Engineering Design Competitions: A Motivating & Learning Experience

Howard Kimmel

Levelle E. Burr-Alexander

Joel Bloom

New Jersey Institute of Technology

Newark, NJ, USA

Engineering design competitions can show engineering as a fun experience and applicable to their everyday experiences both in and outside the classroom.

PURPOSE OF STUDY

- Review the nature of these competitions;
- How competitions might impact on participants.

OUTCOMES

- Methods and possible resources for better preparing participants and their coaches for the competitions.
- Strategies for using these experiences to motivate students.
- Strategies for integrating these experiences into secondary school science, math and technology courses.

COMPETITIONS INCLUDED IN STUDY

- FIRST HS Robotics Competition
- FIRST LEGO League Competition
- Panasonic Design Challenge
- Mission Possible Event in the NJ Science Olympiad
- JETS TEAMS Competition

GOALS OF COMPETITIONS

- To enhance and enrich the knowledge and appreciation of math and science for secondary school students through the application of engineering principles and designs.
- To encourage career exploration in engineering fields.
- To enhance the interest of these students in these fields, and thereby increase the number of potential engineering students entering the profession.

NJIT

US FIRST (For Inspiration and Recognition of Science & Technology

Mission: *"to excite young people about the fun, accessibility and importance of science & engineering "*

FIRST LEGO ™ League

Goal: Introduce middle school students, age 9-14, to the fun and experience of solving real-world problems by applying math, science and technology.

Strategy: Students design, build and program robots to solve an annual real-world problem using LEGO™ Mindstorms kits while working with mentors.

FIRST Robotics Competition

Goal: Inspire high school students, grades 9th-12th, to learn more and pursue further opportunities in science, engineering and technology.

Strategy: Students design, build and program robots for an annual competition while working with mentors to develop skills in engineering, technology, math, project management, communications and teamwork.

Panasonic Design Challenge

Initiated by PIC & NJIT in 1991, the challenge is meant to be a fun learning experience for students as they design and build a robot to accomplish a set of tasks within a set period of time. Students must apply basic principles of science and understand the impact of trade-offs on design and development, as they must work on a limited budget.

NEW JERSEY SCIENCE OLYMPIAD

The Science Olympiad is devoted to improving the quality of science education and increasing student interest in science. The Science Olympiad tournaments are rigorous academic interscholastic competitions that consist of a series of individual and team events that follow the format of popular board games, TV shows and athletic games.

NEW JERSEY SCIENCE OLYMPIAD - EVENTS

High School	Middle School
n Bottle Rocket	n Bottle Rocket
	n Bridge Building
n Mission Possible	n Mission Possible
	n Naked Egg Drop
n Robot Ramble	n RoboBilliards
n Storm the Castle	n Storm the Castle
n Tower Building	n Wheeled Vehicle

JETS TEAMS COMPETITION

TEAMS is an academic activity that enables teams of high school students to learn team development skills and then participate as a group in an engineering problem competition. TEAMS presents multidisciplinary aspects of the engineering profession by illustrating how math and science concepts learned in the classroom work together in the solution of real-world problems.

Observations and Perceptions of Student Participation

- The students found the competitions challenging and fun.
- The competitions appeared to provide a positive learning experience for a wide spectrum of students.
- The students were more interested in building devices that worked and less interested in the science and engineering necessary to optimize the operation of the device.

Information Gathering - Surveys

- Surveys of Students
  - All Competitions
- Surveys of Teachers/Coaches
  - FIRST HS Robotics
  - FIRST LEGO League
  - JETS TEAMS
- Survey of Students Technical Assistants
  - FIRST HS Robotics
  - FIRST LEGO League
- Survey Former Participants of Competitions

TABLE II

SURVEY RESULTS OF 15 MICHIGAN TECH STUDENTS

Survey Question	Response Synopsis
As a result of your participation in this project, do you feel you have improved your skills in the following areas:	
Communication	9 positive 6 negative
Programming	12 positive 3 negative
Overall Technical Knowledge	12 positive 3 negative
Will you participate in this project again next year?	8 positive 5 unsure 2 negative
What is your overall feeling about the FLL/Michigan Tech program?	9 positive 6 neutral 0 negative

Oppliger, Doug (2002). "Using First LEGO League to Enhance Engineering Education and to Increase the Pool of Future Engineering Students." *Proceedings for the 32st ASEE/IEEE Frontiers in Education Conference*, Boston, MA, November 6-9.

Sample of Survey Items for Participants in Competitions

- School
- Intended Major.
- In your own words, please describe the design process.
- How confident are you of your ability to design an object?
- As a result of this competition, do you feel more confident of your ability to design an object?
- Has your participation altered your career goals?
- Has your participation altered your concept of what engineering is or what engineers do?

Initial Data from Panasonic Design Challenge
Participated: 72 Students (24 Teams)
Respondents: 33 Students

Intended Major		Affected Career Goals
n Engineering/CS	19	n None
n Life Sci/Medicine	5	n Not Sure - 4
n Bus/PolSci/Psych	4	n Not Sure - 1
n Uncertain	5	n Not Sure - 4

Engineering Design Protocol
Ten Steps

- Identify the Problem
- Research the Problem (I. e., Gathering & Analyzing Information)
- Performance Criteria (I. e., Specifications & Constraints)
- Brainstorm – Alternative Design/Solutions
- Preliminary Design – Prototype

Engineering Design Protocol (Continued)

- Test – Evaluate
- Refine
- Retest
- Final Design
- Communication

Scores on Design Process

Points	Panasonic Design Challenge (33 Responses)	H.S. Robotics Competition (36 Responses)
0	7	27
1	3	4
2	2	4
3	3	1
4	7	0
5	7	0
6	1	0
7	3	0
8-10	0	0

Students ' Perception of Confidence

Confidence of Design Ability		Increased Confidence	
Very	17%	Yes	86%
Moderate	71%	No	7%
Slight	12%	Not Sure	7%

Next Steps

- Implement Teacher Training Program for High School Teachers.
- Expand on After-School Activities for Students.
- Extend Activities to FIRST LEGO League teams.
- Develop instructional materials for students and for teacher coaches.
- Develop Measures for Learning Outcomes for Comprehensive Assessments.
- Summarize Resources and Effective Strategies
- Disseminate “Best Practices for Motivating & Enriching Student Learning”
- Continue involvement in STEM competitions