vs. 29 non-whites) were interviewed after a recruitment survey. About 85% of interviewed students were from STEM-related majors. The interview questions were crafted and analyzed based on the known scales and theories in the literature, namely the Expectancy-Value-Cost Scale [16] and the Theory of Planned Behavior [18]. Through student interviews, student perceptions of fitting in ICPs were explored, with a particular interest being students who are underrepresented in STEM. The complete recordings of the interviewee's responses to interview questions were transcribed into text.

B. Analytical Approaches

Data analysis was carried out using NVivo, Release 1. Our data analysis followed a grounded theory approach [19] and proceeded with three distinct steps. We began by reviewing the interview transcripts. From these data, we used an "open-coding" approach to identify distinct concepts that were repeated in the data [20]. This initial coding round produced 188 distinct codes. Some examples from the first round of coding include codes related to how students perceived innovation competitions and programs (e.g., fun, interesting, take too much time and so forth), codes related to time cost (e.g., time-consuming, busy schedules with classes in major, and so forth), and codes related to benefits (e.g., monetary awards, learning a lot, resume building, and so forth). In developing these codes, we iterated between the data and theory, tentatively evaluating the appropriateness of distinct theoretical frameworks for understanding the evolving coding structures. We continued to code and refine the data, and then discussed each of the codes and distilled the codes into first-order concepts. This step in the analysis allowed us to understand many of the key themes in our data, including the multifaceted dimensions of time cost, variations in coding patterns across gender, and so on. As a second step, we started interpreting the data more closely with various theoretical lenses. Given the importance of how students perceived costs and benefits of ICPs, we settled on expectancy-value theory as a specific lens [21] and started examining the data for evidence of constructs such as barriers and costs. We found that some of the data fit well within the existing theoretical framework, other aspects of the data did not. Therefore, we categorized the data using both existing and novel constructs for our analysis. When the coding process was complete, the categories were grouped together to form larger themes. The third step, which includes assembling the key constructs into theoretical arguments, is a work in progress.

III. Findings

Two major categories of themes emerged from the data: barriers to and costs of participating in student ICPs. Barriers are conceptualized as factors that make students unmotivated to invest time, energy, and resources [22] into ICPs and therefore, they did not engage in ICPs. Costs are conceptualized as what an individual must give up doing a task, as well as the anticipated effort one will need to put into task completion [21].

A. Barriers

Two levels of barriers were identified, institutional and individual. Institutional-level barriers include "low program awareness" and "lack of diversity and inclusiveness." Individual barriers, on the other hand, include "not matching self-identity" and "low expectancy of success."

1) Institutional- Low program awareness: Many students are unaware of the benefits and availability of ICPs, which impedes their participation and engagement. One of the possible reasons for low awareness is suboptimal communication strategies to break through the information clutter faced by students. Students are constantly bombarded with flyers, emails, social media, newsletters, and so on, but most of the promotional materials go unnoticed.

> *"Basically lack of information, since I know there's just so many things going on around campus, different things to do. You can get kind of lost in all of it."* (Female, Black, 4th year agriculture major)

2) Institutional- Lack of diversity and inclusiveness: Underrepresented students may have personal and academic issues associated with demonstrating grit and overcoming institutional racism over the course of their lives [23]. When the campus environment is not socially or culturally supportive of underrepresented students, they may not feel comfortable, visible, or represented in student life as they are not included in the conversations and decisions that affect them [24].

> *"I am a woman of color. It was obvious sometimes where my ideas would be cut short or undermined..."* (Female, Black, 4th-year engineering major)

3) Individual- Not matching self-identity: As students progress in their academic careers, their self-identities form and enact accordingly. Students put differential levels of importance on various tasks and activities that tie to their identities (e.g., gender-role identity, professional identity) [21]. Underrepresented students who perceived ICPs as irrelevant to their self-identity formation are not motivated to engage in them.

> *"I think (ICPs) are for students of engineering students, that are constantly being bombarded by the flyers, everything that's around that... "* (Female, Hispanic, 4th-year science major)

4) Individual- Low expectancy of success: Behavioral choices, such as education and occupation, are influenced by students' expectancy of success and the perceived importance the students attach to the various available options. If one has a low expectancy of success, i.e., having low confidence in one's skills, characteristics, and competencies to succeed, s/he is unmotivated to engage in the activity [25].

> *"I think maybe it's like lack of competence or lack of a specific idea that could gear me towards like... having a feeling like I have a fair shot... And if I knew that wasn't going to be as fruitful... because I don't have the necessary skills, talents, or whatever in order to succeed in that endeavor. Like I just haven't really wanted to pursue that or invest time in that."* (Female, Hispanic, 4th-year science major)

5) Disconfirming subjective norms: Subjective norm is an individual's perception that most people who are important to them think they should (or should not) perform a particular behavior [26]. If the students believe that their social referents do not support their participation, they are less motivated to engage in ICPs.

> *"No one really ever encouraged me to go into it, or really related to any of my studies."*(Female, Black, 4th-year agriculture major)

B. Costs

Every activity has costs as well as benefits, and individuals avoid those that cost too much relative to their benefits, particularly when compared to alternative tasks with higher benefit-to-cost ratios [21]. Three types of costs are conceptualized in the expectancy-value theory framework: 1) effort cost – the perceived amount of effort needed to complete it and whether it is worth the time and energy; 2) opportunity cost – the extent to which doing one task reduces the ability or time to do other activities that are valued; 3) psychological cost – the emotional costs of pursuing the activity, particularly anticipated anxiety and the emotional and social costs of failure [27].

Nevertheless, teamwork cost has emerged to be another important cost dimension among students [28]. Students mentioned that they had challenges in forming teams:

> *"It's hard to... make a big enough group because we didn't have that many people that wanted to do like interests... because they have a different priority for the weekend."* (Female, White, 4th year engineering major)

Students also complained about free riders in the team, as they had little control over the process, and they could not force anyone to engage intensively in ICPs.

> *"We were in a group and maybe everyone in the group didn't participate at the full extent in which they should have."* (Female, Black, Graduate science major)

C. Gender Comparison

We used a crosstab query to examine the distribution of emergent themes across gender. Table I presents the crosstab query results. Based on the interview data, "not matching self-identity" and "low expectancy of success" are the most mentioned barriers. However, female students were more likely to mention "low program awareness" and "not matching self-identity" as barriers to participation. As for the themes related to costs, "opportunity cost" and "teamwork cost" were the most mentioned cost dimensions. Female students were more likely to associate "opportunity cost" with participating in ICPs.

> *"I just don't have a lot of time...I'm doing my class work, my lab work, so I don't have time to do other things that might also be interesting."* (Female, Black, Graduate science education major)

IV. Conclusion and Further Research

Innovation competitions and programs (ICPs) play important roles as a recruitment ground for many other co-curricular

TABLE I
THE EXTRACTED THEMATIC CONCEPTS AND NUMBER OF PARTICIPANTS MENTIONING THE CONCEPTS

	Female (N=25)	Male (N=13)
Barriers	20 (80%)	9 (69%)
Low program awareness	5 (20%)	1 (8%)
Lack of diversity or inclusiveness	2 (8%)	1 (8%)
Not matching self-identity	9 (36%)	2 (15%)
Low expectancy of success	6 (24%)	3 (23%)
Disconfirming subjective norms	2 (8%)	0
Costs	15 (60%)	7 (54%)
Effort cost	4 (16%)	2 (15%)
Opportunity cost	9 (36%)	3 (23%)
Psychological cost	0	1 (8%)
Teamwork cost	7 (28%)	3 (23%)

programs and expose students to entrepreneurship and innovation. In this paper, barriers to and costs of participating in student ICPs are found to be the two major categories of themes that emerged from student interview data. Furthermore, two levels of barriers were identified, institutional and individual. Institutional-level barriers include "low program awareness" and "lack of diversity and inclusiveness," whereas individual barriers include "not matching self-identity" and "low expectancy of success." As for costs, apart from "opportunity cost," "teamwork cost" is found to be an important factor that affects students' involvement in ICPs. The ongoing research direction is towards compiling our findings in the 'theoretical' and 'inductive' thematic analyses and sharing them with the STEM educators and ICP organizers so that they are aware of these barriers and costs of participating in ICPs, which might be a basis for designing and testing interventions.

REFERENCES

[1] B. Shulruf, "Do extra-curricular activities in schools improve educational outcomes? a critical review and meta-analysis of the literature," *International Review of Education*, vol. 56, no. 5, pp. 591–612, 2010.

[2] A. Olewnik, Y. Chang, and M. Su, "Co-curricular engagement among engineering undergrads: do they have the time and motivation?" *International Journal of STEM Education*, vol. 10, no. 1, p. 27, 2023.

[3] A. C. Alves, F.-J. Kahlen, S. Flumerfelt, and A. B. Siriban-Manalang, *Lean engineering for global development*. Springer, 2019.

[4] G. da Silva, H. Costa, and M. Barros, "Entrepreneurship in engineering education: A literature review," *International Journal of Engineering Education*, vol. 31, pp. 1701–1710, 2015.

[5] M. S. A. Karim, "Entrepreneurship education in an engineering curriculum," *Procedia Economics and Finance*, vol. 35, pp. 379–387, 2016.

[6] H. Liu, S. Kulturel-Konak, and A. Konak, "Key elements and their roles in entrepreneurship education ecosystem: comparative review and suggestions for sustainability," *Sustainability*, vol. 13, no. 19, p. 10648, 2021.

[7] M. Htun, "Promoting diversity and inclusion through engagement: The apsa 2018 hackathon," *Political Science & Politics*, vol. 52, no. 4, pp. 677–683, 2019.

[8] G. T. Richard, Y. B. Kafai, B. Adleberg, and O. Telhan, "Stitchfest: Diversifying a college hackathon to broaden participation and perceptions in computing," in *Proceedings of the 46th ACM Technical Symposium on Computer Science Education*, A. Decker, K. Eiselt, C. Alphonce, and J. Tims, Eds., 2015, pp. 114–119.

[9] N. Taylor and L. Clarke, "Everybody's hacking: participation and the mainstreaming of hackathons," in *Proceedings of Conference on Human Factors in Computing Systems (CHI) 2018*, R. L. Mandryk, M. Hancock, M. Perry, and A. L. Cox, Eds., 2018, pp. 1–2.

[10] S. E. Walden, C. Foor, R. Pan, R. Shehab, and D. Trytten, "Leadership, management, and diversity: Missed opportunities within student design competition teams," in *Proceedings of 2015 ASEE Annual Conference and Exposition*, 2015.

[11] S. E. Walden, C. E. Foor, R. Pan, R. L. Shehab, and D. A. Trytten, "Advisor perspectives on diversity in student design competition teams," in *Proceedings of American Society for Engineering Education Annual Conference*, 2016, pp. 26–29.

[12] B. A. Kos, "The collegiate hackathon experience," in *Proceedings of the 2018 ACM Conference on International Computing Education Research*, L. Malmi, A. Korhonen, R. McCartney, and A. Petersen, Eds., 2018, pp. 274–275.

[13] J. Warner and P. J. Guo, "Hack.edu: Examining how college hackathons are perceived by student attendees and non-attendees," in *Proceedings of the 2017 ACM Conference on International Computing Education Research, ICER 2017, Tacoma, WA, USA, August 18-20, 2017*, J. Tenenberg, D. Chinn, J. Sheard, and L. Malmi, Eds., 2017, p. 254–262.

[14] H. P. Dang and B. Nguyen Viet, "Inside the intention to join extracurricular activities: Integrating the theory of planned behavior and signaling theory," *Cogent Education*, vol. 8, no. 1, p. 1888672, 2021.

[15] S. Kulturel-Konak, A. Konak, N. Webster, and K. Murphy, "Building inclusive student innovation competitions, exhibitions, and training programs," in *Proceedings of Hawaii International Conference on System Sciences (HICSS)*, T. X. Bui, Ed., 2023, pp. 1–10.

[16] J. J. Kosovich, C. S. Hulleman, K. E. Barron, and S. Getty, "A practical measure of student motivation: Establishing validity evidence for the expectancy-value-cost scale in middle school," *The Journal of Early Adolescence*, vol. 35, no. 5-6, pp. 790–816, 2014.

[17] R. M. Ryan and E. L. Deci, "Intrinsic and extrinsic motivations: Classic definitions and new directions," *Contemporary educational psychology*, vol. 25, no. 1, pp. 54–67, 2000.

[18] I. Ajzen, "The theory of planned behavior," *Organizational behavior and human decision processes*, vol. 50, no. 2, pp. 179–211, 1991.

[19] B. G. Glaser and A. L. Strauss, *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Chicago: Aldine, 1967, vol. 20.

[20] J. W. Creswell, *Qualitative Inquiry and Research Design: Choosing among Five Approaches*. Thousand Oaks, CA: Sage, 2006.

[21] J. S. Eccles and A. Wigfield, "From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation," *Contemporary Educational Psychology*, vol. 61, p. 101859, 2020.

[22] K. E. Barron and C. S. Hulleman, *Expectancy-Value-Cost model of motivation*, 2nd ed. Oxford: Elsevier Ltd., 2015, vol. 8, pp. 503–309.

[23] A. Kundu, "Understanding college "burnout" from a social perspective: Reigniting the agency of low-income racial minority strivers towards achievement," *The Urban Review*, vol. 51, no. 5, pp. 677–698, 2019. [Online]. Available: https://osf.io/5pyhq/download

[24] J. M. McCabe, *Connecting in College: How Friendship Networks Matter for Academic and Social Success*. Chicago, IL, UNITED STATES: University of Chicago Press, 2016.

[25] J. S. Eccles, "Who am i and what am i going to do with my life? personal and collective identities as motivators of action," *Educational Psychologist*, vol. 44, no. 2, pp. 78–89, 2009.

[26] M. Fishbein and I. Ajzen, *Predicting and Changing Behavior: The Reasoned Action Approach*. United States: Taylor & Francis Group, 2009.

[27] J. K. Flake, K. E. Barron, C. Hulleman, B. D. McCoach, and M. E. Welsh, "Measuring cost: The forgotten component of expectancy-value theory," *Contemporary Educational Psychology*, vol. 41, pp. 232–244, 2015.

[28] P. M. Reeves, S. E. Zappe, and D. J. Follmer, "A comparison of the types of problems encountered by entrepreneurial students and successful professional entrepreneurs," *Entrepreneurship Education and Pedagogy*, vol. 2, no. 3, pp. 214–244, 2019.