
AC 2011-1705: ASSESSING THE IMPACT OF ACTIVE LEARNING ON STUDENTS IN GRADES 3-8 DURING GK-12 OUTREACH PROGRAM ADMINISTERED FAMILY STEM NIGHTS

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Dr. Bottomley has authored or co-authored 37 technical papers, including papers in such diverse journals as the IEEE Industry Applications Magazine and the Hungarian Journal of Telecommunications. She received the President's Award for Excellence in Mathematics, Science, and Engineering Mentoring program award in 1999 and individual award in 2007. She was recognized by the IEEE with an EAB Meritorious Achievement Award in Informal Education in 2009 and by the YWCA with an appointment to the Academy of Women for Science and Technology in 2008. Her program received the WEPAN Outstanding Women in Engineering Program Award in 2009. Her work was featured on the National Science Foundation Discoveries web site. She is a member of Sigma Xi, past chair of the K-12 and Precollege Division of the American Society of Engineering Educators and a Senior Member of the IEEE.

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Assessing the Impact of Active Learning on Students in Grades 3-8 and Their Parents during GK-12 Outreach Program Administered Family STEM Nights

Abstract

RAMP-UP administered Family STEM Nights are supported by North Carolina State University and are held at public elementary or middle schools in Wake County throughout the school year. They are an opportunity for parents to bring their children to school in the evening to learn about science, technology, engineering and math (STEM) through fun, hands-on activities. The outreach program brings the activities to the school, sets them up and administers them. Each activity is designed from everyday materials to teach parents and children that STEM fields exist and are learnable. The impact of the Family STEM nights on students in grades 3-8 was assessed through a pre and post event survey that measured their awareness of what science, technology, engineering and math are as well as how well they like each discipline at two elementary schools (ES1, ES2) and one middle school (MS1).

There was a 24%, 9% and 21% improvement in awareness of engineering at ES1, ES2 and MS1 respectively through participation in the Family STEM Night. Upon performing a paired t-test on each sample, ES1 ($p < 0.05$, 28 df) and MS1 ($p < 0.05$, 18 df) were significant for improvement in awareness of engineering.

There was an 11%, 9% and 16% increase in likeability of science and a 47%, 16% and 21% increase in likeability of engineering at ES1, ES2 and MS1 respectively through participation in the Family STEM Night. Upon performing a paired t-test on each sample, ES1 ($p < 0.05$, 28 df), ES2 ($p < 0.5$, 17 df) and MS1 ($p < 0.05$, 18 df) data were significant for increases in science and engineering likeability. MS1 also showed significant gains in math likeability: a very positive result for this age group.

RAMP-UP, a GE Foundation and National Science Foundation funded GK-12 Outreach Program at North Carolina State University administers Family STEM Nights at eleven public elementary and two public middle schools throughout Wake County during the academic year. A RAMP-UP graduate Fellow schedules the events with the school representative and recruits undergraduate RAMP-UP Fellows, Engineering Outreach Ambassadors and Women in Science and Engineering (WISE) from the College of Engineering and Teaching Fellows from the College of Education. The event is a true collaboration between the Colleges of Engineering and Education at North Carolina State University and Wake County public schools. Attendance at each Family STEM Night ranges between 150 – 250 parents and children.

Introduction

In the fall of 2005, RAMP-UP, a GK-12 Outreach Program at North Carolina State University (NCSU) ran its first Family Math Night at a Wake County public elementary school. The Family Math Night was created to supplement the new Trailblazers (math)

curriculum with hands-on activities to help teach the concepts. No fewer than six activities were created for each grade level, K-5. RAMP-UP follows Dr. John Dewey's example that math could be learned through everyday activities such as cooking. [1] Following this philosophy, common items found in the home were used to create several, original activities. For example, toothpicks and marshmallows are used for both a Kindergarten and a fifth grade activity where the students build 2D and 3D shapes respectively. Another very popular activity called, *Diaper Hold'em*© teaches students about liquid volume and the SI and English metric systems using kitchen turkey basters, yellow colored water and diapers. The activities are neatly packaged with instructions and worksheets (as necessary) into large Ziploc™ bags and stored in plastic tubs for easy transportation.

Following a pragmatist approach, it is believed that active learning is a fun and feasible teaching style that replaces words with activities as the means of communicating new concepts. This often takes the “fear-factor” out of learning for those who feel overwhelmed or intimidated about learning math. RAMP-UP creates opportunities for active learning through many out of classroom learning experiences such as math clubs, Energy Clubs, tutoring, FAME (Fun Applications in Math and Engineering), assistance with science fair projects and Family STEM Nights which are discussed in this paper.

Activities for a Middle School Family Math Night were created in January of 2007. All activities were designed to enhance skill levels in grades 6-8 such as geometry, algebra, probability and logic. Several original activities were created such as *Foil Boat*, *Float*, *Float*© where students are challenged to build boats out of aluminum foil that can support large quantities of glass beads. Not only is the activity fun but it also teaches students about geometry and buoyancy.

RAMP-UP conducts no fewer than one dozen Family Math Nights per academic year and this past year has changed the scope of the events to include STEM (Science, Technology, Engineering and Math) activities including five that were specifically tailored for engineering disciplines. The events are now referred to as Family STEM Nights and RAMP-UP is currently supporting eleven at elementary schools and two at middle schools within a 26-mile radius of the university. A RAMP-UP graduate Fellow schedules the events with the school representative and recruits RAMP-UP undergraduate Fellows, Engineering Outreach Ambassadors and Women in Science and Engineering (WISE) from the College of Engineering as well as Teaching Fellows from the College of Education. The event is a true collaboration between the Colleges of Engineering and Education at NCSU and Wake County public schools. Attendance at each Family STEM Night ranges between 150 – 250 parents and children.

For this paper, the impact of the Family STEM Nights on students in grades 3-8 was assessed through a pre and post event survey that measured their awareness of what science, technology, engineering and math are as well as how well they like each discipline. The survey was only given at two elementary schools and one middle school hereafter referred to as elementary school 1 (ES1), elementary school 2 (ES2) and middle school 1 (MS1). The results were positive.

Definitions

For the purpose of this paper, any use of the word “student” refers to a child in grades 3-8, any use of the word “Fellow” refers to an undergraduate or graduate student from North Carolina State University, and any use of the word “teacher” refers to a teacher in a Wake County public school. The RAMP-UP Fellows work in the primary schools when the university semester is in session, which results in a 12-13 week presence in the schools. The program has had a presence in three, inner-city Raleigh elementary schools and one middle school for the past six years and continues today.

Measuring the Impact

The goal of this project was to measure the effectiveness of a Family STEM Night in introducing students to science, technology, engineering and math in order to increase their awareness of these disciplines and hopefully inspire them to like these fields. Science and math are taught regularly in the classroom and most students own some form of technology therefore, the growth in awareness was not expected to be great or significant but perhaps the Family STEM Nights could inspire them to like these disciplines more. We weren't sure if the students had any awareness or understanding of engineering since it is not taught to them in the classroom nor are they exposed to it through any common media channels. Therefore, the growth in awareness and likeability of engineering was expected to be great and significant.

In order to measure the effectiveness of Family STEM Nights, the students were given a survey prior to engaging in hands-on activities. They were then allowed to participate in as many activities as they liked for the entire duration of the event if they so desired. (Family STEM Nights run from 6 p.m. until 7 p.m.) The activities represented learning opportunities from all four disciplines: science, technology, engineering and math. The five engineering activities and food activities were the same for both the elementary school and middle school Family STEM Nights. There were a core group of approximately ten undergraduates at each event running the activities with supplemental assistance from 5-10 undergraduates and graduate students who varied with each event. Before leaving the event, the students were asked to take the same survey again.

The Assessment

At the first Family STEM Night of the semester, we attempted to measure the students' awareness of what technology is and what an engineer does. We encountered two obstacles. The first was using the assessment from the Engineering is Elementary workbook, “Catching the Wind”. [2]. While an excellent assessment tool, it was not conducive to the Family STEM Night environment, which is very noisy, chaotic and filled with fun. Students did not want to pause to take the assessment, which required at least 2-5 minutes of concentration. They instead wanted to immediately participate in the activities. The second obstacle involved administering the assessment. In order to measure growth, the same students needed to be assessed before entering the event and

then again when leaving. Due to the location of the table, which was in the cafeteria with all the activities, it was difficult to stop the students and administer the assessment. Then, it was nearly impossible to catch any of the students on the way out. The lessons learned from the first attempt were; shorten the assessment, place the assessment table at the entrance to the building and not the entrance to the activity rooms, and have teachers administer the assessments. Applying these adjustments greatly improved our return rate at the second Family STEM Night: especially having the teachers involved since they knew the students and were able to command them to pause and take the assessment. This resulted in getting 64 students to fill out the survey before and 70 students after the event. Of all those students, 29 filled out the assessment before and after to give a healthy sample size of N=29 students in grades 3-5 at ES1. Applying this strategy at two more schools – one elementary (ES2) and one middle (MS1) – gave us similar return rates and a sample size of N=18 students in grades 3-5 and N=19 students in grades 6-8 respectively.

The revised assessment consisted of two simple sections (Figure 1). In the first section, students were asked if they knew what science is, what technology is, what engineering is and what math is. The purpose of the questions in the first section were to assess the students’ awareness of these disciplines before and after the Family STEM Night. For each question, they merely had to circle yes or no. In the second section, students were asked if they like science, technology, engineering and math. For each statement they used a simple Likert scale of 1 to 5 with 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree. Due to the age of the students, 1 was also redefined as “Not at all” and 5 was redefined as “Very Much” to help clarify the scale.

Figure 1: The Assessment

Name _____ Grade _____
 Time _____

Please answer the following questions by circling Yes or No

- I know what Science is. Yes No
- I know what Technology is. Yes No
- I know what Engineering is. Yes No
- I know what Math is. Yes No

Please respond to the statement using a scale of 1 to 5 with **1 = "Not at all"** and **5 = "Very Much"**

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
	"Not at all"				"Very Much"
I like Science	1	2	3	4	5
I like Technology	1	2	3	4	5
I like Engineering	1	2	3	4	5
I like Math	1	2	3	4	5

Data

In the top section of the survey, students were asked to circle yes or no to the following statements: “I know what Science is.”, “I know what Technology is.”, “I know what Engineering is.”, and “I know what Math is.” The number of yes responses for ES1, ES2 and MS1 are presented in Figures 2-4 respectively.

Figure 2: Number of Yes responses for ES1

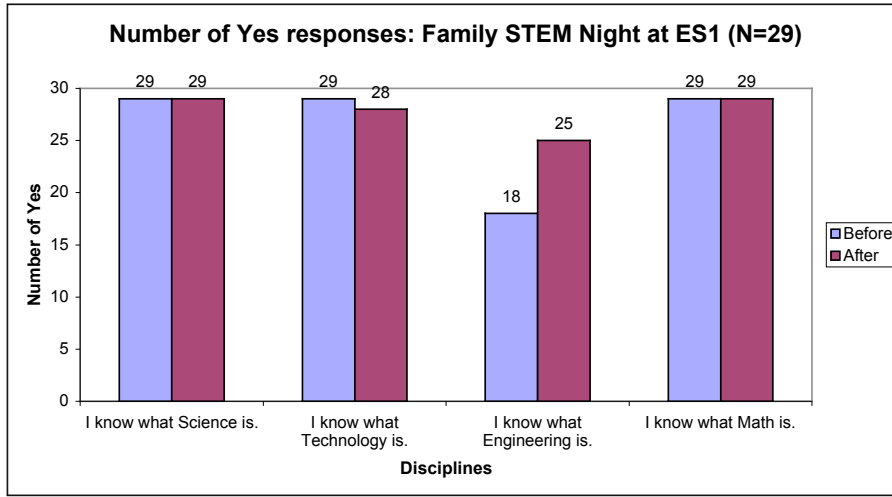


Figure 3: Number of Yes responses for ES2

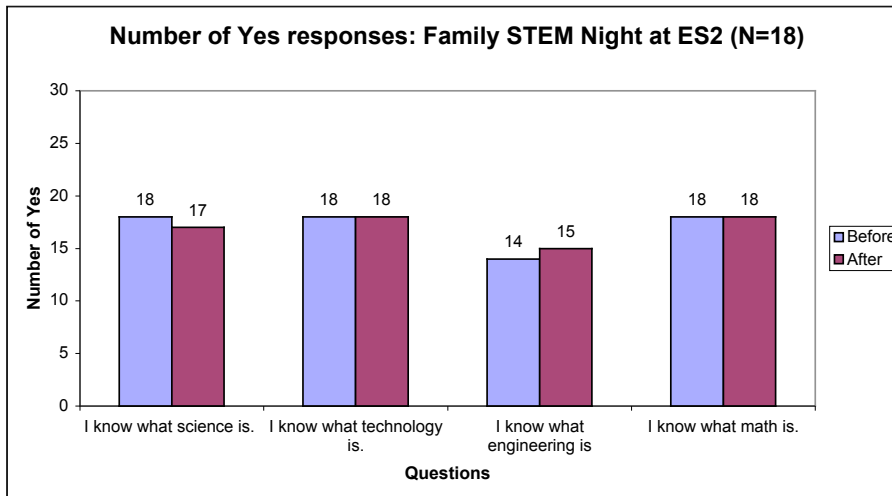
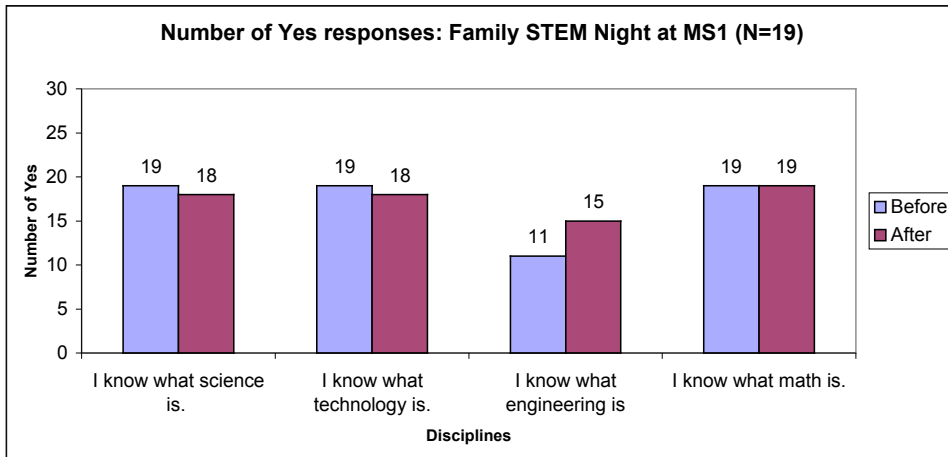


Figure 4: Number of Yes responses for MS1



The bottom portion of the survey asked students to rank how much they agreed with the statements: I like Science, I like Technology, I like Engineering, and I like Math. A Likert scale of 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree was used to measure how much the student liked these disciplines. The number of responses per level of the Likert scale is shown in Figures 5-8 for ES1, Figures 9-12 for ES2 and Figures 13-16 for MS1.

Figure 5: ES1 - "I like Science"

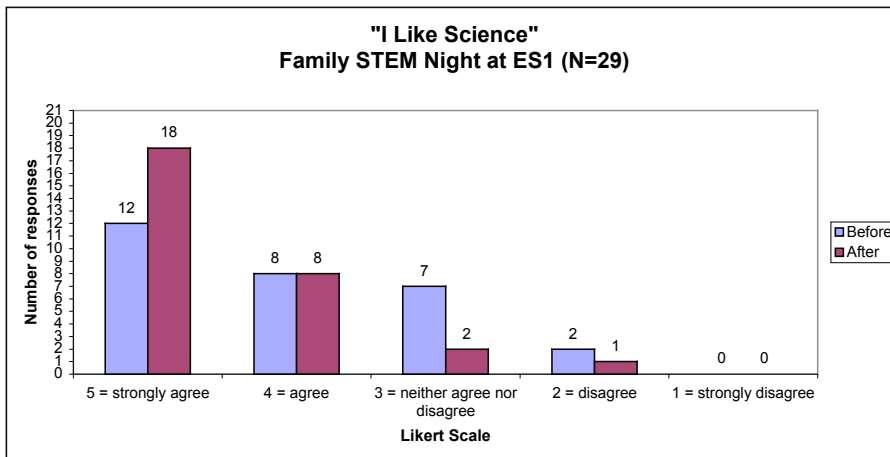


Figure 6: ES1 - "I like Technology"

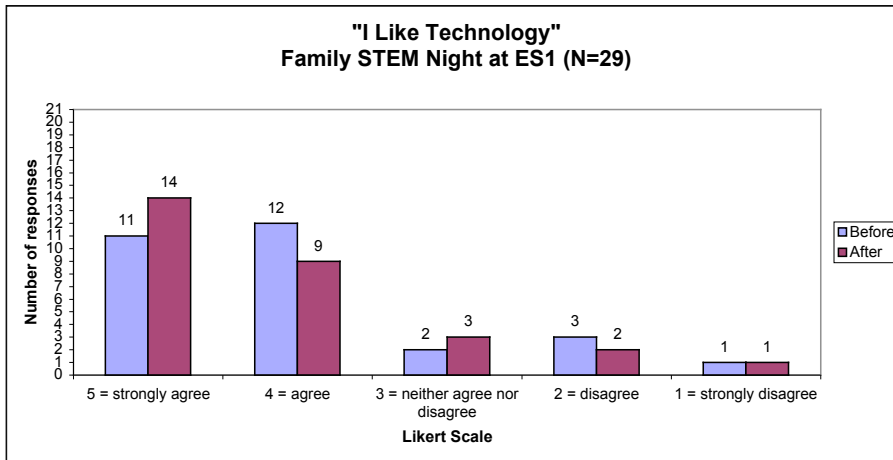


Figure 7: ES1 - "I like Engineering"

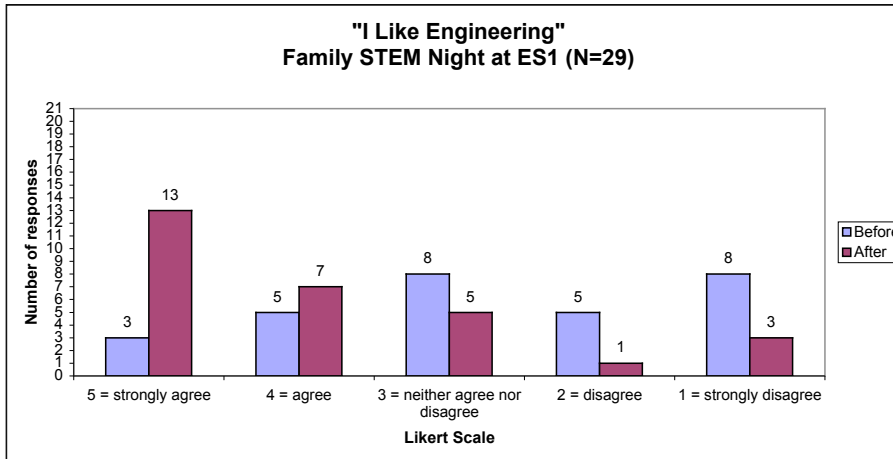


Figure 8: ES1 - "I like Math"

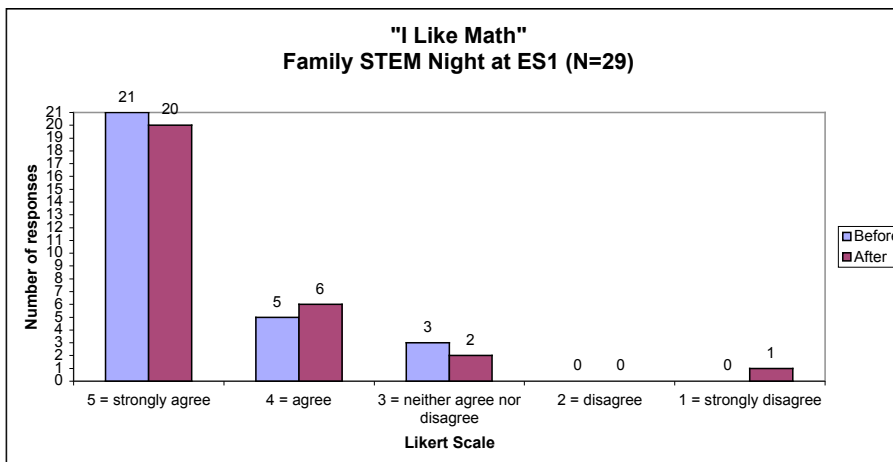


Figure 9: ES2 - "I like Science"

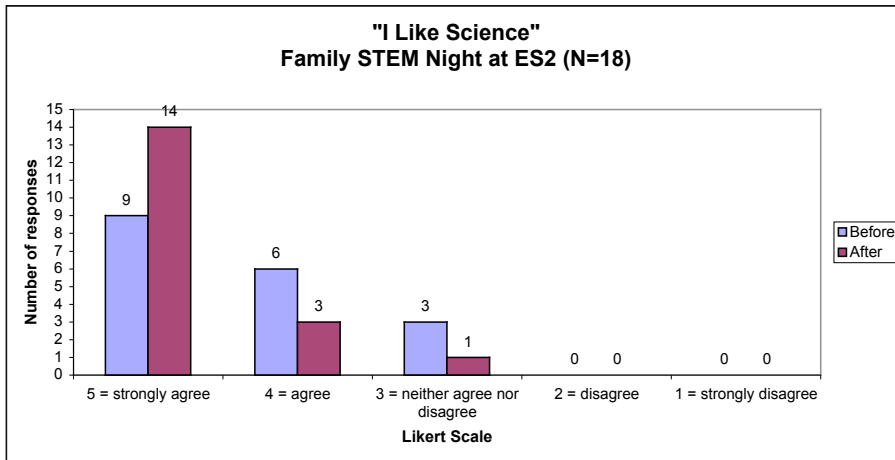


Figure 10: ES2 - "I like Technology"

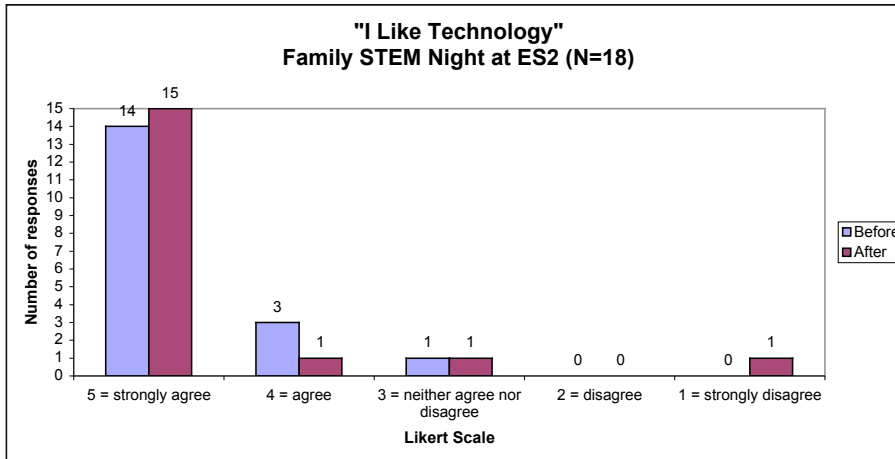


Figure 11: ES2 - "I like Engineering"

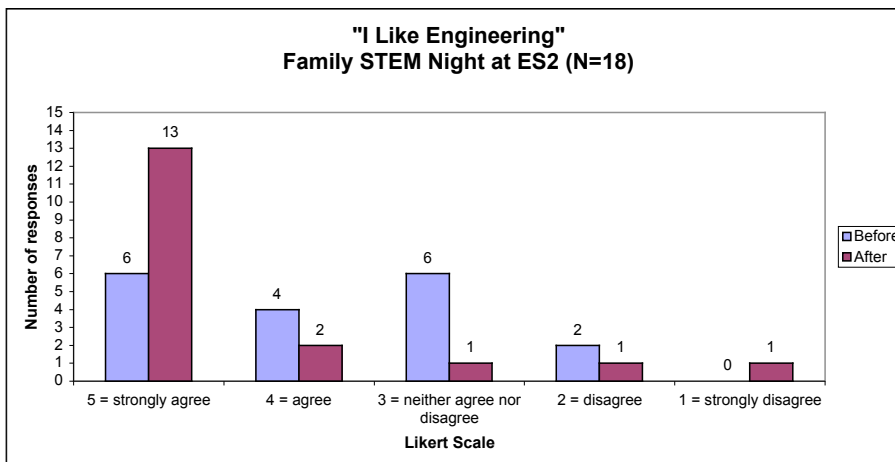


Figure 12: ES2 - "I like Math"

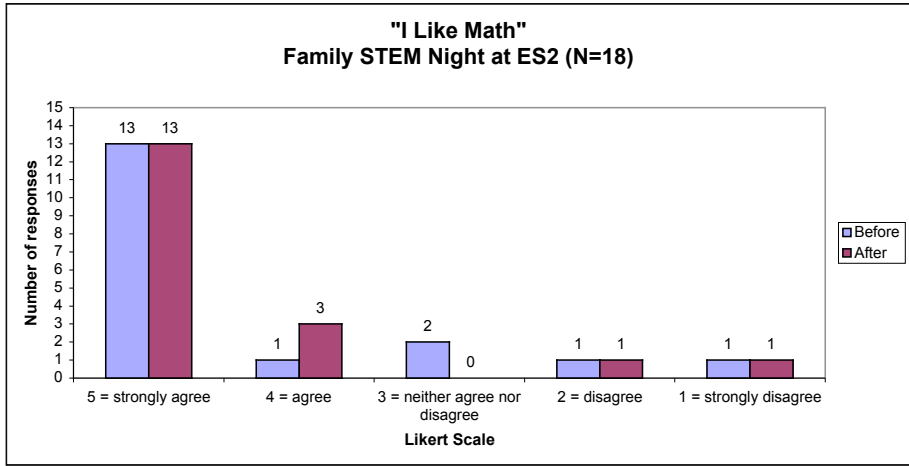


Figure 13: MS1 - "I like Science"

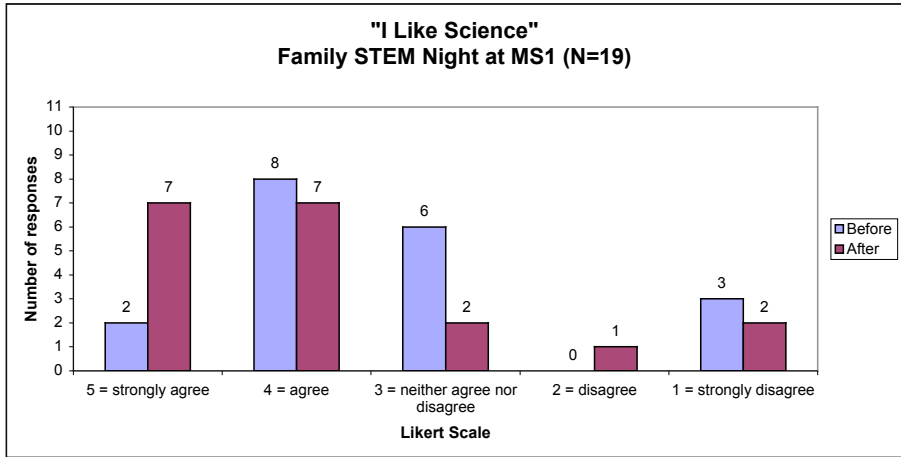


Figure 14: MS1 - "I like Technology"

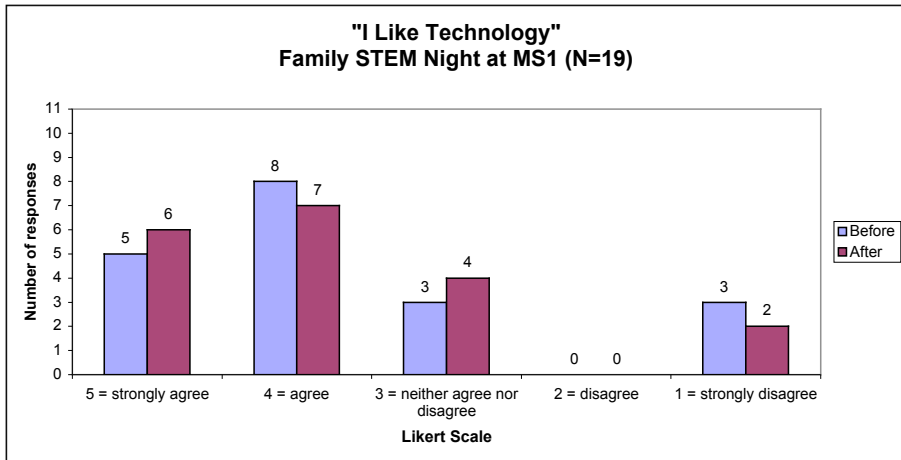


Figure 15: MS1 - "I like Engineering"

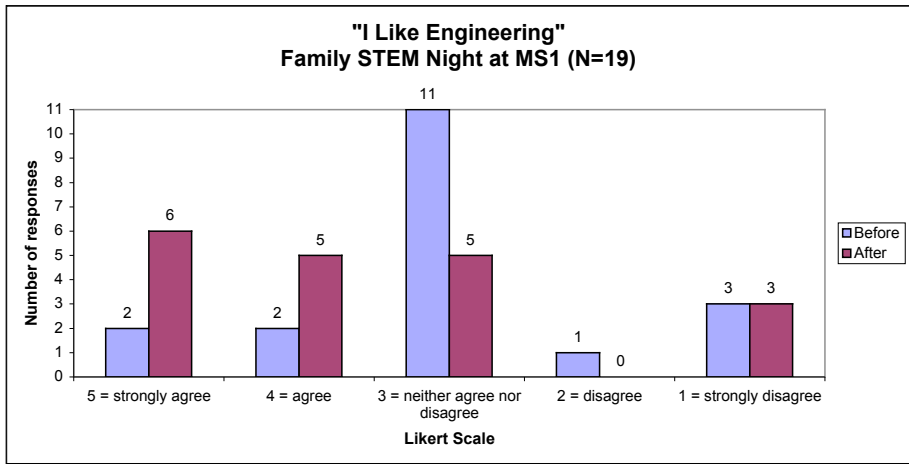
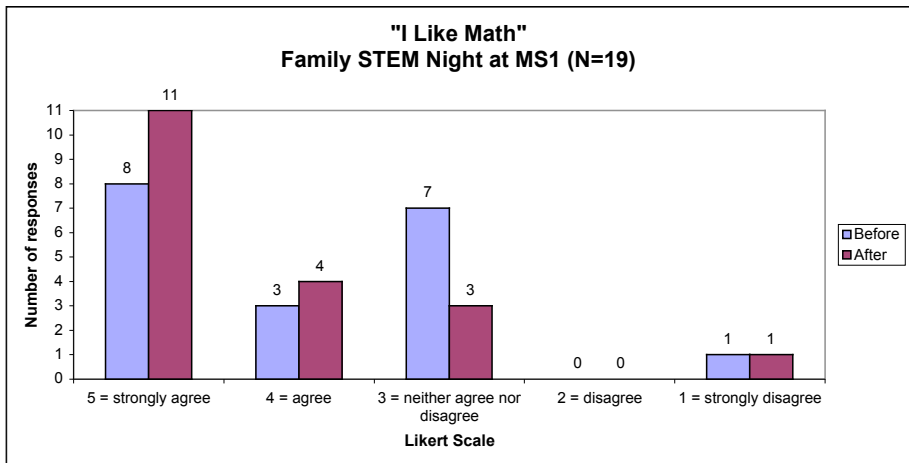


Figure 16: "I like Math"



Results

The goal of this project was to measure the effectiveness of a Family STEM Night in introducing students to science, technology, engineering and math in order to increase their awareness of these disciplines and hopefully inspire them to like these fields.

It was hoped that students would gain a better awareness of science, technology, engineering and math through hands-on activities at the Family STEM Night. While it was not expected to see any change in awareness of science, technology and math, we did expect growth in awareness of engineering. The responses for science, technology and math did meet our expectations. For engineering, there was a 24%, 9% and 21% increase in awareness at ES1, ES2 and MS1 respectively just by participating in a Family STEM Night. Upon performing a paired t-test on each sample, the increases in awareness for ES1 ($p < 0.05$, 28 df) and MS1 ($p < 0.05$, 18 df) were significant.

It was hoped that students would be inspired to like science, technology, engineering and math through hands-on activities at the Family STEM Night. Again, it was not expected to see a change in likeability of science, technology and math, but we did expect a significant, positive change in likeability of engineering. The average response of each sample before and after the event as well as the percent change is depicted in Figures 17-19. The responses for technology and math did meet our expectations. Surprisingly, there was an 11%, 9% and 16% increase in likeability of science and a 47%, 16% and 21% increase in likeability of engineering at ES1, ES2 and MS1 respectively. Upon performing a paired t-test on each sample, ES1 ($p < 0.05$, 28 df), ES2 ($p < 0.5$, 17 df) and MS1 ($p < 0.05$, 18 df) data were significant for increases in science and engineering likeability. MS1 also showed significant gains in math likeability: a very positive result for this age group.

Figure17: ES1 - Likeability of Disciplines

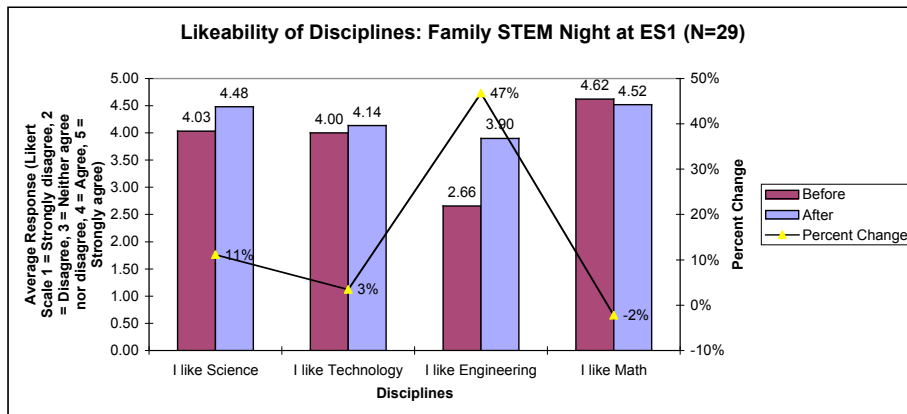


Figure18: ES2 - Likeability of Disciplines

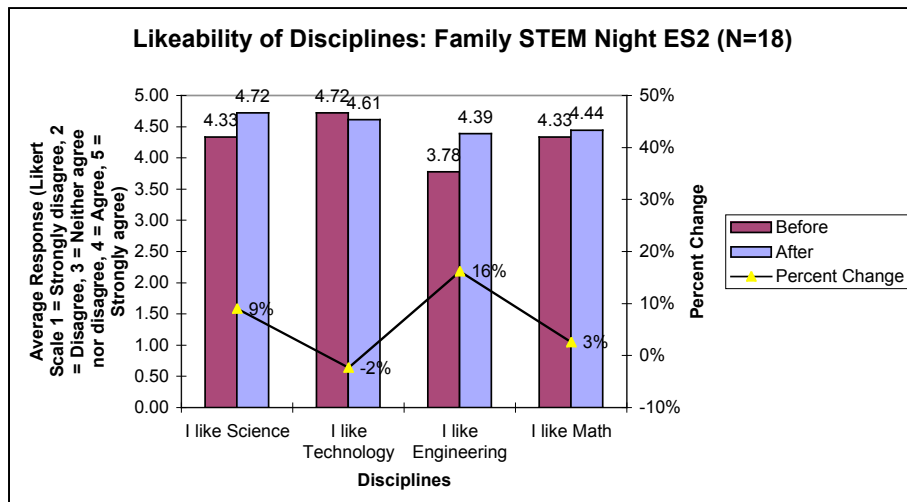
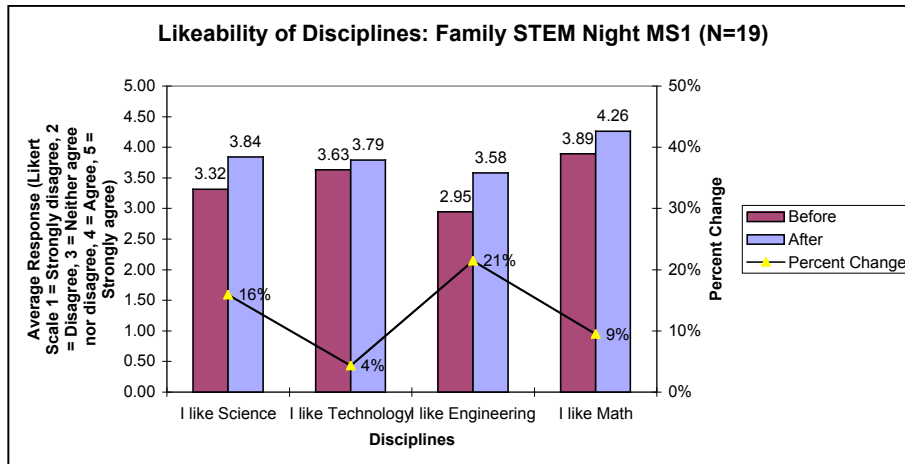


Figure19: MS1 - Likeability of Disciplines



Conclusion

Overall, the results were positive. Because all students were already aware of science, technology and math, there were no significant gains or losses in awareness of these disciplines due to participation at the Family STEM Night. All three schools had positive increases in awareness while only ES1 and MS1 had significant ($p < 0.05$) results.

Since one of the underlying goals of the Family STEM Night is to reduce the “fear-factor” of these disciplines, it was very encouraging to see an increase in the likeability of (almost) each discipline at each school. There was an 11%, 9% and 16% increase in likeability of science and a 47%, 16% and 21% increase in likeability of engineering at ES1, ES2 and MS1 respectively. Family STEM Nights at all three schools showed significant ($p < 0.05$) increases in science and engineering likeability. MS1 also showed significant gains in math likeability: a very positive result for this age group.

Future work would include redefining the assessment tool to remove self-assessment questions. The goal would be to ask more objective questions to better quantify the students’ awareness and knowledge of the STEM disciplines before and after the Family STEM Night so that growth can be more accurately measured. Another area of work would be to improve the response rate. At all three schools, approximately 50-100 students completed both the before and after survey but they were often not the same student and hence the sample sizes were small. A more controlled environment would be helpful to ensure that all the students who complete the before survey, complete the after survey as well.

Given the positive results, one can conclude that the Family STEM nights are effective outreach events that help make students in grades 3-8 more aware of engineering and help improve the likeability of science and engineering without minimizing the awareness or likeability of technology and math.

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References and Footnotes

[1] Neill, J. (2005). *John Dewey: Philosophy of Education*. Retrieved Jan. 5, 2010, from Outdoor Education Research & Evaluation Center, New Hampshire. Web site: <http://wilderdom.com/experiential/JohnDeweyPhilosophyEducation.html>.

[2] Cunningham, C. M. (2010). *Engineering Is Elementary*. Retrieved Jan. 5, 2010, from Engineering is Elementary, Boston, MA. Web site: <http://www.mos.org/eie/index.php>.