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Overview of Student Innovation Competitions and Their Roles in STEM Education

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Abstract

Student innovation competitions have long been an essential part of Science, Technology, Engineering, and Mathematics (STEM) education. Higher education institutions and foundations have expanded their co-curricular program offerings to recruit and support student innovators, such as design challenges, hackathons, start-up incubator competitions, boot camps, customer discovery labs, and accelerator programs. Therefore, student innovation competitions and challenges are increasingly playing a role in educating the next generation of innovators and critical thinkers. This paper focuses on student innovation competitions, which are usually non-credit, co-curricular, and team-based programs in which student teams aim to solve open-ended problems. The benefits and challenges of student innovation competitions for the participants in STEM education are summarized. Hence, the specific focus and details of the reviewed competitions are not in this paper's scope.

Introduction

STEM education literature often mentions students' experiential learning experiences in college settings and their roles in curricular interventions. In particular, student innovation competitions have long been an essential part of STEM education [1]. Research suggested that student competitions provide many benefits and experiences, such as experiencing teamwork, peer interactions and leadership, gaining self-efficacy and enthusiasm, building a growth mindset, working on real-world applications, accessing informal mentorship, and connecting with employers [2], [3], [4]. It is crucial to practice some skills, such as leadership within a technical domain, and participation on an engineering competition team is a popular activity in this regard [5]. Traditional classroom teaching is often based on lecturing and examinations; therefore, they might lack going beyond teaching students technical and discipline-specific skills.

On the other hand, student competitions go beyond and offer students soft skills, which are the key to successful experiential learning [6]. In engineering education, senior capstone projects have become typical venues for teaching soft skills as well; however, these are often still limited with class-time and curriculum expectations [7]. Capstone projects, by nature, are towards the end of students' educational careers, and therefore, students may not have time to practice the soft skills they just have exposure. Earlier research shows that students' ability to understand ethical dilemmas [8] and global issues [9], [10] as well as apply teamwork skills [11] develop rather slowly during their education. However, students with experiential learning experiences demonstrate more significant gains in these soft-skill areas. Student competitions, therefore, play an essential role in engaging students in further design activities that go beyond the curriculum [4], [7].

Student Innovation Competitions- Benefits and Challenges

The focus of this paper is more specifically on innovation competitions and competition-like challenges. More and more universities add innovation hubs to their entrepreneurship ecosystems and run competition-like challenges to attract students working on innovative projects and eventually turning them into start-ups. These innovation hubs and programs, such as training and competitions, help students build entrepreneurial mindsets [12]. Innovation competitions also attract employers, and large corporations even sponsor these competitions. Therefore, students can connect with top employers, such as Google, Facebook, or IBM, that are otherwise not easy to reach [13]. James and Brookfield [14] suggested that students were more likely to engage their curiosity and imagination when they felt socially supported within the learning environment. Student innovation competitions provide a valuable learning tool that exposes students to critical thinking skills applied to problem-solving and managing projects. In addition, these competitions offer students the opportunity to showcase their skills in a wide variety of areas. For example, hackathons nurture the approach that no idea is bad and give team members the confidence to explore any idea, no matter how unlikely it seems, fostering innovation and creativity to develop supportive communities that allow outside-the-box solutions [15]. The learning opportunities in innovation competitions are unique because these competitions enable students to work on their innovations "from conception through presentation—the whole process" [16].

Furthermore, competitions encourage students to adopt innovative techniques and develop their ideas and skills throughout the process. Competitions and challenges can play an important role as facilitators of start-ups in economically distressed regions [17] as well as innovation activity for a larger spectrum of the economy [18], [19].

The majority of the published literature on competition-like challenges and competitions introduced competitions and summaries of student projects [20], [21], [22], [23], [24], [25], [26]. These studies usually concluded that competition-like challenges and competitions have a positive effect on participants. According to Wankat's findings [27], institutional support and competition legacy were important factors affecting the outcomes of participating student teams. Wankat [27] also surveyed many advisors for successful teams in undergraduate student competitions. One survey respondent stated that "Students that have competed consider it one of the highlights of their education. Even those that did not win value the experience." Many team advisors believed that there were long-term benefits from involvement in the experience. It is also worthy of mentioning that even those students who did not win value the experience.

A few studies [28], [29] showed that participating in competitions did not always transfer to learning, and some students failed to gain critical professional skills. Only a few papers pointed out a few adverse effects of participating in competitions, such as the feeling of frustration, depression, or inferiority by low performing students [30], focusing too much on winning rather than learning [4], and social responsibility [31], and misplaced motivations, disappointments and poor academic performance because of poor time management [4].

Table 1 depicts the benefits and challenges of participating in those competitions mentioned in the literature. It is noted that this table is only listing the highlights in the literature summarized in this paper.

Table 1. Benefits and challenges of participating in student competitions, especially in competitions with an innovation focus.

Benefits	***References***
experiencing teamwork, peer interactions, and leadership; gaining self-efficacy and enthusiasm; working on real-world applications; accessing informal mentorship	[2], [3], [4], [5]
networking opportunity with potential future employers	[2], [3], [4], [13]
engaging students in further design activities	[4], [7]
building innovative/growth mindsets	[12]
raising seed capital	[13]
testing ideas in a risk-free environment	[13]
providing practices for critical thinking skills	[14], [16]
fostering innovation and creativity	[15]
fostering economy	[17], [18], [19]
providing long-lasting valuable experience, i.e., sustainability	[27], [32]
Challenges	
having a poor academic performance as a result of poor time management	[4]
focusing too much on winning rather than learning and social responsibility	[4], [31]
having experience which is not transferrable	[28], [29]
feeling frustration, depression, or inferiority by low performing students/teams	[30]

Conclusions

In conclusion, as summarized above, research suggests many benefits of students participating in innovation competitions as co-curricular activities. Students should often be reminded that this is not time wasted even if they do not win; instead, it is time spent learning and growing. Innovation competitions provide students an enriching and stimulating experience that allows them to apply what they learned and are passionate about throughout the process to a specific and often practical problem. In order to enhance the role of student innovation competitions on cultivating an entrepreneurial mindset, developing a theoretical model that explains how students build an innovation mindset as an outcome of participating in innovation competition has been worked by our research team. The factors affecting the success of these innovation competitions in acquiring specific soft skills, i.e., innovative mindset, is another future research agenda.

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