

Best Practices for Cultivating Innovative Thinking Skills in Innovation Competitions and Programs

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Abstract—Engineering and computing education have always embraced student Innovation Competitions and Programs (ICPs), such as design challenges, hackathons, startup competitions, and boot camps. These programs are typically organized to increase interest in STEM fields, achieve the broader objective of forming well-rounded engineers and encourage students to bring their innovative ideas into real life. In addition, all ICPs also aim to advance students' innovative thinking skills. With the increased focus on entrepreneurship and innovation in STEM programs, many higher education institutions now organize some form of ICPs. This increased popularity of ICPs bears the questions of (i) whether ICPs achieve their intended objectives, (ii) what program components are most effective, and (iii) how to design ICPs for recruiting diverse student groups. Although these questions are highly relevant to advancing the educational benefits of ICPs, the literature lacks holistic studies focusing on the best practices of ICPs. In this paper, we present the findings of a qualitative research study to investigate ICP types and attributes that make the most impact on fostering an innovation mindset. We interviewed the organizers of ICPs to understand their objectives for organizing their events and rationales for specific program elements. Besides, we asked questions about how they promote their events, the best ways to reach out to students, team selection and forming, their assessment and judging procedures, during and after competition support, and the best practices and challenges. These interview scripts were transcribed, coded, and analyzed using qualitative data analysis software. An analysis of extracted thematic concepts was performed to identify the best practices and strategies that ICP organizers utilize to increase the impact of their programs. The paper presents the preliminary results of this thematic analysis of the codes. Overall, findings suggest that incorporating more entrepreneurial elements, innovation training in ICPs, and effective mentoring may improve the learning outcomes related to innovative thinking skills.

Index Terms—student competitions, design competitions, innovation, entrepreneurship, critical thinking, extracurricular

I. INTRODUCTION

An increasing number of higher education institutions organize design challenges, idea competitions, and hackathons to attract students to work on innovative projects, collectively called Innovation Competitions and Programs (ICPs), as they usually positively affect participants [1]–[4]. Organizing an ICP is an overwhelming undertaking that requires considerable time, resources, and careful planning. The life cycle of organizing ICPs involves through the following stages: (1) planning, (2) launching, (3) execution, and (4) following up.

The planning stage starts with defining the primary goal and objectives to achieve by organizing an ICP. Goals could range from identifying students interested in entrepreneurship and innovation (i.e., recruitment), raising awareness of entrepreneurship programs among students and the community (i.e., awareness), training students in emerging technologies, finding innovative solutions to problems, building networks or community, etc. The primary goal of a program typically defines the type of ICPs. For example, idea pitch competitions are typically organized with recruitment and awareness goals in mind. Innovation, technical learning, and promoting collaboration are among the most common goals of hackathons [5].

After the objectives are clarified, the guidelines, processes, and timelines can be determined. In the planning stage, an essential step is forming an extended team of mentors, judges, industry collaborators, subject matter experts, training staff, and other personnel who support the execution of the ICP in various ways and at different stages. The extended team members should be involved in designing guidelines and processes, as their commitment is paramount for the success and sustainability of ICPs. Another critical aspect is that the ICP team should be inclusive: including members from various backgrounds and expertise. For many students, the experience of participating could be intimidating and risky, especially for

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first-timers and marginalized students [6]. Therefore, a more diverse team of facilitators and mentors can promote a sense of belongingness among these students and reduce their anxiety. The core extended team can be involved in determining the evaluation criteria and protocol for judging. The next step is planning logistics, which depends on the type and scope of ICPs. A key decision point at this step is deciding on technology platforms to facilitate team formation, mentor-to-team matching, communication, and collaboration.

The launching stage encompasses much more than announcing ICPs through different channels. At this stage, the core team should intentionally reach out to students where they are with a clear, inclusive, welcoming message. The landing web pages and other promotional materials should encourage first-timers and make anti-discriminatory policies visible. Messaging should explicitly state the benefits of participation for all students to increase participation from various disciplines [7]. Most ICPs offer monetary prizes for encouraging students. However, alternative means of awards, such as fellowships or internships, could be more attractive for marginalized students with less access to such opportunities [8].

The execution stage varies depending on the type of ICPs. Hackathons may be completed in a few days, and other programs may continue for multiple semesters. Regardless of the duration, the execution stage should have a structure to guide students through an innovation process. For example, some hackathons programs follow the design thinking process [9]. Providing mentorship, networking, and training opportunities to participants will increase ICPs' positive impacts on participants.

The follow-up stage involves the distribution of awards and setting up meetings to follow up with the teams and projects. It is important to provide constructive feedback to all teams, including those who could not complete the whole ICPs or move through the phases, on improving their ideas and projects. Constructive feedback and recognizing their achievements can inspire them to participate in other ICPs. If the objective is engaging students in a broader innovation ecosystem, students are encouraged to continue their projects beyond the ICPs, which can be achieved by exposing them to additional resources, other programs (e.g., incubators, accelerators), funding resources, or grants. Students will be more willing to continue developing their ideas if they feel supported and can access further resources and mentoring. Program participants may be encouraged to be mentors or facilitators in the upcoming events [10].

This paper presents the preliminary results of a research project to explore the best practices for organizing ICPs from the organizers' perspective and to understand how program organizers apply these practices to achieve different objectives. The outcome of this investigation will support developing a theoretical framework to understand students' professional and personal development as a result of participating in ICPs. The findings can also help ICP organizers design their programs to improve the student experience and learning outcomes.

II. RESEARCH METHODOLOGY

This study used a qualitative research design involving interviews with ICP organizers to gather data about their best practices, perspectives, and lessons learned. The interview participants were recruited from individuals who had direct experience with organizing and running ICPs for several years. Different ICPs, ranging from idea pitch competitions to technical programs, were targeted to ensure diverse perspectives. Interview participants were ICP organizers from 23 different universities across the United States. About 55% of the 31 organizers were female (17/31), and about 45% were male (14/31). The different types of programs discussed in the interviews included student incubators, pitch competitions, hackathons, innovation challenges, start-up challenges, idea bootcamps, customer discovery labs, idea challenges, grant programs, venture fairs, business plan competitions, design challenges, social impact challenges, capstone design support, and venture challenges. The majority of interviewed organizers had over six years of experience running ICPs (16/31). Three organizers had less than two years of experience, and six had three to five years of experience organizing ICPs.

Interviews were conducted through semi-structured questions developed based on the project's research objectives and to explore the participants' experiences and perspectives related to organizing ICPs. Two qualitative-research subject matter experts reviewed the interview questions, and the questions were modified based on their feedback. Next, a few test interviews were conducted to test the questions and interview processes. All interviews were conducted virtually using Zoom. The interviewers received training on effective interview procedures and technology before starting the interview process.

The interviews were transcribed into text verbatim using the automated transcription system of Kaltura. The transcripts were cleaned and verified to ensure the automated transcription was correct. Finally, the transcripts were labeled in terms of questions and were transferred to NVivo for thematic analyses. The thematic analysis involved identifying recurring codes and patterns in the interview transcripts and organizing them into broader thematic categories.

III. PRELIMINARY ANALYSIS

This paper presents the preliminary analysis of two questions:

- What are your top three objectives in terms of what participants should gain through your ICPs?
- Can you share your best practices for organizing and running an ICP?

These two questions were coded, and the codes were combined into higher-level thematic concepts. Table I provides the extracted thematic concepts (the objectives in the columns and best practices in the rows). The number of organizers who expressed a concept related to each objective theme is given in the Total row and best practices in the Total column of the table. The numbers in the body of the table represent how

many times a best-practice theme and an objective theme were mentioned together by the organizers. In the explanations of the extracted themes, the organizers' statements are given in italic quotations.

A. Objectives

The theme of "Innovation Skills" was the most frequently observed one in the interviews, followed by "Entrepreneurial Skills." While the codes related to "Innovation Skills" were more about coming up with new and original solutions to problems, the "Entrepreneurship Skills" refer to bringing those ideas into reality. Another related concept to "Innovation" and "Entrepreneurship Skills" was "Impact", which referred to making a positive change in society and having the students experience this. One organizer stated that "*So having [a] positive impact, going beyond widgets, going beyond mimicry in entrepreneurship, and developing something new that's defensible and worthwhile. That's super important to us.*" These findings suggested that the organizers who participated in this study focused on innovation and entrepreneurship as their primary goals. The other identified themes were about achieving these goals.

Interestingly, the organizers suggested connecting students with the resources within the university system as an essential objective (Connecting to Resources). They want students "*to be able to network and connect with [their] ecosystem and community to get mentoring, to get advice, to get support for progressing or growing or advancing their startup,*" and they consider ICPs as platforms for achieving these objectives. In addition, the organizers see ICPs as platforms for students to connect, collaborate, and celebrate their achievements. Therefore, "Building and Extending Networks" was identified as an objective of ICPs. Note that these objectives assume that students participating in ICPs would continue engaging with these networks and resources after the ICP experience.

The organizers also indicated cultivating students' personal growth and development as one of their objectives. The theme "Experience Entrepreneurship" was about exposing students to the process of entrepreneurship to discover whether entrepreneurship is a viable path for them. Developing self-confidence, self-motivation, self-capacity, and agency were among the codes identified. In this study, such codes formed the theme of "Personal Growth." ICPs allow students to appreciate what they can achieve with their education so far and what areas they need to improve through self-reflection and feedback. Likewise, the "Practical Experience" theme emphasized applying theory to practice and the real world. These aspects of ICPs may help students make better career choices.

Many organizers identified "Effectively Pitching Ideas" and "Developing Soft Skills" as important objectives. Pitching ideas might be considered under entrepreneurship skills. However, this theme was highlighted independently since it was mentioned by about one-third of the organizers.

B. Best Practices

The codes related to best practices were grouped and analyzed in terms of the stages of ICPs. In the planning stage, the organizers emphasized "Clarifying Objectives" and "Defining Clear Guidelines." The organizers indicated that making expectations, judging criteria, and rules up front was critical to running a successful program. However, some organizers suggested balancing prescriptive/specific versus broad/general expectations. Too rigid guidelines may negatively affect students' creativity, while vague rules may lead to frustration and a sense of being overwhelmed because students spend considerable time figuring out the expectations and what to do next. Ambiguous rules and expectations also make providing feedback challenging for mentors and advisors. The organizers emphasized the importance of forming a "Broad Support Structure" involving outside judges, partners, previous winners, different faculty and staff, etc. In the launch stage, "Effective Promotion" involves starting early and clear and continuous communications with students. Typically, prizes are offered to encourage participation.

In the execution stage, organizers indicated creating an "Open Process" that cultivates divergent thinking to experiment with different ideas. The process should be challenging but also fun and feasible. The organizers highlighted an iterative innovation process in which students are given feedback in various phases of ICPs. "Providing Training" during the execution stage emerged as another theme, and teams should have access to mentoring and coaching. Some organizers also emphasized the importance of training judges about the objectives and processes so that they could provide better feedback to students.

Nurturing an "Inclusive/Unbiased Environment" is important for the success of ICPs. The organizers stated that they tried to ensure that selection committees and judging panels represent various disciplines and groups well. They considered diversity broader than ethnicity or gender and emphasized bringing together individuals from different backgrounds and disciplines to prevent bias. A strategy to reduce the bias is relying on different judges at various stages of ICPs. For example, the judges "*who were selecting the top six teams were independent from the individuals who were selecting the ultimate winners.*" The organizers also emphasized being intentional in reaching out to students with diverse backgrounds and ethnicities during the recruitment, especially in fields dominated by white males. The extended ICP team can use their networks to contact students directly. Forming a "Broad Support Structure" in the planning stage also facilitates creating an inclusive environment.

The coding intersections between the best practices and the objectives' themes showed that creating a "Support Structure" and providing "Training Opportunities" were the most frequently mentioned practices to achieve all objectives mentioned above.

TABLE I
THE EXTRACTED THEMATIC CONCEPTS

	Entrepreneurship Skills	Experience Entrepreneurship	Impact	Innovation	Building and Extending Networking	Personal Growth	Effectively Pitching Ideas	Practical Experience	Connecting to Resources	Developing Soft Skills	Total
Inclusive/Unbiased Environment	Clarify Objectives	2	0	3	2	0	2	2	1	0	4
	Clear Guidelines	2	3	1	6	2	1	2	1	0	7
	Effective Promotion	2	3	0	1	1	1	4	5	0	8
	Open Environment	4	1	0	3	1	0	2	2	1	5
	Support Structure	1	2	1	0	2	4	0	3	2	6
	Training Opportunities	6	0	3	9	3	3	4	4	2	13
	Total	8	3	1	4	1	4	1	4	1	8

IV. CONCLUSION AND FURTHER RESEARCH

This study interviewed 31 organizers to discover their best practices while organizing ICPs, and their strategies to increase the impact of their programs on students. Although the literature includes many papers on student competitions, hackathons, and innovation activities, most of these papers introduce individual programs. Therefore, this study addresses a gap in the literature by summarizing the best practices of many ICPs using an interview-based, qualitative research methodology. Our preliminary findings show that it takes careful planning and involvement of individuals with many different backgrounds to organize successful ICPs. In addition to instilling entrepreneurship and innovation mindset supporting students' personal growth was identified as one of the objectives of ICPs. Therefore, the transformative learning theory may be appropriate for explaining students' development as a result of participating in ICPs. In further research, a thematic analysis of all questions will be performed. In addition, the reliability of codes and the formation of emerging themes will be tested. Finally, the findings of the organizer interviews will be compared with the student and mentor interviews to identify common patterns and differences.

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