

# DEVELOPMENT OF METHODOLOGIES TO ASSESS THE IMPACT OF AUTONOMOUS ROBOTICS COMPETITIONS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH EDUCATION

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## Abstract

Competition can drive students to work harder resulting in better acquired skills. Our goal is to assess how robotic competitions improve students' science, technology, engineering, and math skills. To prove the unique benefit of interdisciplinary robotic competitions we need measurable data that quantifies the student's experiences. This can be acquired through short assessments given to a group of students before and after a robotics competition. Another group of students, who did not participate in the competition, act as a control group by also taking the same pre and post-assessments. Methodologies including assessment questions, procedures and web-based database tools were developed to aid in this research. User friendliness was a key requirement. Robofest ([www.robofest.net](http://www.robofest.net)), an annual autonomous robotics competition for 5th to 12th grade students, was used to complete this research. Robofest challenges teams of students to design, build, and program robots. A web-based assessment tool, allowing the researcher to anonymously gather assessment data and analyze the students' performance, was developed and integrated into the website Robofest.org. This tool included functions for contacting competition coaches using the Robofest database, posting online assessments, gathering data, and analyzing results. The tool also generated unique codes to insure full anonymity for students. The codes were used to hold the assessment results to compare the pre- and post-assessment scores. A preliminary test was held during RoboParade 2008, a sub program of Robofest. At this event the tools were proven to work completely for data acquisition. However, the environment, timing, and interface all had unexpected effects on student and coach participation during the test. Psychological aspects of this assessment were realized and had to be incorporated into a refinement of the overall methodology. In order to collect statistically reliable and valid data the system has to be tailored to encourage a dynamic group of volunteers to participate even though they get no direct reward. Incorporating these lessons learned will enhance our scientific process of measuring the improvement of the participants' skills.

## Keywords

academic, assessment, competition, education, engineering, evaluation, mathematics, methodologies, research projects, robotics, science, technology

## 1. INTRODUCTION

The objective of this research is to study the math and science skill levels of students participating in a Robotics competition or event. We hypothesize that students participating in robotics competitions will demonstrate skills they would not have gained outside of the competitions. The robotics aspect requires students to apply and expand their math and science skills beyond what many of them are learning in school [1]. Robotics also strongly encourages creativity and problem solving skills [2]. Furthermore, we believe students are more motivated in an exciting competitive environment than in a typical classroom [3]. To prove this we need measurable data to quantify the students' experiences. We can acquire this data from assessments given to students before and after a robotics competition. The robotics competition we assessed was RoboParade 2008, a sub-event of Robofest.

Robofest [4] is an international autonomous robotics competition that is dedicated to providing the utmost educational experience possible to all the students participating. The goal of the competition is for middle and high school students to make their own autonomous robotic vehicles and devices. They work in teams under an adult coach and take part in tournaments. Robofest strives to provide a fair and challenging contest that encourages learning and dedication as a means to overcome obstacles and best other students. Furthermore, designing, building, and programming autonomous robots provide a comprehensive approach to involving the students in engineering and science.

To acquire the data, students are tested before and after a competition to see if their skills increase. A group of students who are not participating in the competition also take the assessments to act as the control group. A set of evaluation tools was created to allow for easy test creation and data analysis.

Robofest organizers and coaches use its home website, Robofest.org [5], for coordination and communication. A web-based assessment tool was developed and integrated into the website Robofest.org. The tool allows a researcher to anonymously gather assessment data and analyze the students' performance. This tool also includes functions for contacting competition coaches using the Robofest database, posting online assessments, gathering data and analyzing results.

This paper discusses the development of the process, tools, and review methodologies. A description of the actual experiment and an analysis of its results is given. Finally, the overall results of the experiment, including unexpected outcomes, are discussed.

## 2. METHODOLOGY

The main goal of the assessment system is to act as a tool for anonymously gathering test data from students before and after a Robofest competition. The system is used to analyze the students' performance. The assessment process, determined before our development of the tool began, is depicted in the sequence diagram in Figure 1 on the next page.

The process begins with an administrator creating pre-assessments for both the senior and junior divisions (if both are required) and choosing some coaches to participate in the assessment. The selected coaches are each sent an informative email with a link to a personalized PDF. The PDF contains all the materials the coach needs. Codes are created for each student associated with that coach for the current year. The coach codes are used to keep the assessment data anonymous but allow us to compare results of two different assessments taken at different times. The codes are distributed in groups by division (junior or senior).

The coach will give a code for the appropriate division (competition group) to each of the participating students on his/her team. Next, the students with codes go to Robofest.org and click the link on the main page to take the pre-assessment. This forwards them to the assessment page that asks for the code. Once the student enters the code, he/she is taken to the appropriate assessment based on his/her division and year. All of these steps are completed while registration is happening. Each student's unique code is saved by the database to match later with a post-assessment. When registration is over, the pre-assessments will be closed by the administrator. Administrator tools for analyzing and summarizing the pre-assessment data can then be used.

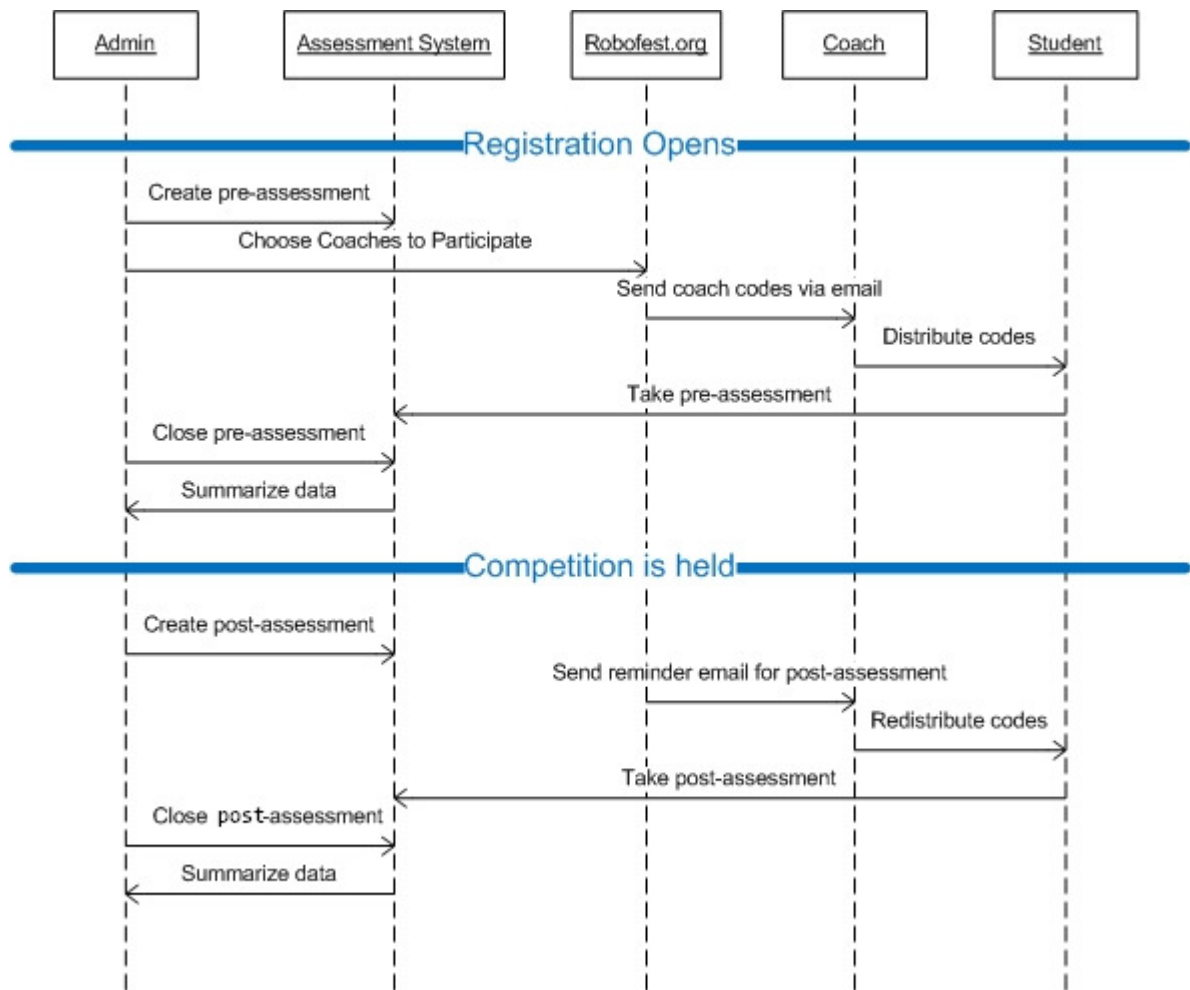


Fig. 1. The Assessment process sequence diagram.

Once the competition is done a post-assessment will be created by the administrator with questions of the same difficulty and subject matter as the pre-assessment. Now the administrator should send an automated reminder email through Robofest.org to all of the coaches who participated in the pre-assessment. The coaches will be asked to redistribute the same codes as they were given before to the same student. The material for the coach, to keep track of the codes and students, is included in the PDF sent in the request for participation email. The interfaces and databases are described in further detail in the 'Tools' section.

### 3. TOOLS

The requirements for the assessment tool lead to the development of a new administrator interface, a new student interface, and added tools on Robofest.org. Further, it required a redesigned database. All tools were created as Servlets to adhere to the structure of the core Robofest system. The server runs apache Tomcat, JDK 1.4, and Struts. The following sections describe the tools developed.

#### 3.1 Administrator Interface

The administrator first sees the assessment view page. Here, all of the assessments are listed and can be viewed. Each assessment can be opened, closed, viewed, edited and/or deleted. Opening an assessment allows students to take the assessment when they input their unique code. When a pre-assessment is closed, the student will be forwarded to the available open post-assessment. If the assessment does not exist or is closed, the student is notified.

The statistics for each assessment can be viewed using the “Get Stats” link (discussed further in a later section). Finally, an assessment can be edited or deleted at any time. The administrator is warned if they try to edit an assessment that already contains data. The administrator interface can be seen in Figure 2.

Assessment Administration								
<a href="#">Robofest.org</a> <a href="#">Robofest.net</a> <a href="#">Admin.Robofest.org</a>								
<b>Menu</b> <a href="#">View Assessments</a> <a href="#">Coaches</a> <a href="#">Analysis</a> <a href="#">Raffle</a>	<b>Status</b>	<b>Title</b>	<b>Year</b>	<b>Post/Pre</b>	<b>Division</b>	<b>URL</b>	<b>Actions</b>	<b>Analysis</b>
	closed	2008 Pre-RoboParade	RP08	pre-Robofest	junior	<a href="http://robofest.org/preroboparade2008.html">robofest.org/preroboparade2008.html</a>	[Edit] [Delete] [Open]	[Get Stats]
	open	2008 Post-RoboParade	RP08	post-Robofest	junior	<a href="http://robofest.org/postroboparade2008.html">robofest.org/postroboparade2008.html</a>	[Edit] [Delete] [Close]	[Get Stats]
[ Create New Assessment ]								

Fig. 2. A screen shot from the administrator interface.

Assessments are quick for administrators to create by following a simple step-by-step process on the website. Each assessment must have six attributes determined at creation: title, file name, year, division, instructions and pre/post designation. The divisions are categorized as junior or senior by the administrator, depending on the grade level of the student in the competition. For example, Robofest junior divisions are defined as 4th – 7th grade students and senior division is 7th – 12<sup>th</sup> grades. The assessment creation interface can be seen in Figure 3.

### Assessment Administration

[Robofest.org](#)   [Robofest.net](#)   [Admin.Robofest.org](#)

Assessment Editor Fill in assessment information

Title:	<input type="text" value="Assessment Title"/>
HTML File Name:	<input type="text" value="assessmentFileName"/> (Enter survey to create survey.html)
Year:	<input type="text" value="2009"/>
Division:	<input type="radio"/> Senior <input checked="" type="radio"/> Junior
Pre/Post:	<input checked="" type="radio"/> Pre Competition <input type="radio"/> Post Competition

Instructions:

Fig. 3. A screen shot from the assessment creation screen

There are three types of questions available to use in question creation: multiple choice, fill in the blank and short answer. Multiple choice questions allow up to five possible choices. In all types of questions, HTML attributes can be embedded into any question or multiple choice answers. Each question type allows the administrator to designate a correct answer allowing automated grading. The multiple choice interface can be seen if Figure 4.

A tool was needed for choosing which coaches would participate and receive codes. A coach can be selected by an administrator who is viewing the yearly participants. The interface displays the number of students being coached and if the coaches have been contacted by email to participate yet. From this screen the administrator can view or create codes. Each code is only embedded with the information from the year and division. There is no other information linking the student and code in the assessment system. The codes contain random numbers added by the database to further ensure anonymity and security. When the codes are generated the system creates a code for every student under that coach grouped by junior or senior division.

## Assessment Administration

Robofest.org   Robofest.net   Admin.Robofest.org

**Menu**

- [View Assessments](#)
- [Coaches](#)
- [Analysis](#)
- [Raffle](#)

Add Question

Question:

A unicycle moves forward 1.5 meters for one rotation of its wheel. How many rotations are needed for the same unicycle to move forward 9 meters?

Select Correct Answer: A

Choice A:	3	A		
Choice B:	6	B		
Choice C:	9	C		
Choice D:	18	D		
Choice E:		E		
		None		

Fig. 4. A screen shot from the multiple choice question creation screen.

From the administrator's coach detail page, an email can be sent to the coach that gives a brief description of what the coach should do. An automatically and dynamically generated PDF is created by the tool to provide an explanation of the procedure the coach should take when distributing the codes. The PDF also contains the exact number of consent forms for the students to sign and return. Finally, the PDF contains a table for the coach to record the students' codes, to track which students have returned the consent form and taken the assessment.

An answer checker was created to automatically check the assessment as soon as it is submitted. The checker stores the score with the code information. When the data is later analyzed by the researcher, the total scores for an assessment can be quickly viewed without any additional calculating. The administrator also has access to all of the basic statistics for the assessments and each individual question. Average test scores for each group tested and an overall average are available. Each question shows the percentage of frequency for each choice selected. The correct answer is highlighted in green. Examples are in Figure 5.

## Assessment Statistics

Robofest.org   Robofest.net   Admin.Robofest.org

**Menu**

- [View Assessments](#)
- [Coaches](#)
- [Analysis](#)
- [Raffle](#)

**Assessment Title**

2009, Junior Pre-Test  
Robofest Students: 2, Guest Students: 2, Total: 4

Average Scores:

Robofest Students	Guest Students	Total
50.00%	75.00%	62.50%

**1. A unicycle moves forward 1.5 meters for one rotation of its wheel. How many rotations are needed for the same unicycle to move forward 9 meters?**

Choice	Robofest Students	Guest Students	Total
A. 3	50%	0%	25%
B. 6	50%	100%	75%
C. 9	0%	0%	0%
D. 18	0%	0%	0%

Fig. 5. A partial screen shot from the statistical analysis page.

An offline tool was created to assist in ensuring a post-assessment was comparable with the pre-assessment. The tool is a simple excel sheet that tabulates the count for each subject and type of question. The breakdown of the subjects and types is referenced in Table 1. When writing the post-assessment we made sure there was an equivalent amount of each subject and type of question. The post-assessment questions consisted of: one combined question from the pre-assessment, 2 split

questions from the pre-assessment, 6 parameter changed questions from the pre-assessment, and 6 new questions. The last variable in the table shows the average difficulty for the pre and post-assessments. The pre-assessment question difficulty was determined by giving a score based on the percentage of students who actually gave the correct answer averaged with our own estimate of difficulty. The post-assessment difficulty was based only on our own estimate of difficulty. From here we tweaked the post-assessment questions until an average difficulty similar to the pre-assessment was achieved.

A raffle function was developed after RoboParade for reasons discussed in the 'Results' section of this paper. This function is used by the administrator to identify random winners for a raffle held at the end of the competition. Each coach that is able to get 80% or more participation from his/her students in the assessment is entered into the raffle for a prize for the coach/team. A raffle function for individual students was also created. If a student participates in both the pre and post-assessments, then his/her code is entered into the raffle. This code is associated with a specific coach so all winners will be notified through the coach via email. The coach should have a list of students and their associated codes that only the coach will possess. This process ensures that anonymity is continued throughout the entire assessment process.

Pre-Assessment		Post-Assessment	
Subject	Count	Subject	Count
Algebra Questions:	6	Algebra Questions:	6
Geometry Questions:	3	Geometry Questions:	3
Logic Questions:	1	Logic Questions:	1
Statistical Questions:	3	Statistical Questions:	3
Physics Questions:	2	Physics Questions:	2
Type	Count	Type	Count
Multiple Choice:	13	Multiple Choice:	13
Fill in the Blank:	2	Fill in the Blank:	2
<b>Average Difficulty:</b>	<b>2.23</b>	<b>Average Difficulty:</b>	<b>2.20</b>

Table 1. The pre-assessment and post-assessment subject and type counts.

### 3.2 Student Interface

The student interface is a simple code input page that directs the student to the correct assessment based on pre/post, year and division. If anything is wrong with the code, or if the student has already taken the assessment before, then the student is given a helpful message describing the error. The assessment itself is a simple HTML page. Each multiple choice question has radio buttons to select the choices. Each question has a hidden "default" radio button to track if the student did not attempt an answer.

## 4. EXPERIMENT

The first large scale experiment was conducted during RoboParade 2008. RoboParade is a Robofest sponsored robotics event held near the U.S. Thanksgiving holiday. During this event students worked on teams to design a small robotic parade float. Students often use this event as an opportunity to display their creativity with an interesting and intricately designed robot float, including moving parts. The robots must be able to follow a black line and stop if they bump into a slower moving float.

We started requesting students to take the pre-assessment during early RoboParade registration. Every student taking the assessment was required to have a guardian sign a participation consent form. Additionally, a disclosure form was required for the online assessment, as seen in Figure 6.

## DISCLOSURE

This survey questionnaire is for a research project for improving math, science, engineering, and technology education. You will be asked some basic math and science questions. Filling it out is completely voluntary. All answers will remain completely anonymous. An analysis of the results and an explanation of the study will be available at [www.robofest.net](http://www.robofest.net). If you have any questions about this research, you can contact me in the address below.

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This research project has been approved by the Institutional Review Board at Lawrence Technological University. Thank you for your help.

Do you agree and give consent to take the survey?

Fig. 6. Disclosure Form – Approved by LTU IRB

To increase the number of participants, we encouraged students to take the pre-assessment during workshops held by Robofest. Coaches and students attend free workshops at Lawrence Technological University on robotics basics. For our control group, we found teachers to distribute the pre-assessment to his/her class during the same period as the Robofest students took the pre-assessment. We provided printed assessments to students who did not have access to a laptop computer. The pre-assessment period was open for a week and a half. The post-assessment was opened the day of the RoboParade event. Students were reminded at the event to complete the post-assessment just before the event started. Printed tests and computers were available for students to sit down in a quiet corner to complete the post-assessment. The online post-assessment was kept open for an additional two weeks after the event.

## 5. ANALYSIS

The data acquired through the online assessment system was analyzed in depth. Both the Robofest and control group were analyzed separately for both pre- and post-assessments. The sample data was first checked for normality and then summarized with some basic descriptive statistics. The useable data was analyzed for significant correlations and meaning.

### 5.1 Pre-Assessment

The pre-assessment yielded a rather small sample size for both the Robofest student group and the control group. The sample size for the Robofest group was  $n = 29$  and the sample size for the control group was  $n = 26$ . These are both under the recommended sample size of 40 for a population of 65 (RoboParade participant population). With a sample size of 40 we could assume a 10% margin of error, 95% confidence level and a 50% response distribution [6]. With a sample size of 29 and 26 we can assume a 15% margin of error, 95% confidence level and a 50% response distribution. This data was then checked for normality. A normality check is important so that all later statistical calculations are considered valid since they require a normal population. First, the data was plotted on a normal probability plot. This is a vague test for normality, if the data shows a pattern that is almost a straight line then the data can be considered from a normal population. The probability plots can be seen in Figure 7 for both the Robofest and control group samples, respectively. Both probability plots appear to be a somewhat straight line. The Robofest group appears to have a higher variance.

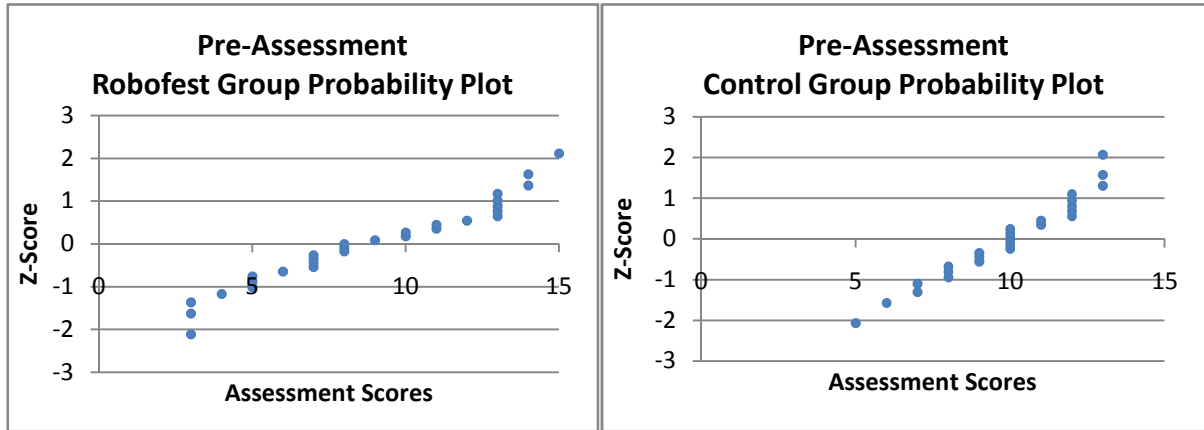


Fig. 7. Pre-assessment probability plots for the Robofest and control groups.

For more precision needed we decided to use the Shapiro Wilk Test for Normality. This test checks the null hypothesis that a sample comes from a normally distributed population. The results of this test can be seen in Table 2 below.

Robofest Group			Control Group		
$\alpha$ Quantile Shapiro-Wilk:	0.932		$\alpha$ Quantile Shapiro-Wilk:	0.946	
$\alpha$ Significance Level	Test Statistic	Test Result	$\alpha$ Significance Level	Test Statistic	Test Result
0.01	0.898	Passed	0.01	0.891	Passed
0.05	0.926	Passed	0.05	0.920	Passed
0.10	0.937	Failed	0.10	0.933	Passed

Table 2. Table of Shapiro Wilk Test results for the pre-assessment.

The Robofest group passed the test for normality for all levels of significance except for the 0.1 level. The control group passed all of the normality tests. This information indicates that the control sample is more normally distributed than the Robofest group but both data groups are usable. The descriptive statistics for the pre-assessment sample data for both the Robofest and control group can be seen below in Table 3.

Robofest Group			Control Group		
<b>Average Score:</b>	8.86	59.08%	<b>Average Score:</b>	9.88	65.90%
<b>Max Score:</b>	15	100.00%	<b>Max Score:</b>	13	86.67%
<b>Min Score:</b>	3	20.00%	<b>Min Score:</b>	5	33.33%
<b>Standard Deviation:</b>	3.75		<b>Standard Deviation:</b>	2.21	
<b>Variance:</b>	14.05		<b>Variance:</b>	4.91	
<b>Grade</b>			<b>Grade</b>		
<b>5th Grade or Below</b>	10	34.48%	<b>5th Grade or Below</b>	0	0.00%
<b>6th Grade</b>	2	6.90%	<b>6th Grade</b>	0	0.00%
<b>7th Grade</b>	2	6.90%	<b>7th Grade</b>	0	0.00%
<b>8th Grade</b>	2	6.90%	<b>8th Grade</b>	26	100.00%
<b>9th Grade or Above</b>	13	44.83%	<b>9th Grade or Above</b>	0	0.00%
<b>Gender</b>			<b>Gender</b>		
<b>Male</b>	21	72.41%	<b>Male</b>	22	84.62%
<b>Female</b>	8	27.59%	<b>Female</b>	4	15.38%

Robofest Group			Control Group		
Experience			Experience		
First Time	18	62.07%	First Time	22	84.62%
1 Year	6	20.69%	1 Year	2	7.69%
2 Years	4	13.79%	2 Years	1	3.85%
3 Years	0	0.00%	3 Years	0	0.00%
4+ Years	0	0.00%	4+ Years	1	3.85%

Table 3. Descriptive statistics for the Robofest and control group for the pre-assessment. (Continued from previous page)

The most striking issue with the data is that the control students are all the same grade. The control students are at least three grades higher than 35% of the Robofest student group. This issue does seem to reflect in the average test scores with the control students scoring an average of 65.90% and the Robofest students scoring a 59.08% on average, a 6.82% difference. It should also be noted that the maximum and minimum scores are closer for the control group than the Robofest group. This can be attributed again to the distribution of grade levels. The Robofest group had mostly 5th grade and below and 9th grade and above where as the control data all came from the 8th grade level.

## 5.2 Post-Assessment

The post-assessment data was much more difficult to obtain. Only 58.62% of the Robofest students who took the pre-assessment also took the post-assessment. The sample size was just  $n = 17$ . The control students' participation was 100%, most likely due to the tenacity of the control group teacher who gave the assessment. Considering the Robofest student group sample size, the percent margin of error is assumed to be 20%. The data was checked for normality, and the results can be seen in the probability plots and table of Shapiro Wilk Test results in Figure 8 and Table 4.

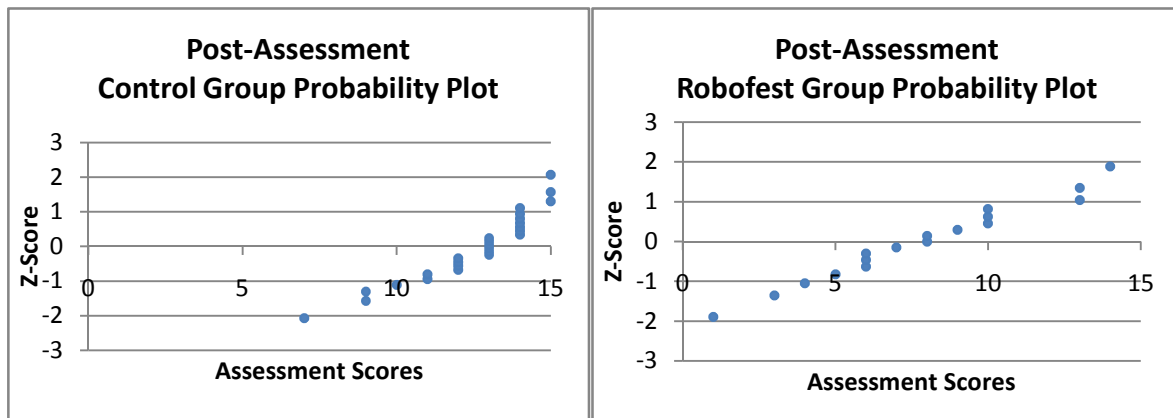


Fig. 8. Post-assessment probability plots for the Robofest and control groups.

Robofest Group			Control Group		
$\alpha$ Quantile Shapiro-Wilk:	0.974		$\alpha$ Quantile Shapiro-Wilk:	0.889	
$\alpha$ Significance Level	Test Statistic	Test Result	$\alpha$ Significance Level	Test Statistic	Test Result
0.01	0.851	Passed	0.01	0.891	Failed
0.05	0.892	Passed	0.05	0.920	Failed
0.10	0.910	Passed	0.10	0.933	Failed

Table 4. Shapiro Wilk results for the post-assessment.

As can be seen in the probability plot for the control data, the pattern is not a straight line. The Shapiro Wilk Test also indicates that at all significance levels tested the control groups data is not considered normal. This makes the control group data impossible to use for any statistically sound correlation studies. A look at the statistical description for the control group allows for more understanding as to why the data failed the normality check, as seen in Table 5.

Robofest Group			Control Group		
<b>Average Score:</b>	7.823529	52.16%	<b>Average Score:</b>	12.53846	83.59%
<b>Max Score:</b>	14	93.33%	<b>Max Score:</b>	15	100.00%
<b>Min Score:</b>	1	6.67%	<b>Min Score:</b>	7	46.67%
<b>Standard Deviation:</b>	3.626901		<b>Standard Deviation:</b>	2.024466	
<b>Variance:</b>	13.15441		<b>Variance:</b>	4.098462	
<b>Grade</b>			<b>Grade</b>		
<b>5th Grade or Below</b>	6	35.29%	<b>5th Grade or Below</b>	0	0.00%
<b>6th Grade</b>	0	0.00%	<b>6th Grade</b>	0	0.00%
<b>7th Grade</b>	1	5.88%	<b>7th Grade</b>	0	0.00%
<b>8th Grade</b>	1	5.88%	<b>8th Grade</b>	26	100.00%
<b>9th Grade or Above</b>	9	52.94%	<b>9th Grade or Above</b>	0	0.00%
<b>Gender</b>			<b>Gender</b>		
<b>Male</b>	10	58.82%	<b>Male</b>	22	84.62%
<b>Female</b>	6	35.29%	<b>Female</b>	4	15.38%
<b>Experience</b>			<b>Experience</b>		
<b>First Time</b>	11	64.71%	<b>First Time</b>	19	73.08%
<b>1 Year</b>	5	29.41%	<b>1 Year</b>	4	15.38%
<b>2 Years</b>	0	0.00%	<b>2 Years</b>	0	0.00%
<b>3 Years</b>	0	0.00%	<b>3 Years</b>	1	3.85%
<b>4+ Years</b>	0	0.00%	<b>4+ Years</b>	2	7.69%

Table 5. Descriptive statistics for the Robofest and control group for the post-assessment.

It is very interesting that the control group did so well on the post-assessment. The variance is very low and the data has a very high max and min score. The Robofest group has a high variance and a low average score. Again it seems this variance is normal considering the distribution of grade level.

### 5.3 Analysis Results

We first address the pre and post-assessment average test scores for the Robofest student group. We needed to know if the drop in the average test scores for the Robofest student group is significant enough to formulate any conclusions from it. First, an F-Test was performed on the pre and post-assessment data for the Robofest group. This test identifies if the null hypothesis, the variances of the two data sets were equal, can be rejected. We found the two-tailed F-Critical ( $F_{crit} = 1.847$ ) values for the data and F-Stat value ( $F_{calc} = 1.068$ ). Since  $F_{calc} < F_{crit}$  we cannot reject the null hypothesis that the variances for the pre- and post-assessment data sets are the same.

Knowing that the variances are the same, a T-Test for two samples assuming equal variances can be calculated. The null hypothesis was defined as  $mean_{pre} = mean_{post}$ . For this T-Test we found that for the two-tailed test values were  $T_{crit} = 2.015$  and  $T_{calc} = 0.918$ . Because  $T_{calc} < T_{crit}$ , the null hypothesis cannot be rejected and we can assume the calculated mean for both the pre and post-assessments of the Robofest student group came from the same population. This means that with a 95% confidence limit the means are not significantly different. Thus the drop in the average assessment score from the pre to the post-assessment was only due to random error and signifies no meaning for our analysis.

Because the control group's post-assessment data did not pass the normality check we will not attempt to analyze the pre- compared to the post-assessment control group data. The fact that the control group data failed the normality check indicates that the average score increase cannot be used to make any statistically sound assumptions.

So far, we have not been able to answer our original question. We continued by testing the correlation between some variables. The correlation between the amount of robotics experience the student listed and their test score was analyzed. The Spearman's rank of a 0.04 correlation was found, meaning that with our sample data there was no apparent correlation.

## **6. RESULTS**

Beyond the statistical analysis results there were many interesting revelations that led to a review of the methodologies of this experiment. The most detrimental issue to this experiment was the coaches' and students' lack of interest in participating. We assumed that an easy to access online assessment would not burden coaches and students. Because of the lack of participation we had to ask students to take the assessment at workshops. There we could request participation from coaches face-to-face.

For the coaches and students alike, the initial incentives offered were inadequate. We believe that the participation request was lost on coaches who were given the security and anonymity of the internet. The burden of taking the assessment, though slight and for the greater good, was too much. It should also be noted that the students showed a lot of anxiety when asked to complete the assessment. Even after the purpose and anonymity of the assessment was as completely as possible explained to the students they complained and showed a lot of frustration when asked to take the test. To attempt to turn this negativity into enthusiasm we introduced a new raffle with a corresponding function tool into our assessment process. The rewards, if well advertized, will hopefully give the coaches and students an incentive to participate in the assessments.

Another issue was the environment that the students took the tests in. We gave online instructions that the coaches should provide a quiet and stable environment for the students to take the assessment. Coaches were advised not to provide any help to the students during the assessment. We clearly stated that the test results were anonymous and would not reflect on the student in any way. Most coaches were teachers, so we assumed that most coaches would know how to create a proper test taking environment.

We witnessed the coaches' real behavior during assessments at some of the workshops. Coaches were seen leaning over their students' tests and pressuring them to select the correct answer. This could be the result of the event being RoboParade, which is a less technical event with more parents coaching rather than teachers. We hope that this issue will not be as prevalent during Robofest due to the heightened seriousness during the main event. It should also be noted that the control group tests were given in a classroom during school hours and resulted in a much more stable and static environment for testing. We believe this was a major contributor to the superior scores from the control group.

Time pressure also played a role during the post-assessment. Due to lack of online participation we requested the students who took the pre-assessment to take the post-assessment when they were arriving for the RoboParade event. This seemed to severely affect the students' performance. Most students wanted only to test their robots and sit down with their teammates to work and did not expect to spend time on a test. Taking the post-assessment separated many students from their coaches and teams for 15 – 20 minutes while they completed the assessment. This concerned them greatly and some students even finished the assessments in less than five minutes, indicating a very lacking attempt to do well. Many of these assessments were turned in with most questions unanswered. Finally, the control group must be selected more carefully. Future control groups will contain students from multiple grade levels.

## 7. CONCLUSION

The goal of this project was to develop methodologies to assess the impact of autonomous robotics competitions in science, technology, engineering and math education. The objective of this research was to study the math and science skill levels of students participating in a Robotics competition or event. We were unable to prove or disprove our hypothesis that robotics requires students to apply and expand their math and science skills beyond what many of them are learning in school in our preliminary experiment. This was due to our sample data set size along with the non-normality of the control group data. Furthermore, the data was greatly affected by unexpected environmental variables. However, we were able to acquire data from assessments given to students before and after a robotics competition by using the methodologies we developed.

In conclusion, we completed the tool set and successfully executed a preliminary experiment. During this experiment we were able to identify the weaknesses and strengths of our methodologies. The methodology employed required review and evaluation based on the needs of our attendant participant group. Our plan is to use this new knowledge during the 2009 Robofest season and beyond. The online toolset will be improved for easier use for both students and coaches. Finally, we will insure that our methodologies represent this experiment's full potential by selecting a larger and more diverse control group.

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