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THE IMPACT OF A PARTNERSHIP BETWEEN CORPORATION AND POST-SECONDARY INSTITUTION TO PROMOTE INTEREST IN STEM EDUCATION: THE LOWCOUNTRY PERSPECTIVE

POTISUK, SIRIPONG

THE CITADEL

SCHOOL OF ENGINEERING

DEPT. OF ELECTRICAL AND COMPUTER ENGINEERING

Dr. Siripong Potisuk
Electrical and Computer Engineering Dept.
School of Engineering, The Citadel.

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Synopsis:

A case study involves an annual Trebuchet competition called ‘Storm The Citadel!’ through a partnership between Google and the Citadel to promote interest in STEM education in the Lowcountry of SC. Participants range from kindergarteners to seasoned professionals. Over 86% of the participants surveyed overwhelmingly agreed that the competition helped them learn more about STEM and problem solving. The competition also helped them learn how to function as a team and to communicate ideas.

The Impact of A Partnership between Corporation and Post-secondary Institution to Promote Interest in STEM Education: The Lowcountry Perspective

Siripong Potisuk

*Department of Electrical & Computer Engineering
The Citadel, The Military College of South Carolina
Charleston, SC 29409
e-mail: siripong.potisuk@citadel.edu*

Abstract

This paper presents findings from the investigation on how a partnership between Local Corporation and post-secondary institution has impacted the effort to promote interest in STEM education. A case study involves an annual Trebuchet competition called 'Storm The Citadel!' The competition was one of several events held at The Citadel, Charleston, SC, in honor of national Engineers Week. Thanks to the strong partnership between Google and The Citadel, the annual competition provided an educational and fun experience for competitors in the Lowcountry region. The competition, which focused on growing interest and engagement in science, technology, engineering, and math (STEM), was made possible through a \$25,000 grant from Google. Participants ranging from kindergarteners to seasoned professionals spent months designing, building and testing their team's trebuchets. Data Analysis is based on the third annual Trebuchet Competition, which takes place on the Citadel's Summerall Field on Saturday, February 16, 2013. A survey was administered to K-12 participants before and after their involvement in the competition. The instrument consisted of seven affective-type questions using a Likert scale for responses. These questions were analyzed using descriptive statistics and a non-parametric Wilcoxon Signed-Rank Test for two correlated samples. Statistical significance was indicated at the .01 level. The results suggested that the Trebuchet competition was successful in meeting its goals and objectives. Over 86% of the participants surveyed overwhelmingly agreed that the competition helped them learn more about STEM and problem solving. They also agreed that STEM education can be interesting, enjoyable, and important in their everyday life. In addition, the competition helped them learn how to function as a team and to communicate ideas effectively to others.

Keywords: STEM education promotion, Trebuchet competition, Lowcountry STEM

1. Introduction

It is generally agreed that STEM education is important for the US economic competitiveness in the 21st century. According to the Bureau of Labor & Statistics 2010 report [1], computer and mathematical science occupations are projected to add 785,700 new jobs by 2018. Furthermore, eight of the ten top jobs on the 2010 US Department of Labor top jobs report [2] require some form of specialized skills obtained through STEM education. Yet, according to the 2007 Trends in International Mathematics and Science Study (TIMSS) of the National Center for Education Statistics (NCES), which provides reliable and timely data on the mathematics and science achievement of U.S. students compared with that of students in other countries, fewer than 15% of high school graduates have enough math and science to pursue scientific or technical degrees in college. According to [3], a full 50% of Chinese students received their undergraduate degree in natural science or engineering in 2004, while only 15% of the US counterparts did so. The statistics gets even more staggering in post-graduate STEM education. It is reported that 56% of engineering Ph.D.'s in the US were awarded to foreign-born students in 2004 [4]. Moreover, the US is underinvesting and underperforming in STEM related fields. For example, over the next ten years, China will spend approximately \$440 billion dollars for research and development in renewable energy, while South Korea has committed over \$85 billion dollars during the next five years. The US, on the other hand, will invest roughly \$6-12 billion annually [5].

Despite the grim picture painted above, by now the mentioning of the acronym STEM, which stands for Science, Technology, Engineering, and Mathematics, does not meet up with the usual resistance by students and parents. In fact, it has become a popular household term during career path discussion. The notion that STEM education are for only the bright and gifted students is waning among students and parents. Student positive attitudes toward STEM subjects are also improving as they become more familiar with STEM related professions resulting in a renewed openness toward pursuing STEM majors in order to develop marketable STEM knowledge and skills. Thanks to the concerted effort by leaders in education, business, industry, and politics at the state and federal level, STEM education has become better understood and its importance recognized. The following paragraph reiterates what STEM education is and what it is not.

For one thing, it is not a new name for incorporating technology and engineering onto traditional science and math curricula. More importantly, it is not the teaching of more science and math classes which rely heavily on lecture and labs that place an emphasis on solution and replication of factual information. Rather, STEM education is an interdisciplinary approach to learning by linking with real world problems and emphasizing process and design challenges. Simply put, it is a teaching method that aims at developing problem-solvers and critical-thinkers. By creating a learning environment that promotes exploration, problem-solving and discovery, students are offered opportunities to make sense of the world and take charge of their learning.

Throughout the whole United States, many solutions and recommendations have been put forth. For example, in Alaska STEM: Education and the Economy [6], the author offers the following recommendations for improving STEM education in the state of Alaska. This ranges from conducting needs assessment to determine projected need for a

STEM-educated workforce to investing in teachers through high-quality, sustainable professional development. Other recommendations also include expanding and improving opportunities for students to take high-quality STEM classes at an early age and continue throughout middle and high school. These classes should be aligned with expectations of post-secondary education and the workplace. More importantly, there should be a comprehensive public awareness campaign to educate the public on the importance of STEM education for future economic success within the local region and nationwide area. The key to this effort lies in community-based and statewide partnership to develop meaningful and sustainable collaboration among K-12 schools, business, industry, and post-secondary institutions to align outcome competencies for college and career. Strengthening partnerships among these entities will foster success in promoting interest in STEM education.

2. Problem Statement & Its Significance

In the state of South Carolina, STEM education has become one of the many key areas targeted for promotion and improvement as the state struggles to expand economic opportunities to its citizens. Like many other states, South Carolina is no exception when it comes to the promotion of STEM education in an effort to produce highly-skilled workforce to meet the industry demand due to an influx of high-tech companies, such as BMW, Michelin, Google, and Boeing, just to name a few. Their presence can be attributed to the state's very generous tax policies and many other factors.

One of the key geographical locations poised to become a test bed for promotion and improvement of STEM education is the so-called Lowcountry of South Carolina & Georgia. The area encompasses the 200-mile stretch of coastal South Carolina & Georgia; however, precise boundaries for the Lowcountry are unclear, but Charleston is generally agreed to be its largest economic center. In this paper, the focus is on the Charleston metropolitan area and its surrounding counties (i.e., Charleston, Dorchester, and Berkeley). The two major players in the area are Boeing and Google. Boeing had decided to locate its operations center and manufacturing plant for the 787 Dreamliner series close to Charleston International airport in North Charleston around 2010. In 2007, Google announced plans to construct a data center complex in the city of Moncks Corner in Berkeley County in order to expand its pool of server farms. The facility was named Berkeley Data Center. In 2013, Google announced the expansion of the facility, bringing their total investment to \$1.2 billion and establishing a long-term commitment to the region and state. According to their website [7], they claimed to have "created over 150 jobs on site, and promise to work hard to support the communities in which our employees live and work. Since 2009, more than \$1 million were awarded to local schools and nonprofit organizations." Additionally, "we have helped implement a free downtown Wi-Fi network in the city of Goose Creek. In June 2012, we also hosted the 'GOOGLEFEST 2012' event in Charleston to help nonprofits, small businesses, and educators use the full range of Google tools."

In an effort to promote interest in STEM education in the Lowcountry, several stakeholders have been identified including K-12 schools, local corporations, post-secondary institutions, nonprofit organizations, and local governmental agencies. As

previously mentioned, strong partnership among these stakeholders can foster success in promoting and improving STEM education. And, two of the stakeholders in the Lowcountry area are the Citadel and Google. The Citadel, being one of the post-secondary institutions that produce STEM graduates, and Google, being one of the local high-tech corporations that need STEM graduates, can both benefit from their partnership. The Citadel stands to gain a higher-quality pool of local applicants for their STEM-related programs of study, while Google can reap the benefit of having a talented pool of local graduates for employment. In addition, they can fulfill their service responsibility to the community. Consequently, the Citadel, through its School of Engineering, School of Science and Mathematics, and STEM Center of Excellence, has joined forces with the leadership team of Google's Berkeley Data Center to create one of the successful partnerships to promote interest in STEM education in the Lowcountry. A brain child of one of Google's executive, the idea of a Trebuchet competition called 'Storm The Citadel!' was devised, and its planning and execution by the Citadel was successfully launched in 2010. The competition has now become one of several events held at The Citadel, Charleston, SC, in honor of national Engineers Week. The annual competition provided an educational and fun experience for competitors in the Lowcountry region. The competition, which focused on growing interest and engagement in STEM, was made possible through a \$25,000 grant from Google.

The primary goal of the competition is to provide a fun and interesting STEM activity to help engage K-12 students in the Lowcountry. They are the targeted audience for promoting STEM education. An equally important goal of the event is to expose students, parents and the local community to various STEM disciplines in an informal setting. Finally, the event is to highlight the presence of local corporations/organizations and their service to the community. Participants ranging from kindergarteners to seasoned professionals spent months designing, building and testing their team's trebuchets. The competition is subdivided into three divisions: Hoplite (Elementary & Middle School), Centurion (High School, College, Professional Organization, Military), and Barbarian (College, Professional Organization, Military) Division. Also, in response to a request from Google, a "Physics of Trebuchet" workshop was offered to mentors of all registered K-12 teams. The workshop was developed and conducted by Head of The Citadel's Department of Physics in the School of Mathematics and Science. Below is an investigation on how the event has impacted STEM engagement in the Lowcountry since its first launch in 2010.

3. Methods

The marketing to promote the competition was done through event advertisement using various different means and methods: social media, The Citadel STEM websites, local newspaper, and words of mouth from year to year. The process usually starts in the early month of Fall. Participating teams are required to familiarize themselves with the rules for constructing and competing in the event. They are also required to register and submit their design prior to the date of the event. This process is very important especially for the middle and high school teams to learn the scientific method and how to communicate one's idea. The following subsections describe the population, data

collection process, and data analysis procedure based on the third annual Trebuchet Competition, which takes place on the Citadel’s Summerall Field on Saturday, February 16, 2013.

3.1 Population

A total number of 338 participants from 38 teams comprised elementary students, middle school & high school students, and college/organization/military students/personnel. The information was compiled from registration data on the day of the event and broken down into teams according to their grade level [8]. Table 1 below details the characteristics breakdown of all participants into teams according to their grade level.

Table 1 Characteristics breakdown of participating teams

Division	Grade Level	Number of Teams	Number of Students/Participants
Hoplite	Elementary	10	53
Centurion	Middle School	13	132
	High School	10	97
	College/Organization/Military	3	31
Barbarian	College/Organization/Military	2	25
	Total	38	338

It is important to note that the number of teams actually participated in the competition was less than the number of teams registered. The reasons for the team’s inability to participate include insufficient time to prepare, unsatisfactory testing results, and unforeseen circumstances during trebuchet construction.

3.2 Data Collection

As a part of the team registration process, only K-12 team members were required to complete a pre-survey either online through surveymonkey.com or a paper version of the survey if access to a computer was not possible. In addition to demographic information (Gender, Race, and Grade level), they were asked to rate their interest, understanding and attitudes towards STEM. Those participated in the competition were asked to complete a post-survey prior to their team’s departure. The post-survey again asks each participant to rate their interest, understanding and attitudes towards STEM after participating in the competition. The survey consisted of seven affective-type questions. Table 2 lists the survey questions for both before and after the competition. The seven questions in both the pre- and post- survey were designed to be answered using an odd-level Likert scale set of responses, (Strongly disagree = 1, Disagree = 2, Unsure = 3, Agree = 4, Strongly agree = 5). Recommended by surveymonkey.com, an odd-level (5) scale was used to avoid random answer since people tend to give random answers if provided with more than seven response choices.

The pre- and post-survey were designed to assess the impact of the event on participant’s attitudes and knowledge about STEM using repeated-measures or within-

subjects non-parametric test (i.e., the Wilcoxon Signed-Rank Test). Typically, this repeated-measures test involves situations in which each subject is measured twice, once in condition A, and then again in condition B. In this case, condition A is the condition before the event, and B is after the event. In order to have the same group of subjects for statistical analysis, the last question of each survey asked the participant to indicate their last name, which allows for pre and post-surveys to be matched creating two groups of correlated samples. A total of 304 pre-surveys were collected, while only 92 post-surveys were returned despite follow-up requests. After eliminating post-survey responses that were incomplete or with illegible or missing names, a sample containing 25 randomly selected sets of matched pre- and post-survey was retained for further statistical analysis.

Table 2. A list of survey questions

Pre-Survey	Post-Survey
1. Learning about science, technology, engineering, math, and problem solving is interesting to me.	1. My participation in the 2013 Trebuchet competition made learning about science, technology, engineering, math and problem solving interesting to me.
2. Learning about science, technology, engineering, math, and problem solving is enjoyable to me.	2. My participation in the 2013 Trebuchet competition made learning about science, technology, engineering, math and problem solving enjoyable to me.
3. Learning about science, technology, engineering, math, and problem solving is important to me.	3. My participation in the 2013 Trebuchet competition made learning about science, technology, engineering, math and problem solving important to me.
4. I know all about science, technology, engineering, math, and problem solving.	4. My participation in the 2013 Trebuchet competition helped me learn more about science, technology, engineering, math, and problem solving.
5. I believe having a good understanding about science, technology, engineering, math, and problem solving is important in my everyday life.	5. My participation in the 2013 Trebuchet competition helped give me a better understanding about how science, technology, engineering, math, and problem solving is important in my everyday life.
6. I know how to work well with others.	6. My participation in the 2013 Trebuchet competition helped me to learn how to work well with others and/or fine-tuned my ability to work well with others in a team setting.
7. I know how to communicate my ideas effectively to others.	7. My participation in the 2013 Trebuchet competition helped me to learn how to communicate my ideas effectively to others and/or it fine-tuned my communication skills.

3.3 Data Analysis

Two types of data analysis were performed. First, all of the post-survey responses were analyzed using descriptive statistics to initially gauge the impact of the after-the-competition experience. Then, the non-parametric Wilcoxon Signed-Rank Test was performed on the sample of 25 randomly chosen matched pre- and post-survey sets of responses. The reason for using this test instead of a t-test for correlated samples is that the scale of measurement for the emotional rating scores cannot be assumed to have the property of an equal-interval scale. The test is performed on each of the seven questions separately to ascertain whether or not the experience from participating in the event has any impact on the participants in terms of change in attitudes or knowledge gain about STEM education.

4. Results & Discussion

The following is a summary of the data from the post-survey responses. For students' demographics, the following percentage distribution was compiled.

Gender distribution: Male 60.5% and Female 39.5%
Race: Black 9.3% Hispanic 3.5% White 80.2% Other 3.5%
Grade level; Elementary 23.3% Middle School 60.5%
High School 14.0%

To summarize the impact of the event, the following percentage distribution for each of the seven post-survey questions is given below. For question 1, 95.7% (88/92) of students agreed or strongly agreed that participation in the competition made learning about STEM and problem solving interesting to them. For question 2, 91.3% (84/92) of students agreed or strongly agreed that participation in the competition made learning about STEM and problem solving enjoyable to them. For question 3, 87.0% (80/92) of students agreed or strongly agreed that participation in the competition made learning about STEM and problem solving important to them. For question 4, 92.4% (85/92) agreed or strongly agreed that the participation in the competition helped them learn more about STEM and problem solving. For question 5, 87.0% (80/92) of students agreed or strongly agreed that participation in the competition helped give them a better understanding about how STEM and problem solving is important in their everyday life. For question 6, 90.2% (83/92) of students agreed or strongly agreed that participation in the competition helped them learn how to work well with others and/or fine-tuned their ability to work well with others in a team setting. For question 7, 86.0% (79/92) of students agreed or strongly agreed that participation in the competition helped them learn how to communicate their ideas effectively to others and/or it fine-tuned their communication skills. From the results above, it initially appears that the Trebuchet competition was successful in meeting the goals and objectives previously mentioned.

To further investigate whether or not the event actually did change the attitudes of participants toward STEM, a statistical analysis, namely the Wilcoxon Signed-Rank Test, was performed on the sample of the matched survey responses. The responses to the seven questions in the sample of the matched surveys are summarized in Table 3 below.

Table 3. Responses to the seven questions in the 25 samples of the matched surveys (SD=Strongly Disagree, D=Disagree, U=Unsure, A=Agree, SA=Strongly Agree)

Pre-Survey							Post-Survey						
Q	SD	D	U	A	SA	Mean	Q	SD	D	U	A	SA	Mean
1	0	0	1	9	15	4.56	1	0	0	2	8	15	4.52
2	0	0	0	10	15	4.60	2	1	0	2	8	14	4.36
3	0	0	1	5	19	4.72	3	0	1	4	11	9	4.12
4	3	4	9	6	3	3.08	4	0	1	4	6	14	4.32
5	0	0	2	8	15	4.52	5	1	1	3	11	9	4.04
6	0	0	3	10	12	4.36	6	0	1	2	7	15	4.44
7	0	2	4	11	8	4.00	7	0	1	3	12	9	4.16

From Table 3, it can be seen that the pre-survey responses for each of the seven questions have a relative high mean values except for Question 4. This indicates that participants generally agreed with the statement in each question about their knowledge in and attitude toward STEM. Moreover, they value the importance of soft skills, such as teamwork and effective communication. The mean value of 3.08 for Question 4 indicates that students were unsure whether they knew “all about STEM.” The reason for being unsure might have to do with the wording of the statement with the qualifier word ‘all’. Nobody wants to sound cocky or overconfident.

The results from the Wilcoxon Signed-Rank Test for each of the seven questions indicate that the difference in the mean scores is not statistically significant except for Question 4, which shows a statistically significant increase ($z = -3.128$, $\alpha = 0.01$, $\sigma_w = 61.604$, $N = 22$) from pre- to post-survey. That is, from the table of critical value of z , the observed value of $z = -3.128$ is significant beyond the 0.01 level for a two-tailed non-directional test. Again, this could have resulted from the wording of the statement with the qualifier word ‘all’. On the other hand, even though the other six post-survey questions were specifically worded such that the response must be based on their participation in the trebuchet competition, no statistically significant increase is observed. At the surface level, this result might be interpreted that the event has no impact whatsoever on the participants about STEM. However, a closer look at the high mean scores for the pre-survey responses reveals the fact that participants are already inclined toward having an interest in STEM. And, it is perhaps the reason why they chose to participate in the first place. The competition, in fact, does reinforce their interest in STEM as can be seen from the equally high mean scores for the post-survey responses. In addition, it is encouraging to see that the competition helps them realize the importance of the soft skills of teamwork and effective communication as they, on the average, agree with the statements in Questions 6 and 7.

In performing both statistical analyses, we did not distinguish among students from different grade levels or divisions. It is likely that the competition or the event as a whole might have more positive impact on elementary or middle school students than on the high school students. Unlike high school students who might have already decided to pursue or not pursue STEM disciplines in college, elementary and middle school students are still open to be more accepting of STEM. That is, they are more impressionable. This is in agreement with the idea that students should be exposed to STEM at an early age.

5. Conclusion

The findings presented above show how a partnership between Local Corporation, like Google, and post-secondary institution, like the Citadel, can have a positive impact, although not evident from statistical data analysis, on the effort to promote interest in STEM education. An annual Trebuchet competition called ‘Storm The Citadel!’ is a perfect example of such a partnership, which provided an educational and fun experience for competitors at all levels in the Lowcountry region while focusing on growing interest and engagement in STEM. It is worth noting that a \$25,000 grant from Google, although small in size, have had such a tremendous impact on the Lowcountry community. Overall, it was a great experience, and everyone involved was glad that they participated. Through sustained funding from Google from year to year, interests in STEM education in the Lowcountry have increased and, hopefully, will continue to do so in the future to come. Anyone interested in learning more about the event, the competition and other STEM-related programs at the Citadel can visit the Citadel’s STEM website through the following URL: <http://www.citadel.edu/stemcenter/>

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