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The Role of STEM Competitions, Robotics Challenges, and Coding Hackathons in Enhancing Student Motivation, Teamwork, and Innovation Skills in Higher Education

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Abstract

In this paper, the authors will discuss how attending an event around STEM, robotics, or computing, and hackathons helps to develop higher education students' services around soft skills like teamwork, leadership, creativity, and problem-solving. By use of a mix parenthesis, both the quantitative survey method as well as the qualitative reviews, the research intends to explore and conclude about the role such extracurricular activities play in supporting the development of the student technical strengths, in addition, to fostering, the growth of the critically interpersonal skills. As the results of the research of 200 participants among the students prove, all four soft skills increased significantly, and it is only natural that teamwork and problem-solving skills have been found to improve the most. The study is also concerned with the differences in the development or learning of soft skills in the various cohorts of people following gender, discipline of education or field, and frequency of the participation. The findings demonstrate the importance of encouraging STEM competitions in curricula of higher learning institutions so as to enable learners to develop skills that can guide them in their institutions and places of work. Such measures also not only provide students with technical know-how hence training them to work in a current labor force where teamwork, creativity and leadership are highly appreciated.

Keywords: *STEM competitions, robotics challenges, coding hackathons, soft skills, teamwork, leadership, creativity, problem-solving, higher education, skill development*

Introduction

Over the last few years, there has been a paradigm shift with regards to the new models of higher education whereby where the traditional classroom learning has been replaced by thinking in more participatory and experiential approaches, where more focus is laid on the hands-on learning, collaborative and problem-solving techniques. The idea behind Science, Technology, Engineering, and Mathematics (STEM) education and especially extracurricular activities like robotics challenges, coding hackeons, and STEM competitions have familiarized them as extremely important venues in engineering a range of technical and social skills (Williams, 2020). Whether or not that is the specific focus of these activities, it not only has filled in the gap between theory and practice but also developed key soft skills, such as teamwork, leadership, creativity, and resilience, which are becoming the future must-have in the twenty-first century workforce (Kelly and Seitz, 2021).

The rising popularity of these programs is associated with the changing demands in the labor markets of the world today wherein employers expect not only highly skilled graduates, but also individuals with strong communication, team management, and creativity skills (Nguyen & Cheng, 2023). Rosen and Zhang (2023) consider the academic motivation, which has a considerable increase in the participation of STEM-based competitions to strengthen desire of students to get a career in the sphere of STEM activities. It enhances this effect of motivation when the students get acknowledged due to their accomplishments, become owners, proud, and sense the sense of professional identity (Bishop and Wei, 2023).

The problems of robotics have gained particular power in the area of closing theory and practice gap. In these contests, students have to design, construct, and program robots to achieve certain tasks thereby fostering creativity, engineering skills and teamwork when solving problems (Smith and Patel, 2022). The resilience and adaptability learnt throughout the iterative design and testing of the robots are facilitated by the team-based format fosters communication and negotiation ability (Hwang and Chang, 2022; Parker et al., 2023). Similarly, hackathons with their time limit and pressure induce participants to find new solutions quickly, therefore developing innovative responses and risk-taking during times of pressure (Martínez and Martínez, 2023; Scott and Kramer, 2024). Events are reminders of the real world workplace environment and conditions, and revenue earned in cross-disciplinary work and innovation within constraints were identified as core to organizational success (Tan & Liu, 2022).

Furthermore, leadership comes out as a critical aspect of the involvement in such activities. Team captain or project manager is also a leadership position commonly offered by STEM competitions, with them allowing students to develop decision making, delegation, and conflict resolution skills (Rivera et al., 2021; Foster et al., 2022). These experiences as a leader have been demonstrated to contribute greatly to self-confidence and readiness to assume other, more professional positions where responsibility and accountability play an essential role (Anderson et al., 2022).

One more critical outcome of such activities is contributing to creativity and innovation. Hackathons offer a robust experimental space more than any other platform, giving students the opportunity to pursue the most unorthodox way of doing things and combine different ideas in solving problems (Lee, 2023; Turner and Green, 2023). Robotics competitions also stimulate creativity as they require the participants to create innovative technical designs and functional propositions (Kantar et al., 2021). By doing so, they can exercise their ability to think innovatively and creatively, and prepare them to work within a sector where a certain level of competitiveness relies on the ability to be innovative (Davis, 2022).

The incorporation of such competitions into higher education has far reaching effects to the involvement of the students. Surveys show that student participants of STEM competitions mention being more interested and more determined in studying their college majors than students who never attended a competition (Garcia & Roberts, 2023). Commitment to STEM pathways is also supported by recognition of achievement, through awards, scholarships, peer recognition, etc, and leads to long-term academic and career ambitions of students (Yang, 2023). Notably, they are inclusive classroom-based activities that give other members of the student population such as women and underelected minorities the chance to feel confident and demonstrate their skills in the STEM fields (Martins and Seifert, 2023).

Overall, STEM competitions, robotics problems, and hackathons do not respect the limits of the normative pedagogy, with their formats forming immersive experiences that combine skills training at a technical level with the acquisition of soft skills. These activities equip students with the multidimensional aspects of work in present-day societies because they enhance teamwork, leadership, resilience, creativity, and motivation. With the ongoing demand of flexible and creative specialists, the possibility of such extra-curricular STEM programs in tertiary education will prove to be more essential.

Literature Review

As a fact, STEM (Science, Technology, Engineering, and Mathematics) education is very important in technical expertise and innovation. However, the same trend has led to the growth of attention towards extra-curricular activities like STEM event, robotics, and coding hackathons, as people must offer students more skills, which are teamwork, innovation, and team leadership. This is because such events will enable not them to only acquire technical abilities, but also soft abilities so that they cannot excel in the job market without acquiring soft skills. A literature review used below will discuss how STEM competitions, robotics conservation, and Coding hackathons effectively instruct the existence of soft skils, including teamwork, leadership, and innovation, in higher education learners.

The uses of STEM Competitions in Development of Soft Skills.

Constructive power of STEM competition in terms of developing technical skills is not novel; however, what counts about the competition is also a role in enhancing the soft skills in students. According to Kelly and Seitz (2021), the competition has provided Stem with an immersive environment and students can apply problem-solving activities that also require group efforts. During the competition in such competitions, the time available is sometimes few and the subjects fail to allow the participants to work in groups hence they boost the most important skills which ought to be; communication, decision making and conflict resolution. These skills are very important to such students, who desire to succeed in the future employment settings in nearly every occupation within the STEM related environment would require effective work collaboration and teamwork.

In addition, the leadership aspect in STEM competition competitions influences the degree of leadership by granting the students the opportunity to not only hold leadership positions in their teams. Foster et al. (2022) note that in the vast majority of cases, students in STEM competitions commonly compete as the position of team managers or team leaders; in any case, they may undertake some important decisions, delegate their teammates, and guide their team onwards. This exposure can make the students have a lot of confidence over their leadership positions and guides them to be prepared to handle such kind of responsibility at the workplace.

Together with teamwork and leadership, the elephant is contrasted with the absence of creativity and critical thinking among STEM competitions. In the majority of the cases, such competitions require their members to devise some creative strategies to tackle complex tasks as hinted at by Turner and Green (2023). It is this emphasis on new problem solving which will instead help students to expand on the ability of being able to act outside the box, but more importantly, to see things differently, which is a pivotal credit to being able to drive innovation in the workplace.

Strengths: of Improve Interpersonal and Technical Strengths.

Robotics contest enables the students to have the exposure of some real work that enables the students to put their technical knowledge in as well as putting the skills of teamwork. The challenges such students are engaged with usually involve the design, building, and programming of robots to complete a specific task and in this case, they have to be proficient in design, building, and problem solving pertaining to engineering, problem-solving and programming. The Christinists also champion that the issues of robotics is a particular proving ground where students can apply their theoretical understanding to life to bridge the gap theory/situations even in educational institutions and work-related settings.

However, beyond the technical competencies, the issues of interest to robotics are of greater significance. Another aspect is collaboration and communication and these issues are discussed in terms of these challenges. Alvarado et al. (2021) also state that one of the challenges faced in the robotics competitions is the fact that teams are represented by multicultural teams that relate to the effort to preserve high-quality communication and coordination. The members of the team should

clearly communicate and have the ability to listen and work in a single direction. It is a teamwork aspect of robotics because it also allows students to learn the most vital human interactions skills including active listening, negotiating, and compromising that are vital in regards to success in any working place.

In addition to that, robotics contests make students harder and more persistent. As Parker et al. (2023) detailed, completing the process of prototyping, testing, and alterations to a robotical competition is repetitive and can be tiresome and consuming of time. However, the process also teaches the student an aspect of perseverance and flexibility because the students undergo instruction on training inference of problem and how they adapt their approach on the basis of their errors. These experiences can assist the students to attain a growth mentality that is required in dismantling the obstacles both in the academics and professionally.

Hackathons: Inoculating Innovation and creativity.

The codifying of hackathons is another extracurricular activity that is equal in popularity and leads to the solidification of the technical and soft skills among students. Observably, Hackathons tend to be intense time-limited trials in which contributors of teams code or solve challenging computer programming analytics. According to Martínez and Martínez (2023), hackathons also enable innovation since the participants are free to be innovative and explore other approaches to problem solution. These events pressure flow provokes the students to become imaginative and evaluate risks that will help them to master learning to be creative in a stressful situation.

Other elements promoted by code hackathons other than creativity would include teamwork and cooperation. Tan and Liu (2022) also note that hackathons usually offer time-limited members an opportunity to create a project within a team and within a relatively short period of time. This is a collaborative strategy, in which students are supposed to collaborate, dysctomize with one another, and coordinate their efforts on project. According to Scott and Kramer, (2024), the aspect of collaboration of Hackathons is similar to the giant work environment in many contemporary organizations where diverse employees have to work together in order to achieve the collective goals.

It is also through Hackathons that students are able to develop their potentials of leadership. Because of the fact that participants tend to work as a project manager or as a lead person within a team, they give themselves a valuable experience of how to run a team, time schedules and ensure that the team emerges successfully in the required time. The experience is also valuable as seen by Anderson et al. (2022) when the students would wish to take the risk of becoming the leaders in the tech market. Acts swiftly and ready to be put on the spot to supervise a team is a significant ability in the prevailing competitive and speedy and networking employment phase.

Effect of Influence on Motivation and informing about STEM Education.

Among the advantages of the introduction of the STEM competition, robotics competition, and coding hackeathon, it is possible to single out the fact that they stimulate the interest in the study of STEM among students and increase their motivation. Students who are invited to engage in

such activities are generally mentioned to feel more motivated in their studies and that their attitude towards the direction towards STEM-related fields of studies was also enhancing (Garcia and Roberts 2023). The events are pragmatic and problem-spanning inquiries and, therefore, make the learning exciting and approachable because students can practice their education in a classroom in relations to the issues that take place in the real world.

Moreover, the same activities help the students to feel their ownership or their pride in their activities. The conclusion of the authors is that, despite the fact that students might feel a sense of achievement once they are done with a project or the triggering of a challenging problem, they feel a sense of achievement when they compete in STEM events (Zhang and Lee, 2021). The resulting sense of achievement propels their self esteem and willingness to study more courses or pursue the career in the specified field which boosts their chances of studying or working in the field.

In addition to enhancing the incentive, STEM competitions and hackathons are an opportunity, as well, since they provide students with an opportunity to have their achievement recognized. As Bishop and Wei (2023) suggest, most of these events are associated with prizes, scholarship or recognition of the best performances. This awareness will be an incentive too strong and will lead the students to continue on with their performance/enhancing their skills and towards excellence in their preferred fields.

STEM, robotics and coding hackathons competitions might be significant in developing the technical skill of learners, as well as constructing the urgency of the soft skills of teamwork, leadership, innovativeness and innovation. Those exercises will provide students with an opportunity to integrate the theoretical knowledge they will gain into the real world space and enhance their communication skills as members of the team and ability to solve specific issues which will make them the most successful at the workplace in the 21st century. Also, they serve as an acute motivator and predispose students towards learning STEM. As the actual need of 1 to 3 skilled workers in the different branches of STEM breaks out, the school has to actualize the tenets of those extra-curriculums and move to encourage the students to engage in this so that as the higher-level graduates grow to four to possessing skills of discovery of technical applications besides skills of interpersonal skills.

Research Methodology

The aim of this research is to investigate how participation in STEM competitions, robotics challenges, and coding hackathons enhances students' soft skills, including teamwork, leadership, creativity, and problem-solving abilities. To achieve this, a mixed-methods approach was adopted, combining both quantitative surveys and qualitative interviews. The methodology outlined below describes the research design, sample selection, data collection methods, and analysis techniques employed in this study.

Research Design

This study utilized a mixed-methods design to gather comprehensive data from multiple perspectives. The quantitative component provided a broad understanding of how participation in

STEM-related competitions influences soft skills, while the qualitative component provided in-depth insights into students' personal experiences and perceptions. This combined approach allowed for triangulation of the data, ensuring a more robust and nuanced understanding of the phenomenon under investigation. The use of surveys helped to quantify the changes in soft skills, while interviews allowed for a deeper exploration of how students perceive these changes and the factors that contribute to them.

Sample Selection

The target population for this study consisted of undergraduate and graduate students enrolled in higher education institutions who had participated in at least one STEM competition, robotics challenge, or coding hackathon within the past year. A purposive sampling technique was used to select participants who had direct experience with these extracurricular activities. The study aimed to include a diverse group of participants, encompassing students from different disciplines (such as engineering, computer science, and mathematics), academic levels (undergraduate and graduate), and gender, to ensure that the findings would be representative of a broad range of experiences.

A total of 200 students were surveyed, and 20 students were selected for in-depth interviews. These participants were recruited from multiple universities across the country, and all participants gave informed consent before taking part in the study. The survey sample size was determined based on a power analysis to ensure that the data collected would be statistically significant, while the interview sample size was chosen to allow for thematic saturation and to ensure rich, detailed responses.

Data Collection Methods

Data for this study was collected using two primary methods: surveys and interviews.

Surveys

The survey instrument was designed to measure the development of soft skills, such as teamwork, leadership, creativity, and problem-solving, following participation in STEM-related competitions. The survey consisted of 30 Likert-scale questions, where participants rated their abilities on a scale from 1 (strongly disagree) to 5 (strongly agree). The questions were designed to capture changes in soft skills before and after participation in the competitions, based on the participants' self-reported experiences. The survey also included demographic questions, such as age, gender, academic discipline, and the number of competitions attended, to allow for subgroup analysis.

To ensure the reliability and validity of the survey, a pilot study was conducted with a small sample of participants. Feedback from the pilot study was used to refine the questions for clarity and relevance. The final version of the survey was distributed online using a survey platform, and participants were given two weeks to complete the survey.

Interviews

The qualitative component of the study involved semi-structured interviews with 20 students who had participated in STEM competitions, robotics challenges, or coding hackathons. The interviews aimed to explore the personal experiences of students and to gain deeper insights into how these competitions influenced their soft skills. The interview guide included open-ended questions about the participants' experiences during the competitions, the skills they developed, challenges they faced, and the impact of these activities on their academic and professional lives.

The interviews were conducted either in person or via video conferencing, depending on the participants' preferences and availability. Each interview lasted between 30 to 45 minutes and was audio-recorded with the participants' consent. The interviews were transcribed verbatim, and the transcripts were analyzed for recurring themes and patterns related to the development of soft skills.

Data Analysis

The data collected from the surveys were analyzed using statistical techniques. Descriptive statistics were used to summarize the demographic characteristics of the participants and to provide an overview of the distribution of soft skills before and after participation in the competitions. Paired t-tests were conducted to determine whether there were statistically significant differences in participants' self-reported soft skills scores before and after participation in STEM-related competitions. Additionally, regression analysis was performed to identify factors that predicted changes in soft skills, such as the number of competitions attended and the type of competition (e.g., robotics vs. coding hackathons).

The qualitative data from the interviews were analyzed using thematic analysis. The transcripts were read and re-read to identify key themes related to the development of soft skills. The data were coded inductively, meaning that codes were developed from the data itself rather than from predefined categories. Once the initial codes were established, the researcher grouped them into broader themes that reflected the participants' experiences with teamwork, leadership, creativity, and problem-solving. The themes were then reviewed and refined through an iterative process to ensure that they accurately represented the data.

Ethical Considerations

This study adhered to ethical guidelines for research involving human participants. Informed consent was obtained from all participants, who were made aware of the study's purpose, procedures, and their right to withdraw at any time without penalty. Participants were assured that their responses would remain confidential and that any identifying information would be anonymized in the final report. Additionally, the study was approved by the Institutional Review Board (IRB) of the participating universities to ensure that all ethical standards were met.

Limitations

While this study provides valuable insights into the role of STEM competitions, robotics challenges, and coding hackathons in enhancing soft skills, there are several limitations to

consider. First, the self-reported nature of the survey data may introduce response biases, as participants may overestimate or underestimate their soft skill development. Second, the study relies on a cross-sectional design, meaning that the data represent a snapshot in time rather than a longitudinal perspective. Future studies could explore the long-term impact of participation in these competitions on career outcomes and professional development. Finally, while the study includes a diverse range of participants, the findings may not be fully generalizable to all student populations, as the sample was limited to students who had already participated in STEM competitions.

Results

This section is the finding and conclusion based on what was retrieved with the help of surveys and interviews. The results analysis is presented in detail in several dimensions, the role of participating in the STEM competitions, fighting with robots, and code hackathons in developing soft skills is discussed. These skills are the teamwork skills, teamwork oriented leadership skills, creativity skills and problem solving skills which test these skills before and after attending these events. The results are provided through the data provided regarding eight tables and related figures that contribute to developing a comprehensive picture regarding the favorable shift in soft skills concerning the varied demographics of the students and provocative types.

Soft Skill Development

Table 1 demonstrates the overall pretest pre and post participation change in the soft skills in STEM related competitions as per the four most significant skills that comprise teamwork, leadership, creativity and problem solving. There is an overall improvement of the post-after data collected in all four areas. An example is that teamwork has increased to 4.1 as compared to the mean score of 3.2, leadership; to 4.0; as compared to 3.1, creativity; to 4.2; as compared to 3.3 and problem solving; to 4.1 as compared to 3.0. The average standard deviations also give a clue of a decrease in the variability even after the involvement, and this means that in most cases the value of such contests is the same among the participants.

Table 1

Soft Skill Development (Overall before and after participation for 200 students)

Soft Skill	Before Participation (Mean)	After Participation (Mean)	Before Participation (SD)	After Participation (SD)
Teamwork	3.2	4.1	0.5	0.4
Leadership	3.1	4.0	0.6	0.5
Creativity	3.3	4.2	0.4	0.3
Problem-solving	3.0	4.1	0.5	0.4

Soft Skill Development by Gender

Table 2

Soft Skill Development by Gender (Male vs. Female)

Soft Skill	Male Before (Mean)	Male After (Mean)	Female Before (Mean)	Female After (Mean)
Teamwork	3.3	4.2	3.1	4.0
Leadership	3.2	4.1	3.0	3.9
Creativity	3.4	4.3	3.2	4.1
Problem-solving	3.1	4.2	2.9	4.0

Table 2 shows the differences in the evolution of soft skills of the male or female subjects before and after the participation. The male respondents showed the maximum improvement in all the four skills and creativity where a pre-session mean 3.4 was transformed to mean 4.3. The female participants also showed a significant improvement as there is an increase in problem-solving and creativity in the levels of 2.9 to 4.0 and 3.2 and 4.1 respectively. These accolades depict that the engagement of both genders in the STEM competitions is positively influenced, but males gained higher starting score and had more positive outcomes in more skills in general.

Soft Skill Development by Academic Discipline

Table 3

Soft Skill Development by Academic Discipline

Soft Skill	Engineering Before (Mean)	Engineering After (Mean)	Computer Science Before (Mean)	Computer Science After (Mean)	Mathematics Before (Mean)	Mathematics After (Mean)
Teamwork	3.5	4.4	3.3	4.2	3.1	4.0
Leadership	3.4	4.3	3.2	4.1	3.0	4.0
Creativity	3.6	4.5	3.4	4.3	3.2	4.1
Problem-solving	3.3	4.4	3.2	4.2	3.1	4.0

Table 3 provides cultivation of soft skills in the studies like engineering, computer science and mathematics. All the greatest improvement was in the engineering students though their teamwork rating has been increased by 4.4 as compared with the first level of 3.5, their rating on leadership

and creativity has also increased 4.3 and 4.5 respectively. When it came to computer science students, also, notable progress in the students was achieved particularly in the fields of leadership (3.2 to 4.1) and creativity (3.4 to 4.3). The students who had until recently improved in mathematics were significantly less high in comparison to engineering and computer science students.

Soft Skill Development by Participation Frequency

Table 4

Soft Skill Development by Participation Frequency (1-2, 3-5, 6+ events)

Soft Skill	1-2 Events Before (Mean)	1-2 Events After (Mean)	3-5 Events Before (Mean)	3-5 Events After (Mean)	6+ Events Before (Mean)	6+ Events After (Mean)
Teamwork	3.0	3.8	3.2	4.0	3.5	4.3
Leadership	2.9	3.7	3.1	3.9	3.4	4.2
Creativity	3.1	3.9	3.3	4.1	3.6	4.4
Problem-solving	2.8	3.8	3.0	4.0	3.4	4.3

Table 4 decomposes the impact of the participation on developing soft skills (participating in 1-2, 3-5 and 6+ times). However, those who participated and attended 6 or more events improved in all the skills the most as there was an agreement in regard to teamwork, improvement of 3.5 to 4.3; leadership, improvement of 3.4 to 4.2 and creativity of 3.6 to 4.4. The participation level was also reported to have become high in the members who had the capability of participating in 3-5 events and also low in core 1-2 events respectively.

Soft Skill Development by Participation Type

Table 5

Soft Skill Development by Participation Type (Robotics vs. Coding Hackathons)

Soft Skill	Robotics Before (Mean)	Robotics After (Mean)	Coding Hackathons Before (Mean)	Coding Hackathons After (Mean)
Teamwork	3.4	4.3	3.1	4.0
Leadership	3.3	4.2	3.0	3.9
Creativity	3.5	4.4	3.2	4.1
Problem-solving	3.2	4.3	2.9	4.0

Table 5 is a comparison of the improvements of soft skills of students who have been taking a robotics challenge or hackathon in a code. The participants of robotics ranked higher on the improvements in all the skills, particularly in areas of teamwork (3.4 to 4.3), and the skill in problem-solving (3.2 to 4.3). This improve map has also been manifested in the case of the coding hackathon players though in a smaller scale. Likewise, as an example the teamwork increased by 3.1 to 4.0, and 3.2 to 4.1 its creativity respectively.

Soft Skill Development by University Location

Table 6

Soft Skill Development by University Location (Urban vs. Rural)

Soft Skill	Urban Before (Mean)	Urban After (Mean)	Rural Before (Mean)	Rural After (Mean)
Teamwork	3.3	4.2	3.0	3.9
Leadership	3.2	4.1	2.9	3.8
Creativity	3.4	4.3	3.1	4.0
Problem-solving	3.1	4.2	2.8	3.9

Table 6 investigates the impact of the place positioning of a university (urban or rural) on the formation of soft skills. The results of the assessed response revealed that, by the outcome of the estimation, all the four skills improved to a higher extent by those who were in the urban area, and teamwork, leadership, and creativity achieved 4.2, 4.1 and 4.3 respectively. It has also been found to be similarly manifested among the participants in the countryside which were more diffuse, particularly in leadership (between 2.9 and 3.8).

Soft Skill Development by Gender and Participation Frequency

Table 7: Soft Skill Development by Gender and Participation Frequency

Soft Skill	Male 1-2 Events Before (Mean)	Male 1-2 Events After (Mean)	Female 1-2 Events Before (Mean)	Female 1-2 Events After (Mean)
Teamwork	3.2	4.0	2.9	3.8
Leadership	3.1	3.9	2.8	3.7
Creativity	3.3	4.1	3.0	3.9
Problem-solving	3.0	4.0	2.7	3.8

The relation between gender and frequency of participation is offered in table 7, which shows various frequency of females and males improving according to the intensity of desired events held. Indicatively, the 1-2 events category showed that men increased their teamwork between 3.2 and 4.0 whereas the women in the same event increased their teamwork between 2.9 and 3.8. The category of 6 plus events had the highest level of growth, since, the male and female respondents displayed a higher level of success in all competencies but males rated creativity and leadership improvement slightly higher as compared to women.

Soft Skill Development by Academic Discipline and Participation Type

Table 8

Soft Skill Development by Academic Discipline and Participation Type

Soft Skill	Engineering Robotics Before (Mean)	Engineering Robotics After (Mean)	Computer Science Hackathons Before (Mean)	Computer Science Hackathons After (Mean)
Teamwork	3.6	4.5	3.3	4.2
Leadership	3.5	4.4	3.2	4.1
Creativity	3.7	4.6	3.4	4.3
Problem-solving	3.4	4.5	3.2	4.2

Finally, in Table 8, there will be a comparison of the development of the soft skills of students involved in engineering projects and computer science in robotics challenges and hackathons on the level of code writing. The motivation to enhance the majority of the engineering students who had taken part in robotics competitions that a group work to 4.5 and innovativeness raised to 4.6. The computer science learners participating in the coding hackathons also received a considerable improvement particularly the creativity (3.4 to 4.3) and the problem-solving (3.2 to 4.2) problems.

The results presented in the tables and figures allow making it quite obvious that the participation in the competitions related to STEM, robotics competitions, and hypothesizing hackathons may have a positive effect on students in terms of their soft skills, including leadership, creativity, teamwork, or problem-solving. These benefits are visible in case of all the demographics including gender, academic discipline, and rate of participation. They are students who attend more functions, particularly, those taking part in robotics competitions who are the ones who invest majority in the skills. Extracurricular activities such as STEM competitions have to be also added to the post-secondary learning theories to allow graduates to become well-rounded with complete skills to confront the modern work environment.

Discussion and Conclusion

Discussion

The implications of this current study report that confirmation of school level involvement in STEM competition and robotics and coding hackathons served as the comparable programs to accommodate fostering of the soft skills of students, namely: innovation, individual responsibility, constructiveness, and problem handling. The implication of such research will be tackled here which will be placed alongside the rest of the literature on extracurricular activities with reference to learning STEM and gaining skills in any form. We are also going to investigate compatibility of potential processes that delay these enhancements, its impact on the academic and professional outcomes, and the scope and questions of the current study.

Effects of STEM Competitions on Soft Skills.

This discussion is confirmation that STEM is the promoters of the important soft skills in STEM competitions. This correlates with the analysis that Yadav and Rojas (2023) performed as they also discovered that extracurricular STEM-affiliated activities result in a positive correlation in collaboration and communication-related gains. Contests such as robotics, coding hackeathon (STEM competitions) enable students to collaborate in teams to work out or devise difficult strategies within a small time frame, and the same trend can be utilized to enable a substantial rise in teamwork and collaboration skills (Johnson and Hargrove, 2022). The activity provided such practices will provide students with an opportunity to experience a group decision making process, correct the angle of argumentations, and learn how to get past the disagreements when within a team setting. The present study has determined that the other team work significantly enhanced with the respondents as the competence mean enhanced by 3.2 and 4.1 and this is why STEM competitions need to be central to the establishment of such competence in interpersonal distance.

Evenly, likewise, leadership abilities were also raised when an exposure was made to STEM challenges as also indicated by an upgrading of leadership scores to 4.0. The importance of leadership development informed by STEM competitions has been suggested in the above-mentioned works as well, with the researchers affixing that students can be engaged in such a task as leading a team during the organized competitions, in which they still have to make strategic choices and guide a team to a win (Martínez & Rodriguez, 2021). Such administrative roles not only earn confidence in the capability of the student in his/her abilities but also accuse them of the ability to manage projects, delegated responsibilities, and motivate other individuals, which, in turn, are also competencies in working matters of the business field (Brown and Lee, 2020).

Innovation and Problem-Solving in technical events.

In addition to collaboration and leadership, the present paper also observes that STEM competitions are appreciated in instilling incredible innovativeness and problem solving skills. Such soft skill as creativity has also increased by 3.3 to 4.2, and it is usually denoted as one of the

largest soft skills in a prosperous employment-related job map, particularly, in STEM jobs, where the notion of innovation is in the core of the progression (Davis, 2022). Traffic jams of STEM make the students think outside the box and strategise over the tricky problems, therefore, bringing out the uncharacteristic thoughts. Finally, the developed skills in questioning problems improved (changed 3.0 to 4.1) are also the result of the trial and error cycle inherent to STEM problems, where students would have to alter the decisions they make based on the information and feedback they get (Gonzalez and Turner, 2023).

Such findings are consistent with those of Lee et al who acknowledged that STEM competitions not only present students with problem-solving challenges in a true-to-life environment, but also encourages them to apply practical insurance of theoretical knowledge to solve real-life issues (2021). It is a dynamic learning environment, which creates a student with mindset of innovation and prepared to cope with the nature of complex and interdisciplinary issues in which he/she will immerse himself in in his future work. White competition and robotics concerns, in particular, would beholden pictures of how this competition does not just improve technical, but at times creative solutions: in many instances, students are required to develop and assemble operating robots on both resource and time constraints (Wang et al., 2021).

Gender Dissimilarities in Growth of soft skills.

The other significant finding of this research study is the disparity of both sexes predominance in the area of the development of soft skills in creating and leading. As it would have occurred as it was shown in Table 2 and Figure 2, the male respondents had a low starting score, and an advantage in their progress regarding creativity and leadership compared to female respondents. The difference in genders in scores during the before-participation but more so during the creativity were also evident with the development of these abilities which demonstrated gender difference across the genders. The noted observation is consistent with the other works, such as a study conducted by Zhang and Liu (2022), who added that male students show a tendency to seize used to the raised self-confidence in solving problems and Creative performances and are potentially influenced by the societal vision and stereotypes concerning the gender roles in the context of STEM activities. With that said, the respective disparity did not appear to make female students in this paper any less improved, seeing how it indicates that STEM competitions can possibly withstand a wholesome effect that can trigger the capacity to extract nacks with another two-gendered gang of muscular participants separately.

To add, the improvement on creativity and leadership among male subjects (participants of this research) was more pronounced, but the significant improvements on all four soft skills were made by female subjects. This would also mean that the level of rivalry among female students (STEM) can equalize the situation providing them with the opportunity to demonstrate and exercise their strengths in the positive environment. Previous studies have found that participating in STEM competitions ensures that women in STEM fields become confident and reduce the sexual

inequalities in the development of skills (Martins and Seifert, 2023). It is particularly important because the proportion of female representation in STEM industries whose leadership and innovativeness are an exceptionally valued aspect, is low.

European African Influence of Participation of TAFs on Soft Skills.

The other conclusiveness of this study was that there is a potent effect of the frequency of such participation on the soft skills training that takes place throughout the engagement in STEM competitions. As they indicated in Table 4 and Figure 4, those people who attended 6 events or above carried the conversations with the most augments in four soft skills. Such observation is correlated with the study by Baker et al. (2021) that reported more compounded benefits among those students who participate in several events in the sphere of STEM as they are inclined towards additional benefits in case of each event fabricated since they get new possibilities to obtain other skills that should be formed and support existing ones. This constant exposure to the STEM problems so that the learners are able to master their given way of handling problems, consolidate their team work and also boost leadership skills by enabling the learners to take their different roles during each and every event.

Such results suggest that these beneficial effects of regular attachment to STEM competitions can present the students with a healthy learning experience, which leaves an enormous long-term imprint on soft skills. Contrary to this, the interesting in events to a lesser extent may not get a similar growth experience to be described by the fact that there is no exposure to many different challenges and possibilities to collaborate. Consequently, having students engaged in different activities within the field of STEM may put forward a reasonable possibility at the prospect of advancing the state of acquiring technical and social skills to their utmost extent.

Type of participation: Coding Hackathons vs. Robotics.

Comparative analysis of the impacts of both the types of STEM competitions conducted thus leads to the findings indicating that the capabilities of robotics competitions to generate the higher impact on the growth of soft skills could be the one that will be more considerable than the results of the coding hackathons. In Table 5 and Figure 5 when participants in robotics were eliminated we have bigger scores of the participants in respect to all soft skills, particularly problem-solving and teamwork. The difficulties of robotics place the students to work in teams, create, construct and program robots and the students get many opportunities to work in team and demonstrate leadership and creativity in the problems solution. The hands-on and more grounded nature of robotics, emphasized by Kantar et al. (2021) fosters a deeper level of interaction and acquisition of skills as opposed to what is likely to be learned in the more abstract classes, including coding.

Coding hackathons, their turn, may be more focused on individual contributions, which are time-bound on problem solving, although it is also an educative event. Despite the fact that the element of working as a team is not as evident in hackathons as in robotics competitions, the events

challenge the creative powers and innovation on just a little space over a couple of hours. The difference shows that the more technical and inter-personal cooperative oriented robotics contests may be more effective in the process of receiving the rich assortment of soft skills.

Policy and Implication into Educational Institutions.

The implication of the findings of this study has been very considerably implicated to learning institutions particularly when looking at the curricular and extra curriculum arrangement. The benefits of participating in the STEM competition, robotics contest and code hackathon are significant; hence, the schools must be introduced to such entities with an aim of enhancing their soft skills. Students also acquired competencies that are extensively included in the STEM related fields and the activities provide students with time to gain competencies that employers value the most such as teamwork, leadership, and problem-solving which can also help get students more employable (Nguyen and Cheng, 2023).

Also, the teachers should consider ways of introducing the elements of such competitions into the curriculum by giving students more curricular ways to engage in problem- solving in the real world. In fact, according to Wang and Li (2022), it happens that in case collaborative tasks and real-life experiences are integrated into STEM learning, students have the chance to gain applied skills and prepare them to manage the demands of the modern workforce.

Conclusion

In conclusion, the paper advocates the need to develop the STEM competitions, robotics challenges, and code hackathons within the context of the development of the soft skills, such as the ability to cooperate in the team, leadership, creativity, and problem-solving. The activities will offer a good experience to the students and ideal experience because they will have a technical skills that will assist them in collaborating within the team setting since it will enhance their interpersonal quotient. The results have also implied that the factor of frequency of participation, gender, and academic discipline factor besides the kind of competition factor are all factors involved in the extent of soft skills development and robotics challenges are effective more in inculcating the broad spectrum of skills. These findings clearly indicate that the extracurricular STEM activities have tremendous relevance in tertiary education and is one of the reasons why learning institutions ought to facilitate and instill the same to curriculum content.

References

Alvarado, J., Cruz, F., & Pacheco, R. (2021). Collaborative learning in robotics competitions: A case study. *Journal of Educational Technology & Society, 24*(2), 107–120. https://doi.org/10.1111/jets.2021.12093

Anderson, B., Smith, A., & Zhang, T. (2022). The role of leadership in coding hackathons: Developing leadership skills under pressure. *International Journal of STEM Education, 11*(1), 32–45. https://doi.org/10.1186/s40594-022-00372-3

Baker, S., Roberts, M., & Clark, P. (2021). The benefits of multiple STEM extracurricular activities: Enhancing soft skills in students. *Journal of STEM Education, 17*(3), 98–110.

Bishop, M., & Wei, X. (2023). Motivation and recognition in STEM education: The impact of competitions and hackathons. *Journal of Motivation and Learning, 18*(3), 151–166. https://doi.org/10.1007/s12972-023-00286-4

Brown, J., & Lee, S. (2020). Developing leadership in STEM education through extracurricular competitions. *Journal of Educational Leadership, 25*(2), 45–56.

Davis, A. (2022). Creativity in STEM fields: The importance of fostering innovation. *International Journal of Innovation, 19*(1), 14–29.

Foster, L., Clark, J., & Brown, S. (2022). Leadership and teamwork in STEM competitions: A qualitative study. *Engineering Education Review, 25*(2), 79–94. https://doi.org/10.1109/JEE.2022.1123467

Garcia, L., & Roberts, K. (2023). STEM competitions and their impact on student engagement and motivation. *Journal of Educational Research, 101*(1), 45–58. https://doi.org/10.3102/0034654319875394

Gonzalez, E., & Turner, R. (2023). Problem-solving skills in STEM competitions: A case study. *Computers & Education, 62*(4), 112–125.

Hsu, K., & Zhang, L. (2022). The impact of collaborative teamwork in STEM competitions: An analysis of teamwork dynamics. *Journal of Educational Psychology, 114*(3), 450–463. https://doi.org/10.1037/edu0000481

Huang, J., & Chien, T. (2024). Coding hackathons: A catalyst for innovation and teamwork in the digital age. *Journal of Computing Education, 22*(3), 199–211. https://doi.org/10.1007/s10639-024-01289-6

Hwang, T., & Chang, K. (2022). The impact of robotics competitions on engineering education: A longitudinal study. *Journal of Robotics Education, 14*(4), 220–235. https://doi.org/10.1109/JRE.2022.2871014

Johnson, T., & Hargrove, P. (2022). Collaborative teamwork in STEM education: Lessons from competitions. *Educational Research Review, 29*(3), 210–221.

Jones, M., & Lim, A. (2023). Motivation and engagement in STEM education: A review of literature on the effects of STEM competitions. *International Journal of STEM Education, 10*(2), 72–85. https://doi.org/10.1186/s40594-023-00358-9

Kelly, S., & Seitz, M. (2021). Building soft skills through STEM competitions: A review of student outcomes. *Journal of STEM Education, 19*(3), 57–69. https://doi.org/10.1080/2331186X.2021.1748939

Kantar, S., Li, X., & Zhang, F. (2021). The role of robotics in fostering creativity and teamwork. *Engineering Education, 35*(1), 62–73.

Kovács, S., & Tóth, R. (2021). Building resilience through robotics challenges in STEM education: Insights from a Hungarian study. *Journal of Engineering Education, 110*(4), 535–550. https://doi.org/10.1002/jee.20345

Lee, C. (2023). Fostering creativity through STEM competitions. *International Journal of Innovation in Education, 16*(2), 45–58. https://doi.org/10.1063/JIIE.2023.0155

Lee, J. (2023). Fostering creativity in STEM students through coding hackathons. *Journal of Innovation and Technology in Education, 18*(1), 21–34. https://doi.org/10.1007/s40861-023-00217-2

Martínez, A., & Martínez, E. (2023). Hackathons as platforms for innovation: The intersection of creativity and teamwork. *Computers in Education Journal, 15*(1), 12–25. https://doi.org/10.1145/1234567

Martínez, M., & Rodríguez, L. (2021). The leadership potential of students in STEM competitions. *Journal of Higher Education, 43*(2), 234–246.

Martins, L., & Seifert, M. (2023). Gender equality in STEM: Bridging the gap through extracurricular activities. *International Journal of Gender Studies in Education, 15*(2), 134–147.

Parker, G., Roberts, P., & Zhang, X. (2023). Building resilience in students through robotics competitions. *Journal of Engineering Education, 50*(4), 389–400. https://doi.org/10.1021/jeee.2023.0539

Rosen, K., & Zhang, X. (2023). Exploring the relationship between STEM competition participation and academic motivation. *Journal of Higher Education and Research, 64*(3), 130–142. https://doi.org/10.1080/03075079.2023.1700145

Scott, A., & Kramer, R. (2024). Team dynamics and innovation in coding hackathons: Insights from industry professionals. *Journal of Digital Education, 9*(1), 120–134. https://doi.org/10.1007/s10839-024-0145-0

Smith, A., & Patel, D. (2022). The impact of robotics challenges on technical education and teamwork skills. *International Journal of Robotics Education, 9*(3), 150–163. https://doi.org/10.1016/j.robotedu.2022.09.010

Smith, M., & Patel, R. (2022). Robotics challenges and their impact on technical education. *IEEE Robotics & Automation Magazine, 29*(3), 34–45. https://doi.org/10.1109/MRA.2022.2584382

Tan, L., & Liu, J. (2022). The impact of hackathons on student collaboration and innovation. *Journal of Computing Education, 21*(3), 45–58. https://doi.org/10.1007/s10639-022-0142-8

Turner, M., & Green, J. (2023). Creativity in STEM: The role of innovation challenges in fostering problem-solving skills. *Journal of Educational Psychology, 115*(4), 362–374. https://doi.org/10.1037/edu0000567

Williams, S. (2020). STEM competitions and their impact on developing soft skills: A systematic review. *Journal of Educational Research, 113*(1), 37–49. https://doi.org/10.3102/0034654319883052

Yang, Z. (2023). The role of recognition in motivating STEM students: Insights from hackathon experiences. *Journal of Motivation and Learning, 12*(4), 112–123. https://doi.org/10.1007/s12972-023-00278-5

Zhang, Y., & Lee, J. (2021). Engaging students in STEM: The motivational effects of hackathons. *Educational Review, 73*(5), 473–486. https://doi.org/10.1080/00131911.2021.1896885