Evaluation of Innovative Technology Experiences for Students and Teachers (ITEST) 2014-2015 Grant Activities

For

The Marine Advanced Technology Education (MATE) Center

July 2015

Submitted by:

SESRC

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Evaluation of Innovative Technology Experiences for Students and Teachers (ITEST) Grant Activities

For the Marine Advanced Technology Education (MATE) Center

BY: CANDIYA MANN & YI JEN WANG

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JULY 2015

In September 2013, the National Science Foundation (NSF) funded the Marine Advanced Technology Education (MATE) Center's proposal for an Innovative Technology Experiences for Students and Teachers (ITEST) grant. The MATE Center's ITEST program, titled *Scaling Up Success: Using MATE's ROV Competitions to Build a Collaborative Learning Community that Fuels the Ocean STEM Workforce Pipeline*, leverages their extensive network of remotely operated vehicle (ROV) student competitions. The project's overarching goal is to encourage multi-year student participation in an effort to deepen student interest and learning and reinforce pathways leading to the STEM workforce.

The evaluation is based on multiple data sources, primarily surveys and interviews, and reflects the input of a variety of stakeholders, including students, teachers, parents, judges, volunteers, regional coordinators, and MATE management and staff. This report covers grant activities that took place between July 1, 2014 and June 30, 2015.

Findings

Project Goal 1: Increase middle and high school students' interest in STEM and STEM careers, as well as their knowledge of STEM and understanding of how science and engineering work together to solve real-world problems.

- **Increased Awareness of STEM Careers:** After building their ROV, over three-quarters of the students (77%, N=1,420) indicated that that they knew more about careers in marine STEM.
- **Increased Interest in STEM Careers:** Over three-quarters (77%, N=1,418) of the students stated that their ROV project made them more interested in pursuing a STEM career, and 85% of the teachers (N=304) observed an increase in their students' interest in pursuing a STEM career. Ninety-six percent (96%, N=298) agreed that the ROV program provided a valuable venue to help prepare their students for STEM careers.

- **Increased Interest in STEM:** Over three-quarters of the students (84%, N=1,413) indicated that their ROV project made them want to learn more about STEM. Ninety-four percent (94%) of the teachers (N=304) and 95% of the parents (N=344) observed greater interest among the students in learning STEM.
- **Increased STEM Knowledge & Skills:** The great majority of the students reported increased skills and knowledge due to their ROV project in several subjects: engineering (92%, N=1,404), technology (90%, N=1,388), the competition theme of science under the ice and offshore oil and gas operations in extreme environments (82%, N=1,388), science (79%, N=1,398), and math (59%, N=1,392). The majority of the teachers (99%, N=298) observed improvements in their students' STEM knowledge and skills. Parents reported that building an ROV contributed to improving their children's grades in engineering/robotics (69%, N=264), science (54%, N=343), math (40%, N=338) and computers (47%, N=277).
- **Increased 21st Century Skills:** Students reported that participating in the ROV project improved their problem solving (87%, N=1,393), teamwork (87%, N=1,401), critical thinking (82%, N=1,398), leadership (74%, N=1,393), and organization skills (65%, N=1,396). Ninety-eight percent (98%, N=304) of the teachers observed increases in their students' skills in team building, problem solving, and/or critical thinking. Parents reported that their children were better problem solvers (96%, N=344), critical thinkers (93%, N=343), team members (93%, N=344), and/or leaders (89%, N=345).
- **Overall Rating of MATE Center Support:** After the competition season, 61% of the teachers (N=310) rated the support provided by MATE as excellent, and 32% provided a rating of good, for an overall positive rating of 93%.
- **Overall Opinions of ROV Program:** The ROV program was rated positively (excellent or good) by 99% of the students (N=1,419), 99% of the teachers (N=310) and 98% of the parents (N=345).
- **Ability to Apply STEM to Real World Problems:** In the post-competition surveys, 86% of the students (N=1,415) indicated that participating in the ROV project helped them learn to apply STEM to real world problems, and 95% of the teachers (N=303) observed improvements in their students' abilities in this area, as did 95% of the parents (N=341). In the ROV competition student alumni survey, 91% of the alumni (N=426), indicated that participating in the ROV program helped them learn to apply STEM to real-world problems.
- **Ability to Communicate Engineering Process and Designs to a Wide Audience:** Eighty-one percent (81%, N=1,412) of the students stated that participating in the ROV project helped them learn how to communicate their engineering design to other people. Ninety-four percent (94 %) of the instructors (N=301) observed improvements in their students' skills in this area.

- **Influence on Students' Educational and Career Paths:** Preliminary ROV competition student alumni survey results include the following:
    - Among the 220 alumni who earned a college degree, 85% earned a degree in a STEM discipline.
    - Among the 236 current college and university students, 85% are studying towards a STEM degree.
    - Among the employed alumni (N=320), 73% are currently working a STEM-related job, and 22% currently or previously worked a job related to ROVs or other underwater technologies.
    - Two-thirds (67%, N=432) of the alumni credit the ROV competition with influencing their educational or career path "to a great extent" or "somewhat".
    - The ROV competition played a role in alumni attaining employment (37%), admittance into educational programs/college/university (36%), internships (30%), awards (21%), and scholarships (21%).
- **Effect of Multi-Year Competition Participation:** Multi-year participants were statistically significantly more likely to report that their participation in the ROV program resulted in higher levels of awareness of and interest in STEM careers, gains in interest in taking STEM courses, improvements in STEM knowledge and skills, increased 21st Century skills, and the receipt of awards, honors, and new educational and career opportunities.
- **Impacts among Underrepresented Groups:** According to the demographic data in the surveys (N=1,426), the students were roughly one-quarter female (26%), 36% were of minority backgrounds, 31% came from high poverty areas, and 3% reported that they had disabilities requiring accommodations. Statistically significant differences existed between the groups (gender, ethnicity, socioeconomic status, and disability status) in the following measures:
    - ***Awareness of and Interest in STEM Careers:*** Male students, white students, and students with disabilities were more likely to report that the ROV program led to gains in knowledge about STEM careers and interest in a STEM career.
    - ***Interest in STEM Topics:*** Male students were more likely to report increased interest in computer, math, and engineering courses. Students with disabilities were more likely to report increased interest in engineering courses and math courses.
    - ***STEM Knowledge:*** After the competition, male students and students with disabilities were more likely to report increased skills and knowledge in engineering, math, and technology. Students living in a lower socioeconomic area were more likely to report gains in skills and knowledge in math.

Project Goal 2: Provide teachers with professional development, instructional resources, and mentors to support and sustain the delivery of STEM career information and learning experiences.

- **Increased Confidence Facilitating STEM Learning Experiences:** The percentage of workshop survey respondents (N=84) who rated themselves as “very comfortable” facilitating STEM learning experiences for students rose between the pre and post workshop surveys in all STEM areas: science (pre: 61%, post: 75%), technology (pre: 40%, post: 60%), engineering (pre: 25%, post: 45%), and math (pre: 42%, post: 55%).
- **The MATE Community:** Among the post-competition surveys, 85% of the teachers (N=297) agreed that they felt they were part of a MATE community that provides support and relevant resources.
- **MATE Robotics Activities/Curriculum Incorporated into Courses and Afterschool Programs:** Sixty-one percent (61%) of the post-competition teacher survey respondents (N=313) incorporated building ROVs into an after-school club. Twenty-six percent (26%) built ROVs as part of a course; 28% built ROVs as a voluntary activity; and 7% built ROVs in another venue. Over three-quarters (83%) of the teachers (N=275) stated that they used MATE materials and resources to incorporate ROV building into their course or club, and more than half (59%) modified their curriculum and teaching based on MATE resources.
    - In the online resource survey, respondents reported that the MATE online resources were used as part of in-school classes (52%, N=73) and out-of-school programs/clubs (59%, N=76). Over half of the respondents (54%, N=68) developed new curricula or activities based on the MATE online resources. Seventy-one percent (71%, N=72) shared the online resources with others (noting that they shared the resources with a total of 666 other people), and 78% (N=74) built a total of 420 ROVs using the online resources as a reference.
- **Classroom Mentors:** In several regions, the regional coordinator matched up college and high school students – in many cases, former ROV competitors themselves – with middle school ROV teams to work with them throughout the competition season. For 22% of the post-competition teacher survey respondents (N=298), a classroom/club mentor came to their site to help their teams. Among these teachers (N=77), over half (53%) indicated that the mentor helped them incorporate robotics into their course or club to “a great extent”. The vast majority of respondents (89%) indicated that their mentors were adequately prepared to help them and their students through the ROV design and building process.

Project Goal 3: Increase parental involvement in order to support and encourage students to pursue STEM education and careers.

- **Increased Parental Support of Their Children’s Interest in STEM:** Ninety-two percent (92%, N=342) of the parents indicated that participation in the ROV program changed how they envisioned their child’s future, making it easier to picture their child with a STEM career.

- **Enhanced Online Resources:** The online Parent Resource Center was launched in the spring of 2015. It contains competition videos, frequently asked questions, background information, highlights, and contact information for the MATE Center, along with types of information that the MATE Center can provide upon request.
- **Regional Advisory Committees:** Advisory committees included participation from parents as well as industry representatives, professional organizations (e.g., Marine Technology Society), government agencies (e.g., NOAA) 6-12th grade educators, community college faculty, and university faculty. In the second year, some regions held an annual advisory meeting, while others held quarterly advisory meetings, monthly advisory meetings, or communicated on an ongoing basis with advisory members outside of formal meetings. The regional coordinators were responsive to their committees' recommendations.

Conclusions

The MATE Center successfully implemented the 2014-2015 year of ITEST grant activities. The 2015 MATE ROV Competition was held, with ITEST funding helping to support 11 of the 17 US-based regional events. Seventy (70) regional workshops were held for teachers and students, and teachers attended the intensive (60 hour) Summer Institute professional development. The Center disseminated a suite of online instructional materials, including videos, PowerPoints, ROV kits, and an online course.

Evaluation results continue to show strong positive outcomes for students and teachers. Involvement in the ROV competition generated greater awareness of and interest in pursuing STEM careers; increased interest in studying STEM topics; improved STEM knowledge and skills; and increased teamwork, critical thinking, leadership, and problem solving skills. Participating in the ROV competition helped students learn how to apply STEM skills to real world problems. They also learned how to communicate their engineering process and design to a wide audience.

Preliminary ROV competition student alumni survey results suggest that the majority of ROV competition participants go on to study STEM topics, earn STEM degrees, and work in STEM fields. In fact, roughly one in five former participants have worked in a job related to ROVs or other underwater technologies. The majority of ROV competition alumni credit the ROV competition with influencing their educational and career paths, including playing a role in attaining internships, scholarships, admittance to educational programs, and employment.

These findings suggest that the MATE ROV Competition is effective in increasing the STEM workforce, especially related to underwater technologies.

INTRODUCTION

In September 2013, the National Science Foundation (NSF) funded the Marine Advanced Technology Education (MATE) Center's proposal for an Innovative Technology Experiences for Students and Teachers (ITEST) grant. The MATE Center's ITEST program, titled *Scaling Up Success: Using MATE's ROV Competitions to Build a Collaborative Learning Community that Fuels the Ocean STEM Workforce Pipeline*, leveraged their extensive network of remotely operated vehicle (ROV) student competitions. The project's overarching goal is to encourage multi-year student participation in an effort to deepen student interest and learning and reinforce pathways leading to the STEM workforce.

As stated in the proposal, the goals are fourfold:

1. Increase middle and high school students' interest in STEM and STEM careers as well as their knowledge of STEM and understanding of how science and engineering work together to solve real-world problems.
2. Provide teachers with professional development, instructional resources, and mentors to support and sustain the delivery of STEM learning experiences and career information.
3. Increase parental involvement in order to support and encourage students to pursue STEM education and careers.
4. Track students longitudinally to document how participation impacts their education and career path.

This report covers grant activities that took place between July 1, 2014 and June 30, 2015. The MATE Center's ITEST grant evaluation was performed by the Puget Sound Division of the Social and Economic Sciences Research Center at Washington State University.

Methodology

The evaluation connects each of the project goals with evaluation questions and expected outcomes of the project. These goals and evaluation questions are presented below.

Table 1: Project Strategies and Evaluation Questions

<table>
<tr><th>Project Goal</th><th>Evaluation Questions</th></tr>
<tr><td rowspan="6">1. Increase middle and high school students’ interest in STEM and STEM careers as well as their STEM knowledge and understanding of how science and engineering work together to solve real-world problems.

• Add SCOUT+ class
• Support for students who want to continue competition at next grade/school
• Mentoring from students/industry professionals
• Career advice/videos</td><td>1.1. To what extent did the MATE robotics activities lead to an increase in the students’ interest in and knowledge of STEM content and STEM careers? Did educators and parents observe an increase in the students’ interest in STEM content and STEM careers as a result of the robotics activities? An increase in the students’ STEM knowledge and skills and 21st Century workplace skills?</td></tr>
<tr><td>1.2. How did the robotics activities affect students’ ability to apply STEM knowledge and skills to finding solutions to real-world problems?</td></tr>
<tr><td>1.3. How did the robotics activities affect students’ ability to communicate their engineering process and designs to a wide audience (from engineers and technicians to the general public)?</td></tr>
<tr><td>1.4. How did participation in the robotics activities influence students’ educational and career paths?</td></tr>
<tr><td>1.5. What effect did multi-year participation have on the above evaluation questions?</td></tr>
<tr><td>1.6. Did the robotics activities create the same impacts among underrepresented groups (by gender, ethnicity, socio-economic status, disability) as were found among students who traditionally participate in these types of activities?</td></tr>
</table>

2. Provide teachers with professional development, instructional resources, and mentors to support and sustain the delivery of STEM career information and learning experiences. • Curriculum continuum • Progression of ROV kits • Professional development workshops • Regional workshops • Regional teacher-leaders • Increase preparedness of mentors	2.1. Are teachers more confident delivering STEM learning experiences? Delivering career information and outlining career pathways?
	2.2. Do teachers feel they are a part of a larger MATE community that provides support and relevant, necessary resources?
	2.3. Do teachers incorporate MATE robotics activities/curriculum into courses and afterschool programs? Are the courses and/or curriculum adopted by school districts?
	2.4. Are teachers able to access classroom mentors as needed? Do the classroom mentors help them successfully incorporate robotics activities into the course? Are the classroom mentors adequately prepared?
3. Increase parental involvement in order to support and encourage students to pursue STEM education and careers. • Parent online resources/listserv • Regional parent advisory committees	3.1. Did the MATE robotics activities lead to an increase in the parents' support of their children's interest in STEM careers? 3.2. Did the enhanced parent online resources lead to an increase in the parents' ability to provide assistance and support for their children's involvement in the MATE robotics activities? 3.3. Did the regional parent advisory committees provide feedback and advice to help improve the competitions and ensure that the program is inclusive of all participants?

DATA SOURCES

The evaluation relies upon multiple sources of data. The data collection includes input from a variety of stakeholders, including students, teachers, parents, judges/volunteers, regional coordinators, and MATE staff. Below are descriptions of each of the data sources. All of the surveys were developed in collaboration with MATE staff and regional coordinators.

Student Follow-up

In 2014-2015, the evaluation began several student follow-up efforts: 1) the Washington State Follow-up, 2) The ROV Competition Student Alumni Survey, and 3) the National Student Clearinghouse Data Match.

WASHINGTON STATE FOLLOW-UP

Background: As part of the ITEST proposal, the Washington State Education Research and Data Center (ERDC) agreed to match the ROV competition program participants from Washington with the ERDC P-20 data and also to create a comparison group. They will return high school, postsecondary, and workforce data. The economics section of the Washington State Office of Financial Management (OFM) Forecasting division agreed to do the statistical analysis of the ERDC data.

This analysis will explore two main research questions:

1) To what extent are the ROV competition participants the same/different from the general population of students, and

2) What is the impact of the ROV competition on the probability of attending college, studying STEM, persisting, and completing college degrees?

2014-2015 Progress: After receiving WSU IRB approval in December of 2014, the next step consisted of creating a cleaned list of student contact information to send to the ERDC. This effort proved to be more challenging than anticipated. The MATE AlumniWeb registration has gone through several iterations since it began in 2006, including a proprietary website (2006-2012 competition years), Google forms (2013), and the Active registration system (2014 through present). Over the years, the variables within AlumniWeb have changed, as MATE attempted to make the system more user friendly, more useful for the regional coordinators, and to collect more information on the registrants. In addition, the registration system was used by several different user-groups from 2006-2012, including ROV competition student team members, ROV competition teacher/mentors, MATE interns (MATE runs an at-sea internship program outside of the competition), MATE Summer Institute participants (faculty professional development), and others. The proprietary website was set up not as a flat file but as several related tables, and in some cases, variables that should have been assigned at the individual level were assigned at the team level. In addition, there were consistency issues within the variables, such as birth date, which was input with a wide variety of formats. With these challenges, we took our time and created the cleanest files possible before selecting the students for the Washington State Follow-up.

For the Washington State Follow-up, the dataset was selected based on the following criteria:

- ROV competition student team members
- Who participated in the Pacific Northwest regional event, or
- Had a Washington State address.

We included all variables that might provide insight to whether the student was homeschooled, since these students would not be expected to be found in the ERDC P-20 data. The dataset was provided to ERDC in three tables: one for the 2006-2012 competition years, one for 2013, and one for 2014. This is because the students who participated for multiple years had the same identifying number in 2006-2012. With the change in systems, these students had different identifying numbers in 2013 and 2014. The 2006-2012 file had 632 records (including one record per student per year of participation). The 2013 file had 210 records (one per student), and the 2014 file had 244 records (one per student).

On February 12, 2015, a planning meeting was held with the MATE Center evaluator, ERDC, and OFM, where ERDC and OFM clarified the information that they would like in the student dataset. The evaluator uploaded the student dataset and data notes to the ERDC Secure File Transfer site on April 2, 2015. After data delivery, the evaluator had weekly check-in emails and/or telephone calls with Tim Norris, ERDC analyst.[1]

On June 5, 2015, Mr. Norris reported some promising initial findings from his preliminary data match. Of the 210 students from the 2013 competition year, he was able to find 170 of the students in his K-12 data, a match rate of 81%. With additional review, he anticipates increasing this match to about 180 students (86% match).

On July 8, 2015, Mr. Norris provided the following work plan, detailing the remainder of the work to be done, along with the timeline:

***

ERDC has received all the necessary data to perform the requested analysis. The research plan below splits the work up into two phases. Initial work will be done using the 2013 data. This will allow us to familiarize ourselves with the data, and generate initial datasets, then where necessary make changes. The second phase will be to expand that work to all participants, and generate a comparison group. Work on this phase is scalable, depending on the resources provided.

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[1] In the ITEST proposal, Dr. Lorrie Jo Brown, Sr. Forecast Analyst with OFM, had agreed to perform the analysis. Sadly, Dr. Brown passed away in 2014 so this study was assigned to different ERDC/OFM personnel.

ID	Task	Description	Completion Date
	Phase I		
1	*Evaluate data quality for 2013 file and perform quick link to k12*	*Task complete. About 170 of the 210 records were able to be linked to K12 with no manual review.*	*6/11*
2	*Establish necessary items out of K12 to perform analysis and to help identify comparison group*	*Complete. Develop initial list of research data items from K-12 for descriptive analysis used to identify comparison group*	*6/19*
3	*Finalize linking of file to k12 for 2013 participants*	*Perform linkage to K12 system for 2013*	*7/23*
4	*Generate research dataset of K12 variables for the 2013 participants*	*Extract K12 variables for participants and create initial research dataset*	*7/28*
5	*Descriptive data for 2013*		*7/31*
	Phase II		
6	*Generate a combined 2006-2014 participant file*	*Merge data from multiple files for both identity matching/linking but also input variables into research*	*7/31*
7	*Link combined file to K12, post-secondary enrollment, and workforce*	*Perform linkage of participants to various outcome sectors*	*8/14*
8	*Generate descriptive data for combined years*	*Extract variables for participants and create research dataset*	*8/28*
9	*Generate comparison group and propensity score algorithms*	*Develop dataset and define comparison groups*	*9/15*
10	*Final analysis complete*		*9/30*

***

Results of the Washington State Follow-up study will be provided to the MATE Center for sharing with the NSF, as soon as they are received.

ROV COMPETITION STUDENT ALUMNI SURVEY

Background: The creation of the cleaned AlumniWeb data for the Washington State Follow-up also allowed the MATE evaluator to move forward with the ROV Competition Student Alumni Survey. The goal of the alumni survey was to answer the questions: “Where are they now?” and, “To what extent did their involvement with MATE influence their trajectory?” The survey included questions about their higher education, employment, internships, scholarships and other opportunities that opened due to their involvement with the ROV competition.

2014-2015 Progress: The web survey attempted to contact all former competition student participants who were at least 18 years old at the time of the survey. This was complicated by several factors:

- Birthdates entered in multiple formats,
- Unclear identification of student and teacher/mentor status in several competition years, and
- Students often provided parents' or teachers' email addresses. Alternately, they provided their school addresses, which were not active after they left that school.

To resolve the uncertainty created by the first two above factors, two screening questions were added to the beginning of the survey.

1. "This survey is designed for people who are at least 18 years of age. Are you at least 18 years old today?" The response options were yes and no. Respondents who marked "no" were filtered out of the survey.
2. "How have you participated in the MATE ROV Competition program? [Mark all that apply.]" The response options were: student on a team, instructor leading a team, judge at a competition, classroom/club mentor assigned to help other teams, and other. Respondents who did not mark "student on a team" were filtered out of the survey.

The survey was programmed into Qualtrics, and quality control was done by the evaluation team, as well as the MATE PIs. The survey was launched on June 16, 2015, with email invitations to 8,544 email addresses. Email reminders were sent to the non-respondents on June 22 and 29, 2015. The survey remains open. The disposition thus far consists of the following:

Of the 8,544 email addresses…

- 1,081 bounced
- 156 possible respondents opted out, including several who contacted the evaluator to explain that they were parents or teachers
- 118 surveys were partially completed
    - 16 were filtered out because they were under age 18
    - 21 were filtered out because they were not a student
    - 79 student alumni over age 18 partially completed the survey
- 626 surveys were completed
    - 109 were filtered out because they were under age 18
    - 85 were filtered out because they were not a student
    - 432 student alumni over age 18 completed the survey

The response rate was calculated using the Response Rate 4 (RR4) calculation from the American Association of Public Opinion Research's 2011 *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*. 7th Edition.

RR4 = (Completed + Partially Completed) / (Completed + Partially Completed) + (Refusals + Noncontact + Other) + e(Unknown)

e is the proportion of eligible sample to not eligible sample: e = (Known Eligible Sample) / (Known Eligible Sample + Known Ineligible Sample)

e = (432 + 79) / (432 + 79 + 109 + 85 + 16 + 21) = 511 / 742 = .689

RR4 = (626 + 118) / (626 + 118) + (156 + 1,081 + 0) + .689 (7,644) = 744 / (744 + 1,237 + 5,267) = 744/7,248 = .102 = 10.2%

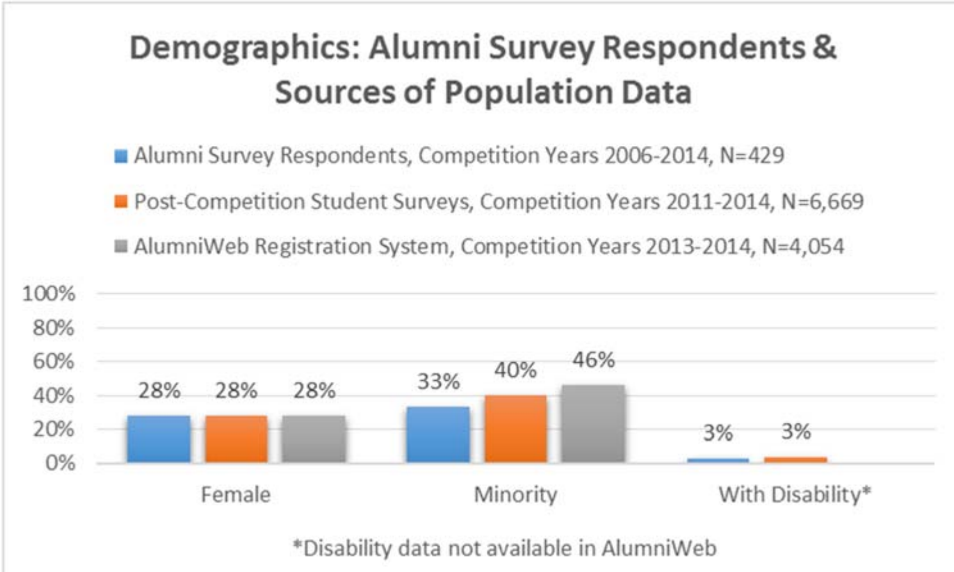
With this calculation, **the preliminary response rate was 10.2%.**

To determine whether the respondents were representative of the population, researchers intended to compare respondent demographics with population demographics. Unfortunately, good sources of population demographics are not available for the entire population of the competition (competition years 2006-2014). The demographics of the survey respondents are detailed below, along with the available sources of population demographics.

- The survey respondents were 28% female; 33% were of minority backgrounds; and 3% had a disability. (See *Figure 1* below) It appears that the respondents are representative of the population by gender and disability, but the responses of the white students may be over-represented in the survey results.
- The AlumniWeb registration system did not collect student demographics on an individual basis (only a team basis) prior to 2013. This oversight has been rectified, and in 2013 and 2014 (which account for roughly half of the population or 4,054 of 8,544 email addresses), 28% of the students were female, and 46% were minority. Information on student disability was not collected in AlumniWeb.
- The student post-competition surveys are another source of demographic data. Prior to 2011, the post-competition surveys were only administered at the MATE International ROV Competition; beginning in 2011, coverage was broadened, and the post-competition surveys were administered at regional competitions. Between 2011 and 2014, the student demographics on the post-competition surveys (N=6,669) included a total of 28% female students, 40% minority, and 3% with a disability. [2]

[2] Student demographics from 2011-2014 post-competition surveys: 2014 competition: 29% female, 40% minority, N=1,442; 2013 competition: 29% female, 38% minority, N=1,733; 2012 competition: 29% female, 41% minority, N= 1,878; 2011 competition: 26% female, 39% minority, N=1,616.

Figure 1: Demographics of Alumni Survey Respondents and Sources of Population Data



Once the National Student Clearinghouse data match and the Washington State Follow-up are completed, the results will be compared with the alumni survey to look for consistencies/inconsistencies in student demographics as well as student follow-up results (e.g., college attendance, completion, and pursuit of STEM degrees).

See evaluation question 1.4 for preliminary findings from the alumni survey.

NATIONAL STUDENT CLEARINGHOUSE DATA MATCH

Background: With the production of the student identifying information out of AlumniWeb, we are now ready to send data for matching to the National Student Clearinghouse (NSC). The NSC is a nationwide source of higher education information. Colleges and universities, numbering over 3,400 institutions enrolling over 96% of college students, share their enrollment data with NSC. The NSC database includes over 130 million students. See http://www.studentclearinghouse.org/ for further information about the NSC.

2015-2016 Plans: In August of 2015, the evaluator will securely transmit the ROV competition student names and dates of birth to NSC, and they will match our files with their database of higher education records and return reports of postsecondary activities. Their reports include 30 charts and tables showing the number of students attending college (2-year and 4-year), college persistence, degree attainment, top colleges where students enroll, and time to college graduation. We will coordinate with their special research projects division to see if they could construct a matched comparison group for our results. Regardless of whether they can construct a matched comparison group, the NSC results will be useful for comparison with our other sources of follow-up data: the Washington State Follow-up and the alumni survey.

Curriculum and Online Instructional Resources

PRE-POST KNOWLEDGE TESTS

In the ITEST proposal, the MATE Center proposed creating a complete curriculum, tied to standards, with pre-post knowledge tests corresponding to each module. In 2014-2015, the MATE Center changed focus in response to user feedback in an intensive set of 103 interviews conducted as part of an NSF I-Corps grant. Rather than a complete curriculum, PIs determined that teachers preferred online resources that they could incorporate into their own curricula. (See MATE Center Annual Report for further description of the training and professional development.)

With this change in focus, the curriculum-based pre-post knowledge tests were not developed. Instead, the MATE Center has moved towards producing online courses ("Diving into Sensors") and instructional videos, in addition to the rich selection of PowerPoint presentations, activities, and other materials posted on the MATE Center website. The Diving into Sensors course is currently being piloted with 63 participants. In 2015-2016, Dr. Li will assess the pre-post knowledge tests associated with the online courses and other instructional materials.

ONLINE RESOURCES SURVEY

With the increased focus on the online resources provided by the MATE Center (instructional videos, PowerPoints, activities, kits, etc.), the evaluation shifted focus to assessing user satisfaction and usage of the online resources. (This survey is not as strong a source of evaluation data as the pre-post tests would be; however, it provided the MATE Center PIs with valuable information on how the online resources are being used and how the resources and website can be improved.)

Website users must register to gain access to the online resources. On June 18, 2015, an email invitation was sent to the website registrants who registered or accessed the website between September 2013 and June 2015, a total of 1,995 registrants.

Of the 1,995 emails sent:

- 93 emails bounced
- 19 opted out
- 113 surveys were started
- 106 surveys were completed (5.3%), and 91 respondents had viewed or downloaded resources from the MATE Center website.

The response rate was calculated using the Response Rate 4 (RR4) calculation from the American Association of Public Opinion Research's 2011 *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*. 7^{th} Edition.

RR4 = (Completed + Partially Completed) / (Completed + Partially Completed) + (Refusals + Noncontact + Other) + e(Unknown)

e is the proportion of eligible sample to not eligible sample: e = (Known Eligible Sample) / (Known Eligible Sample + Known Ineligible Sample)

e = (91) / (91 + 15) = 91 / 106 = .858

RR4 = (106 + 7) / (106 + 7) + (19 + 93 + 0) + .858 (1,863) = 113 / (113 + 112 + 1,598) = 113/1,823 = .062 = 6.2%

With this calculation, **the preliminary response rate was 6.2%.**

See evaluation question 2.3 for the preliminary findings of the online resources survey.

ROV Competitions

Background: At the ROV competitions, input was solicited from as many stakeholders as possible, including students, teachers, parents, and judges/volunteers. The competition surveys were primarily administered as paper surveys in a "scannable" format; there was a web option as well. Data entry was completed by scanning the surveys and entering the written comments by hand. Data analysis was performed with the Statistical Package for the Social Sciences (SPSS). Student and parent surveys were offered in Spanish as well.

POST-COMPETITION SURVEYS: STUDENTS

At the ROV competitions, students were asked to complete surveys. The survey protocol was a modified version of the student survey that has been administered to more than 4,400 students over the past seven years at regional and international ROV competitions. The survey covered the following topics: awareness and interest in ocean STEM careers, increased desire to take STEM courses due to involvement in the program, awards/honors received as a result of competition experience, and self-assessment of change in STEM knowledge.

POST-COMPETITION SURVEYS: TEACHERS

Teachers also completed surveys at the ROV competitions. The survey protocol was a modified version of the faculty/mentor survey that has been administered to more than 1,000 respondents over the past seven years at ROV competitions. The survey addressed topics such as the value of the competition, incorporation of competition into course curriculum, interest in participating in future competitions, assessment of change in their students' STEM knowledge and skills, 21st Century skills, interest in STEM careers, and related topics.

POST-COMPETITION SURVEYS: PARENTS

In contrast to the student and teacher surveys, which have been conducted for years at MATE ROV competitions, the 2010 competition season was the first time parent input was solicited. Parents responded enthusiastically and seemed to appreciate the opportunity to provide input. Parent surveys addressed the topics of parental support of their children's interest in STEM and STEM careers, the value of the competition, and changes they have observed in their children since they became involved in the program.

POST-COMPETITION SURVEYS: JUDGES

In the 2011 competition season, input was solicited for the first time from industry representatives serving as judges at the competitions. This survey collects information on the judges' experience at the competition, whether they feel it was a worthwhile use of their time, the skills of the students they observed, and their opinions on the usefulness of the competition in preparing future employees.

PSYCHOMETRIC ANALYSIS: VALIDATION OF SCORING RUBRICS, IMPROVING INTERNAL CONSISTENCY OF POST-COMPETITION SURVEYS

2014-2015 Update: In 2014-2015, the MATE Center began a valuable collaboration with Dr. Min Li, Associate Professor at the University of Washington's Department of Education. In this grant year, Dr. Li focused on validating the competition scoring rubrics, aligning the student competition manual with scoring rubrics, and improving the internal consistency of the post-competition surveys. In response to Dr. Li's analysis, the scoring rubrics were updated, as were the student and parent surveys. Please see below for Dr. Li's summary of work conducted in 2014-2015, findings, and plans for 2015-2016:

***

The psychometric analysis to validate various instruments developed and used in this project focused on two main goals: (1) employing a process for validating competition scoring rubrics and determining and/or establishing methods for ensuring inter-rater reliability of competition scoring such that they may be used as an indicator of student learning; and (2) improving the internal consistency of existing surveys by adding questions and standardizing the question constructs.

Related to the goal of validating competition scoring rubrics, we started with the content analysis of the competition manuals for participations and then analyzing the judge scores using both the Cronbach's alpha as the indicator of the internal consistency and the Generalizability (G) coefficients calculated based on the G theory. For the second goal of improving the internal consistency of the existing surveys, we performed the explorer and confirmatory factor analysis with the survey items and identified the areas that survey items could be refined. The data for running the psychometric analysis came from collected from the round of 2014 competitions. The analytic procedures and syntax files can be easily applied with the collected from previous rounds to cross validate the validity issues that we have found from the last year's data collection.

In what follows we organize our report the psychometric findings into two sections corresponding to the two goals described.

Validation of Competition Scoring Rubrics

Participants' products to the ROV competition are scored by volunteering judges into four types of scores: (1) technical report that focuses on the technical aspects of the report that a team submits electronically; (2) mission that assesses the performance of the ROV demonstrated by the team; (3) poster that a team summarizes necessary information about their ROV project; and (4) presentation that a team interactively reports the ROV project to a group of audience.

We started the content analysis of the scoring rubrics by reviewing the focus of each rubric and compare them against the competition manual. The manual is supposed to include all the instructions to the participants which need to explicitly communicate the scoring rubrics and expectations. Applying this guideline, we modified, simplified, and clarified some aspects of the competition manual to streamline the instructions and align them closely to each of the scoring rubrics. We also made the language of the instructions consistent to the scoring rubrics and comparable across the four forms of products. We anticipated that this revision of articulating the scoring rubrics will ultimately improve the inter-rater reliability of the rubrics.

We chose to analyze the technical quality of three rubrics except the mission rubric. The mission rubric was believed to yield a much higher reliability because the vehicle performed the tasks or it did not, which less involves subjective judgments compared to other three rubrics. For these three rubrics, experienced engineers were assigned into either pairs or triads each of which then was randomly assigned to rate a group of eight to ten projects.

We employed both the classical test theory (CTT) and Generalizability theory to examine the inter-rater reliabilities. For the CTT, we computed the Cronbach's alphas. For the G theory, we used the random model of a project x judge (P x J) design. This should result in three variance components: variance due to product differences as the object of the measurement (σ_p^2) as well as two sources of measurement errors, variance due to the judge effect (σ_j^2), and variance due to the product by judge interaction confounded with residual ($\sigma_{pj,e}^2$). We also calculated two types of G coefficients. Absolute G coefficients indicate the extent to which the judges provided comparable scores or not when evaluating projects; in contrast, relative G coefficients refer to the extent to which the judges ranked the projects consistently or not regardless if some might give much higher scores compared to their peer judges. In the one-facet model of P x J design, relative G coefficients are exactly the same as the Cronbach's alpha coefficients under the CTT approach. Relative G coefficients are more relevant for this project because score reliability only matters regarding how the judges ranked the projects submitted by the competition teams. As we move to the psychometric work proposed for next project year in which we align the specifics of each rubric to the NGSS, it will be important to take the absolute G coefficients into account. Absolute G coefficients allow us to examine the reliability of score inferences when we evaluate how well projects demonstrate participants' mastery of the targeted NGSS standards.

Table 1 summarizes the variance components and G coefficients for the three rubrics we studied. Our interpretations of results primarily focus on the relative G coefficients. Poster rubric was the most reliable among the three rubrics we studied. The relative G coefficients were greater than .80 even when *randomly selecting one judge instead of using two judges based on the scores from the six judge pairs, indicating that fewer than 80% of score variation was accounted for by the measurement error associated with judge. In other words, only one rater is needed due to the small amount of measurement error. Similarly, the engineering rubric was reliably applied by the judges. All the relative G coefficients were satisfactory with magnitudes greater than or closer to .80 even when using 1 judge.*

However, in the case of the technical report rubrics, the reliability coefficients varied greatly across the seven triads of judges. For Teams 8 and 11, each triad of judges scored consistently the projects to such a degree that only one of the judges would be needed while still maintaining an interrater reliability above .80. However, Team 13 was the least reliable as the three judges rarely reached any agreement at all with each other when ranking the projects based on this rubric.

In order to further understand the reasons why the technical report rubric was much more demanding to maintain a reasonable interrater reliability, we took a closer look at the reliabilities of sub-categories (also called as sub-scales that judges needed to assign scores to). Table 2 reports the estimated variance components from the G studies and the G coefficients for running the decision studies when using different number of judges. We summarize the patterns of relative G coefficients in Table 3.

As shown in Tables 2 and 3, the reliabilities were found uneven across the sub-categories and across the judge triads. Generally the G coefficients yielded much lower reliabilities compared to the technical report score which should have more score variations as the sum of all the sub-categories. It appeared that only the sub-categories of Design Rationale, Teamwork, and Safety were attainable for most judge triads to score consistently (highlighted in green in Table 3). The sub-categories of Overall Presentation, Trouble Shooting, Lessons Learned, and Future Improvement were relatively challenging for the judges (highlighted in orange in Table 3) whereas the rest of sub-categories were just too problematic for judges to make reliable scoring decisions compared to their peer judges.

The reliabilities also varied greatly across the scoring teams. The judges within Triads 8, 9, and 11 tended to have a stable interrater reliability for approximately half of the sub-categories. The three judges in Triad 13 had the lowest interrater reliability across multiple sub-categories, which could explain why the G coefficients for the technical report score (i.e., the sum of all the sub-category scores) across them were below .30.

Table 1. *Estimated Variance Components and G Coefficients for the Poster Rubric*

ID of Judge Team[a]	Estimated Variance Components In P x J (Project x Judge) Design			G Coefficients					
				Using 1 Judge (n_j=1)		Using 2 Judges (n_j=2)		Using 3 Judges (n_j=3)	
	EVC (project)	EVC (judge)	EVC (pj,e)	Abs. G Coeff. [b]	Rel. G Coeff. [c]	Abs. G Coeff.	Rel. G Coeff.	Abs. G Coeff.	Rel. G Coeff.
Poster scores									
1	99.82	0	1.69	0.983	0.983	0.992	0.992	-[d]	-
2	57.31	0.14	2.61	0.954	0.957	0.977	0.978	-	-
3	29.06	0.66	6.24	0.808	0.823	0.894	0.903	-	-
4	103.36	0	0.29	0.997	0.997	0.999	0.999	-	-
5	84.75	0	0	1	1	1	1	-	-
6	70.28	0	0	1	1	1	1	-	-
Pooled[e]	444.57	0.800	10.830	0.975	0.976	0.987	0.988	-	-
Technical report scores									
7	127.93	89.97	70.92	0.443	0.643	0.614	0.783	0.705	0.844
8	269.63	79.09	47.76	0.680	0.850	0.810	0.919	0.864	0.944
9	93.50	33.67	78.97	0.454	0.542	0.624	0.703	0.713	0.780
10	98.51	152.61	39.89	0.339	0.712	0.506	0.832	0.606	0.881
11	77.88	20.18	16.57	0.679	0.825	0.809	0.904	0.864	0.934
12	152.53	37.97	73.69	0.577	0.674	0.732	0.805	0.804	0.861
13	5.76	32.87	49.55	0.065	0.104	0.123	0.189	0.173	0.259
Pooled	825.74	446.37	377.34	0.501	0.686	0.667	0.814	0.750	0.868
Engineering scores									
14	275.19	16.57	19.49	0.884	0.934	0.939	0.966	0.958	0.977
15	125.62	0	14.40	0.897	0.897	0.946	0.946	0.963	0.963
16	40.41	2.28	11.76	0.742	0.775	0.852	0.873	0.896	0.912
17	440.64	3.36	15.12	0.960	0.967	0.979	0.983	0.986	0.989
18	318.10	5.15	23.91	0.916	0.930	0.956	0.964	0.970	0.976
19	92.16	1.29	9.37	0.896	0.908	0.945	0.952	0.963	0.967
Pooled	1292.12	28.66	94.06	0.913	0.932	0.955	0.965	0.969	0.976

Notes: a. Abs. G coeff. refer to absolute G coefficient. Rel. G Coeff. refers to relative G coefficient.
b. Posters were rated by two judges whereas technical reports and engineering were scored by three judges.
c. For poster scores, relative G coefficient when **using 2 judges** was equivalent to the Cronbach's alpha obtained. For the technical report and engineering scores, relative G coefficient when **using 3 judges** was equivalent to the Cronbach's alpha obtained.
d. Judges for the poster rubric were highly reliable, therefore there is no need to estimate the reliability by using three raters instead of two raters.
e. Pooled estimates were based on the sum of the estimated variance components. The estimates indicate the averaged reliabilities across multiple judge pairs or triads.

Table 2a. *Estimated Variance Components and G Coefficients for Sub-categories Codes of the Technical Report Rubric*

	Estimated Variance Components In P x J (Project x Judge) Design			G Coefficients					
				Using 1 Judge (n_j=1)		Using 2 Judges (n_j=2)		Using 3 Judges (n_j=3)	
Triad ID of Judges	EVC (project)	EVC (judge)	EVC (pj,e)	Abs. G Coeff.	Rel. G Coeff.	Abs. G Coeff.	Rel. G Coeff.	Abs. G Coeff.	Rel. G Coeff.
Design Rationale									
7	12.16	2.90	6.82	0.556	0.641	0.714	0.781	0.790	0.842
8	9.70	4.79	3.51	0.539	0.734	0.700	0.847	0.778	0.892
9	3.40	2.20	3.23	0.385	0.512	0.556	0.678	0.652	0.759
10	1.52	5.58	3.76	0.140	0.289	0.246	0.448	0.329	0.549 [a]
11	4.92	0.92	0.91	0.728	0.844	0.843	0.915	0.889	0.942
12	9.34	1.31	3.12	0.678	0.749	0.808	0.857	0.863	0.900
13	0.23	0.11	4.93	0.043	0.044	0.082	0.084	0.119	0.121
Pooled	41.259	17.811	26.286	0.483	0.611	0.652	0.758	0.737	0.825
Vehicle Systems									
7	1.11	2.86	1.03	0.222	0.518	0.364	0.683	0.462	0.763
8	2.32	0.34	5.73	0.277	0.288	0.433	0.447	0.534	0.548
9	1.35	1.36	2.11	0.280	0.390	0.438	0.561	0.538	0.657
10	0.55	7.72	2.11	0.053	0.206	0.100	0.341	0.143	0.437
11	0.43	1.38	1.45	0.131	0.228	0.232	0.371	0.312	0.470
12	0	8.31	2.49	0.000	0.000	0.000	0.000	0.000	0.000
13	1.05	0.55	1.70	0.319	0.383	0.484	0.554	0.584	0.651
Pooled	6.808	22.521	16.617	0.148	0.291	0.258	0.450	0.343	0.551
Teamwork									
7	0	1.08	0.59	0.000	0.000	0.000	0.000	0.000	0.000
8	1.24	0.41	0.75	0.515	0.622	0.680	0.767	0.761	0.832
9	0.57	0.35	0.51	0.398	0.527	0.570	0.690	0.665	0.770
10	1.43	0.81	1.69	0.364	0.458	0.533	0.628	0.632	0.717
11	0.33	0.26	0.33	0.359	0.500	0.529	0.667	0.627	0.750
12	0.94	0	1.03	0.477	0.477	0.646	0.646	0.733	0.733
13	1.12	0.03	1.30	0.456	0.462	0.627	0.632	0.716	0.720
Pooled	5.627	2.940	6.207	0.381	0.476	0.552	0.645	0.649	0.731
Overall Presentation									
7	2.37	0	3.92	0.376	0.376	0.547	0.547	0.644	0.644
8	5.33	0.57	1.73	0.699	0.755	0.823	0.860	0.874	0.902
9	1.66	1.21	2.23	0.326	0.428	0.492	0.599	0.592	0.691
10	0.80	2.08	1.13	0.199	0.415	0.332	0.586	0.427	0.680
11	3.10	0	1.36	0.696	0.696	0.820	0.820	0.873	0.873
12	3.01	0.11	2.53	0.533	0.544	0.696	0.705	0.774	0.781
13	0.57	0.27	1.85	0.212	0.236	0.350	0.382	0.447	0.481
Pooled	16.842	4.248	14.740 0	0.470	0.533	0.640	0.696	0.727	0.774
Safety									
7	1.73	1.38	0.46	0.486	0.792	0.654	0.884	0.739	0.919
8	2.40	0.36	0.80	0.673	0.749	0.804	0.857	0.861	0.900
9	2.00	0	1.45	0.579	0.579	0.733	0.733	0.805	0.805
10	2.15	0.21	0.91	0.657	0.703	0.793	0.826	0.852	0.877
11	0.64	0.11	0.18	0.686	0.775	0.814	0.873	0.868	0.912

12	0.52	0.10	0.67	0.405	0.438	0.577	0.609	0.671	0.700
13	0.14	0.28	1.14	0.092	0.112	0.168	0.201	0.232	0.274
Pooled	9.586	2.438	5.614	0.543	0.631	0.704	0.774	0.781	0.837

Table 2b. *Estimated Variance Components and G Coefficients for Sub-categories Codes of the Technical Report Rubric (Cont.)*

	Estimated Variance Components In P x J (Project x Judge) Design			G Coefficients					
				Using 1 Judge (n_j=1)		Using 2 Judges (n_j=2)		Using 3 Judges (n_j=3)	
Triad ID of Judges	EVC (project)	EVC (judge)	EVC (pj,e)	Abs. G Coeff.	Rel. G Coeff.	Abs. G Coeff.	Rel. G Coeff.	Abs. G Coeff.	Rel. G Coeff.
Abstract									
7	0.13	0.00	0.72	0.156	0.156	0.270	0.270	0.356	0.356
8	0.00	0.07	0.27	0.000	0.000	0.000	0.000	0.000	0.000
9	0.13	0.00	0.21	0.385	0.385	0.556	0.556	0.652	0.652
10	0.00	0.03	0.89	0.000	0.000	0.000	0.000	0.000	0.000
11	0.05	0.04	0.17	0.205	0.243	0.340	0.391	0.435	0.491
12	0.08	0.00	0.17	0.318	0.313	0.483	0.477	0.583	0.578
13	0.11	0.05	0.11	0.404	0.500	0.576	0.667	0.671	0.750
Pooled	0.507	0.188	2.533	0.157	0.167	0.272	0.286	0.359	0.375
Budget									
7	0.00	1.57	1.66	0.000	0.000	0.000	0.000	0.000	0.000
8	0.74	0.56	0.74	0.363	0.499	0.533	0.666	0.631	0.749
9	0.32	0.00	0.74	0.304	0.304	0.466	0.466	0.567	0.567
10	0.00	0.79	1.34	0.000	0.000	0.000	0.000	0.000	0.000
11	1.83	0.12	0.59	0.721	0.757	0.838	0.862	0.886	0.903
12	0.37	0.34	0.89	0.233	0.295	0.378	0.456	0.476	0.557
13	0.31	0.90	0.64	0.167	0.327	0.287	0.493	0.376	0.593
Pooled	3.580	4.272	6.595	0.248	0.352	0.397	0.521	0.497	0.620
SID (System Integration Diagram)									
7	0.01	0.11	0.72	0.013	0.015	0.026	0.030	0.038	0.044
8	0.84	0.01	0.49	0.626	0.633	0.770	0.775	0.834	0.838
9	0.76	0.07	1.73	0.298	0.306	0.459	0.469	0.560	0.570
10	0.03	0.29	0.38	0.043	0.072	0.082	0.135	0.118	0.190
11	0.98	0.00	0.36	0.730	0.730	0.844	0.844	0.890	0.890
12	0.64	0.00	0.72	0.473	0.473	0.643	0.643	0.730	0.730
13	0.45	0.00	1.59	0.219	0.219	0.360	0.360	0.457	0.457
Pooled	3.714	0.482	5.987	0.365	0.383	0.534	0.554	0.633	0.650
Troubleshooting Techniques									
7	1.18	0.39	0.83	0.491	0.586	0.658	0.739	0.743	0.809
8	0.53	0.19	0.71	0.370	0.428	0.541	0.600	0.638	0.692
9	0.84	0.28	0.46	0.534	0.649	0.696	0.787	0.775	0.847
10	0.52	0.24	1.26	0.259	0.293	0.411	0.454	0.512	0.555
11	0.00	0.29	0.46	0.000	0.000	0.000	0.000	0.000	0.000
12	1.07	0.17	0.76	0.533	0.584	0.696	0.738	0.774	0.808
13	0.38	0.02	0.48	0.432	0.444	0.604	0.615	0.696	0.706
Pooled	4.520	1.587	4.952 0	0.409	0.477	0.580	0.646	0.675	0.732

Challenges									
7	0.21	0.00	1.47	0.126	0.126	0.224	0.224	0.302	0.302
8	1.03	0.04	0.49	0.660	0.679	0.795	0.809	0.853	0.864
9	1.02	0.00	1.08	0.486	0.486	0.654	0.654	0.739	0.739
10	0.71	0.00	0.25	0.741	0.741	0.851	0.851	0.896	0.896
11	0.10	0.00	0.66	0.126	0.126	0.224	0.224	0.302	0.302
12	0.27	0.21	0.32	0.339	0.460	0.507	0.630	0.607	0.718
13	0.10	0.00	0.36	0.211	0.211	0.348	0.348	0.444	0.444
Pooled	3.446	0.256	4.627	0.414	0.427	0.585	0.598	0.679	0.691

Table 2c. *Estimated Variance Components and G Coefficients for Sub-categories Codes of the Technical Report Rubric (Cont.)*

Triad ID of Judges	Estimated Variance Components In P x J (Project x Judge) Design			G Coefficients: Using 1 Judge ($n_j=1$)		Using 2 Judges ($n_j=2$)		Using 3 Judges ($n_j=3$)	
	EVC (project)	EVC (judge)	EVC (pj,e)	Abs. G Coefficient	Rel. G Coefficient	Abs. G Coefficient	Rel. G Coefficient	Abs. G Coefficient	Rel. G Coefficient
Lessons Learned									
7	0.23	0.14	0.63	0.231	0.269	0.375	0.424	0.474	0.525
8	1.56	0.02	1.41	0.521	0.525	0.685	0.688	0.765	0.768
9	1.11	0.00	0.90	0.551	0.551	0.711	0.711	0.787	0.787
10	0.52	0.10	0.73	0.383	0.414	0.554	0.586	0.651	0.680
11	0.10	0.26	0.33	0.140	0.225	0.246	0.368	0.329	0.466
12	0.61	0.43	0.60	0.373	0.505	0.543	0.671	0.641	0.753
13	0.31	0.02	0.40	0.426	0.437	0.598	0.608	0.690	0.700
Pooled	4.441	0.971	5.010	0.426	0.470	0.598	0.639	0.690	0.727
Future Improvements									
7	0.04	0.02	0.53	0.074	0.077	0.138	0.143	0.194	0.200
8	0.12	0.01	0.12	0.471	0.492	0.640	0.660	0.727	0.744
9	0.13	0.23	0.12	0.276	0.533	0.432	0.696	0.533	0.774
10	0.43	0.00	0.31	0.584	0.584	0.737	0.737	0.808	0.808
11	0.10	0.00	0.09	0.516	0.516	0.681	0.681	0.762	0.762
12	0.11	0.04	0.26	0.270	0.297	0.426	0.458	0.526	0.559
13	0.10	0.02	0.23	0.276	0.291	0.432	0.451	0.533	0.552
Pooled	1.032	0.322	1.666	0.342	0.383	0.510	0.553	0.609	0.650
Reflections									
7	0.20	0.00	0.28	0.414	0.414	0.585	0.585	0.679	0.679
8	0.14	0.00	0.17	0.452	0.452	0.623	0.623	0.713	0.713
9	0.00	0.05	0.22	0.000	0.000	0.000	0.000	0.000	0.000
10	0.30	0.01	0.24	0.543	0.549	0.704	0.709	0.781	0.785
11	0.05	0.09	0.29	0.125	0.158	0.222	0.273	0.300	0.360
12	0.02	0.03	0.20	0.074	0.085	0.137	0.156	0.192	0.217
13	n/a[b]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Pooled	0.710	0.177	1.402	0.310	0.336	0.474	0.503	0.574	0.603

Note: a. Relative G coefficients below .600 were in orange color.
b. Triad 13 assigned the same score to all the projects, therefore no score variation was observed.

Overall, the reliability analysis based on the CTT and G studies provide supportive evidence for the psychometric quality of poster and engineering rubrics. For both rubrics, only one judge is needed to maintain an interrater reliability at an acceptable level for the relative score interpretation (i.e., rank ordering the competition projects). For the engineering, it is worth noting that judges who attended the presentation could ask teams all kinds of probing questions and have an interactive discussion therefore the presentation and Q&A section more likely influenced and resulted in similar scores by judges.

In contrast, the technical report rubric was rather challenging for judges to reach agreeable scores. The detailed findings of the sub-categories of the technical report rubric offered two insights for improving the interrater reliability in this coming year:

(1) Triad 13 definitely needs additional training to get familiar with the rubrics and close monitoring of their scores in the upcoming competition events. A follow-up analysis confirmed that the inconsistency was caused by all of the three judges rather than the situation that two judges scored reliably but differed from the other judge.

(2) Some sub-categories may need to be revised substantially to improve the clarity and easiness of the rubrics. Vehicle Systems is the top candidate because of two reasons. First, it is the only sub-category was considered as relevant, yet failed to meet the acceptable level for interrater reliability.[3] Second, this sub-category has a maximum of 14 points out of the 100 possible points, the second highest weighted sub-category. Budget and SID should be placed as the next two candidates for the rubric revision because of the number of points allocated to these two sub-categories.

(3) Revisions for other problematic sub-categories should be waited after we conduct additional analysis related to construct validity. The planned factorial analysis will help us pinpoint how the sub-categories relate to the underlying construct intended to measure. We also plan to conduct a cognitive interview with a small sample of judges to unpack their reasoning processes when they review projects and assign scores as well as possible difficulties or confusions they may experience when applying the rubrics. With new findings we may recommend to collapse or drop a couple of sub-categories to simplify the cognitive process of making scoring decisions.

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[3] Regarding the relevance of sub-categories to the construct that the technical report rubric is intended to assess (e.g., students' technical competence, communication, and engineering design skills), five sub-categories (i.e., *Design Rationale*, *Vehicle Systems*, *Teamwork*, *Overall presentation*, and *Safety*) are theorized as the most relevant. On the related note, it is encouraging that four of the five relevant sub-categories could be reliably applied by the scoring teams.

Table 3. *Summary of Relative G Coefficients for Sub-categories of the Technical Report Rubric*

Triad ID of Judges	Design Rationale	Vehicle Systems	Teamwork	Overall Presentation	Safety	Abstract	Budget	SID	Troubleshooting Techniques	Challenges	Lessons Learned	Future Improvements	Reflections	Summary of Number of Rel. G Coeff. (ρ^2) by Sub-category: Number of $\rho^2 \geq .60$	Number of $\rho^2 \geq .75$
7	**0.842**	**0.763**	0.000	0.644	**0.919**	0.356	0	0.044	**0.809**	0.302	0.525	0.200	0.679	5	4
8	**0.892**	0.548	**0.832**	**0.902**	**0.900**	0	**0.749**	**0.838**	0.692	**0.864**	**0.768**	0.744	0.713	11	8
9	**0.759**	0.657	**0.770**	0.691	**0.805**	0.652	0.567	0.570	**0.847**	0.739	**0.787**	**0.774**	0	10	6
10	0.549	0.437	0.717	0.680	**0.877**	0	0	0.190	0.555	**0.896**	0.680	**0.808**	**0.785**	7	4
11	**0.942**	0.470	**0.750**	**0.873**	**0.912**	0.491	**0.903**	**0.890**	0	0.302	0.466	**0.762**	0.360	7	7
12	**0.900**	0.000	0.733	**0.781**	0.700	0.578	0.557	0.730	**0.808**	0.718	**0.753**	0.559	0.217	8	4
13	0.121	0.651	0.720	0.481	0.274	**0.750**	0.593	0.457	0.706	0.444	0.700	0.552	0	5	1
Max score pts	15	14	7	13	8	3	7	6	4	4	4	2	2		
Relevance	High	High	High	High	High	Low	Low	Low	Low	Low	Low	Low	Low		
Summary of Number of Rel. G Coeff. (ρ^2) by Triad															
Number of $\rho^2 \geq .60$	5	3	6	5	6	2	2	3	5	4	5	4	3		
Number of $\rho^2 \geq .75$	5	1	3	3	5	1	1	2	3	2	3	3	1		

Improving the Internal Consistency of Existing Surveys

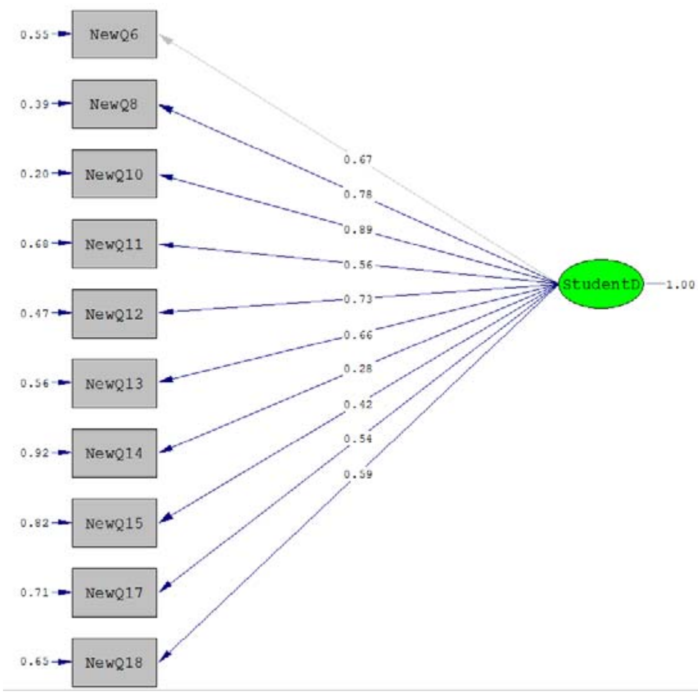
This year we evaluated the internal structure and consistency of four existing surveys based on the data collected from all the competition events in 2014: student survey, parent survey, instructor survey, and volunteer survey. For each of the surveys, we first examined the descriptive statistics to make sure that responses were properly recoded if needed and checked if items may involve a usually high non-response rate (which was one indication that the wording of the survey question might be confusing or ambiguous to respondent) or may have too small standard deviation that can potentially cause poorly behaving items due to the restricted range of scores. We then performed both exploratory factor analysis (EFA) and confirmation factor analysis (CFA) to verify the internal structure of the construct. Lastly, we calculated the Cronbach's alpha coefficients as indicators for internal consistency for the sub-scales corresponding to the factor model identified by the factor analyses. In what follows we only report the key findings of the psychometric analysis based on the CFA and Cronbach's alpha.

Student Survey. Based on the χ^2 value, we recommend the 3-factor model because it has a much lower χ^2/df ratio and statistically better than the other two factor models (see Table 4 for fitness statistics and

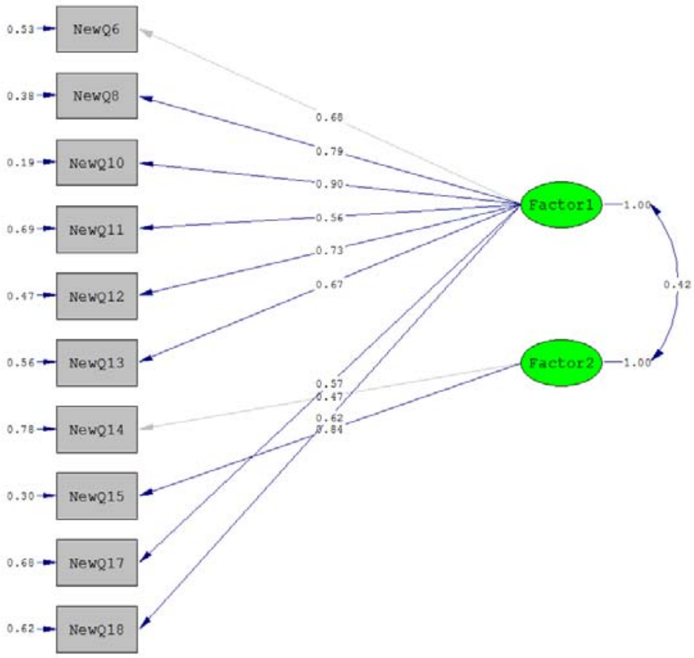
Figure 1 for factor loadings for each tested model). Still this 3-factor model is not statistically robust which means there is room to improve the model fit and factor loadings of the survey items.

Table 4. *CFA Model Fit for Student Survey Items*

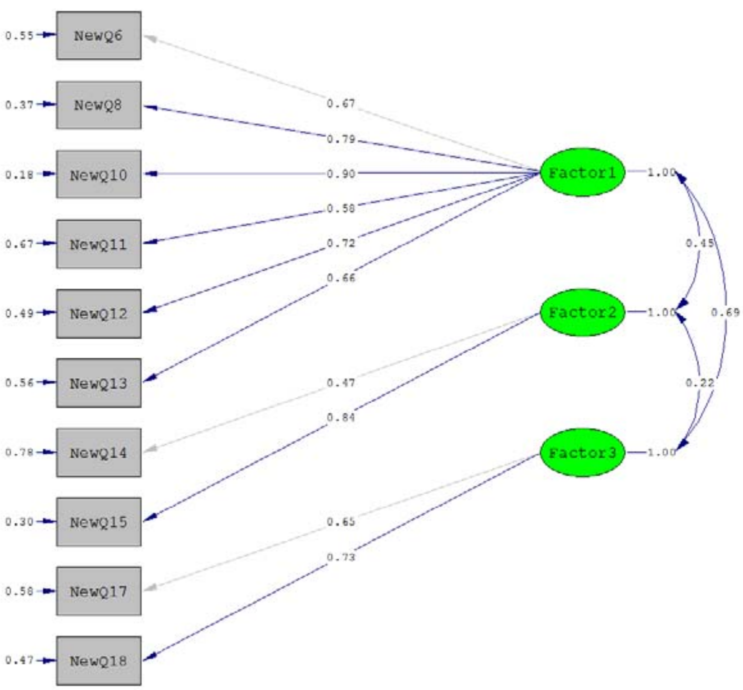
CFA model	Model Fit Indices (in terms of χ^2 statistic)
1-factor model	913.457 (df=35)
2-factor model	788.361 (df=34)
3-factor model	573.956 (df=32)



a. Standardized Solutions of 1-factor model



b. Standardized Solutions of 2-factor model



c. Standardized Solutions of 2-factor model

Figure 1. Standardized loadings for the tested CFA models

Table 5 below provides the detailed information for the underlying factors as we choose the 3-factor model. We report the internal consistency for the three factors (i.e., sub-scales). Based on the Spearman-Brown formula (Brown, 1910; Spearman, 1910), we also computed the total number of items needed for each sub-scale to maintain an alpha coefficient of .70. Factors 2 and 3 need at least double the length of the items in order to reach an acceptable level of Cronbach's alpha whereas Factor 1 only needs to add one more survey item.

Table 5. *Descriptions of Sub-scales for Student Survey and Internal Consistency Statistics*

Factor	Survey Item IDs	Description of the Factor	Cronbach's Alpha Coefficient	# of Items Needed for Alpha=.70
1	Q6, Q8, Q10, Q11, Q12, Q13	STEM learning outcomes resulted from the ROV competition	.64	8
2	Q14, Q15	Career impacts of the ROV competition	.40	7
3	Q17, Q18	Learning outcomes related to the theme from the ROV competition	.50	5

<u>Parent, Instructor, and Volunteer Surveys</u>. Following the same procedure described above, we examined the internal structure of the three other surveys based on the content review of all the survey items, using both EFA and CFA modeling. Table 6 reports the CFA model fits in the form of χ^2 statistics and recommends one model for each survey that yields the best model fit and theoretically aligns with our assumptions of the underlying constructs.

Table 6. *CFA Model Fit for Parent, Instructor, and Volunteer Survey Items*

CFA model	Model Fit Indices (in terms of χ^2 statistic)	Selected Model
Parent Survey		
1-factor model	3482.92 (df=35)	x
3-factor model	3522.52 (df=32)	
Instructor Survey		
1-factor model	913.457 (df=35)	
2-factor model	788.361 (df=34)	
3-factor model	573.956 (df=32)	x
Volunteer Survey		
1-factor model	392.476 (df=65)	
3-factor model	110.474 (df=62)	x

For each survey, we continued to calculate the internal consistency of survey items for sub-scales for the recommended model based on the factor analysis results (see Table 7). Only one sub-scale in Parent Survey had satisfactory internal consistency. The other two sub-scales apparently need to include additional items. For the third sub-scale, a better way of improving the technical quality is to revise the items instead of adding similar items because it is not practically reasonable or efficient to include 22 items for one sub-scale. The internal consistency statistics for both Instructor Survey and Volunteer Survey confirmed that the sub-scales identified from the factor analysis had strong internal consistency (i.e., all of them were above .80).

Informed by the factor analysis and reliability analysis, we provided revision comments to Student Survey and Parent Survey around three issues: (1) change items that did not behave well in the Cronbach's alpha by clarifying the wording of the stem or the labels of the Likert scale or even drop items when they overlapped significantly with others; (2) use similar layouts to present survey questions and the Likert scale across the four surveys; (3) make the use of words and phrases consistent across all the four surveys so that potentially the response patterns can be compared; and (4) revisit and revise items that were grouped around one common stem as multiple statements when appropriate or create new set to organize items into such a set. The revised versions of surveys had been used with participants of different roles this year.

Table 7. *Descriptions of Sub-scales for Parent, Instructor, and Volunteer Surveys and Internal Consistency Statistics*

Factor	Survey Item IDs	Description of the Factor	Cronbach's Alpha Coefficient	# of Items Needed for Alpha=.70
Parent Survey				
1	Q4,Q5	Overall comments to the ROV competition experience	.42	7
2	Q6A,Q6B,Q6C, Q6D	ROV impacts on academic learning of subjects	.88	-
3	Q7A,Q7B,Q7C, Q8	ROV impacts on your child(ren)'s 21 century skills	.30	22
Instructor Survey				
1	All 12 items	Comments on the effects of the ROV competition on student learning	. 88	-
Volunteer Survey				
1	Q3A, Q3B, Q4A,Q4B, Q4C	Overall comments on the ROV competition experiences	.87	-
2	Q5A, Q5B, Q5C	ROV impacts on students' academics	.84	-
3	Q6A, Q6B, Q6C, Q6D, Q6E	ROV impacts on students 21st century skills	.86	-

Plan of Psychometric Analysis in Year 3

In Year 3, we will continue with the psychometric work around three types of instruments to analyze and organize empirical evidence to evaluate the validity claims and plan for a measurement publication for the scoring rubrics used for the ROV competition.

Validation of Competition Scoring Rubrics. We will continue the interrater reliability analysis using CTT and G theory with the judge scores collected from Year 2. Also based on the findings, we will revisit and refine the scoring rubric for the technical report, especially the sub-category of Vehicle Systems, and develop annotated examples and scoring tips for some challenging sub-categories.

Furthermore, we plan to conduct four validity studies with the rubric scores of poster, engineering, and technical report:

(1) An alignment study to evaluate the content validity of each rubric. We will review the criteria of each rubric and link each criterion to the engineering practices of the NGSS.

(2) A set of factor analysis modeling with the sub-category scores. After we establish the interrater reliability, we will run the structural equation modeling (SEM) to perform the factor analysis to identify the internal structure for each rubric. This will allow us to determine whether some sub-categories can be collapsed (or dropped if the sub-category is difficult to maintain interrater reliability and does not contribute to the underlying constructs).

(3) Multi-trait multi-method (MTMM) correlation to explore the convergent and discriminant evidence of measuring various sub-scales of students' engineering performance. We hypothesize that the correlation patterns across the three rubrics (e.g., are the Design Rationale scores from both poster and technical report highly correlated?) can be empirically tested, which then can inform us to revise the three rubrics to ascertain what aspects of student performance can be captured by all the three rubrics or uniquely assessed only by one particular rubric.

(4) Cognitive interview with the judges via audio-taped conference calls. We will recruit the judges for the technical reports to score a middle of the road report from a previous competition. We will then conduct the panel review to ask each judge to explicitly explain why one judge gave a certain category a 2, etc. The transcriptions will be analyzed to understand how judges made evaluative decisions when applying the rubrics, what evidence they chose to focus on, and which parts or pieces of rubrics caused inconsistency or difficulties in scoring. In addition to the research purpose, the transcribed excerpts of the cognitive interview can be augmented with annotations as training examples for new or returning judges.

<u>Analysis of Existing Survey</u>. We will replicate the factor analysis and internal consistency analysis with the data collected in Year 2 to cross validate the findings from previous year and evaluate the technical quality of revised items in Student Survey and Parent Survey. Furthermore, we will start to streamline four surveys to ensure that information can be triangulated across multiple surveys by running regression analysis and SEM with latent variables in order to compare the response patterns. Examples of the research questions include: did students who participated in the ROV competition for multiple times report higher scores in academic outcomes than their peers who only participated once? Did students or instructors report the same obstacles for the ROV competition?

*****

Regional Workshops

PRE AND POST TEACHER WORKSHOP SURVEYS AND KNOWLEDGE TESTS

Pre and post paper surveys were administered to teacher workshop attendees at the beginning of the workshop day and at the end of the training. The surveys addressed issues of teacher confidence facilitating STEM learning experiences, commitment to bringing a team to competition, concerns about mentoring students in designing and building an ROV, expectations of the workshops, and additional ways that the regional coordinators and the MATE Center could support the participants. In the 2015 competition season, pre-post knowledge tests were added to the surveys administered at the New Orleans workshops.

Summer Institute

IMMEDIATE FEEDBACK AND SIX-MONTH FOLLOW-UP SURVEYS

The evaluation of the Summer Institutes is a two-step process, collecting feedback from the participants immediately after the Institutes (using the Institute feedback surveys) then again a year later (using the Institute follow-up surveys). The follow-up surveys intend to measure the Institutes' longer-term impact and, in particular, to compare participants' actions once they returned to their classrooms with the intentions they had expressed at the close of the Institute. Because of the timing of the Summer Institute and the evaluation reporting, this evaluation covers the 2014 Summer Institute.

Other Data Sources

Additional data sources informing the evaluation include the annual reports turned in by the regional coordinators to the ITEST grant PI, observations of the Pacific Northwest regional competition, review of regional fidelity reports (based on site visits by the PI's and evaluator), review of participation data, unsolicited letters sent to the regional coordinators and the MATE Center from students, parents and teachers, website review and document review, including supporting technical materials and the MATE Center's annual report.

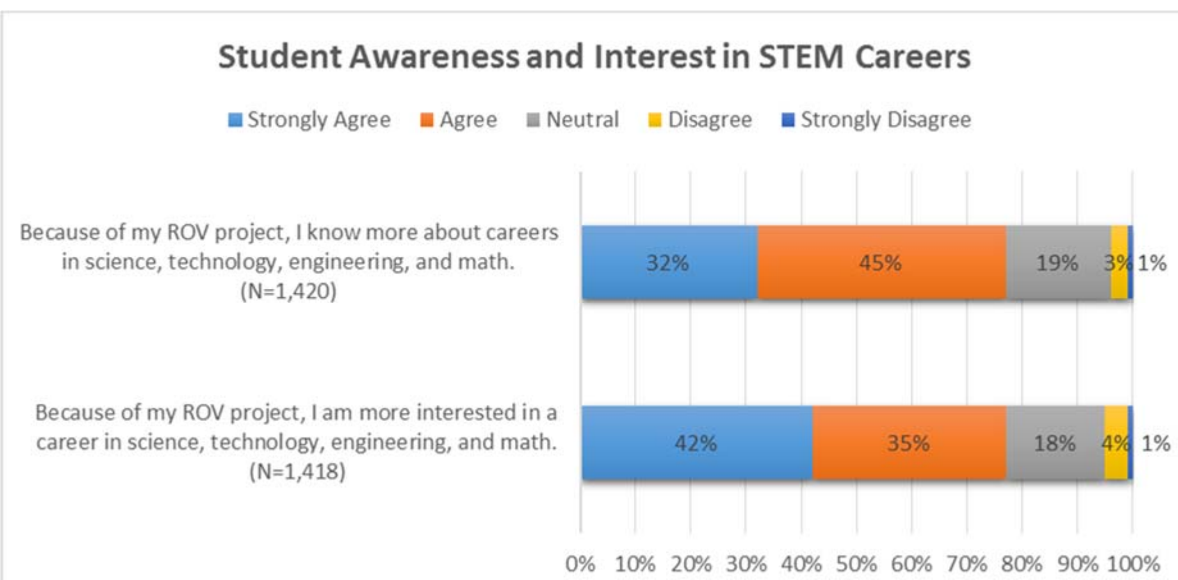
FINDINGS

Project Goal 1: Increase middle and high school students' interest in STEM and STEM careers, as well as their knowledge of STEM and understanding of how science and engineering work together to solve real-world problems

Evaluation Question(s) 1.1. To what extent did the MATE robotics activities lead to an increase in the students' interest in and knowledge of STEM content and STEM careers? Did educators and parents observe an increase in the students' interest in STEM content and STEM careers as a result of the robotics activities? An increase in the students' STEM knowledge and skills and 21st Century workplace skills?

Increased Awareness of and Interest in STEM Careers: In the post-competition surveys, over three-quarters of the students (77%, N=1,420) indicated that due to their ROV project, they knew more about careers in science, technology, engineering, and math (STEM), and over three-quarters (77%, N=1,418) stated that their ROV project made them more interested in pursuing a STEM career.

Figure 2: Effect of ROV Project on Students' Awareness and Interest in STEM Careers

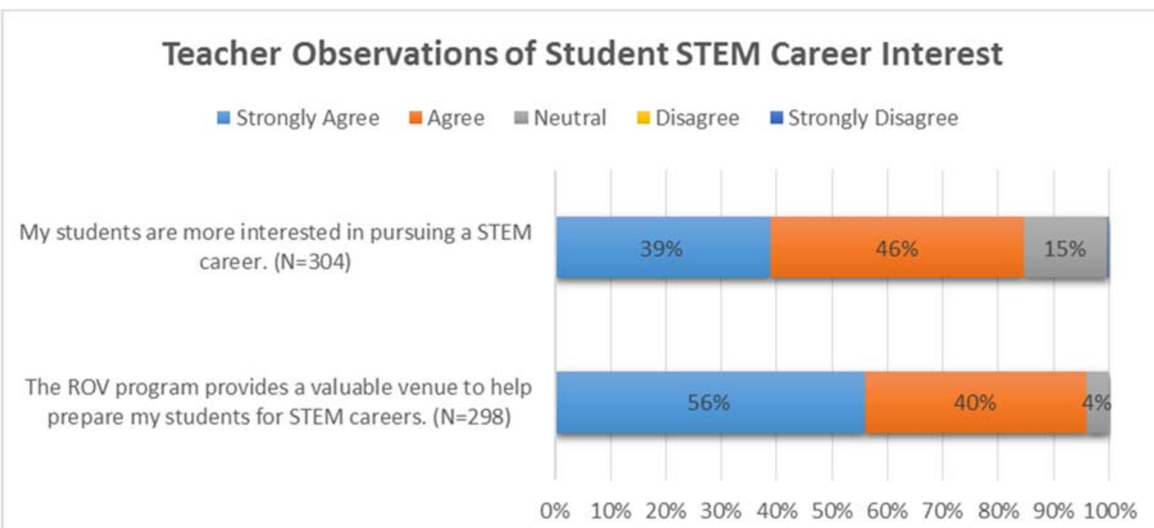


Overall, 78% of the students were interested in a STEM career; 18% were not sure, and 4% were not interested in a career in this field. Students mentioned wanting careers such as mechanical engineer, electrical engineer, ROV pilot, robotic prosthesis engineer, marine biologist, technological entrepreneur, and software engineer. Students noted that their experience in the ROV program sparked their interest in STEM careers, with comments such as the following:

> *It was a great experience, and it really makes me want to have a job in engineering!*
>
> *Robotics helped me to want to have a career in engineering later in my life.*
>
> *This is a great experience that helps build and solidify my engineering career.*
>
> *I just want to thank the MATE program. I have competed with a team for the past 4 years and watched my brother compete for 4 years before then. The competition has introduced me to countless contacts and industry professionals who have already begun to help me as I continue my journey towards a career.*

Among the teachers/mentors who completed post-competition surveys, 85% (N=304) indicated that they had observed that their students were more interested in pursuing a STEM career since they began designing and building their ROVs. Ninety-six percent (96%, N=298) agreed that the ROV program provided a valuable venue to help prepare their students for STEM careers.

Figure 3: Teacher Observations of Student STEM Career Interest



Parents also noted an increased awareness and interest in STEM careers; 92% (N=342) agreed that due to the ROV project, their child(ren) know more about STEM careers (57% strongly agreed, 35% agreed, 7% neutral, 0.6% disagreed, 0% strongly disagreed, 0.6% don't know). Also, 85% (N=340) agreed that participating in the ROV project has led their children to be more interested in pursuing a STEM career (58% strongly agreed, 28% agreed, 13% neutral, 1% disagreed, 0.3% strongly disagreed, 0.6% don't know). Parents described their children's interest in STEM careers in comments such as the following:

> *Has become more interested in technological careers.*

> *Enthusiasm for science and a career as a scientist. This program is great!*

> *Exceptionally good program for children to explore and grow, to learn about future career options and teamwork.*

Increased Interest in STEM: Over three-quarters of the students (84%, N=1,413) stated that their ROV project made them want to learn more about science, technology, engineering, and math (48% strongly agreed, 36% agreed, 13% neutral, 2% disagreed, 1% strongly disagreed).

Students indicated that their ROV projects increased their desire to take courses in engineering (65%, N=1,410), science (72%, N=1,408), computer science (69%, N=1,401), math (59%, N=1,405), and other hands-on classes or club activities like robotics, electronics and shop courses (88%, N=1,406). (See *Figure 4* below.) As one student explained his experience, "I am very, very thankful you are putting this program on. Without it my life would be robotics free, and I would never know my interests in engineering." Another stated that the competition affected his interest in robotics as follows:

> *This has been an amazing experience for me, and I love hearing my teachers comment on the creative ideas and thoughts from my teammates and me.*

ROV Program Testimonials

Students

MATE is a great program and has helped me grow both in intelligence and in character.

This was a very fun hands-on experience, and we learned a lot of things necessary for starting a career in the sciences.

MATE ROV was a wonderful experience that I regret not becoming a part of earlier. The memories I have made are countless, and the technical experience gained priceless. Any STEM-related major or field should seize the opportunity to be a part of an ROV team.

Parents

My son has grown exponentially in maturity. He's not afraid to fail. He looks for innovative ways to solve the problem. He's part of a team and he LOVES this program.

Actually excited about school. He was diagnosed with severe depression in the fall, and I believe, along with his therapist and doctor, that this program helped him to overcome it and [he] begin to feel better about school, himself, and life.

We love this program. We've never seen our daughter so excited and engaged.

Faculty/Mentors

This was an incredible, life-changing experience for many of my students. It was very challenging to pull off but completely worth it, and I'll definitely do it again next year.

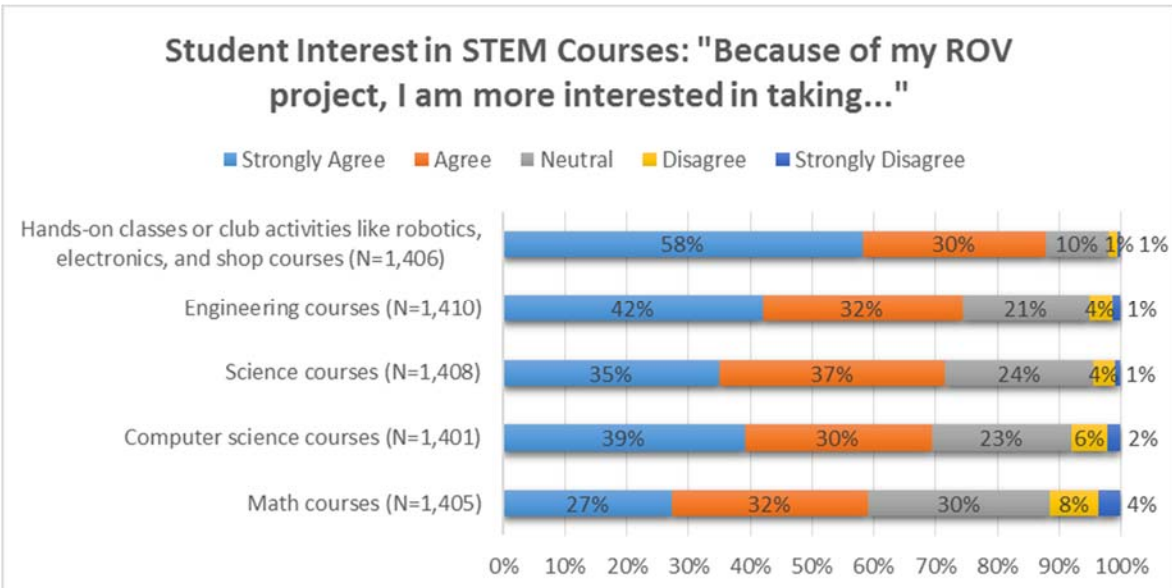
This is the way STEM should happen and how you bring students into the field - with application and engagement. MATE has their priorities right.

These experiences with robotics and ROVs have strongly increased my interest in engineering and different ways technology can be used.

In the post-competition survey, 94% of the teachers/mentors (N=305) indicated that their students were more interested in learning about science, technology, engineering and math (53% strongly agreed, 41% agreed, 5% neutral, 0.3% disagreed, 0.3% strongly disagreed). Teachers described experiences such as the following:

> *One example, we have a student who was a little discouraged about her technical prowess, and didn't see the value of practicing a technical subject when she was planning on a humanitarian career. She met some mentors along the way who helped her see the value in learning STEM subjects so that you can apply the principals to help others in need. This was a real 'aha' moment!*

Figure 4: Effect of ROV Project on Students' Interest in STEM Courses



Parents concurred with the other sources reporting increased student interest in STEM. Ninety-five percent (95%) of the parents surveyed (N=344) stated that building an ROV has made their child more interested in learning about science, technology, engineering or math (62% strongly agreed, 33% agreed, 5% neutral, 0% disagreed, 0% strongly disagreed). Parents wrote comments such as the following:

> *Excellent program. One of the sons clinched his decision to go into engineering as his major and received an engineering scholarship.*

My son has become very interested in an engineering degree.

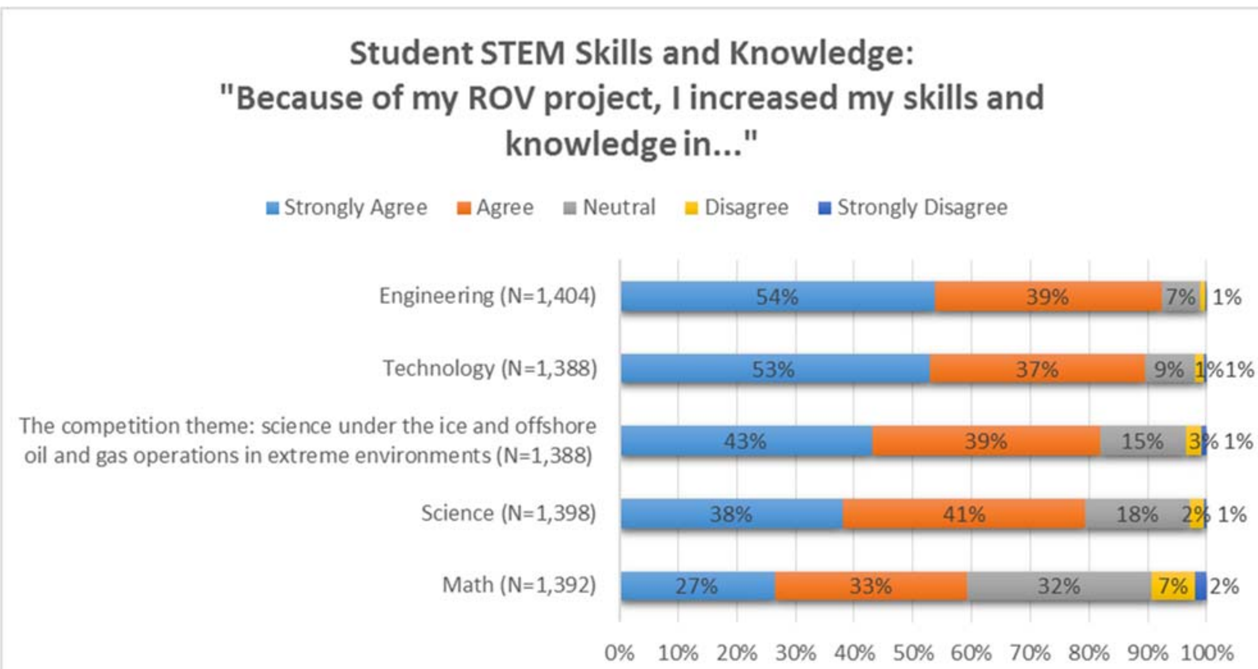
Excited about his studies and passionate about studying engineering.

Increased STEM Knowledge and Skills: In the post-competition surveys, students reported increased skills and knowledge due to their ROV project in several subjects: engineering (92%, N=1,404), technology (90%, N=1,388), the competition theme of science under the ice and offshore oil and gas operations in extreme environments (82%, N=1,388), science (79%, N=1,398), and math (59%, N=1,392). Students noted their increased STEM skills in comments such as the following:

This is the best experience of my life. This increased my skills at science etc. I never want to leave.

This is my first year in a competition. I enjoyed it really much. In this competition, I've learnt more about science and electronics, and moreover how to build an ROV by ourselves. We use Arduino to control our ROV, so we have to learn more about electronics. I'm glad that I have a chance to participate in this competition, and I hope that I can join it again next year.

Figure 5: Effect of ROV Project on Students' STEM Skills and Knowledge

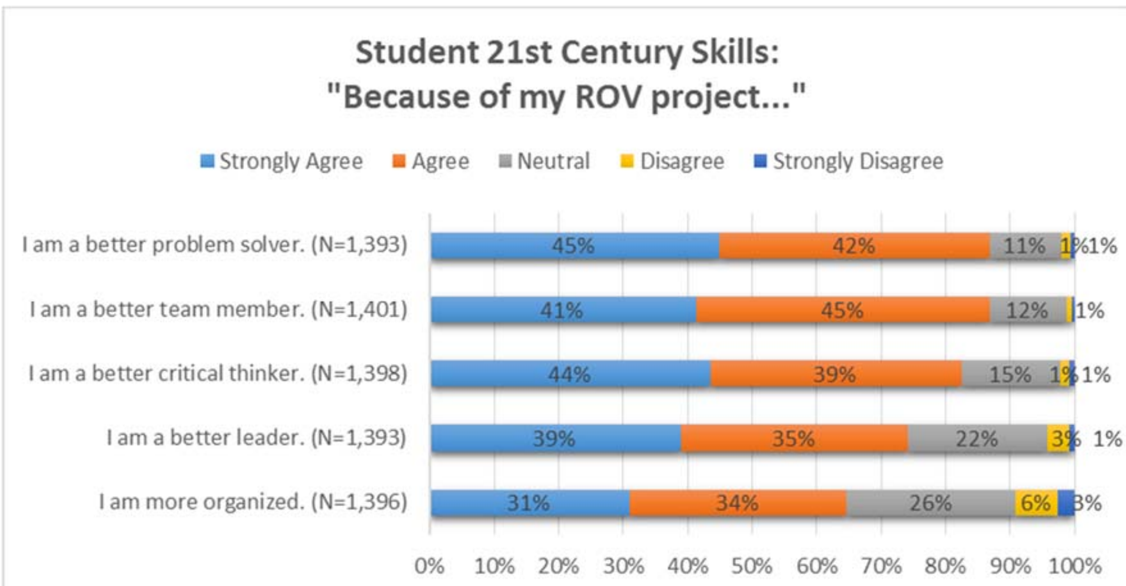


Among the teachers/mentors who completed post-competition surveys (N=298), 99% of the respondents reported that they observed improvements in their students' STEM knowledge and skills (67% strongly agreed, 32% agreed, 1.3% neutral, 0% disagreed or strongly disagreed).

Parents reported that building an ROV contributed to improving their children's grades in engineering/robotics (69%, N=264), science (54%, N=343), math (40%, N=338) and computers (47%, N=277).[4] As one parent explained, "My son has found that what he has learned through the ROV project has made him more successful in Physics & Calculus."

Increased 21st Century Skills: Students reported that participating in the ROV project improved their problem solving (87% agreed or strongly agreed, N=1,393), teamwork (87%, N=1,401), critical thinking (82%, N=1,398), leadership (74%, N=1,393), and organization skills (65%, N=1,396).

Figure 6: Effect of ROV Project on Students' 21st Century Skills



In responses to open-ended survey questions, students also described gaining 21st Century skills through their experiences building an ROV, such as the following:

> *This program has opened a world of experiences to me that I otherwise wouldn't have been able to achieve. I've gained plenty of skills such as teamwork and communication*

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[4] Percentages are calculated among students studying each topic.

skills. My team and I have overcome the obstacles that others told us were impossible to complete.

The program has been a great way to learn engineering, math, science and teamwork skills.

Great experience, very good for learning more about engineering and how to be a good problem solver.

Because of this competition, I learned many things. I learned how to work in a team, and how to work under stress. I learned socializing with people I've never met before. I learned leadership and teamwork, and of course engineering, so I want to say thanks for it.

In the post-competition surveys, 98% of the teachers/mentors (N=304) mentioned that they observed increases in their students' skills in team building, problem solving, and/or critical thinking (61% strongly agreed, 37% agreed, 2% neutral, 0.3% disagreed, 0.3% strongly disagreed). Teachers/mentors saw skill development in many areas, as evidenced by their written comments:

MATE is a great program that builds numerous skills, including team building, critical thinking, design, engineering, problem solving.

My students have learned to work as a team. They have realized they are capable of doing the tasks required of them and procrastinating is not a good thing. They are already planning what they would like to do next year.

Parents were asked about their observations of changes in their children due to the ROV program. The vast majority agreed or strongly agreed that because of the ROV program, their children were better problem solvers (96%, N=344), critical thinkers (93%, N=343), team members (93%, N=344), and/or leaders (89%, N=345). In the open-ended comments, parents noted other changes that they observed in their children, including public speaking, leadership, prioritizing, working under pressure, resiliency, focus, time management, and self-confidence. Comments in this theme include the following:

Stronger leadership skills, problem solving skills, ability to work under pressure, abilities to work in a team atmosphere, ability to work long hours and stay focused, ability to solve real world problems and challenges

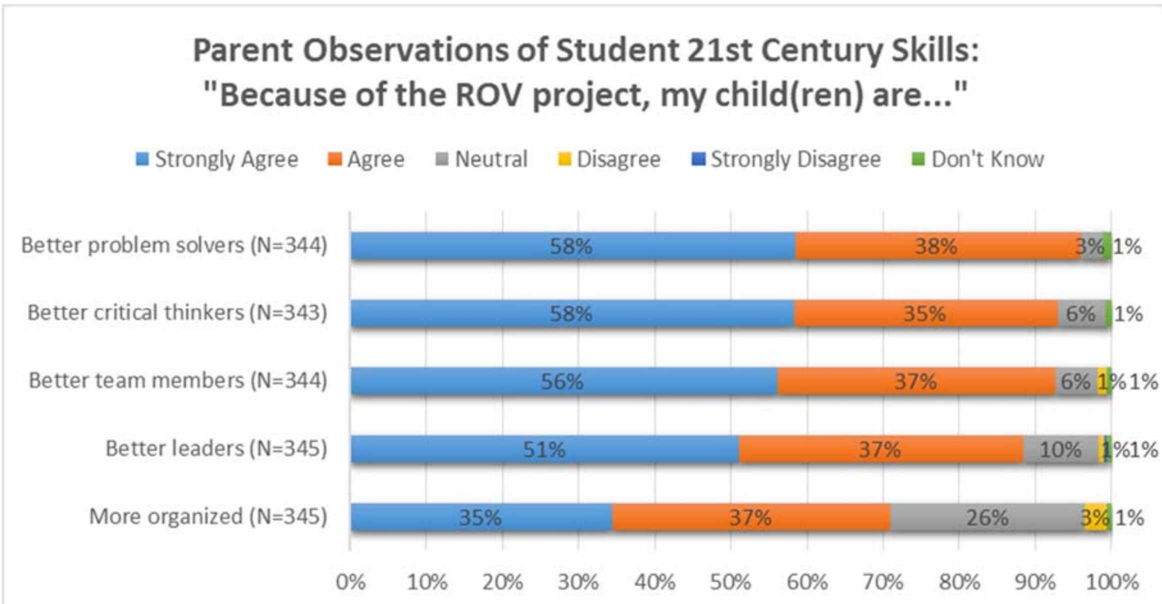
My oldest son had low self-confidence, but today he spoke at the team presentation and drove the ROV.

The experience has helped my son to develop his presentation, leadership, and team building skills.

Ability and confidence to attack problems which, previously, he would shy away from

This program and the MATE competition have had a huge impact on my son as it has given him so many opportunities and responsibilities that he would never have gotten from school. As team captain, he has gained not only technical knowledge but organizational and management skills that he will be able to draw from in his future career.

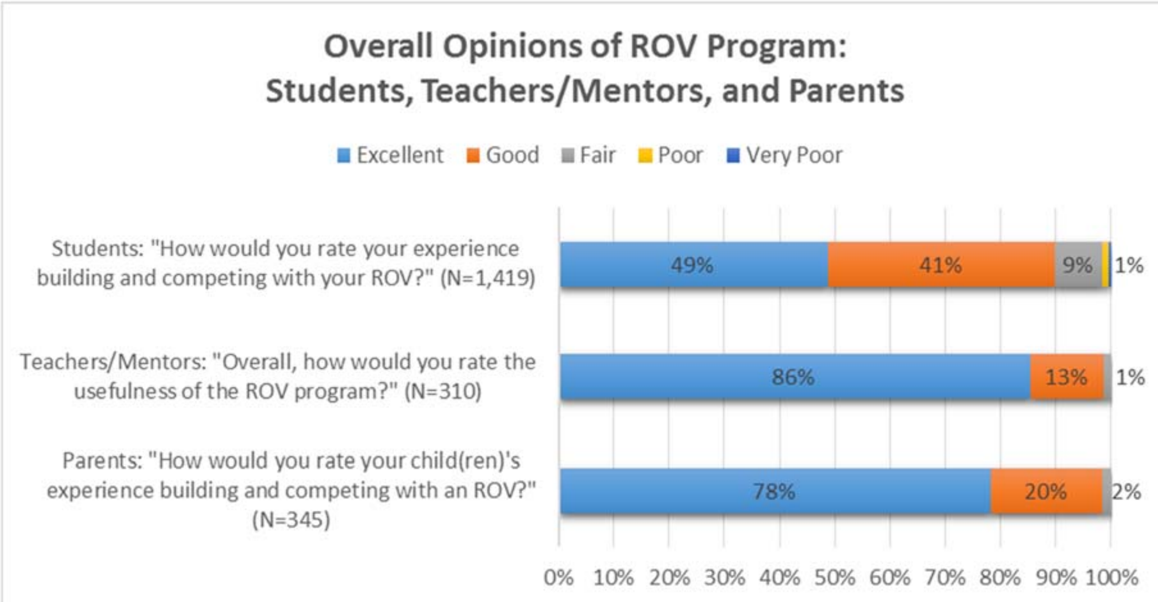
Figure 7: Parent Observations of Effect of ROV Competition on Students' 21st Century Skills



Overall Opinions of ROV Program: Overall, students rated their experiences building and competing with their ROV very positively, with almost half (49%) rating their experience as excellent, and 41% providing a rating of good. Nine percent (9%) thought their experience was fair, and less than 2% gave the experience a poor or very poor rating. (See *Figure 8*) In the post-competition surveys, students wrote comments such as the following:

I enjoyed myself immensely in this competition. I learned some amazing skills in problem-solving, fabrication, mathematics, and science which will help me in the long run. I learned how to collaborate with a team, think outside the box, and cooperate with group decisions, even if it's not within my personal opinions. This has been a great, and memorable experience. I'll definitely be back next year.

Figure 8: Overall Opinions of the ROV Program from Students, Teachers/Mentors, and Parents



Teachers/mentors (N=310) gave uniformly positive ratings of the usefulness of the competition, with 86% stating that it was excellent and 13% indicating that it was good. Teachers/mentors also rated the support provided by the MATE program highly (61% excellent, 32% good, 7% fair, 0.6% poor, and 0% very poor). Teachers/mentors stressed the importance of the program in comments such as the following:

> *MATE is a great program for our young scientist and engineers. There is so much interest in the program that students must be selected to participate. This is a sign of the strength of the program and interest in not only science and engineering, but finance, presentation, reporting, and all of the other aspects of the MATE program.*

> *We love the MATE Competition, it is well organized, fair and professional. It has taught our high school students technical skills and teamwork which is instrumental in their success in college and career.*

> *MATE is an absolutely awesome program! The interesting technical challenge that underwater robotics provides (seals, control systems, video systems, etc.), the complexity that forces the need for good program management, the technical writing requirement, the salesmanship, the public speaking, etc. provide a very well rounded experience that the students do not get any other way. I receive a lot of feedback from parents that the MATE program at our school was the highlight of their student's high school experience and was key to solidifying their plans for the future.*

Overall, parents gave extremely positive ratings to their children's experience building and competing with an ROV. Seventy-eight percent (78%, N=345) rated it as excellent, 20% gave a rating of good, and 2% marked fair. When asked whether the competition has been valuable for the educational development of their child, three-quarters strongly agreed that it was (75%, N=345), 24% agreed with the statement, 0.6% were neutral, and 0.3 (one individual) disagreed. No respondents strongly disagreed.

> *They have developed communication skills, leadership skills as well as increased knowledge of science and technology. For both of my children, the confidence developed through this program has been incredible. This team building activity has opened the door to career paths for both of my children. Great job MATE!*

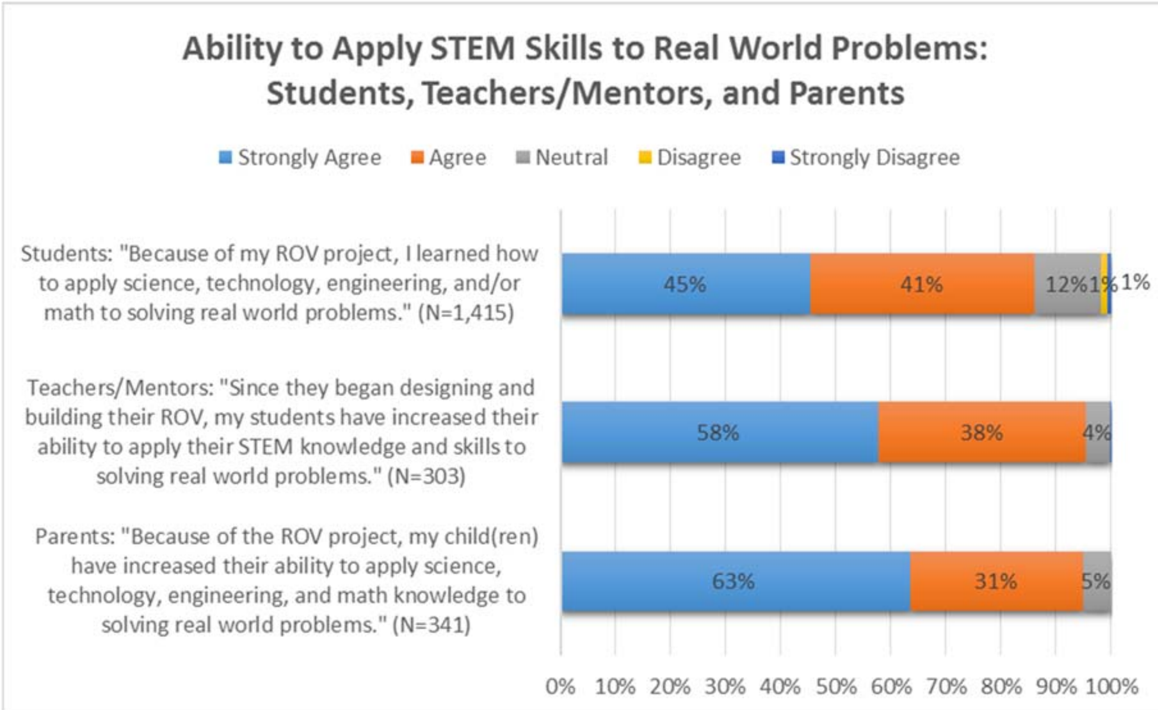
> *This is a wonderful program. It teaches team building, problem solving, and engineering/math skills and builds confidence. I guarantee the outcome of this event on my daughter's team equals new future scientists.*

Evaluation Question 1.2. How did the robotics activities affect students' ability to apply STEM knowledge and skills to finding solutions to real-world problems?

In the post-competition surveys, 86% of the students (N=1,415) indicated that participating in the ROV project helped them learn to apply STEM to real world problems. Ninety-five percent (95%) of the teachers/mentors (N=303) observed improvements in their students' ability to apply STEM knowledge and skills to real world problems, as did 95% of the parents (N=341). (See *Figure 9*)

In the ROV competition student alumni survey, 91% of the alumni (N=426), indicated that participating in the ROV program helped them learn to apply science, technology, engineering and/or math to real-world problems.

Figure 9: Effect of ROV Program on Ability to Apply STEM Skills to Real World Problems: Students, Teachers/Mentors, and Parents



Students recognized the connection between the competition and real-world application of their science and technology skills in the following quotes:

> *The competition is a great way to put math, technology, and science in to real world applications.*
>
> *I think the competition is a great way for students to learn about careers in STEM, and it also helps educate students about real-world problems with a robotics-based solution.*

Teachers appreciated the opportunities that the ROV projects gave for their students to apply their classroom knowledge to hands-on activities modeled after real-world problems, as evidenced in the following comments:

> *I truly appreciate the real world experience this program has provided for my students.*
>
> *The program is great for kids, because it provides opportunities to interact professionally with industry and academic engineers and business professionals, as well as providing access to hands-on experience in Marine Science and Industry.*

Parents also appreciated the real-world engineering industry focus of the competition, in comments such as the following:

> *He has definitely become more self-confident and has learned a lot more about science and technology and real world situations.*
>
> *"Real world" problem solving on the spot and dealing with (at times) [low] participation from all team members. Voicing opinions. Taking risks.*
>
> *Our son has improved his ability to conceptualize practical, real world solutions to problems.*
>
> *This is a great program that takes classroom learning to another level. Solving real world problems in a team setting prepares students for adult work situations. Keep projects like this alive.*

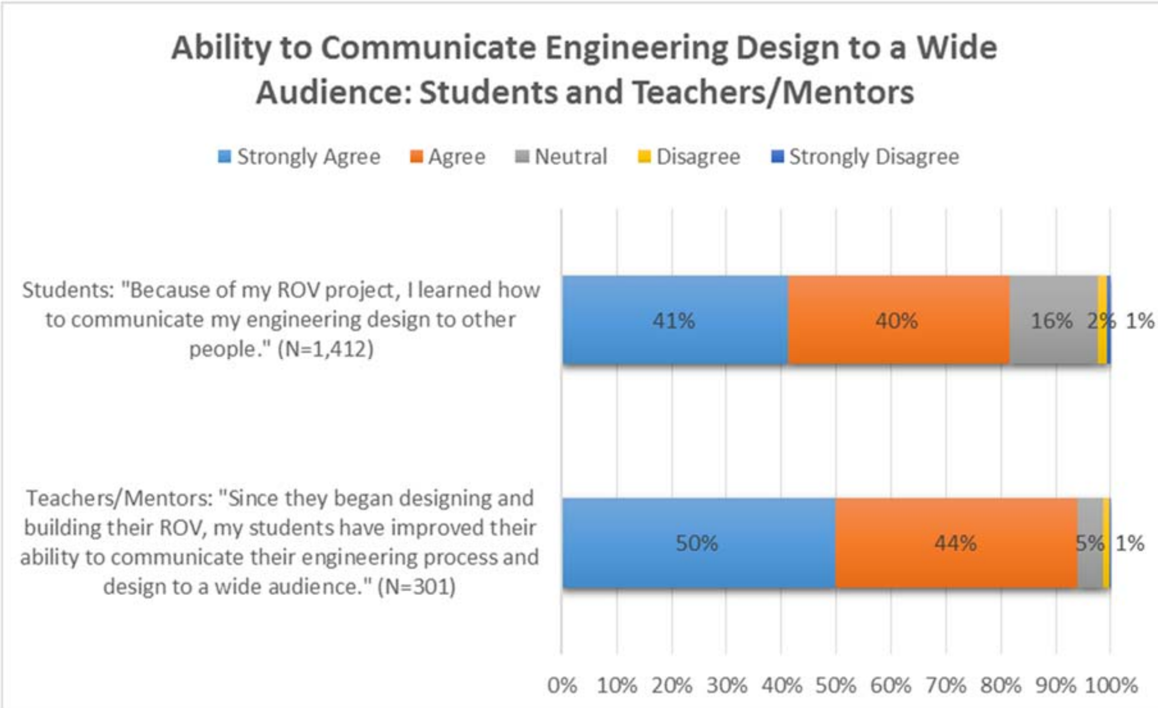
Evaluation Question 1.3. How did the robotics activities affect students' ability to communicate their engineering process and designs to a wide audience (from engineers and technicians to the general public)?

Eighty-one percent (81%) of the students in the post-competition surveys (N=1,412) stated that participating in the ROV project helped them learn how to communicate their engineering design to other people. Ninety-four percent (94%) of the teachers/mentors (N=301) indicated that their students had improved their ability to communicate their engineering process and design to a wide audience. (See *Figure 10*)

Many students commented that their communication and presentation skills had increased, in quotations such as the following:

> *I have improved team building and communications skills.*
>
> *It was a great and fun experience, and I learned more about communication and teamwork.*

Figure 10: Effect of ROV Program on Ability to Communicate Engineering Process and Design



Evaluation Question 1.4. How did participation in the robotics activities influence students' educational and career paths?

Among the 432 student alumni survey respondents over age 18, the preliminary findings included the following:

BACKGROUND: ALUMNI PARTICIPATION IN ROV COMPETITION

- Nine percent (9%) of the student competitors later served as a classroom/club mentor assigned to help other teams, 6% served as a judge at a competition, and 4% served as an instructor leading a team.
- Respondents competed as student team members for between one and nine years, with an average of 2.15 years per student.
- Respondents competed as student team members in competition years 2006 through 2015.
- Respondents competed as student team members in all four competition classes: SCOUT (11%), NAVIGATOR (3%), RANGER (36%), and EXPLORER (36%).

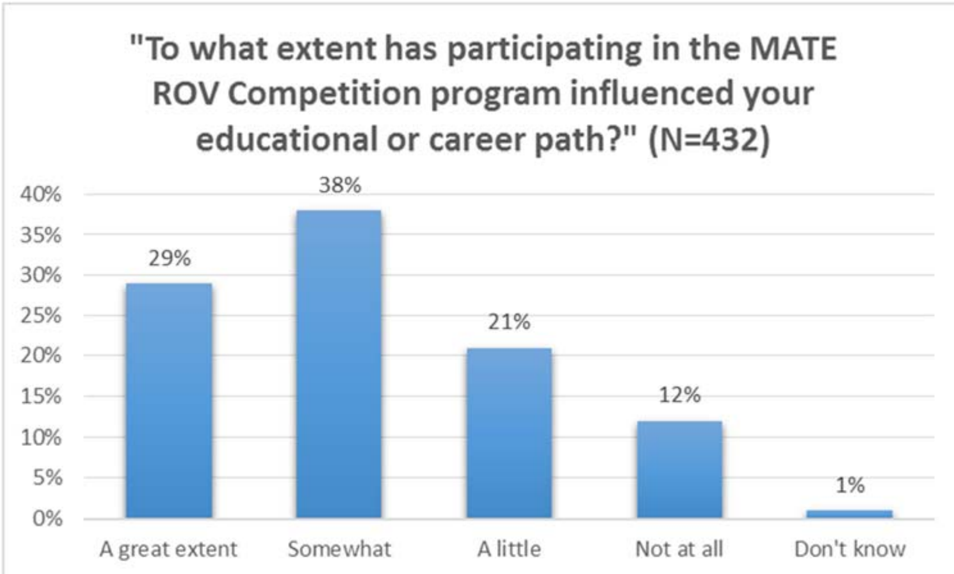
ALUMNI EDUCATION AND EMPLOYMENT

- The alumni's highest level of education ranged from high school (no diploma) to doctorate.
- **Among the 236 current college and university students, 85% are studying towards a STEM degree.**
  - Examples of colleges and universities attended include: Memorial University, Dalhousie, Drexel University, University of California at Santa Cruz, University of North Carolina at Chapel Hill, Naval Postgraduate School, Brown University, Cornell University, Texas A&M
  - Examples of college majors include: Aeronautical engineering, mechanical engineering, computer science, math, electrical engineering, physics, information technology
- **Among the 220 alumni who earned a college degree, 85% earned a degree in a STEM discipline.**
  - Examples of degrees include the following: BS and MS in Mechanical Engineering, MS in Electrical Engineering, BS and MS in Biomedical Engineering, BS in Computer Engineering, AS in Applied Marine Biology and Oceanography and BS in Marine Biology
- Almost three-quarters of the alumni are currently employed (74%).
  - **Among the employed alumni (N=320), 73% are currently working a STEM-related job.**
  - **Among the employed alumni, 14% are currently working a job related to ROVs or other underwater technologies, and an additional 8% have ever worked in a job related to ROVs or other underwater technologies.**
  - Examples of current jobs include, in the respondents' own words: Electrical Engineer at General Dynamics Electric Boat designing communication systems for the ships, Motor and Drive Systems Research Engineer, Final Test Technician at Sea-Bird Electronics, I work for Subsea 7 in a department called Intervention and Autonomous Systems as a design engineer. This department designs remote, underwater, technology. Much of our designs are tooling for ROVs or are designed to be functioned and or deployed by ROVs.

ROV COMPETITION'S INFLUENCE ON EDUCATIONAL AND CAREER PATHS

Eighty-eight percent (88%) of the alumni credit the ROV competition with having at least a little influence on their educational or career path. Over one-quarter (29%) indicated that the competition influenced them to a great extent, and 38% marked that the competition influenced them somewhat. Twenty-one percent (21%) noted that the competition influenced them a little; 12% indicated that the competition did not affect them at all, and 1% didn't know. (See *Figure 11*)

Figure 11: ROV Competition's Influence on Education or Career Path

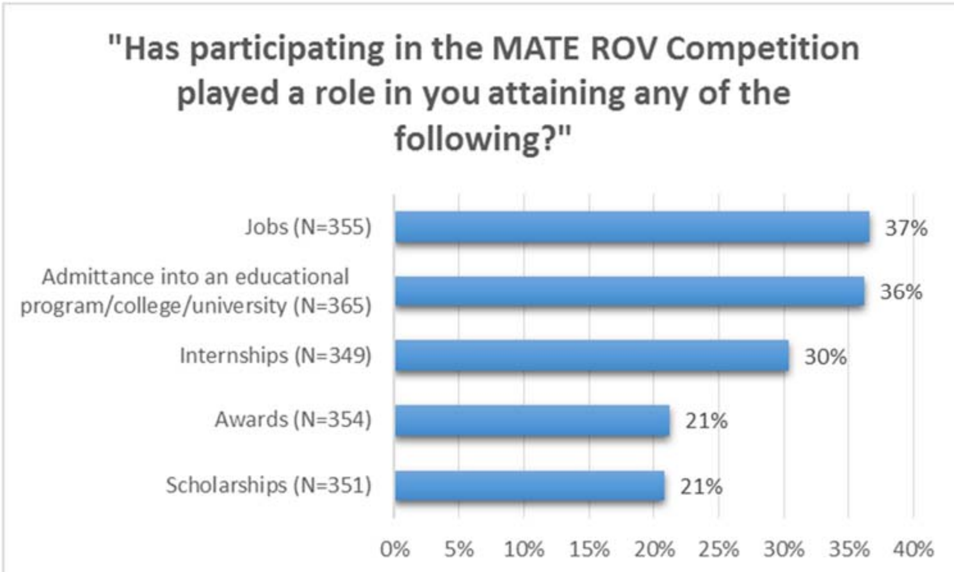


Alumni explained how the ROV competition influenced them in statements such as the following:

> *The MATE ROV competition gave me my first taste of practical engineering skills and projects. It also was influential in landing my first co-op term with one of our team sponsors.*
>
> *It showed me another path in life that I wouldn't have realized. It showed me a deeper love for sciences and has influenced me to become a processing engineer.*
>
> *The MATE ROV competition really brought the realm of underwater robots into my life. Without it, I would have never worked for a company doing R&D for syntactic foams or R&D for sonar systems or even thought of applying for a job designing submarine systems.*

The ROV competition played a role in alumni attaining employment (37%), admittance into educational programs/college/university (36%), internships (30%), awards (21%), and scholarships (21%).

Figure 12: The Role that the ROV Competition Played in Attainment of Employment, Educational Program Admittance, Internships, Awards, and Scholarships



Examples include the following:

Employment

> *When interviewing for the job, one of the people I talked to asked me about when I first knew I wanted to be an engineer, and we got to talking about my time on the MATE team. He had been on a FIRST team and knew what it takes to be so involved at so young an age, and everything I learned there carried on to my experiences in college.*
>
> *Documentation on my resume of my roles and responsibilities on my MATE team was noted by many employers as a talking point, not only because it was obviously engineering application focused, but also it was a unique differentiator compared to the other resumes in the pile they have for positions.*
>
> *I did a ton of electrical design as part of my involvement in the ROV team. It was as a result of that experience that I got hired for my co-op jobs, which led me to being hired full-time.*

I am currently an ROV technician and pilot for Oceaneering. The competition gave me exposure to the use of ROVs and allowed me to network with the right people, landing me a job.

Admittance into Educational Programs/College/University

George Fox University was very impressed with my work through MATE. They had never heard of such a program and were very excited about it.

In my acceptance letter into college, they referred to the MATE competition on my resume.

As part of my acceptance to the Faculty of Pharmacy at Memorial University for Fall 2015, I had to complete an interview. This program at MUN is extremely competitive as they will receive over 200 applicants but only accept 40 into the program annually. So during the interview I was asked behavioural questions where I had to reflect on past experiences. For example, "Describe a time when you had to use creative thinking or innovation to solve a problem." So, of course, I used my experiences in the MATE Competition for a number of different questions as I had gained and learned so much from my time participating. In this way, MATE ROV played a major role in my acceptance into the program.

Internships

NSF REU student researcher (focusing on perovskites solar cells), Hardware engineering intern – electrical at Raytheon SAS (designed circuitry for ATFLIR program)

Pacific Northwest National Laboratory – Battelle Marine Science Lab Summer Intern. NASA Langley Research Center – Langley Aerospace research Summer Scholars Intern

SpaceX Avionics Internship, designing, building, and testing hardware

Scholarships

I received a number of scholarships – all of which I used my experience in the MATE ROV competition on my resume – and received about $10,000.

I was awarded a local scholarship that was for students aiming to study STEM in college. I used my experiences with the MATE program in several parts of my application. It was ~$5,000. I was also awarded the Vera Joseph scholarship at my college, which is given to five freshman who exhibit great potential in the STEM fields. While I did not apply for this scholarship, I am sure it was based off of my college application, in which I heavily *spoke about my experiences with MATE and how they had influenced my studies. I was awarded ~$5,000.*

Awards

Mortar Board Leadership Conference Nominee

Best Senior Design Project Student of the Year 2010

Presidents Undergraduate Research Award

Technova Student Achievement Award

Asia Pacific ICT Alliance Award 2011

Evaluation Question 1.5. What effect did multi-year participation have on the above evaluation questions?

There were several statistically significant differences between the first year and multi-year competition participants. Multi-year participants reported that their participation in the ROV program resulted in higher levels of awareness of and interest in STEM careers, gains in interest in taking STEM courses, improvements in STEM knowledge and skills, increased 21st Century skills, and the receipt of awards, honors, and new educational and career opportunities.

Specifically, multi-year participants were significantly more likely to report the following:

Table 2: Statistically Significant Differences between First-Year and Multi-Year Participants

	First-Year Participants: Percentage Strongly Agreeing	Multi-Year Participants: Percentage Strongly Agreeing
Increased awareness of STEM careers due to ROV program**	28%	38%
Increased interest in pursuing a STEM career due to ROV program*	39%	46%

They learned how to apply STEM knowledge to solving real world problems due to ROV program*	43%	49%
They learned how to communicate their engineering designs due to ROV program*	39%	43%
More interested in taking engineering courses due to ROV program*	38%	48%
More interested in taking science courses due to ROV program*	32%	39%
More interested in taking math courses due to ROV program*	25%	31%
Increased skills and knowledge in engineering due to ROV program*	50%	59%
Increased skills and knowledge in science due to ROV program*	34%	43%
Increased skills and knowledge in math due to ROV program**	22%	33%
Increased skills and knowledge in technology due to ROV program*	50%	57%
Increased leadership skills due to ROV program**	33%	46%
Increased problem solving skills due to ROV program**	41%	51%
Increased critical thinking skills due to ROV program**	41%	47%
Received an award or honor due to ROV program**	26%	47%
ROV program participation opened educational or career opportunities**	30%	44%

* $p < 0.05$

**$p < 0.01$

DEMOGRAPHIC BREAKDOWNS

The multi-year participants were significantly more likely than the first-year participants to be male (first-year: 72%, multi-year: 77%) and white (first-year: 61%, multi-year: 68%). The first-year participants were more likely to live in a low socioeconomic status neighborhood (first-year: 36%, multi-year: 25%).

Compared to the multi-year participants, a greater proportion of the first-year participants were in the SCOUT (entry-level) competition class (first-year: 43%, multi-year: 21%). The bulk of the multi-year students were in the RANGER (intermediate) class (first-year: 38%, multi-year: 52%) and NAVIGATOR (beginner-intermediate) class (first-year: 9%, multi-year: 18%). Ten percent (10%) of both groups were in the EXPLORER (advanced) competition class.

The first-year participants did not differ significantly from the multi-year participants according to disabilities requiring accommodations (first-year: 2.6%, multi-year: 3.0%).

Evaluation Question 1.6. Did the robotics activities create the same impacts among underrepresented groups (by gender, ethnicity, socio-economic status, disability) as were found among students who traditionally participate in these types of activities?

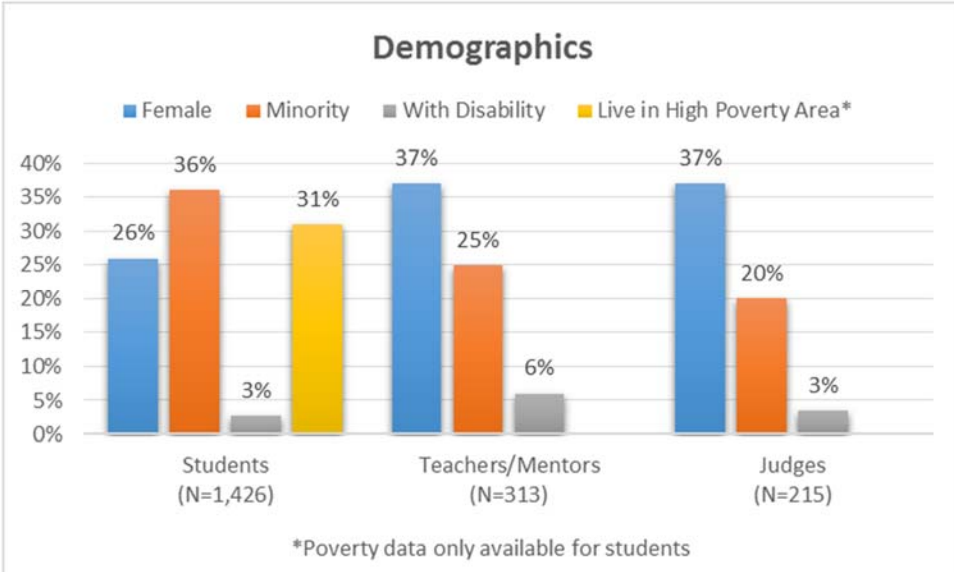
BACKGROUND: DEMOGRAPHICS OF STUDENTS, TEACHERS AND INDUSTRY REPRESENTATIVES

According to the demographic data in the surveys, the students were over one-quarter female (26%, N=1,426), 36% percent were of minority backgrounds [5], 31% came from high poverty areas[6], and 3% reported that they had disabilities requiring accommodations. (See *Figure 13*)

[5] The sample size of participant surveys from each ethnicity was not large enough to do analysis by individual ethnicity. Instead, all non-white respondents were coded as "minority", and results were analyzed by this "minority status" variable.

[6] High poverty areas were defined as zip codes where the percentage of families with children under age 18 in poverty was higher than the nationwide average of 13.6%. This calculation is based on data from the American Community Survey at the ZTCA level.

Figure 13: Student, Teacher/Mentor, and Judge Demographics



The project has made efforts to include the participation of teachers, college students, staff, and competition judges (industry professionals) of diverse backgrounds who can serve as role models for the middle school students. Over one-third (37%) of the teachers (N=313) were female, 25% were of minority backgrounds, and 6% indicated that they had a disability.

Among the judges completing surveys (N=215), 37% were female, 20% were of minority ethnic backgrounds, and 3% marked that they had a disability.

ANALYSIS

As the MATE Center is a longstanding center, the evaluation has improved over time. In the 2009-2010 evaluation report, preliminary results presented the trends by gender and ethnicity only. In 2010-2011, the analysis took a different approach. Rather than simply look at trends, the changes in survey administration methods helped us produce a dataset more suitable for more sophisticated analysis. Thus, we looked for statistically significant differences between the under-represented students and the students who more typically participate in these types of STEM events.

This new analysis begged the question: how should success be defined? In consultation with project managers, the evaluators decided that the measure of successfully engaging under-representative students would be that their results were not statistically different from the other students' results. In other words, the under-represented students made the same gains as the other students.

FINDINGS BY STUDENT DEMOGRAPHICS

The analysis focuses on whether there were statistically significant differences between the groups (gender, ethnicity, socioeconomic status, and disability status) in the following topics:

- Awareness of STEM careers
- Interest in STEM careers
- Interest in STEM topics
- STEM knowledge

Statistically significant differences existed between the groups in the following measures:

Awareness of and Interest in STEM Careers

- **Gender:** Male students were more likely to report that the ROV program led to gains in knowledge about STEM careers (male: 35% strongly agreed, female: 27% strongly agreed) and they were more likely to be interested in a STEM career (male: 45%, female: 34%).
- **Ethnicity:** White students were more likely to report that the ROV program led to gains in knowledge about STEM careers (white: 33%, minority: 31%). There were no differences in interest in STEM careers by ethnicity.
- **Socioeconomic status:** There were no statistically significant differences by socioeconomic status.
- **Disability status:** The students with disabilities were more likely to report that the ROV program led to gains in knowledge about STEM careers (students with disabilities: 53%, students without disabilities: 32%), and they were more likely to be interested in a STEM career (students with disabilities: 50%, students without disabilities: 43%).

Interest in STEM Topics

- **Gender:** Male students were more likely to report increased interest in computer science (male: 44% strongly agreed, female: 29% strongly agreed), math (male: 29%, female: 23%) and engineering (male: 46%, female: 34%) courses. There were no significant differences between the genders in the interest in taking science courses or hands-on classes or clubs like robotics, electronics, or shop.
- **Ethnicity:** There were no significant differences by ethnicity in the desire to take courses in STEM topics.
- **Socioeconomic status:** There were no significant differences between the responses of the students living in high and low poverty areas.
- **Disability status:** Students with disabilities were more likely to report increased interest in engineering courses (students with disabilities: 66%, students without disabilities: 42%) and math courses (students with disabilities: 38%, students without disabilities: 27%). There were no

significant differences between the responses of the students with and without disabilities in regards to interest in science courses, computer science courses, or hands-on classes or clubs.

STEM Knowledge

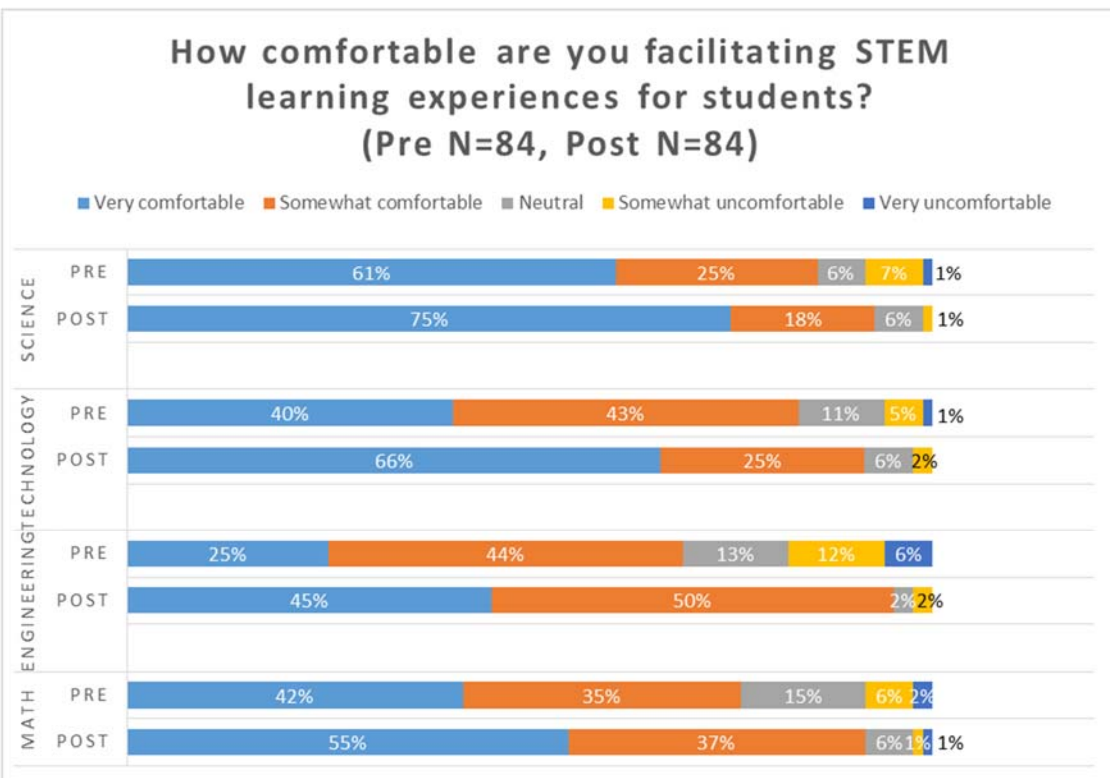
- **Gender:** Male students were more likely than female students to report increased skills and knowledge in engineering (male: 56% strongly agreed, female: 48% strongly agreed), math (male: 29%, female: 21%), and technology (male: 56%, female: 46%). There were no differences by gender in gains in knowledge in science or knowledge about the competition theme.
- **Ethnicity:** There were no significant differences by ethnicity.
- **Socioeconomic status:** Students living in a lower socioeconomic area were more likely to report gains in skills and knowledge in math (low socioeconomic status: 28%, not low socioeconomic status: 27%). There were no other significant differences in the STEM skills and knowledge according to socioeconomic status.
- **Disability status:** Students with disabilities were more likely to report increased skills and knowledge in engineering (students with disabilities: 75%, students without disabilities: 54%), math (students with disabilities: 56%, students without disabilities: 26%), and technology (students with disabilities: 69%, students without disabilities: 53%). There were no significant differences between the responses of the students with and without disabilities in regards to skills and knowledge in science or knowledge about the competition theme.

Project Goal 2: Provide teachers with professional development, instructional resources, and mentors to support and sustain the delivery of STEM career information and learning experiences.

Evaluation Question 2.1. Are teachers more confident delivering STEM learning experiences? Delivering career information and outlining career pathways?

Pre and post workshop surveys, post competition surveys, and Summer Institute feedback surveys demonstrate that the participants gained confidence facilitating STEM learning experiences through the training and support provided by MATE. The percentage of respondents who rated themselves as "very comfortable" facilitating STEM learning experiences for students rose between the pre and post workshop surveys for science (pre: 61%, post: 75%), technology (pre: 40%, post: 66%), engineering (pre: 25%, post: 45%), and math (pre: 42%, post: 55%).

Figure 14: Level of Teacher Confidence Facilitating STEM Learning Experiences: Pre and Post Workshops

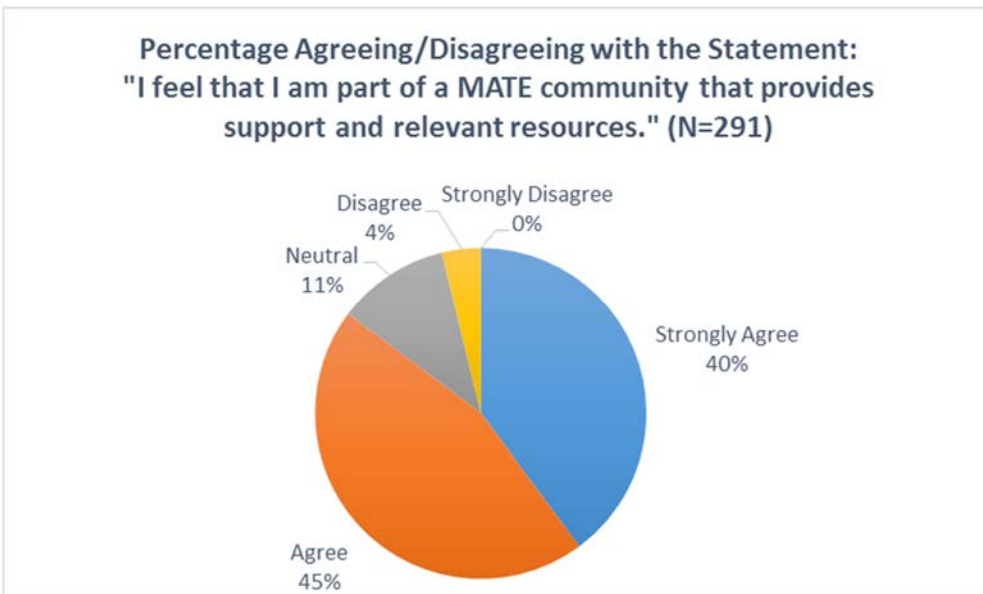


In addition, pre-post knowledge surveys were piloted before the workshop in New Orleans. All of the attendees (100%, N=13) improved their knowledge between the pre- and post-tests. The average scores rose from seven to 11 points, out of a possible 15.

Evaluation Question 2.2. Do teachers feel they are a part of a larger MATE community that provides support and relevant, necessary resources?

Among the post-competition surveys, 85% of the teachers (N=297) agreed that they felt they were part of a MATE community that provides support and relevant resources.

Figure 15: Percentage Agreeing/Disagreeing that They Feel a Part of a MATE Community

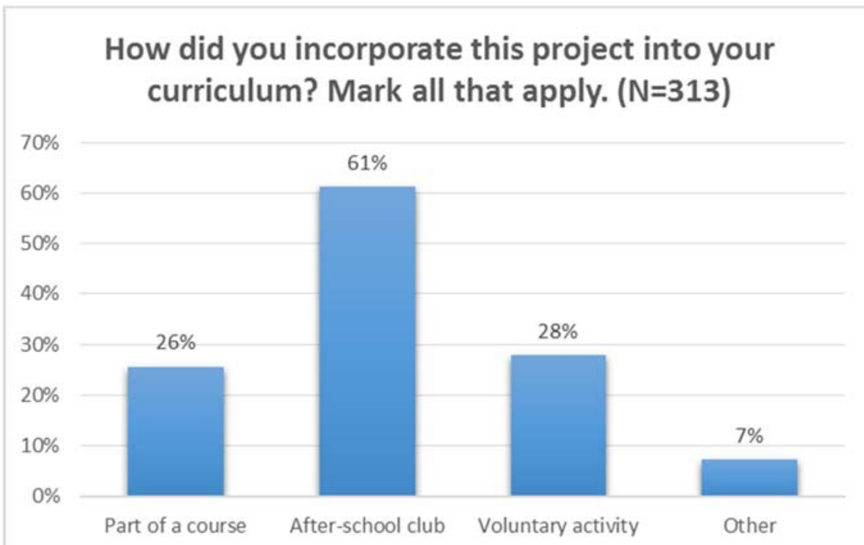


Evaluation Question 2.3. Do teachers incorporate MATE robotics activities/curriculum into courses and afterschool programs? Are the courses and/or curriculum adopted by school districts?

In the post-competition surveys, over three-quarters (83%) of the teachers (N=275) stated that they used MATE materials and resources to incorporate ROV building into their course or club, and over half (59%) modified their curriculum and teaching based on MATE resources.

Sixty-one percent (61%) of the post-competition survey respondents (N=313) incorporated building ROVs into an after-school club. Twenty-six percent (26%) built ROVs as part of a course; 28% built ROVs as a voluntary activity; and 7% built ROVs in another venue.

Figure 16: ROV Projects in Courses, After-School Clubs, Voluntary Activities, and Other Activities



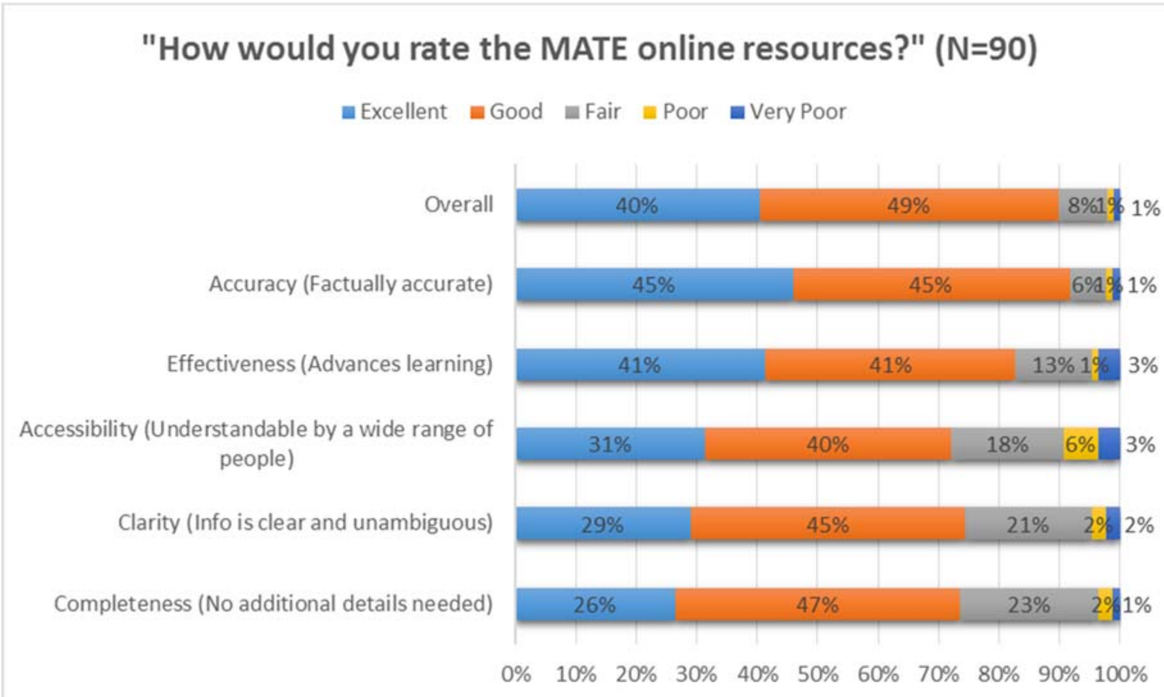
In the online resources survey conducted in June of 2015, the resources on the MATE website were rated highly, with 89% (N=90) indicating that the resources were excellent or good (40% excellent, 49% good). The majority of respondents indicated that the online resources were accurate (90% excellent or good), effective learning aides (82%), accessible (70%), clear (74%), and complete (73%). (See *Figure 17*) Respondents described the materials in the following comments:

> *The students really learned a lot when using the resources. They looked so happy and proud of themselves. We felt like MacGyver!*

> *They were clear and easy to follow for my students.*

I am a big fan of the videos. My students watched several as they were designing their second ROV.

Figure 17: Ratings of MATE Online Resources



Survey respondents noted that the online resources could be improved through refining the organization of the resources on the website. The MATE Center is aware of this deficiency and has plans to improve the website structure for instructional resources.

The online resources were used as part of in-school classes (52%, N=73) and out-of-school programs/clubs (59%, N=76). Over half of the respondents (54%, N=68) developed new curricula or activities based on the MATE online resources. Seventy-one percent (71%, N=72) shared the online resources with others (noting that they shared the resources with a total of 666 other people), and 78% (N=74) built an ROV using the online resources as a reference. Respondents indicated that they built a total of 420 ROVs using the online resources as a reference.

Evaluation Question 2.4. Are teachers able to access classroom mentors as needed? Do the classroom mentors help them successfully incorporate robotics activities into the course? Are the classroom mentors adequately prepared?

In several regions, the regional coordinator matched up college and high school students – in many cases, former ROV competitors themselves – with middle school ROV teams to work with them throughout the competition season. College students also acted as helpers at the workshops. In some cases, the college students received a small stipend (though they stated that they would have done the work without it), and in other cases they received service learning credit, Presidential Volunteer Service Awards, or simply volunteered their time with no recompense. This arrangement worked well for the regional coordinators, college students and middle school students and teachers.

Anecdotal reports suggest that the involvement of college students as mentors can lead to profound experiences for both the college and middle school students. Many sources reported that the middle school students found the college students to be approachable representatives of science. These young adults modeled the paths that the middle school students could take to a STEM career.

For 22% of the post-competition teacher survey respondents (N=298), a classroom/club mentor came to their site to help their teams. Among these teachers (N=77), the mentor helped them incorporate robotics into their course or club to “a great extent” for 53% of the respondents, a “moderate extent” for 23% of the respondents, a “small extent” for 10% of the respondents, and 4% stated that the mentors were not helpful at all.

The vast majority of respondents (89%) indicated that their mentors were adequately prepared to help them and their students through the ROV design and building process. Five percent (5%) marked that the mentors were not adequately prepared, and 6% were unsure.

Project Goal 3: Increase parental involvement in order to support and encourage students to pursue STEM education and careers.

Evaluation Question(s) 3.1. Did the MATE robotics activities lead to an increase in the parents' support of their children's interest in STEM careers?

Ninety-two percent (92%) of the parents surveyed (N=342) agreed or strongly agreed that participation in the ROV program changed how they envisioned their child's future, making it easier to picture their child with a STEM career (63% strongly agreed, 29% agreed). Six percent were neutral. Two percent (2%) disagreed, and no respondents strongly disagreed.

Evaluation Question 3.2. Did the enhanced parent online resources lead to an increase in the parents' ability to provide assistance and support for their children's involvement in the MATE robotics activities?

The online Parent Resource Center (http://www.marinetech.org/parent-resource-center) was launched in the spring of 2015. It contains competition videos, frequently asked questions, background information, highlights, and contact information for the MATE Center, along with types of information that the MATE Center can provide upon request. The Parent Resource Center will be evaluated in the next year of the grant.

Evaluation Question 3.3. Did the regional parent advisory committees provide feedback and advice to help improve the competitions and ensure that the program is inclusive of all participants?

Advisory committees were broadened to invite participation from parents as well as industry representatives, professional organizations (e.g., Marine Technology Society), government agencies (e.g., NOAA) 6-12th grade educators, community college faculty, and university faculty. The committees were implemented at the regional level so the recommendations would be applicable to the local community needs.

In the second year, some regions held an annual advisory meeting (e.g., the Pacific Northwest and Southeast Regions), while others held quarterly advisory meetings (e.g., Pennsylvania Region), monthly advisory meetings (e.g., Carolina and Southeast Regions), or communicated on an ongoing basis with advisory members outside of formal meetings (e.g., SHEDD and Mid-Atlantic Regions).

Advisory committees provided recommendations in the following areas:

- Timing and content of workshops
- Funding sources
- Marketing competition
- Associated activities during competition

The regional coordinators were responsive to their committees' recommendations.

Broader Impacts

The MATE Center's ITEST activities have been leveraged by regional coordinators and participants in ways that were unanticipated during the writing of the proposal. Thus, they don't fit under any particular evaluation question. Since the evaluation was not set up to monitor these activities, the findings presented here should be considered preliminary. Next year, the evaluation tools will be modified to capture more of this data.

These "broader impacts" fall into three main categories:

1. Leveraging ITEST activities/funding to raise additional funding by regional coordinators, teachers, schools, and student teams;
2. Using ROVs and ROV-based activities outside of the competition by teachers and students;
3. Broader impacts on teachers and institutions: new careers, new classes, deeper relationships with students, improved STEM knowledge, increased motivation and engagement with their discipline, and increased professional development opportunities.

LEVERAGING ITEST ACTIVITIES/FUNDING

Faculty who led ROV teams and/or attended the Summer Institute reported that they have applied for and won funding from grants and school boards and have received equipment donations from local industry. Examples include the following: "Having an ROV program makes it easier for me to go to local companies and receive equipment for classroom use, e.g. oscilloscopes, multimeters, and computers." Additionally, ROV competition regions outside of the United States have leveraged news of the ITEST grant to raise additional funds.

USING ROVS OUTSIDE THE COMPETITION

Many faculty have reported using ROVs or ROV-based activities outside of the competition, incorporating these tools and topics into their classes or clubs in order to bring science to life.

BROADER IMPACTS ON TEACHERS AND INSTITUTIONS

Teachers report a broad variety of positive results from their participation in the ROV competition and professional development, including the following:

- New careers
- New classes
- Deepened relationships with students
- New collaborations with industry, research orgs, and other educational institutions
- Improved STEM knowledge
- Increased motivation and engagement with their discipline
- Increased professional development opportunities (in addition to that offered by MATE)

CONCLUSIONS

Overall, the MATE Center successfully implemented the 2014-2015 year of ITEST grant activities. The 2015 MATE ROV Competition was held, with ITEST funding helping to support 11 of the 17 US-based regional events. Seventy (70) regional workshops were held for teachers and students, and teachers attended the intensive Summer Institute professional development. The focus on a formal curriculum was changed to development of a suite of online instructional materials, which were disseminated, including videos, PowerPoints, ROV kits, and an online course.

The evaluation expanded, with several student follow-up efforts underway: the alumni survey, the Washington State Follow-up, and the upcoming National Student Clearinghouse data match. The collaboration with Dr. Li from the University of Washington resulted in improvements to the survey instruments and competition scoring rubrics and manuals.

Overall, evaluation results continue to show strong positive outcomes for students and teachers. Involvement in the ROV competition generated greater awareness of and interest in pursuing STEM careers, increased interest in studying STEM topics, improved STEM knowledge and skills, and increased teamwork, critical thinking, leadership, and problem solving skills. Participating in the ROV competition helped students learn how to apply STEM skills to real world problems. They also learned how to communicate their engineering process and design to a wide audience.

Parents were passionate supporters of their children's involvement in the program, with comments such as, "We love this program. We've never seen our daughter so excited and engaged." Educational research has stressed the importance of family support in a student's choice to follow a STEM career path. Evaluation results show that the ROV program impacted the participants' parents as well, making it easier for them to picture their child in a STEM career.

Preliminary ROV competition student alumni survey results suggest that the majority of ROV competition participants go on to study STEM topics, earn STEM degrees, and work in STEM fields. In fact, roughly one in five former participants have worked in a job related to ROVs or other underwater technologies. The majority of ROV competition alumni credit the ROV competition with influencing their educational and career paths, including playing a role in attaining internships, scholarships, admittance to educational programs, and employment.

These findings suggest that the MATE ROV Competition is effective in increasing the STEM workforce, especially related to underwater technologies. As one parent stated:

> *This is a wonderful program. It teaches team building, problem solving, and engineering/math skills and builds confidence. I guarantee the outcome of this event on my daughter's team equals new future scientists.*