# Robofest Carnival – STEM Learning through Robotics with Parents

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***Abstract* – It has been widely known that introducing robotics in formal and informal learning environments improves STEM learning as well as problem solving skills. An underutilized resource in this process of teaching STEM is parents. Robofest Carnival is an informal learning program with multiple interactive challenge learning stations where students are challenged to complete robotics tasks. A new approach for the Carnival was explored. Instead of technical staff, parents of participants were trained to manage the challenge learning stations. Ongoing research shows that the Carnival program increased the students' knowledge of STEM subjects. In addition, it dramatically increased STEM confidence level of parents who took training and assisted the Carnival learning stations. We believe the Carnival model is a practical and effective informal robotics learning environment to improve student achievement in STEM and increase parents' confidence in their children's education.**

*Index Terms* – Autonomous robotics, STEM education, Learning engaged with parents, The Role of Parents in Education.

## INTRODUCTION

Autonomous robotics can play an important role in Science, Technology, Engineering, and Mathematics (STEM) education because it naturally promotes active hands-on learning and the integration of STEM subjects with computer programming [1].

Robofest is a festival of competitions and events that inspire & support students to learn principles of STEM and computer science through autonomous robots that are designed, constructed, and programmed by students. Robofest offers a wide variety of programs that fit many robotics experience levels and interests as shown in FIGURE I [2].

This paper is about the Robofest "Carnival" program, shown left bottom corner in FIGURE I, launched in April 2014 as a part of annual DENSO's "Bring Your Child to Work Day". In this program, each participant visits multiple hands-on and interactive learning stations of her/his choice, like attending a carnival event with attraction booths. Each station is manned by Robofest staff members or a Lawrence Technological University engineering students who teach visitors basic knowledge & skills to solve the challenge of the specific station.

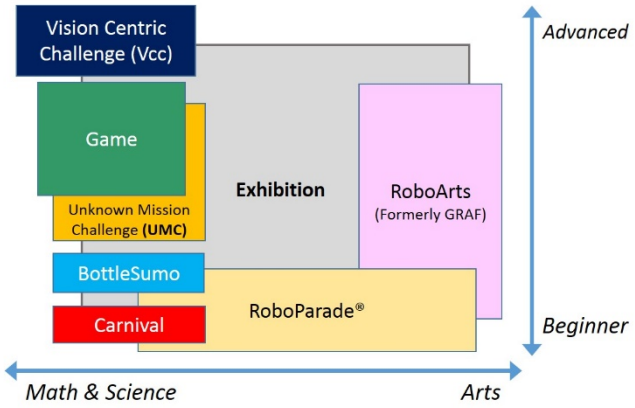



FIGURE I
ROBOFEST PROGRAM CATEGORIES

Every year since 2014, we realized that the only contribution of parents, similar to many other educational programs, was to provide children with transportation. Is anything more possible? Parents are a critical component of STEM education, but most do not have sufficient skills. Is there a way to improve STEM skills sets of parents and enable them to teach STEM to their children?

This paper describes a new way to organize a Robofest Carnival together with parents of the participants. This idea stems from multiple researches about the importance of parental involvement in children's education to foster both cognitive growth and achievement motivation [3][4]. According to [4], the academic outcomes can be very positive when teachers and educational administrators are strongly committed to drawing parents into their children's education. Paper [5] presents a significant difference in building and programming aspects of robotics projects between a project by children only group and a project by parent-child group. Paper [6] stresses the importance of adult involvement in STEM. Paper [7] and [8] underscore the role that hands on robotics can play in STEM education. This work builds on previous work by using robotics as the medium to engage parents, teach them STEM skills, and enable them to teach their children.

Main goals of this study about engaging parents into the Carnival program are: (1) to find out whether parental

involvement increases students' STEM learning and interest in future STEM careers, (2) to suggest an effective model to coordinate parents in their children's STEM education with robots, (3) to develop practical STEM robotics programs that reach out to inner-city families and help parents learn about STEM robotics so that they can inspire and motivate their children.

In this paper, we first introduce tasks of 8 learning stations in the Robofest Carnival. The next section describes how we conducted a specific Carnival on June 9-10, 2017 together with Detroit Parent Network (DPN) by training participants' parents so that they can teach children and manage learning stations. The third section in this paper analyzes pre and post test data from both parents and children to see whether the involvements of parents improved the learning of children in STEM education. The last section summarizes what we have learned in this study and suggests improved methods for both parents and children to maximize STEM learning.

## EIGHT ROBOFEST CARNIVAL CHALLENGES

Robofest Carnival program has developed the following small and incremental challenges targeting novices to provide fun & unforgettable hands-on coding and STEM learning experience through interactive robots.

### *I. Robot-Dance Coding Challenge*

Students will learn how to program a robot to move forward and backward repeatedly. Then a maximum of 20 minutes is given to program a pre-assembled robot to perform twist dance movements from scratch.

### *II. Scorpion Robot Coding Challenge*

This challenge requires successful completion of the Robot-Dance coding challenge above. Students will learn how to (1) use a switch block to make decisions for each case and (2) receive a Bluetooth message. The final task is to program a pre-assembled scorpion robot to move forward, backward, left, right, and stop when the corresponding Bluetooth message is received.

### *III. Scorpion Balloon Blaster*

Students are asked to answer a math or science trivia quiz card. (See FIGURE II.) If the answer is correct, then they will have the chance to play with a LEGO scorpion robot to pop a balloon using a remote computer programmed as "Scorpion Robot Coding Challenge" above. (See FIGURE III and IV.) If the answer is not correct, the student may go back to the end of the line to try the trivia quiz again. Winners will be announced based on the completion time.

FIGURE II
A STUDENT IS ASKED TO ANSWER A MATH OR SCIENCE TRIVIA QUIZ CARD

FIGURE III
A STUDENT WITH A REMOTE CONTROLLER PROGRAMMED

FIGURE IV
A SCORPION ROBOT WITH A PUSH PIN IS POPPING A BALLOON

### *IV. Robot Goal Challenge*

Students are first asked to design and assemble a Lego block structure to kick a tennis ball. Then they will have the chance to play with the soccer robot. There will be 4 or more numbered tennis balls on the field and some obstacles. (SEE FIGURE V.) The goal is to maximize the sum of numbered balls successfully kicked into the goal. Some balls are easy to kick in, but the values will be low. Only 2 minutes will be given for each player. Winners will be announced based on the scores earned.

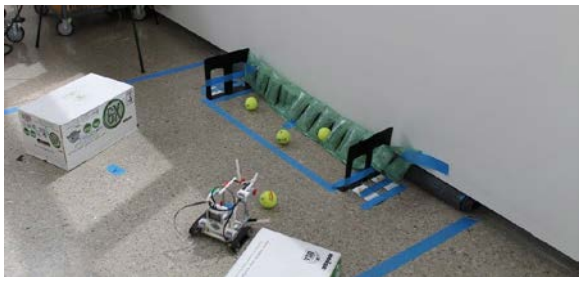


FIGURE V
A ROBOT GOAL CHALLENGE FIELD WITH 4 BALLS AND 2 OBSTACLES

*V. Speed Calculation Challenge*

After introducing the concept of speed/velocity calculation, a robot car will be started to follow a straight black line. (See FIGURE VI.) When it stops at the red color tape at the end of the black line, the robot will display the time taken from the beginning. Students are asked to calculate the speed of the robot car in cm/sec as well as inches/sec. Students will be given a tape measure. Winners will be announced based on the accuracy and mathematical formulas of the calculation.

FIGURE VI
A STUDENT IS MEASURING A DISTANCE TO CALCULATE THE SPEED OF A ROBOT CAR

*VI. Block Math*

Students are asked to calculate the number of Lego blocks used to construct shapes/structures (FIGURE VII), predict a pattern (FIGURE VIII), and calculate a gear ratio (FIGURE IX). 4 minutes are given for all the questions. Winners will be announced based on (1) accuracy, (2) use of math formulas / calculations, and (3) time to calculate.

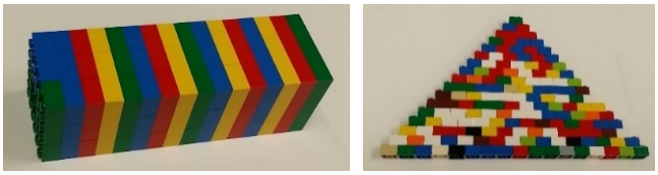


FIGURE VII
LEGO STRUCTURES TO BE USED FOR BLOCK COUNTING

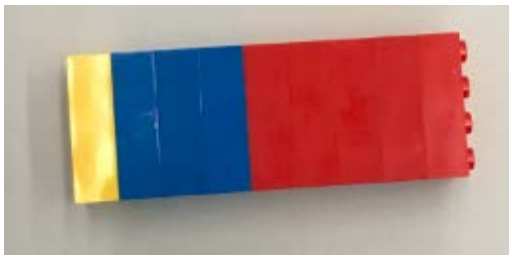
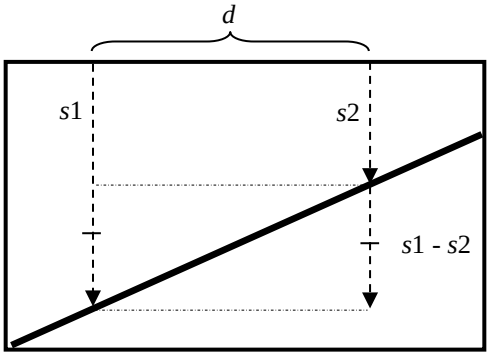


FIGURE VIII
A LEGO STRUCTURE TO PREDICT THE NEXT PATTERN

FIGURE IX
LEGO GEAR STRUCTURE TO CALCULATE A GEAR RATIO. DRIVEN GEAR HAS 24 TEETH

*VII. Calculate the slope*

Each student is given a distance sensor connected to a Lego robot controller. They must watch a presentation to understand how the sensor works. The goal is to calculate the slope of a secret ramp inside a black-box using the distance sensor. FIGURE X shows how the slope can be calculated with two sonar sensors measuring two distances, $s1$ and $s2$. Winners will be announced based on the mathematical description of how to solve the problem and the accuracy of the solution.




$$slope = \frac{s1 - s2}{d}$$

FIGURE X
THE SLOPE INSIDE A BLACK BOX


FIGURE XI
THE BLACK BOX WITH A SECRET SLOPE HAS 4 HOLES FOR SONAR SENSORS ON THE TOP SIDE

*VIII. Lifter Design and Race*

If the controller is programed correctly, Students are asked to design a robot arm to lift a LEGO barbell. If a student brings back the barbell using the robot with the arm, the mission is accomplished. Winners will be determined based on the programming completion time and the game completion time. FIGURE XII shows a solution of the arm for the barbell.

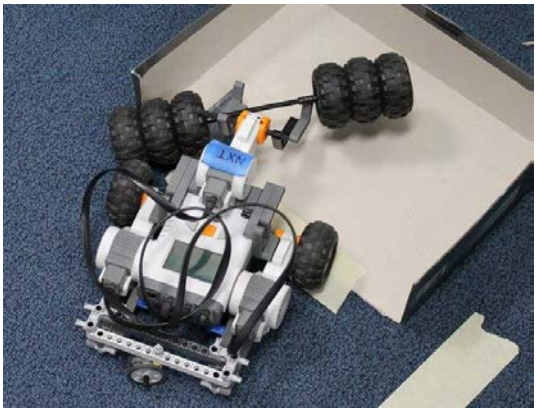


FIGURE XII
A ROBOT WITH AN ARM TO LIFT A LEGO BARBELL

## CARNIVAL WITH DETROIT PARENT NETWORK (DPN)

Detroit Parent Network (DPN) sponsored by Ford Motor Company fund recruited 32 students in 4th ~ 8th grade and 18 parents and grandparents. Parents were assigned to 7 stations based on their preference as well as skills. Robofest staff trained parents one day before the event for around 3 hours in the evening. Since some students left early the total number of student who participated in both Pre and Post-tests was 24. Total number of interactive learning stations were 7. Lifter Design and Race was not used for the DPN Carnival. FIGURE XIII ~ XVII show some interactions between parents and students for the activities.

FIGURE XIII
DETROIT PARENT NETWORK PARENTS AND STUDENTS

FIGURE XIV
PARENTS ARE HELPING WITH CHILDREN FOR CODING

FIGURE XV
LOGO OF THE INSTITUTE FOR ELECTRICAL AND ELECTRONICS ENGINEERS

FIGURE XVI
LOGO OF THE INSTITUTE FOR ELECTRICAL AND ELECTRONICS ENGINEERS


FIGURE XVII
LOGO OF THE INSTITUTE FOR ELECTRICAL AND ELECTRONICS ENGINEERS

## ANALYSIS OF PRE AND POST ASSESSMENT DATA

### *I. Assessment results for Students*

Do you think you learned something about Science, Engineering, Technology, and/or Math (STEM) today? Please circle a number that best represents how you feel on a scale of 0 to 9.

Did not learn any STEM 0 1 2 3 4 5 6 7 8 9 Learned some STEM

The above question was asked only in the post test. Regarding STEM learning, participants gave 7.8 out of 9 (87%) points.

Do you like Science, Technology, Engineering, and/or mathematics (STEM) related classes? Please circle a number that best represents how you feel on a scale of 0 to 9.

Do **not** like STEM classes 0 1 2 3 4 5 6 7 8 9 Love STEM classes

The above question was asked both in Pre and Post-test. Average likeness score of STEM increased to 6.2 in Post-test from 6.1 in Pretest. Even though the average score increased, statistic test does not have convincing evidence that the Carnival experience increased the DPN students' like of STEM classes.

Are you interested in a future career involving Science, Technology, Engineering, and/or mathematics (STEM)? Please circle a number that best represents how you feel on a scale of 0 to 9.

**Not** interested at all 0 1 2 3 4 5 6 7 8 9 Very much interested

The above question was asked both in Pre and Post-test. Average interest score of STEM increased to 6.7 in Post-Test from 6.0 in Pretest. Even if the average score increased, statistic test does not have convincing evidence that the Carnival experience increased the DPN students' interest in future STEM careers.

What's the name of wireless technology for exchanging data over short distance between (mobile) computing devices, typically less than 10 meter (33 feet)? _____

The above question was asked both in Pre and Post-test. Pretest 21% correct, Post-test 63% correct; statistic test shows that we have convincing evidence that the Carnival experience increased the DPN students' knowledge of wireless technology.

If your dad drives 50 miles per hour for *n* hours, how many miles did he drive?
_____ miles

The question had a very high percentage of correct answers on the pretest when n = 2. There were only two incorrect answers out of 24 responses. On the post test, 3 was used for n, there were four incorrect answers. However, three out of the four incorrect answers were "100", which was the correct answer to the pretest. It appears that the students misread the question, assumed that it was exactly the same question as in the pretest, and used the same answer. Therefore, we decided not to analyze this question in this study.

If a little gear is driving a big gear (this is called gearing down), then the big gear will:
A) Rotate faster
B) Rotate slower
C) Rotate at the same speed
D) I don't know

The above question was asked both in Pre and Post-test. Pretest 43% correct, Post-test 75% correct; Statistic test shows that we have convincing evidence that the Carnival experience increased the DPN students' knowledge of gear ratios. Summary Graphs of Assessment results for Students are shown in FIGURE XVIII and FIGURE XIX.

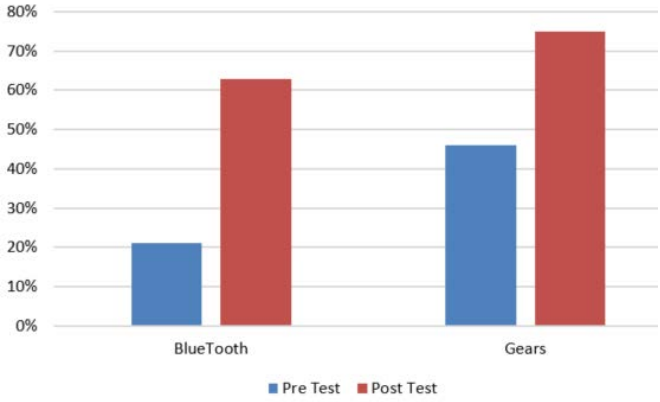



FIGURE XVIII
COMPARISONS OF PRE AND POST TEST RESULTS FOR TWO STEM QUESTIONS

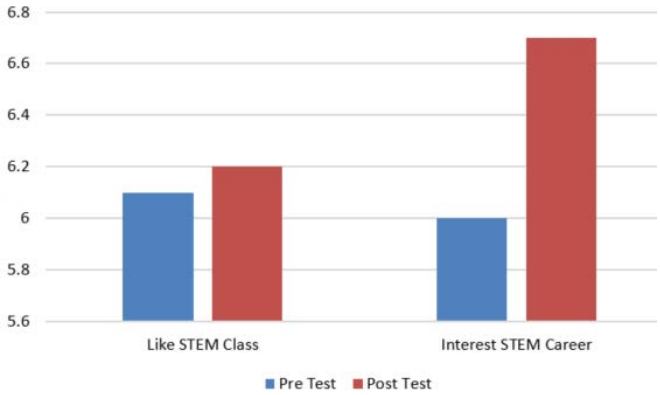
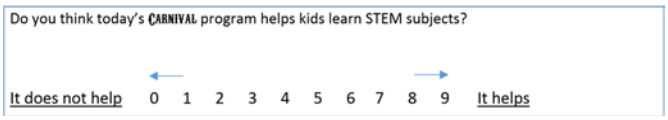
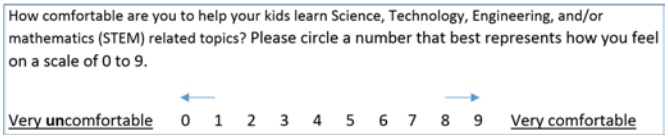



FIGURE XIX
COMPARISONS OF PRE AND POST TEST RESULTS FOR TWO STEM RELATED QUESTIONS

*II. Assessment results for Parents*




12 parents gave average 8.7 points out of 9 (97%) for the question whether the Carnival program helped children learn STEM subjects.




Eight parents participated in both Pre-survey and Post-survey. Their average STEM confidence level increased from 5.8 in Pre-survey to 8.8 in Post-survey as shown in FIGURE XX.

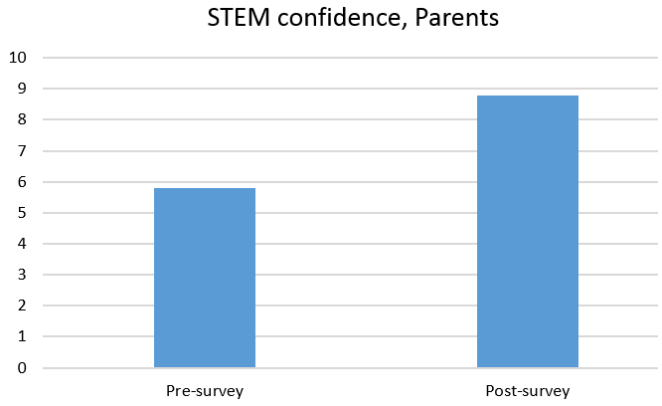



FIGURE XX

COMPARISONS OF PRE AND POST SURVEY RESULTS FOR STEM CONFIDENCE LEVEL OF PARENTS WHO ASSISTED THE CARNIVAL PROGRAM

## SUMMARY AND CONCLUSION

Robofest Carnival statistic tests show convincing evidence that the Carnival experience with parents increased the DPN students' knowledge of some STEM subjects. In addition, the Carnival program dramatically increased STEM confidence level of parents who took training and assisted the Carnival interactive learning stations.

Based on the preliminary assessment results and personal communications with parents, we are certain that the Robofest Carnival model that trains parents before the event and assigns them specific technical roles for small and incremental challenges is an effective and practical model for their children's cutting edge STEM education with autonomous robots.

The event successfully reached out to inner-city underrepresented families and helped parents gain and increase confidence in STEM education. They realized that they can not only provide transportation, but they can also inspire and motivate their children by teaching and instructing children in STEM challenges.

We also learned that scheduling of inner-city parents for stations was not easy since some of parents had busy part-time work schedules on Saturdays. Childcare facilities were needed for younger siblings, since the whole family had to come to participate in the program.

Continued research with lager population size is needed to prove statistically that the Carnival experience can increase students' STEM confidence and interest in future STEM careers. Additional research with a control group is also being planned. We will also investigate how the program can be generalized and scaled.

## ACKNOWLEDGMENT

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