Co-Curricular Activities and their Role in Supporting Experiential Learning

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Abstract *–This paper presents a study into engineering competitions as a type of co-curricular activity that enhances student engagement and skills. The motive of the study is to evaluate the benefits of three selected major competitions and compare these benefits to those published in the literature. In addition, student feedback was collected and analyzed to understand the major benefits of these competitions as seen by students.*

Ten major benefits were summarized and listed based on the literature search. The three competitions under study were analyzed and found to meet the ten listed benefits although the level of focus on a particular benefit varied from one competition to another.

Student feedback showed that students found that competitions, especially competitions that were multidisciplinary in nature, enhanced their understanding of their engineering courses. Students also reported that participation in competitions helped them during job interviews.

Keywords: co-curricular engagement; experiential learning; student competitions; reflection; leadership and time-management skills.

1. INTRODUCTION

Integrating technical competitions into engineering curricula has been shown to be an effective teaching pedagogy [11]. However, having adopted competitions for a number of years, it is a good practice to evaluate these programs, and to determine whether or not the inclusion of these competitions has resulted in the intended outcomes.

The motive of this paper is to analyze the outcomes of three selected competitions in comparison to the published benefits for effective competitions. Feedback from students who took part in these competitions will be analyzed and the perception of competitions among students in the program will also be evaluated.

Several studies suggest that the "the combination of competitive and cooperative learning provides high levels of motivation, performance, and student engagement in learning" [11]. Regueras et al. goes on to describe competitive learning as an effective way to capture student interest, increase satisfaction, encourage participation, reduce procrastination, and improve subject understanding and critical analysis abilities [11].

Furthermore, studies that have been done of engineering programs have pointed "to the need for more effective integration of engineering knowledge with contextual knowledge, competencies of practice, and values of professionalism and ethics" [1]. To ensure that graduates of engineering programs are prepared to be successful in the workforce, programs must provide students with the opportunity to work with new technologies, to develop their problem-solving and creative abilities, and to better understand the complex relationship between engineering, the environment, and society [8].

Kundu & Fowler found that competitions gave students experience working with new technology, and the opportunity to develop technical skills, as well as the "soft skills" of project management, professional communication, and multidisciplinary team building [7]. Students also need to learn from their mistakes, as participation in competitions requires the resolution of mistakes to succeed [5]. Davies cites numerous studies that have demonstrated that "multi-university student design competitions can have tremendous educational value for the student in developing desired skills and competencies," including providing experience in "applying theoretical understanding to real problems" [5].

The benefits of engineering competitions for students, as supported by recent engineering education research, can be summarized in the following ten points: (i) Increase student motivation [6]; (ii) Encourage deeper learning [2][3]; (iii) Improve student research methods [9][2]; (iv): Give students control over their learning [6]; (v) Engage students with academic writing [9][2], (vi) Provide opportunities for interdisciplinary or multidisciplinary work [6]; (vii) Encourage student innovation [4]; (viii) Increase student-to-student and student-to-faculty interaction; [11][2] (ix) Provide students with professional engineering skills including project management and professional communication skills [10][5]; and (x) Provide students with real-world engineering design experience [1][6][5].

In addition to the above benefits, Mackechnie & Buchanan suggested that reflection is an important element of engineering competition [8]. According to Mackechnie & Buchanan, reflection refers to "the application of this new knowledge in improving designs and predictions." Through reflection, students not only see why their design was deficient, but also provide recommendations for how it could be improved [8].

Participation in competitions comes with its challenges. The main challenge reported in the literature as commented by students was that concentrating on competitions meant less time spent studying for other courses or exams, or having to devote extra time to course work [7][11]. When participating in externally run competitions, deadlines occasionally fell during inopportune times in the semester or required students to miss a week of classes in order to travel to events [7][11].

This paper evaluates the framework and outcomes of three technical competitions, and compares these outcomes to the anticipated benefits as outlined in the literature. In addition, surveys were collected to evaluate the students' perceptions of competitions and their opinions of how competitions were likely to influence their studies as well as their future career.

2. THE COMPETITIONS UNDER STUDY

2.1. Concrete Canoe Competition

In this competition, teams from all over Canada design and build a concrete canoe and use it to compete against other teams in a number of races. The design of the canoe involves structural, hydraulics, and materials analyses, enabling collaboration between students in different disciplines. In addition, students require outstanding project management skills in order to complete the work within the allocated time. Students start working on this competition in September and compete in May of the same academic year. The number of members of this team is usually between 20 and 30 students. Due to the wide spectrum of activities, students from all four years of the engineering program take part in this competition.

2.2. Concrete Toboggan Competition

Similar to the Concrete Canoe Competition, students participating in the Concrete Toboggan Competition design and build a toboggan and use it in a number of races. The design of the toboggan involves structural, materials and mechanical analyses, offering the opportunity for collaborative learning. Similarly to the canoe competition, the toboggan competition involves project management, report writing and technical presentation. Toboggan teams are usually 20 to 30 students and the race takes place in February. While the canoe is made entirely of concrete, typically only the toboggan skies are made of concrete with the frame constructed from light metals.

2.3. American Concrete Institute (ACI) Construction Competition

This is a different type of competition where teams consist of only five students. Unlike the concrete canoe and toboggan competitions, the ACI Construction Competition does not involve physical activities. The teams are given a problem statement and required to find the best answer to the problem. Students are allowed to communicate with their faculty advisors as well as professionals from the industry. The solutions are submitted in the form of a technical memo with a strict word limit.

3. ANALYSIS OF BENEFITS AND STUDENTS' FEEDBACK

3.1 Analysis of Benefits

The three competitions are diverse in nature, accommodating the needs of different students. First, the duration and timing of the competitions are not the same. The start and end of the concrete canoe competition coincide with the start and end of the academic year. The concrete toboggan competition requires only half a year of work, starting in September and finishing in February. The ACI competition is the shortest in duration, lasting only two weeks. Students can choose the competitions that fit their schedule and will have the minimum impact on their studies. For students, the first priority for choosing a particular competition is personal interest. However, within each of the canoe and toboggan competitions there are a variety of activities that match the interests of the majority of students. Indeed, students in these competitions are divided into the structural group, material design group, project management group and finance group. A student interested in concrete materials would find her/his interest represented in both competitions, although the performance requirements of the concrete in the canoe is not the same as that of the toboggan. The ACI construction competition focusses mainly on concrete materials with a construction management component. The number of students is relatively small – five students – and the competition offers in-depth learning experience in concrete materials, construction management, report writing and presentation.

In terms of meeting the ten benefits covered in the literature and listed in the introduction of this paper, both the toboggan and canoe competitions meet all benefits. For instance, both competitions encourage deeper learning and improve student research by requiring students to perform research and a deep analysis in order to meet certain criteria. For instance, the canoe requires a sustainable concrete mix that is strong and yet lightweight. This promotes deeper learning as in undergraduate engineering curriculum the focus is typically on strength or density without optimization. Achieving a sustainable mix requires research to understand what makes a mix more sustainable than another. Both competitions require a technical report, engaging students with academic writing. Since each competition requires structural, materials and mechanical or hydraulic analysis in addition to project management, the competitions provide opportunities for interdisciplinary or multidisciplinary work and increase student-to-student and student-to-faculty interaction. Finally, students are required to give a presentation to a panel of judges, providing students with an opportunity to enhance their professional communication skills.

In addition to meeting the ten benefits, reflection is an integrated part of these competitions. Throughout the design and building process, students reflect on their design and improve upon it. Indeed, the process of optimizing the design is iterative and students get multiple opportunities to reflect on their mistakes and improve their approaches.

While meeting the ten benefits, the ACI Construction Competition puts more emphases on engaging students with academic writing, encouraging student innovation, increasing student-to-student and student-to-faculty interaction, and providing students with professional engineering and communication skills and real-world engineering design experience. All participating teams receive the report of the top three teams, giving participants the opportunity to reflect upon their approaches and solutions and to learn from others.

3.2 Students' Feedback

A number of students participated in a short questionnaire to assess the effectiveness of these competitions in terms of the benefits students received. All students were participants in one of the three competitions. The questions are listed in Table 1, and Table 2 lists the numerical value assigned to each answer. While the number of students who participated is not large, the obtained feedback provides some insights into the students' perceptions of the competitions.

Table 1: Questionnaire taken by students who took part in the three technical competitions

Question #	Question
1	What year are you enrolled in the program
2	Has taking part in co-curricular activities helped better your understanding of course materials?
3	Has taking part in co-curricular activities helped better your understanding of lab tests and procedures?
4	Does your involvement in co-curricular activities help you get noticed by potential employers?
5	Are co-curricular activities a topic of discussion in interview situations?
6	Does your involvement in co-curricular activities have a positive impact on your course work?
7	Does your involvement in co-curricular activities leave you feeling more connected to the university and improve your overall experience?

Table 2: Numerical value assigned to answers

Numerical Value	Answer
1	Very dissatisfied
2	Somewhat dissatisfied
3	Neither satisfied nor dissatisfied
4	Somewhat satisfied
5	Extremely satisfied

Figure 1 shows the answers received from students who took part in the concrete canoe competition. It is interesting to see that for question 2, 100% of participants agreed or strongly agreed that their participation in the competition helped them better understand the course material. This supports the earlier analysis that competitions promote deeper learning. In addition, more than 90% of the students agreed or strongly agreed on questions 4 and 5 suggesting that participation in the competition enhanced their career opportunities.

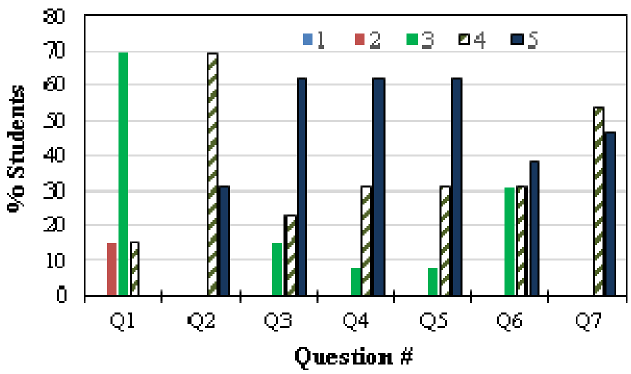

Figure 1: answers received from students who took part in the concrete canoe competition (13 respondents)

Figure 2 shows answers received from students who took part in the concrete toboggan competition. In this competition, 100% of the student strongly agreed that participation enhanced their understanding of the course materials, reflecting the deeper learning offered by the competition. More than 60% of the students strongly agreed that the competition enhanced their employment opportunities (Q4).

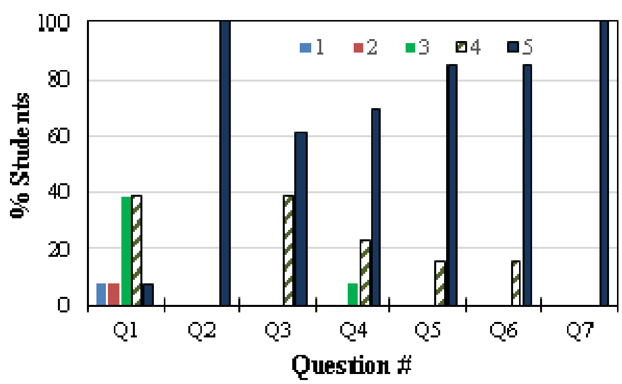

Figure 2: answers received from students who took part in the concrete toboggan competition (13 respondents)

The responses from the students who took part in the ACI Construction Competition are shown in Figure 3. It should be kept in mind that the number of respondents for this competition is only four (the team consisted of 5 students). Since the competition focused only on concrete materials and project management, the influence of participation on the understanding the course material - question 2 referred to the program in general - was not as high as it was in the other two competitions. The response to questions 4 and 5 was relatively positive as this competition involved technical presentation to groups of professionals from the industry, promoting employment opportunities.

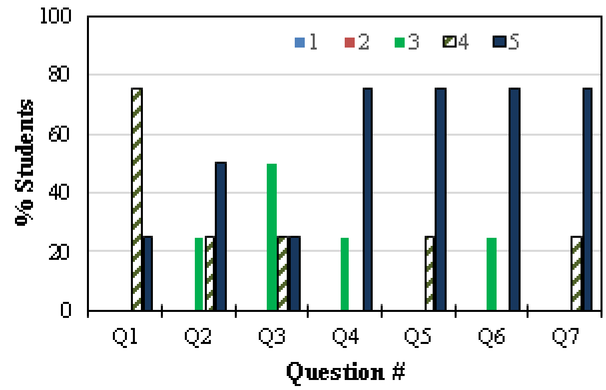

Figure 3: answers received from students who took part in the ACI Construction competition (4 respondents)

Figure 4 shows the responses collected from all students in the program in response to the question “I am satisfied with the number of student competitions and experiential learning opportunities”. While a high percentage of students in 1st and 2nd year selected answer 3 – neither satisfied not unsatisfied – students in their 3rd and 4th year had more positive experiences with competitions, especially 4th year. This is because by the 4th year, students get the opportunity to take part in one of the competitions and experience the benefits.

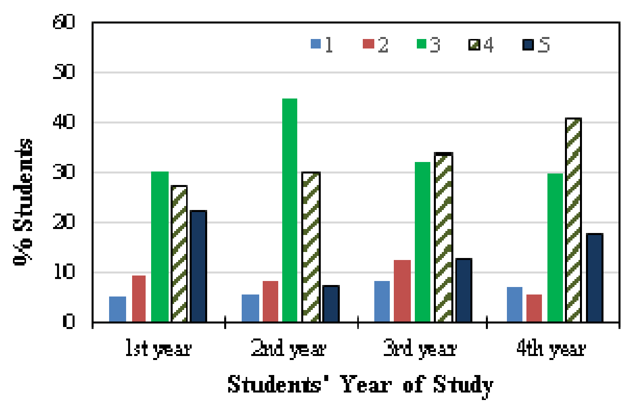

Figure 4: response of all students in the program regarding the satisfaction with the number of students’ competitions and experiential learning opportunities.

4. SUMMARY AND CONCLUSIONS

The positive feedback received from students regarding how participation in competitions enhanced their comprehension of the course work could be attributed to the fact that the competitions under study met a set of qualities that were referred to in the literature. In addition to strengthening the engineering background of students, competitions also increased their opportunities to find employment. While the questionnaire did not address how competitions play a role in student search for employment, the authors believe that this can be through: (a) sponsorship: competitions usually have industry sponsors. Students can establish industry contacts through the sponsorship process or during the competition. For instance, the ACI construction competition is judged by panel of professionals from the industry whom students in the top three teams get to meet and present their results, (b) résumé enhancement: being recent graduates, students usually include their extracurricular activities as part of their résumé. This usually attracts the attention of employers who would inquire about the activities during the interview. This is an opportunity for the student to show her/his leadership skills and talk about the technical challenges and how he/she addressed them and (c) open-questions during the interview: employers can ask the applicant to talk about a challenge that he/she faced and how he/she solved it. Competitions are perfect examples to use in this case. Competitions are also perfect examples of teamwork and project management experience.

The appreciation of competitions among students in their first two years is less that it is with students in the upper years. The reason is that many of these competitions require an appreciable level of design skills that students start to acquire in their third year. So, students in the first and second year can take part in these competitions but perhaps do not have as great an appreciation of the learning outcomes as those students who already have the theoretical background. This implies that simple design competitions that are short in duration and simple in nature are very useful for students in their first and second year of engineering education. Perhaps in-course competitions can have a major role in motivating this cluster of students.

In conclusions, the literature review and student feedback analyzed in this paper support the fact that student competitions enhance student understanding of course materials and help them with future employment. To achieve these goals, competitions should meet certain basic criteria or aim at certain anticipated benefits. Ten of these benefits as referred to in the literature were listed and discussed in this paper.

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