Evaluating the Long-term Impact of Robofest since 1999

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Abstract

Robofest (www.robofest.net) is an autonomous robotics competition launched in 1999-2000 academic year for 4th to 12th grade students with some unique features for STEM (Science, Technology, Engineering, and Mathematics) education. An example of Robofest's unique features is that students need to solve unknown problems on the day of the competition. The Robofest game competition requires use of mathematics and sensors which discourages dead reckoning. One of the ultimate long-term goals of Robofest program is to motivate and encourage young students to pursue STEM and ICT (Information and Communication Technology) careers. The results of tracking Robofest students in three different methodologies show that Robofest is an effective program to attract students into STEM and ICT career path.

1. Introduction

Computer programming has been a part of K-12 STEM Education for over 30 years (Papert, 1980). Robots first appeared in U.S. classrooms for educational purposes over 20 years ago (e.g. Chambers & Carbonaro, 2003; Groff & Pomalaza-Raez, 2001; Kolberg & Orlev, 2001). More recently, several informal learning environments have started to combine computers and robots through such programs as after-school computerized autonomous robotics programs and robotics competitions (Barker & Ansorge, 2007; Chung & Anneberg, 2003). Robotics has been used in educational curriculum at all ages, elementary (Bers, 2005; Cejka, 2006; Rogers, 2004), middle school (Robinson, 2005) and high school (Whitman, 2003). Robotics competitions engage participants in fixed and open-ended activities, and as suggested by Fred Martin, one of the inventors of the popular LEGO robotics platform, open-ended exhibitions might promote more creativity than fixed game competitions (Martin, 2000). Furthermore, the use of autonomous robotics in formal and informal learning environments improves math and science learning (Matson, DeLoach & Pauly, 2004; Robinson, 2005; Weiss, 2004), as well as critical thinking and problem solving skills (Ricca, Lulis & Bade, 2006; Wagner, 1998). Recently, robotics has become a national priority project because of the following reasons (Excerpted from http://www.whitehouse.gov/blog/2011/06/24/developing-next-generation-robots, The White House, Office of Science and Technology Policy).

- Robotics can address a broad range of national needs such as advanced manufacturing, logistics, services, transportation, homeland security, defense, medicine, healthcare, space exploration, environmental monitoring, and agriculture;
- Robotics technology is reaching a "tipping point" and is poised for explosive growth because of improvements in core technologies such as microprocessors, sensors, and algorithms;

- Robotics can play an important role in STEM education because it encourages hands-on learning and the integration of science, engineering, and creative thinking; and
- Members of the research community such as the Computing Community Consortium and program managers in key sciences have developed a shared vision and an ambitious technical agenda for developing next-generation robotic systems that can safely work with humans and augment human capabilities.

There are many robotics competitions, and the effectiveness of robotics competitions for STEM learning has been studied in (Behnke, 2006; Grimes, 2010). This paper concentrates on Robofest, an autonomous robotics competition emphasizing computing aspect of robotics, launched in 1999-2000 academic year, which has been sharing the same vision above more than 12 years now (Chung & Sverdlik, 2001; MacLennan, 2010; Chung, 2011). We have designed Robofest to achieve the following 3 levels of impacts/outcomes (McLaughlin & Jordan. 1999):

Short-term Impact
Gained robotics knowledge and skills can be viewed as a short-term outcome/impact. Robofest is a perfect setting for students who want to be in the STEM career pathway as Robofest demands all the STEM subjects. During four months of the program, many students will learn for the first time in their lives how to write computer programs for real-time embedded control systems, which are their robots! Programming itself is not easy, but when their robots function correctly, it motivates students to work harder. In addition, they will learn many aspects of real world engineering projects, which require problem specification, system design, implementation, and testing skills.

Intermediate-term Impact
Changes in students' behavior can be viewed as an intermediate-term impact/outcome of Robofest. Based on the knowledge and skills they learned and the real-world-like competition experience, their view of STEM related classes will change. Students will have a reason why they need to learn those subjects and they will have changed learning behavior of relating class subjects to real world problems. As a result, they will have confidence in the classes.

Long-term Impact
While they are participating in Robofest competitions, for students who did not decide their career path, Robofest could be a life-changing experience for them, which may result in deciding to study in STEM related fields in college.

In this paper, we would like to focus on the evaluation of the long term impact of Robofest. We would like to see how many students actually went into STEM career paths to provide the workforce for the development of the next generation of technologies.

Figure 1 shows the number of student participants since 2000. We started with only 109 students in the first 2000 competition. In 2011, we had a total of 1,641 students. 496 teams from five countries (Canada, Korea, China, Singapore, and the USA) participated in the Robofest 2010~2011 season. In 2011, 92% of participants were from North America (Chung & Cartwright 2011). The accumulated number of students since 2000 has reached over 10,000. (Note that many students participated in Robofest more than one year.)
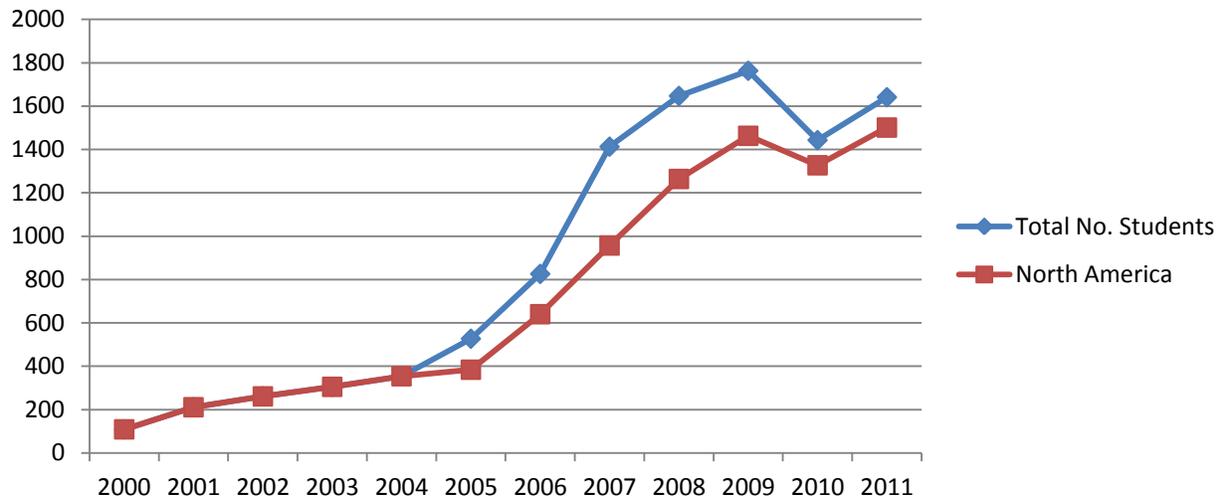
(**Figure 1**) Number of Robofest Student Participants Since 2000

Digging out student data older than 12 years and tracking students was not easy. We decided to do the following 3 approaches for the long-term evaluation.

First of all, we were very interested in tracking students in inaugural year. So we contacted everyone who participated in Robofest on April 15, 2000. The detailed approach and results will be described in section 2.

Since we were not able to contact all the students from the first year, we sent out emails to all coaches since 2003 to collect data. The detailed approach and results will be described in section 3.

The third approach is to contact Robofest scholarship winners, since we have students' contact information. The detailed approach and results will be described in section 4.

2. Long-term Impact of Inaugural year 2000 Robofest students

109 students participated in the first Robofest. Among them 12 Lawrence Tech college students entered the college level fire fighting race. Using the phone number on the photo release form (at that time we asked only phone numbers, no address) we tried to contact 97 K-12 students, after verifying the last name with Internet sites such as whitepages.com. However, after 12 years, we were able to contact only 14 of them (either the student or parent) successfully. Figure 2 shows the summary result. 50% of them (7 students) majored in STEM areas. Figure 3 shows their majors.
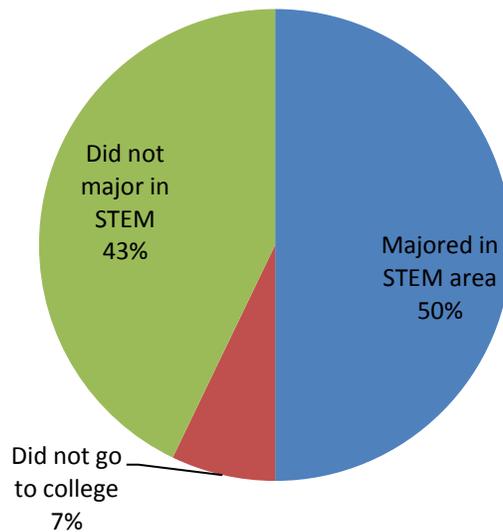
(Figure 2) College education of inaugural Robofest students

|	
Computer Science	1
Computer Science & Eng.	1
CAD (associate degree)	1
Biology	1
Civil Engineering	1
Mechanical Engineering	2
Public policy	1
Film, broadcasting	1
English, Marketing	1
Political Science	1
Business	2
Did not go to college	1

(Figure 3) College majors of inaugural Robofest students

3. Long-term Impact of Robofest students since 2003 (Preliminary Results)

In April 2011 Robofest office created a survey to find out how many of its students have pursued or are planning to pursue STEM careers. The survey was created as a Google document. The actual survey questions are reproduced in the Appendix. The initial question on the survey was to group the respondents into three categories: 1) students 2) parents 3) others- teachers and coaches. There were then questions specific to students, parents, and others. A link to the survey was sent out on April 13 to all of the email addresses collected by Robofest from students, parents, teachers, and coaches who participated in Robofest from the years 2003 to 2011. Coach email addresses from 2000 to 2002 were not able to be included in the survey. There were 144 responses to the survey collected from April 13 to May 16. These included 58 students, 32

parents, and 54 others. Not all of the survey responses were valid, so the data below is generated only from the valid responses.

 Of 51 students who responded to the survey, 84% indicated they are currently in or are planning to pursue a career in STEM (Figure 4). Data obtained from 32 parents who had 38 students involved in Robofest showed that 74% of their children who participated in Robofest were majoring or planning to major in a STEM field. This is well above the national average (NSF, 2009).
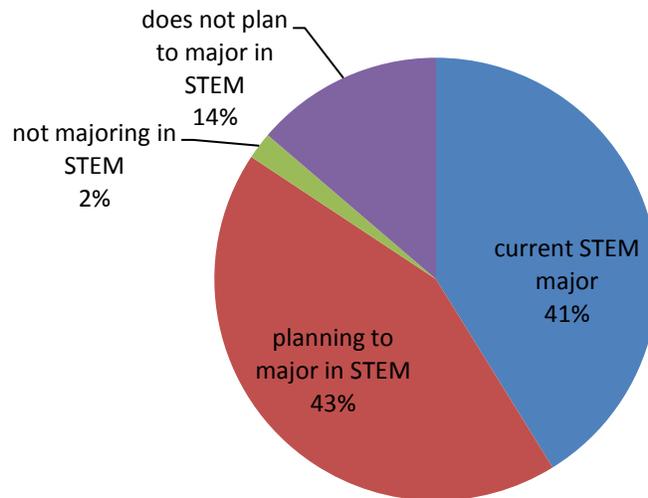
(Figure 4) STEM career data for Robofest students between 2003 and 2011

4. Long-term Impact of Robofest LTU scholarship students since 2006

Lawrence Tech has provided $2,000 annually renewable LTU scholarship for top-placing team members since Robofest 2006. 65 young students have received this opportunity so far in 2011. Among them 13 students enrolled at Lawrence Tech. In July 2011, we contacted 52 scholarship winners who did not come to Lawrence Tech by email and/or phone using the information given when they applied for the scholarship. As of Aug 9, 2011, we were able to get 19 student's post-secondary education data. Figure 5 shows the data from 32 students (19 non-LTU students plus 13 LTU students who applied for Robofest scholarship)
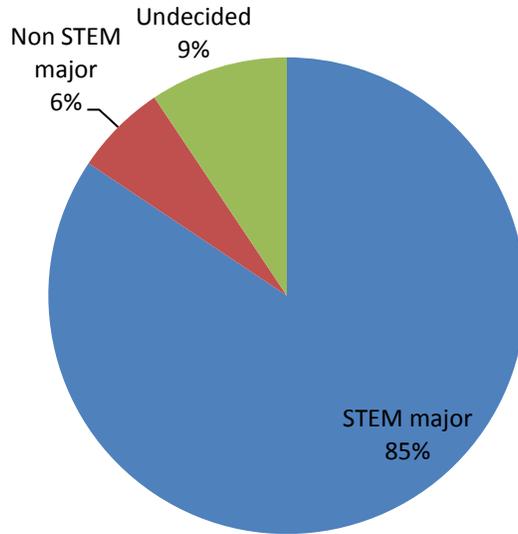
(Figure 5) College majors of Robofest Scholarship Applicants

We also asked the 27 STEM major students whether their experience in Robofest helped to directly influence their decision to concentrate their studies in the STEM major. Figure 6 shows the summary of 27 students who responded the question. The response from those students that replied "yes" to the inquiry regarding the influence of Robofest on their decision to continue on in STEM-related studies was very definitive and enthusiastic. Surprisingly about half of the students said their decision was directly influenced by Robofest participation. These students who said "Maybe" did not respond in the negative, but rather felt that they were interested in a STEM-related education in conjunction with joining Robofest from the outset. The students who said "no" implies that the student were already interested in STEM fields before participating in Robofest.
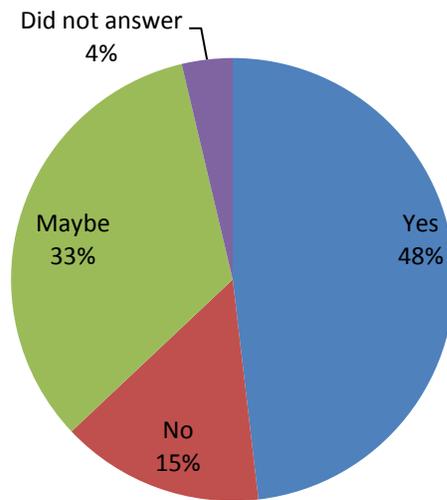
(Figure 6) STEM major decision directly influenced by Robofest participation

One student is in the Mechanical Engineering program based completely on his experience in Robofest. He was very grateful for the knowledge and confidence that Robofest gave him to continue on a path which includes a degree in the ME field. This was also true for one Robofest student that matriculates at U of M Ann Arbor, majoring in Electrical and Computer Engineering. This student reported to us that his computer programming experience through Robofest really prepared him for college, and gave him an advantage in the U of M computer science curriculum. The Robofest alumnus that attends Harvard University credits Robofest for being the sole impetus in changing his goal of becoming an author to becoming a highly successful computer science student at one of the most prestigious universities in America! The Harvard faculty recruited him to teach computer classes as a freshman.

The conclusion from the results of our survey regarding the continued pursuit of STEM-based learning at the college level by Robofest participants, can only be that Robofest has a decidedly positive impact on the decision of senior high school students to actively seek college degrees in science-based areas.

We were also interested in their majors. Figures 7 and 8 show the number of students for each declared major. Since Robofest's emphasis is the computational aspect of robotics, more students were in computer science area.

| Declared Major	College Attending	# of students
Electrical and Computer Engineering	U of M, Ann Arbor	1
	Lawrence Tech	2
Comp. Science and Engineering	U of M, Ann Arbor	1
Computer Science	Harvard	1
	Florida State University	1
	U of M, Dearborn	1
	Purdue	1
	Lawrence Tech	4
Engineering	U of M, Dearborn	1
	U of M, Ann Arbor	2
	RICE Univ	1
Mechanical Engineering	Purdue	1
	Calvin College	1
	Lawrence Tech	2
Computer Engineering	Wayne State University	2
	Michigan Tech	1
Electrical Engineering	Michigan Tech	1
	Lawrence Tech	1
Integrative Biology and Marine Science	UC Berkley	1
Robotics	Lawrence Tech	1

(Figure 7) Declared major, University, and number of students
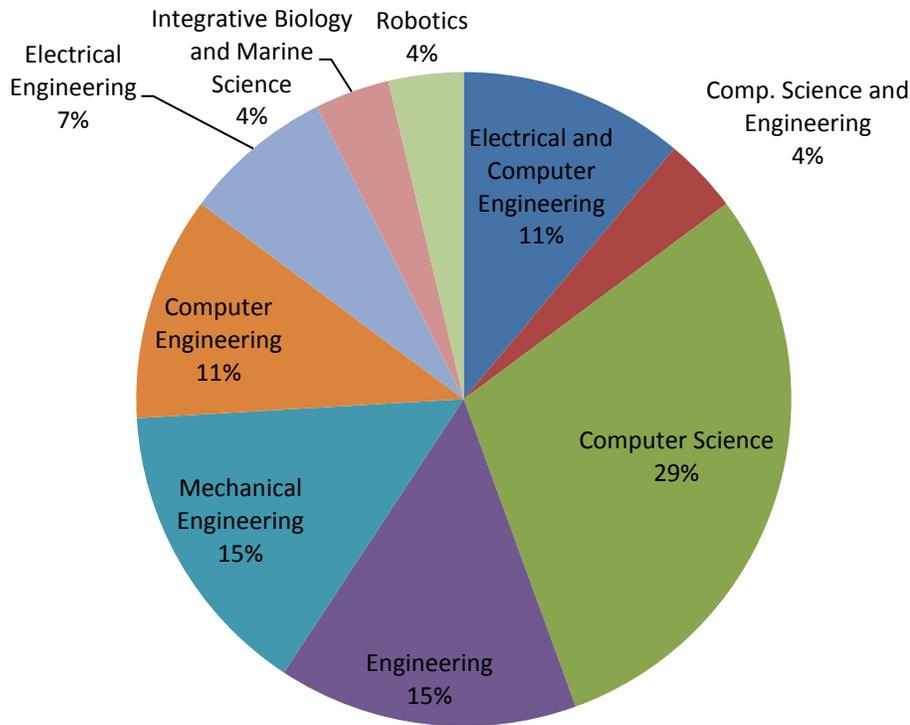
(Figure 8) Robofest scholarship students' declared majors

We were also very interested in comparing the declared majors with another popular robotics competition that does not focus on computational aspect of robotics. Lawrence Tech has been awarding scholarships to the students who participated in this popular robot competition since 2004. We found Lawrence Tech has awarded 18 scholarships to them and Figure 9 depicts their declared majors at Lawrence Tech. Since the popular robotics competition is designed toward construction and operation of robotics, we found that relatively more students chose Mechanical Engineering. Their average Lawrence Tech GPA was 3.30 out of 4.0, which is very good.

Figure 10 shows declared majors from 13 Robofest Scholarship winners since 2006. As expected, Computer Science was the number 1 choice, since Robofest competition is 100% autonomous. Average Lawrence Tech GPA for these students was 3.51.
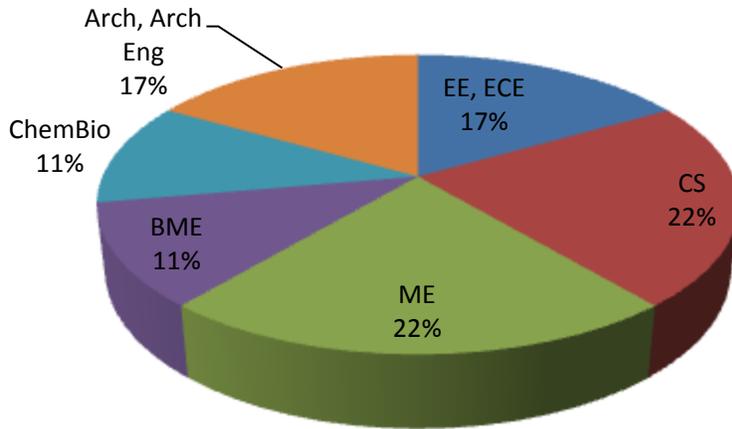
(Figure 9) Declared majors of a popular robotics competition scholarship students who came to Lawrence Tech
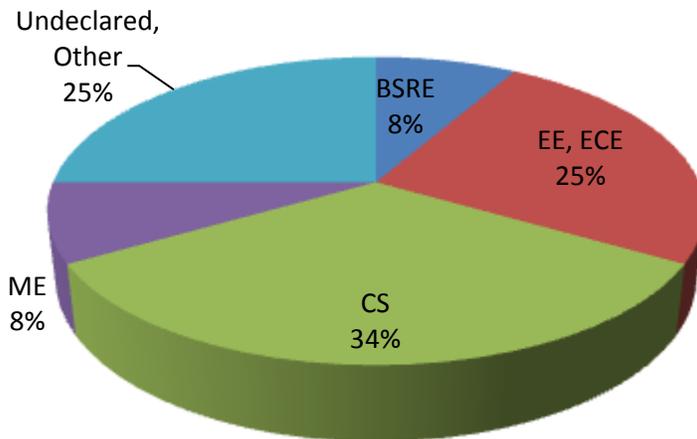
(Figure 10) Declared majors of Robofest scholarship students who came to Lawrence Tech

5. Conclusion and Further research

Preliminary data show that Robofest has been an effective program to motivate and encourage young students to pursue STEM and ICT careers. In addition, Robofest has played a positive role in scholarship students increasing preparedness to be successful in college. Robofest appears to be an efficient model considering the affordability as compared to other expensive robotics competition programs. Further research topics include:

- Method 1 explained in section 2 and Method 2 mentioned in section 3 must collect larger data set that is statistically reliable and valid
- It will be an interesting research to collect data whether students decided to participate in Robofest since they were already interested in STEM or they became STEM driven after Robofest

- It will also be interesting tracking data after college graduation
- In general, tracking students is not easy. It is expensive and time consuming. We need to develop better methodologies and systems to track students' career paths.

Appendix

STEM major survey

Robofest is conducting research on how many Robofest participants went on to study Science, Engineering, Technology, and Mathematics (STEM) in a 2-year or 4-year college after high school.

* Required

Please select the box that best describes you *

○ A student who participated in Robofest for at least one year 2000 to 2011

○ Parent of a Robofest student

○ Other (teacher, coach, volunteer)

[Continue »]

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STEM major survey

* Required

STUDENT Question

If you were a STUDENT who participated in Robofest 2000 to 2011, did you study a major in Science, Technology, Engineering or Mathematics (STEM) at a 2-year or 4-year college or university? *

○ I am a STEM major or completed a degree in STEM

○ I have graduated from high school but am NOT a STEM major

○ I have not yet graduated from high school and plan to major in a STEM area

○ I have not yet graduated from high school and do NOT plan to major in a STEM area

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PARENT Questions

How many of your children participated in Robofest 2000 to 2011?

0 ▼

How many of your children have graduated from high school and are majoring in STEM at college or have completed a STEM degree?

0 ▼

How many of your children have graduated from high school and are NOT majoring in a STEM area?

0 ▼

How many of your children have not graduated from high school and plan to major in a STEM area?

0 ▼

How many of your children have not graduated from high school and do NOT plan to major in a STEM area?

0 ▼

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STEM major survey

OTHER Question

Give us your estimate about the chance that a student who participates in Robofest will choose a STEM major in college

○ Very high

○ High

○ Equally likely to choose a non-STEM major

○ Low

○ Very low

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