

# Adding element of competition to Multi-disciplinary PBL: Case study of Robocon Competition

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**Abstract:** Project-based learning (PjBL) is a variation of Problem-Based Learning where learners are provided with specifications for a desired end product and the learning process is more oriented to following appropriate procedures leading to successful project. Technical competition such as Robocon poses a similar challenge to the students as encountered in a typical PjBL exercise with one unique differentiator, namely, an element of competition. We make and test the hypothesis in this paper that this differentiator adds a great value to PBL/PjBL in terms of outcomes attained and skills acquired. Research questionnaire for testing this hypothesis was designed and is shared. Survey results show that competition boosts the level of student engagement in the learning experience and participant's employability potential. It also helps in attaining crucial program outcomes such as solving complex engineering problems, being able to engage in self-learning and working in a multidisciplinary team. The study also offers an insight in how learning in a team happens when the team is focused on winning a competition. The survey results from this case study make it clear that competition-based PjBL has great potential to prepare industry-ready students in terms of their technical aptitude as well as positive attitude. The paper makes a strong argument to find ways in which element of competition can be added to regular PjBL exercise to boost its established outcome attainment potential.

**Keywords:** Problem Based Learning, Technical Competitions, Student Engagement, Engineering Education, Robocon, Project Based Learning

## 1. Background:

PBL has been gaining ground in India as an accepted delivery method in engineering education very recently. With a few exceptions, engineering pedagogy in India has remained mostly traditional and restricted to passive

Learning of students that comes with classroom teaching. Industry has been ever complaining about the poor outcomes of this system. Nearly all employability surveys show that hardly 10-25% engineering graduates are employable [1][2]. Industry values Analytical thinking and innovation, complex problem-solving, critical thinking and analysis, active learning and learning strategies, creativity, originality and initiative, attention to detail, and trustworthiness [3]. It is encouraging to note that professional societies led by industry have been supporting Technical Competitions over past 15 years. These are essentially multidisciplinary team events of highly competitive nature where the competitors are challenged with a task to be completed under variety of constraints. Robocon is an example of such competitions supported by industry to promote the inculcation of skills required by industry. It is one of the premium robotics competitions in Asia-Pacific region and it has gained national importance in India. In this paper we have studied effectiveness of this technical competition from viewpoint of attaining crucial program outcomes by posing it as a case study in multidisciplinary PBL.

Since PBL's conception in medical education nearly 50 years ago by Barrows it has been employed in many learning and teaching contexts with varying success. The 'elastic' quality of PBL has allowed for different types and culturally variant versions of PBL with associated challenges and successes in implementation [4]. It is in vogue for over 30 years and being practiced in multiple disciplines. Project-based learning (PjBL) is a variation of problem-based learning in that the learning activities are organized around achieving a shared goal stated in form of a project [5]. In PjBL, learners are provided with specifications for a desired end product and the learning process is more oriented to following appropriate procedures leading to successful project. Technical competition such as Robocon [6] poses a similar challenge to the students as encountered in a typical PjBL exercise with one unique differentiator, namely, an element of competition. We hypothesize here that this differentiator adds value to PBL/PjBL in terms of outcomes achieved

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and skills acquired. Though there exist studies in competitions as source of learning [7][8][9], we hardly come across a study based on Indian data and with a focus on crucial program outcomes. This paper is an attempt to fill in this gap.

## 2. Choice of Robocon as a case study

Robocon is organized by Asia-Pacific Broadcasting Union (ABU), a conglomerate of over 20 countries of Asia Pacific Region.[6] The broadcasters of each participant country are responsible for conduct of their national contests to select the team which will represent their country in the International Contest. In India, Doordarshan, the national public service broadcaster organizes National Robocon event every year. First Robocon was held in 2002, in which only 3 teams had participated at IIT Kanpur. Going from strength to strength, this number has reached 66 in Indian National Robocon 2012 and 107 in 2018.

Competition has different themes each year, but generally they revolve around a theme of completing the specified task by two or more robots in an arena. One of the robots is manually controlled while the others are automatic. Teams need to have knowledge in programming, mechanical design, electronic circuit design, sensors etc and they need to work within constraints to win the competition.

## 3. Research Objectives:

Though Robocon task poses an open ended problem to the student team much like in PjBL, it is not consciously designed by its organizers as academic learning experience. At the same time, its effectiveness in attaining the crucial program outcomes for which PjBL is designed, appears to be no less in comparison with any other PjBL. We explore here the hidden aspects of its success, especially its appeal to the students that results in high student engagement level as also the particular outcomes being attained through this engagement. To this end, we formulate our research objectives as follows:

1. To identify the level of student engagement as also the key factors responsible for the same
2. To explore the role, if any, Robocon played in enhancing employability
3. To test the hypothesis that the following crucial program outcomes are attained at the highest level through Robocon:
  - a) Ability to solve complex engineering problems
  - b) Ability to be effective team member
  - c) Ability to engage in self-learning
  - d) Enhance communication skills
  - e) Ability to manage an engineering project
4. To gain insight in how learning happens in a goal oriented team of students and to gain insight in natural scaffolding pathways in technical competitions

5. To explore in what way the learning based on this case study can add value to existing practices in PjBL as well as to explore effectiveness of such technical competitions as a valuable learning experience

## 4. Methodology

We chose to survey a sample of nearly fifty students picked up from nearly 250 students that participated in Robocon from our institute over last 16 years. Survey questionnaire (see Table 1) was designed so as to gather qualitative and quantitative data for analysis in order to meet the above stated research objectives. The questionnaire contained both qualitative open-ended (for Objectives 1 and 4) as well as quantitative close-ended questions (for Objectives 2 and 3). In interpretation of qualitative data, we have used empathic approach [10] where the aim is to get closer to the intended meaning of a text while using quantitative data we relied on conventional statistical methods.

**Table 1. Survey Questionnaire**

1	Name
2	Branch
3	Robocon Participation Year
4	How strongly will you rate Robocon as a memorable experience from your college days? (on Scale of 1-5)
5	Briefly describe your role in Team Robocon
6	Based on your recall, how well can you describe your own Robocon experience as-(on Scale of 1-5)
	Creative
	Learning
	Technical Challenge
	Project management
7	In your opinion, to what extent following abilities are developed through Robocon? (on Scale of 1-5)
	Developing innovative ideas
	Completing project under constraints
	Working in a team
	Communication skills
	Self-learning
8	Working on multidisciplinary issues
	Goal orientation
8	It is believed that knowledge sharing with seniors, juniors, and peers plays an important role in Robocon. Describe your experience.
9	Can you give an approximate estimate of time spent in Robocon in hours? Do you think you would have learnt more/less if you had spent the same time on conventional learning tasks?
10	What was your first placement /higher education?
11	Did your participation in Robocon have any role to play in your first placement or your Post-graduate admission? (on Scale of 1-5)
12	Please give elaborate comment on Q. 11 if the rating is 3 and above.
13	Please write your comments that will help us understand Robocon as a learning experience.

## 5. Results and Discussion

Out of approximately 250 students, 50 students were selected for collecting data. The results given below are premised upon 26 responses actually received by us.

### A. Objective 1

From the survey it is evident that students worked on an average 14-15 hours per day in Robocon laboratory for about 4-6 months of their respective Robocon year of participation. This is a strong indicator of level of student engagement in the project. In a very sharp contrast, students explicitly stated that learning in conventional classes is much less and does not offer any challenges. As against this, technical challenges and need to find viable solutions for winning the competition made them more inquisitive and research oriented. It is to be noted here that Robocon students engage in all the necessary laboratory work without any faculty intervention and take full responsibility of the project. In response to Q6 in the survey questionnaire which prodded them to select a two word phrase describing the lasting impression of Robocon competition with a weightage on a scale of 1 to 5, the overall order of preference calculated over all the twenty six responses came out to be Creative Experience > Learning Experience > Project Management > Technical Challenge. It is clear from the survey that students tend to be completely immersed in a learning experience when it challenges their creativity in order to solve a given problem in the best possible way and thus leading to a win. Another reason for high level engagement in Robocon seems to be lying in its team selection process which is very stringent and entirely designed and executed by students. Only highly motivated students become members and this ensures very high level of student engagement.

#### B. Objective 2

93% of the students surveyed have stated that Robocon had a major role in securing good employment as well as admission to higher studies. With an exception of one candidate out of twenty six surveyed, who has joined a family business, all other students have secured campus placements in core discipline industries or an admission to higher education institutions of international repute. Students have specifically mentioned that recruiters are more interested in projects (practical work) done by students once the academic criteria is met with. Many of the placement interviews were entirely based on the role played by them in Robocon project competition. It is also clear from the responses that apart from the technical skills gained during the project, the positive problem solving attitude imbibed by the students makes them more employable.

#### C. Objective 3

As per the perception of all the surveyed participants, abilities to develop innovative ideas, project completion within constraints, team work, working on multidisciplinary issues, self-learning and goal orientation were highly developed. Only 64% candidates opined highly in favor of development of communication skills.

This result can be attributed to the nature of the Robocon competition described earlier which does not lay great emphasis on report writing or technical presentation and hence is not a part of learning experience that is offered through Robocon.

#### D. Objective 4

Knowledge transfer and building up on experience to upgrade products and performance has always been an essential part of any engineering project. Students have shared their experience of knowledge sharing very candidly and they clearly mention its importance in achieving success in the competition. Natural scaffolding and mentoring amongst team members proves crucial for this essentially collaborative activity. Uniqueness of knowledge transfer pathways in Robocon competition lies in the fact that the required skill set is transferred between consecutive batches and also amongst competing teams. Best practices are established and passed on in the larger 'Robocon community' of the students. Two representative narratives of learning-in-a-team process in Robocon are excerpted below from the many responses we obtained.

*"The cross-functional team chosen on the basis of merit was crucial to bring together the best of the minds; I met so many smart people and got many intellectual sparring partners who helped me learn many things outside of Robotics and Mechanical engineering. It also taught us to self-organize and work as a team in the face of tight timelines teaching us some aspects of project management and trade-offs between exploring and exploiting various paths we could take as a team"*

*"Robocon as a learning experience is unmatched by any other method. It is the perfect combination of team work; self-learning and problem solving skills which play a very crucial role in the future career of the students. There is a stark difference between the students who have experienced Robocon and the ones who haven't, with students who participated in Robocon being well versed with the latest technologies and paradigms in the industry"*

It is also found that students document the entire process very systematically and also conduct sessions to train the new entrants extensively. Such knowledge transfer pathways are totally lacking in regular PjBL. It will be worthwhile to explore the ways in which they can be made part of regular PjBL.

#### E. Objective 5

We find that technical competition like Robocon can add lot of value to regular PjBL because of its inherent multidisciplinary nature. This attribute itself makes the problem more complex, challenging and real life. Teamwork is deemed as more of a strategic necessity than just being mandatory grouping to be followed. Since the team is multidisciplinary, they naturally learn the complimentary roles of various disciplines in a project.

Students develop project management skills such as knowing weaknesses and strengths of team members, strategizing the game plan based on strengths and bypassing/overcoming the weaknesses, setting the realistic time targets, dividing the work on many parallel lines complementing each other etc. These outcomes can hardly be attained in conventional non-competitive PBL.

## **6. Conclusions**

Adding an element of competition to regular practice of Project-based Learning has the potential of attaining many crucial program outcomes which are otherwise unattainable. Most important of them are self-learning and team-learning skills, project management skills, and ability to solve multidisciplinary problem by accepting the role dictated by one's chosen discipline. It is also found that level of student engagement is at its highest possible due to the challenge posed to creativity of students and an incentive of winning in the competition. The survey results from this case study also make it abundantly clear that competition-based PjBL has great potential to prepare industry-ready students in terms of their technical aptitude as well as positive attitude. It is worthwhile to find ways in which element of competition can be added to regular PjBL exercise to boost its established outcome attainment potential.

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