
AC 2011-1804: EVALUATING THE IMPACT OF AN UNDERWATER ROBOTICS COMPETITION: QUESTIONS, METHODOLOGIES AND FINDINGS

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Evaluating the Impact of an Underwater Robotics Competition: Questions, Methodologies and Findings

The Marine Advanced Technology Education (MATE) Center has been sponsoring regional and international underwater robotics competitions for 10 years. In that period, thousands of students and educators have taken part in the independent evaluation of the program, reported annually to the National Science Foundation.¹

The evaluation sheds light on the impacts of involvement in this hands-on engineering design competition. Evaluation topics include changes in student awareness of and interest in pursuing a marine science, technology, engineering and/or math (STEM) career, interest in studying STEM topics, STEM knowledge and skills, and SCANS skills.

This paper provides an overview of the evaluation results for the past three competition seasons, 2008 to 2010. It begins with background on the MATE Center and the competition, which provides context for following two sections: evaluation methodology and findings. Finally, the paper closes with a discussion of conclusions and next steps.

Background: The MATE Center and the Competition

The Marine Advanced Technology Education Center is one of more than 30 Advanced Technological Education (ATE) Centers supported by the National Science Foundation (NSF). The ATE program promotes the preparation of students for careers in skilled technical occupations. MATE has been funded since September 1997 by NSF to help meet the nation's growing need for a highly trained technical workforce in ocean-related occupations. The Center's host institution is Monterey Peninsula College (MPC), in Monterey, California.

In September 2009, the MATE Center received a second NSF grant: Innovative Technology Experiences for Students and Teachers (ITEST). The focus of this grant is to support middle school/junior high students and teachers by expanding the entry-level (SCOUT class) underwater robotics competition, providing marine STEM career information targeted to this age range, and building a cyber-learning center to support them.

The MATE Center has five major goals:

1. Expand and strengthen academic and industry partnerships
2. Update and expand marine workforce information, develop curricula, and help academic partners align their programs and curricula with workforce needs
3. Provide opportunities for students and faculty to collaborate with industry and working professionals

¹ Please note: Throughout this paper “program” is used interchangeably with “competition” to refer to the entire experience of designing, building and competing with an underwater robot.

4. Provide professional development for college and high school faculty
5. Maintain an information clearinghouse

In pursuit of these goals, the MATE Center offers a diverse set of programs, including developing new sources of workforce information, providing at-sea student internships, offering summer institutes (professional development) for faculty and, of course, running the underwater robotics competition (hereafter referred to as the Remotely Operated Vehicle or ROV Competition). The competition fits under goal three: providing opportunities for students and faculty to collaborate with industry and working professionals.

The competitions incorporate several different elements. First and foremost, the students build an ROV and use it to complete several timed tasks (referred to as “missions”). Second, the students present their ROV to a panel of industry professionals and respond to questions from the panel. The third element is the written technical report, in which students must present the technical aspects of their ROV to an audience of industry professionals. The fourth competition component is poster displays, for which the goal is for students to present their ROV design and background on the competition theme (described below) in a way that is understandable to a non-technical audience.

Each year, MATE selects a different competition theme, which helps students draw the connection between the competition tasks and real-world situations. The themes and mission tasks are designed by the MATE Center in collaboration with industry professionals and scientists.

In 2008, the competition theme showcased hydrothermal vents and the technology used to study the deep sea environments (mid-ocean ridges) where these are found. As stated in the 2009 annual report:

The MATE Center worked with Ridge 2000 program staff to design a scenario and mission tasks that highlighted Ridge-related research projects and the potential hazards of working in a hostile environment.² For example, one mission challenged teams to free an ocean bottom seismometer (OBS) that had been buried by lava from a volcanic eruption – exactly what “real-life” engineers, technicians, and scientists were challenged to do during what was supposed to be a routine OBS recovery research cruise in 2006.

In 2009, the competition theme was based on submarine rescue systems. The 2009 MATE competition materials describe the theme as follows:

The MATE Center worked with OceanWorks International and the Deep Submergence Systems Office at Portsmouth Naval Shipyard to create a

² Ridge 2000 is an interdisciplinary research program that focuses on integrated studies of earth’s seafloor spreading centers. See www.ridge2000.org/ for more information.

competition that highlights the history and technological advances being made in submarine rescue systems. The mission scenario focuses on a submarine rescue training exercise where teams pilot their ROVs to inspect the submarine for damage, deliver emergency supplies, and replenish the onboard air supply, among other tasks.

In 2010, the competition theme highlighted Lo'ihī, Hawaii's undersea volcano.

The 2010 competition theme focuses on the Loihi seamount, an active undersea volcano that rises more than 3,000 meters above the seafloor. The mission tasks challenge teams to deploy instruments, take sensor readings, plot data, and collect samples of geologic features as well as organisms that inhabit the volcano's flanks.

The competition includes three different classes: SCOUT, RANGER and EXPLORER. The SCOUT class has the least sophisticated vehicle requirements and mission tasks; RANGER is more challenging; and the EXPLORER class has the most advanced vehicle specifications and mission tasks. Generally, elementary, middle school and junior high teams compete in the SCOUT class; high school teams compete in the RANGER class; and college and university teams comprise the EXPLORER class. There is no requirement, however, that teams register for a particular class based on their school level. Thus, some advanced high school teams compete with the college students in the EXPLORER class. Likewise, some college teams choose to start out in the competition in the RANGER class before moving up to EXPLORER.

Preliminary regional competitions take place in the spring. They are organized and managed by regional coordinators with advice, assistance and oversight from the MATE Center. Each year, one or two new regional competitions join the program. During the period covered by this report, the following regional events were held:

1. Big Island (Hilo, Hawai'i)
2. Carolina (Myrtle Beach, South Carolina)
3. Florida (Cocoa, Florida)
4. Great Lakes (Alpena, Michigan)
5. Hawaii Underwater Robot Challenge (Oahu, Hawai'i)
6. Mid-Atlantic (Hampton, Virginia)
7. Monterey Bay (Monterey, California)
8. New England (Buzzards Bay, Massachusetts)
9. Pacific Northwest (Seattle, Washington)
10. Philadelphia (Philadelphia, Pennsylvania)

11. Southern California Fly-Off (San Diego, California)
12. Shedd Aquarium-Midwest (Chicago, Illinois, New in 2009)
13. Wisconsin (Milwaukee, Wisconsin, New in 2010)
14. Newfoundland & Labrador (St. John's, Newfoundland and Labrador)
15. Nova Scotia (Halifax, Nova Scotia)
16. Scotland (Aberdeen, Scotland)
17. Hong Kong (Hong Kong)

The top one or two winners of each regional competition in the RANGER competition class are invited to participate in the annual international competition, held in June. In addition, one EXPLORER class team from each sponsoring academic institution can participate in the international competition, after trained judges certify that the team has completed a test run. Generally, the EXPLORER certifications take place during the regional competitions.

The international competition takes place over a three-day period in June. Each year, the location of the international competition changes. The 2008 competition was hosted by the University of California, San Diego/Scripps Institution of Oceanography. The 2009 competition was held at the Massachusetts Maritime Academy, and the 2010 competition took place at the University of Hawaii at Hilo.

One additional component of the international competition that sets it apart from the regional competitions is the Ocean Career Expo. Since 2006, in partnership with the Centers for Ocean Sciences Education excellence (COSEE) network, MATE has invited competition sponsors to showcase their companies and internship/career opportunities at the Expo. Students can send their resumes to the participating companies in advance of the international competition or simply visit the company booths during the competition. According to the MATE Center's annual reports, Oceaneering alone has hired more than 20 students since 2006, as a result of the Expo.

During the international competition, the MATE Center also organizes local science-based tours and field trips for the students, faculty and accompanying family. These tours included facilities owned by the Scripps Institute of Oceanography's Floating Instrument Platform and UCSD's Marine Physical Laboratory's Autonomous Underwater Vehicle Lab in 2008, the Massachusetts Maritime Academy's facilities, including the 540' vessel, T.S. Kennedy in 2009, and the W. M. Keck Observatory in Hilo, Hawaii in 2010.

Figure 1: MATE ROV Competition Participation, Number of Educational Institutions

Year	Elementary Schools	Middle Schools	High Schools	Community Colleges	Universities	Other ³	Total ⁴
2008	4	38	166	15	25	5	253
2009	9	52	186	16	32	25	320
2010	23 ⁵	97	202	12	28	28	390

Figure 2: Count of Students and Faculty at International Competitions

Year	Count of Students	Count of Faculty/Mentors
2008	424	80
2009	486	81
2010	546	90

Evaluation Methodology

The MATE Center’s overall ATE and ITEST grant evaluations connect each of the Center’s activities with research questions and expected outcomes of the project. This paper focuses on the subset of research questions that relate to the ROV competition:

1. To what extent did participating in the ROV program lead to an increase in the students’...
 - a. Awareness of STEM careers
 - b. Intention to pursue a STEM career
 - c. Interest in studying STEM topics
 - d. STEM knowledge and skills
 - e. SCANS skills

³ The category of “other” includes after-school clubs/programs and home schooled student teams.

⁴ Many schools have participated in multiple years; thus, summing the “total” column will not result in an unduplicated count.

⁵ The number of SCOUT class teams expanded substantially in 2010 because this was the first year of implementation of the MATE Center’s ITEST NSF grant, which focuses on building the pipeline of younger students.

2. Did the ROV program produce any benefits outside of participating in the competition itself? In what ways did ROV program participation affect the lives of the students and faculty/mentors? Did it have any effect on the teams' home institutions?
 - a. Influence on course/club activities at the faculty members' home institutions
 - b. Awards/honors received as a result of competition participation
 - c. New educational/career opportunities for students
 - d. New educational/career opportunities for the faculty and collaborative opportunities for schools
3. To what extent did the competition lead to increases in the faculty/mentors' own STEM knowledge?
4. Did participation in the program lead to an increase in the parents' support of their children's interest in STEM careers?

The data presented in this paper focuses on the evaluations of competition years 2008 through 2010 because primary evaluation data was available for these years. In 2008, there was a transition in evaluators, and the 2008 competition season is when the current evaluator started to work with the MATE Center. (Evaluation reports are available from prior years but not the original data.) Evaluation results from prior years are consistent with the results presented in this paper.

The data collection instruments have remained largely unchanged for the past 10 years. In 2010, with the first year of implementation of the ITEST grant, several new questions were added to the student and faculty surveys, and input was collected from the parents for the first time. Results from these new questions only represent the 2010 competition and are noted as such in the findings.

The results reported in this paper are mainly based on the international competition surveys so that the analysis could include the 2010 competition season. Data entry has not yet been completed for the paper surveys administered at the 2010 regional events. Analysis of available regional data shows that the regional survey results are consistent with the international surveys.

The evaluation relies upon multiple sources of data, primarily surveys and focus groups. The data collection incorporates input from a variety of stakeholders, including students, teachers, parents, regional coordinators, college students helping with grant implementation, 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.

Post Competition Surveys of Students

At the regional and international competitions, students are asked to complete surveys. The survey covers a variety of topics, including the following: 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.

Most of the regional competition surveys are conducted via paper forms later entered into Survey Monkey. The international competition surveys are conducted in computer labs with direct access to the web survey in Survey Monkey. Data is then extracted from the web system and analyzed with the Statistical Package for the Social Sciences (SPSS).

Some regional competitions offer incentives to complete the survey, such as raffle tickets for prizes or a competition t-shirt. At the international competition, a commemorative MATE ROV competition embroidered iron-on patch is provided upon completion of the survey, with new patch design for each year.

Most of the analysis presented in this paper is based on the 1,025 international competition student surveys completed between 2008 and 2010. Each year is represented by a nearly equal sample: 351 from 2008; 345 from 2009; and 329 from 2010. Since the SCOUT class teams do not participate in the international competition, this means that the results discussed here primarily represent the high school and college/university students.

As mentioned above, the ITEST grant implementation beginning in 2010 brought an expansion of the SCOUT class. Where SCOUT class survey results are included in the analysis, they are based on the 98 SCOUT regional surveys from the 2010 competition year only. There were not enough SCOUT class teams in prior years to merit inclusion in the study.

Post Competition Surveys of Teachers/Mentors

Teachers/team mentors also complete a survey at the regional and international competitions. The survey asks the faculty/mentor to assess:

- the value of the competition,
- how well the competition is incorporated into course curriculum,
- their interest in participating in future competitions,
- their observation of change in their students' STEM knowledge/skills, SCANS skills, and interest in STEM careers.

While most of the regional competition surveys are conducted via paper forms later entered into Survey Monkey, the international competition surveys are conducted in computer labs with direct access to the web survey in Survey Monkey. Data is then extracted from the web system and analyzed with the Statistical Package for the Social Sciences (SPSS).

The analysis presented in this report is based on the 247 faculty/mentor surveys completed at the international competitions between 2008 and 2010 (2008 N=95; 2009 N=76; 2010 N=76).

Post Competition Surveys of Parents

In contrast to the student and teacher/mentor surveys, which have been conducted for many years at MATE ROV competitions, 2010 was the first year parent input was solicited. Paper surveys were administered to parents at the ITEST SCOUT class competitions in Monterey, the Pacific Northwest, and New England. Parents were asked to report on their 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. Data was entered into Survey Monkey and analyzed using the tools within the website.

Interviews of MATE Center Staff and College Student Volunteers

Structured interviews were conducted with MATE regional coordinators, college students involved in mentoring SCOUT class teams through the ITEST grant and the grant PI. The interviews solicited information such as detailed descriptions of program implementation (recruitment of students and teachers, workshops and other methods of providing technical assistance, other support provided to teams, partnerships with other organizations, and staffing), effectiveness of the workshops, observations on student outcomes, parental involvement, successes/program strengths, challenges, changes planned for next year, and ratings of the MATE Center's support of the regions.

Other Data Sources

Additional data sources informing the evaluation include the annual reports turned in by the regional coordinators to the ITEST grant PI, demographic information collected from the schools, clubs, and teams, evaluator observations of the Pacific Northwest regional competition, the regional coordinators meeting, and the Advisory Committee meeting, review of participation data, and document review, such as curriculum and supporting technical materials and the MATE Center's annual report.

Findings

The discussion of evaluation results is presented below in a question and answer format.

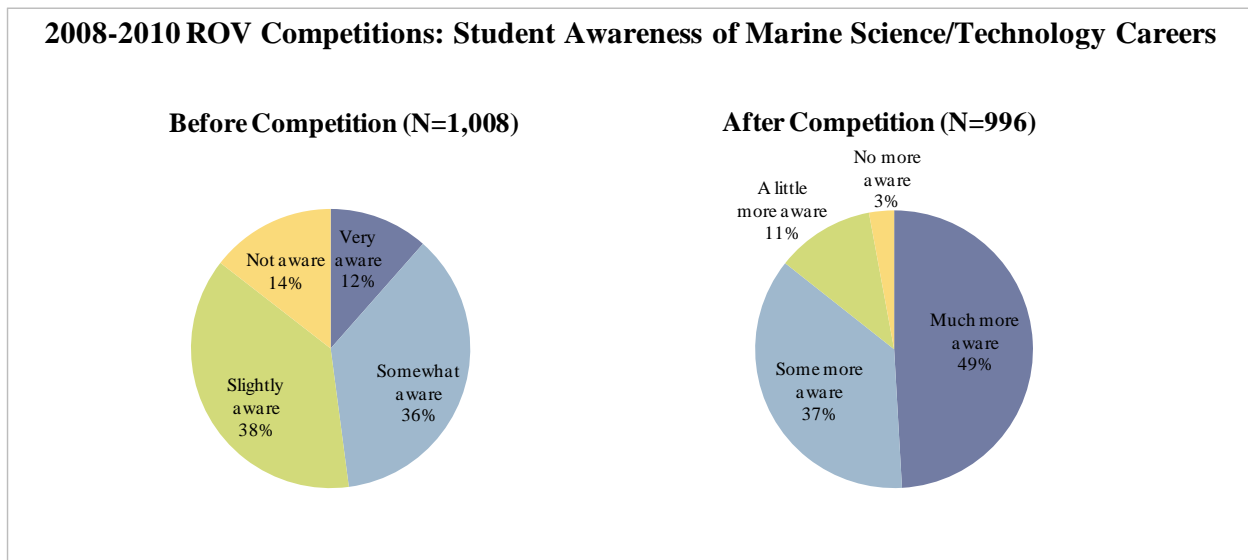
Research Question 1: To what extent did participating in the ROV program lead to an increase in the students'...

- a. Awareness of STEM careers
- b. Intention to pursue a STEM career
- c. Interest in studying STEM topics
- d. STEM knowledge and skills
- e. SCANS skills

Awareness of STEM Careers

After the 2008-2010 international competitions, nearly all the students (97%, N=996) stated that they were more aware of careers in marine science and technology. (See Figure 3) In fact, half of these students (49%) marked that they were “much more aware”. Before they built their ROV and participated in the program, very few of the students (12%, N=1,008) reported that they were “very aware” of these careers.

Figure 3: Student Awareness of Marine Science and Technology Careers

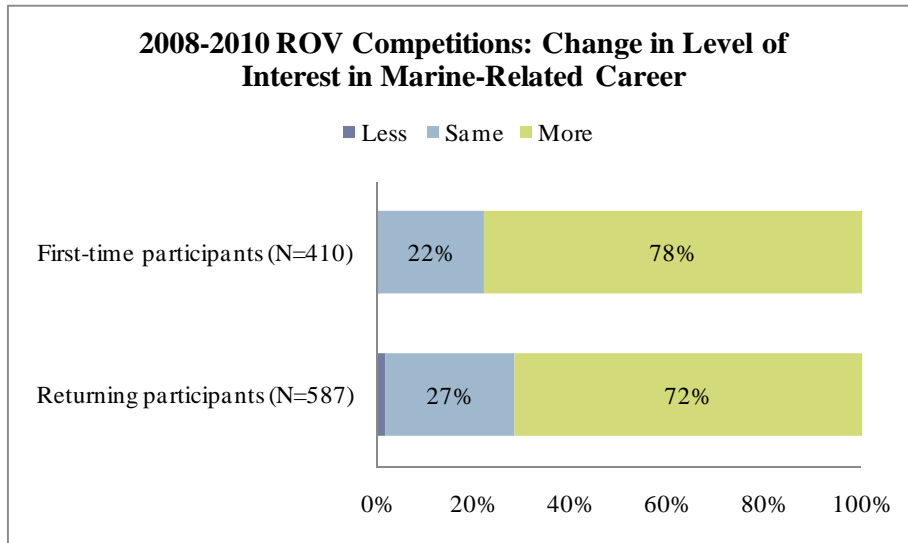


The responses from the younger, SCOUT class students (from elementary schools, middle schools and junior highs) at the 2010 regional events followed the same patterns. After building their ROV, 97% of these students (N=98) indicated that they knew more about careers in marine STEM. Indeed, 50 percent marked that they knew “a lot more”.

Interest in Pursuing Marine STEM Careers

The student survey data indicates that participating in the competition may have helped to move many students closer to a marine STEM career. About three-quarters of the students (74%, N=997) indicated that as a result of their ROV projects and competition experience, they had become more interested in pursuing in a marine-related career. This was especially true of first-time participants (78%, N=410) (See Figure 4) The competition had a similar effect on the younger students, 71% of whom stated that their ROV project made them more interested in a marine career (N=98).

Figure 4: Change in Student Interest in Marine Careers



Almost all of the faculty/mentors at the 2010 international competition (97%) indicated that they observed that their students had become more interested in pursuing a STEM career since they began designing and building their ROV.⁶

This competition helps my students to commit to an engineering career path. Before we started the MATE competitions, our best students always ended up going to business schools. Now they are enthusiastically looking for engineering programs.

- 2009 Faculty/Mentor

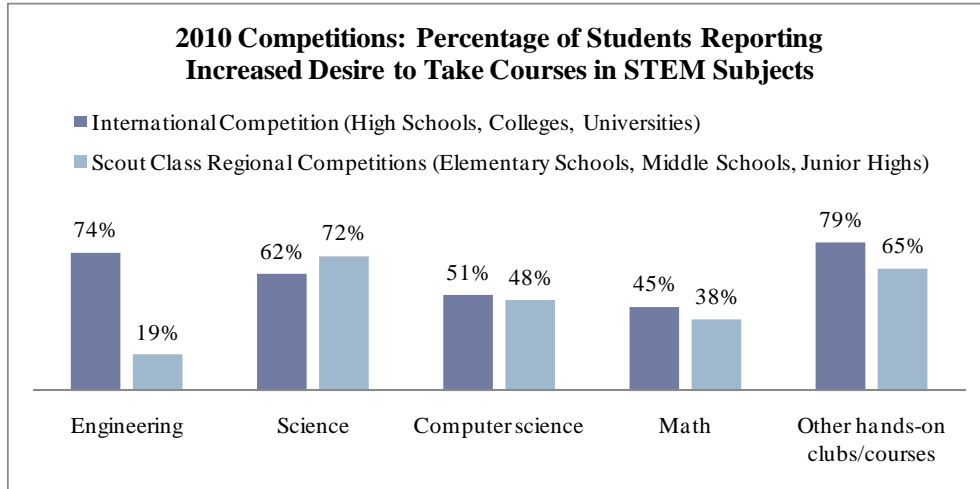
Interest in Studying STEM Topics

Eighty-three percent (83%) of the students competing in the 2010 international competition (N=325) stated that their ROV project made them want to learn more about ocean science, technology, and engineering. Students indicated that their ROV projects increased their desire to take courses in engineering (74%), science (62%), computer science (51%), math (45%), and other hands-on classes or club activities like robotics, electronics and shop courses (79%). (See Figure 5) Additionally, 63% of the students wanted to learn more about undersea volcanoes, the 2010 competition theme that the students researched.⁷

⁶ This survey question was new in 2010 so no comparable data is available for the prior competitions.

⁷ These survey questions were new in 2010 so no comparable data is available for the prior competitions.

Figure 5: Increased Interest in Studying STEM Subjects



These data patterns held true for the younger students as well, with the exception that the students' interest in taking engineering courses was much lower, likely due to the fact that engineering classes are generally not available prior to high school. Among the students in the SCOUT class, 75% (N=98) indicated that their ROV project made them want to learn more about ocean STEM. They also stated that their ROV projects increased their desire to take courses in science (72%), computer science (48%), math (39%), engineering (19%), and other hands-on classes or club activities (65%). Sixty-five percent (65%) of the students wanted to learn more about undersea volcanoes, including how ROV's are used.

Parents concurred with the other sources reporting increased student interest in STEM. Ninety-four percent (94%) of the parents surveyed in the 2010 regional and international competitions (N=163) stated that building an ROV has made their child more interested in science, technology, engineering or math.⁸ Open-ended comments from the parents include the following:

More interest in hydrodynamics

More interested in the ROV industry

Interest in aquatic science

Has had a slight shift from loving astrophysics to also loving marine engineering

⁸ Parent surveys were conducted for the first time in 2010 so no comparable data is available from prior competitions.

Anecdotal faculty data also supports this conclusion, such as the following quotations:

My students who get involved become very focused on sciences as they see their knowledge being used and extended. It is one of the most exciting things in my teaching year.

- 2010 Faculty/Mentor

STEM Knowledge and Skills

Among the teachers/mentors who completed post-competition surveys at the 2010 international competition, 98% (N=64) reported that they had observed improvements in their students' STEM knowledge and skills since the students began designing and building ROVs.⁹ Prior surveys asked about student *motivation* to learn technical skills. In the post-competition surveys at the international competitions of 2008-2010, 95% of the teachers/mentors (N=220) indicated that the competition had motivated their students to learn technical skills. Examples of faculty observations include the following quotations:

An entire generation of my CS students have learned embedded software and hardware development due to this contest, which is a skill that is quite valuable for a variety of careers from scientific instrumentation to consumer product manufacturing.

- 2010 Faculty/Mentor

The total package educational value of this project provides a learning experience beyond anything the classroom can offer.

- 2009 Faculty/Mentor

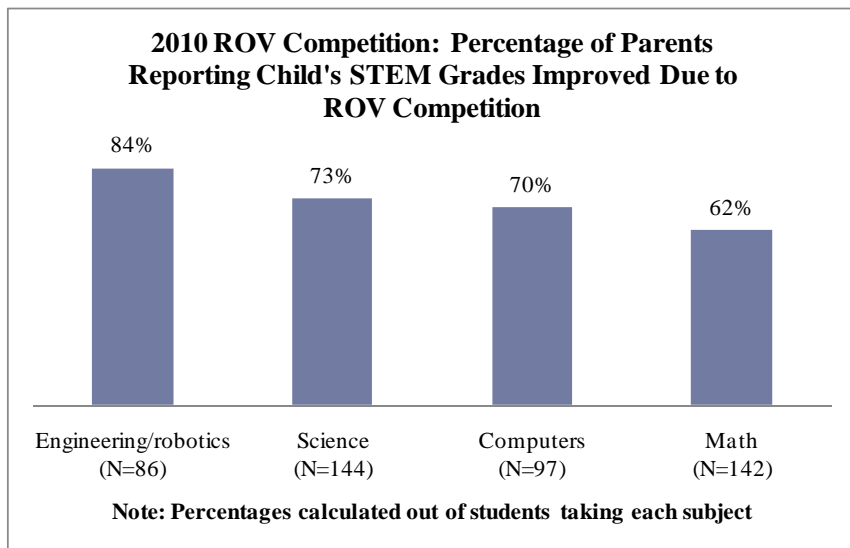
Our club has built ROV's for nine years as a means of interesting students in science and engineering. Having a team goal like this competition has been much more motivating than previous to our involvement with MATE. Adding the need to learn about a mission theme has deepened our curriculum beyond just learning about the underlying science and technology of building the ROV's. It has provided added purpose.

- 2009 Faculty/Mentor

⁹ This survey question was new in 2010 so no comparable data is available for the prior competitions.

Parents of the 2010 competition participants reported that building an ROV contributed to improving their child's grades in engineering/robotics (84%, N=86), science (73%, N=144), computers (70%, N=97) and math (62%, N=142). (See Figure 6)

Figure 6: Parents Reporting Improved Grades in STEM Subjects



SCANS skills

At the 2010 international competition, 98% of the teachers/mentors (N=65) noted that they observed increases in their students' skills in team building, problem solving, and/or critical thinking. ¹⁰ Similar to the survey question on technical skills, prior surveys asked about student *motivation* to learn these soft skills. At the international competitions of 2008-2010, 97% of the teachers/mentors (N=239) stated that the competition motivated their students to learn team building, problem solving, and/or critical thinking skills.

When parents were asked what changes they had seen in their child as a result of involvement in the ROV project, 71% (N=158) indicated that their child's self confidence had improved; 70% (N=158) reported that their children were better able to work with others; and 34% (N=158) marked that their child was better organized. In the open-ended comments, other changes that parents observed in their children included the following:

Increased passion for building, mechanics, out of box thinking, outlet for creativity in thinking of mechanical solutions.

Social skills, leadership, team building skills, collaboration – very positive experience.

¹⁰ This survey question was new in 2010 so no comparable data is available for the prior competitions.

Remarkable improvement in leadership and speaking skills.

More persistent when things don't work right away.

Imagination has improved!

Great to see an interest in something other than videos. Loves the hands on problem solving.

Working on a team was an excellent experience. Having a task that was compelling was very important.

More involved in school, more social, happier.

Excited to go to school on days when the ROV club met.

Research Question 2: Did the ROV program produce any benefits outside of participating in the competition itself? In what ways did ROV program participation affect the lives of the students and faculty/mentors? Did it have any effect on the teams' home institutions?

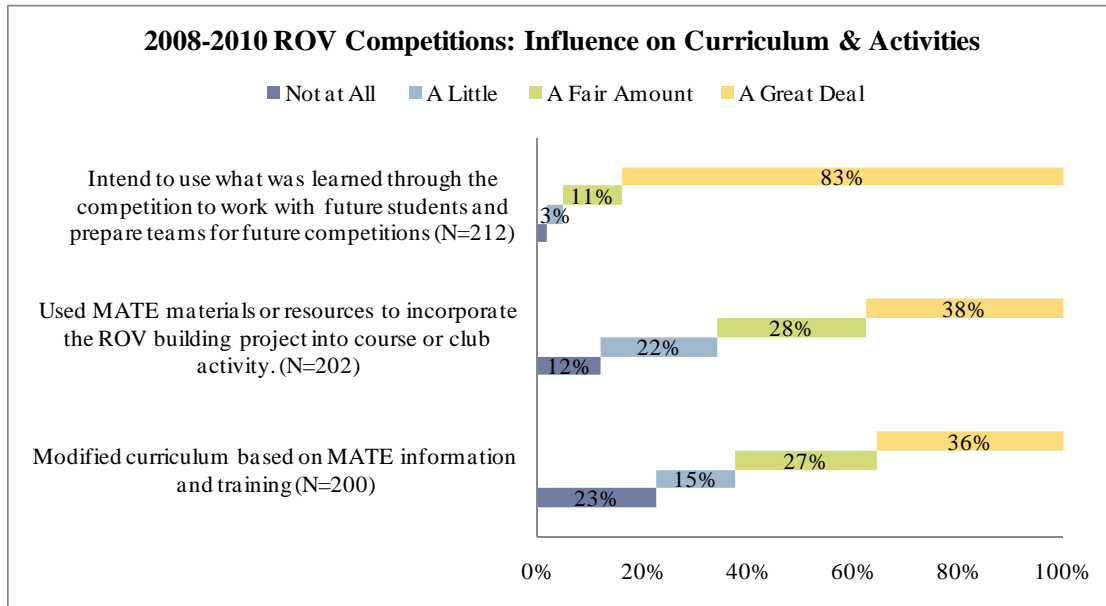
- a. Influence on course/club activities at the faculty members' home institutions**
- b. Awards/honors received as a result of competition participation**
- c. New educational/career opportunities for students**
- d. New educational/career opportunities for the faculty and collaborative opportunities for schools**

Influence on Course/Club Activities at the Faculty Members' Home Institutions

The ROV competition had a strong influence on the faculty/mentors' curriculum and the activities in their course or club. (See **Error! Reference source not found.**) Over three-quarters of the faculty/mentor respondents at the 2008 to 2010 international competitions (78%, N=200) reported modifying their curriculum based on MATE information and training. (See Figure 7)

Most of the faculty/mentors (88%, N=202) also reported using MATE materials or resources to incorporate the ROV building project into their course or club. Almost all of the faculty/mentor respondents (97%, N=212) indicated that they intended to use what they learned through the competition to work with future students and prepare teams for future competitions.

Figure 7: Influence on Curriculum and Activities



Awards and Honors Received as a Result of Competition Participation

The ROV competition provides participating students and their schools with experiences that reach far beyond the competition itself. Well over half of the students participating in 2008-2010 (60%, N=980) indicated that they or their school had received an award or honor as a result of their involvement in the ROV competition. Over 500 students provided additional detail of these awards in the open-ended portion of the question. Examples of these awards, honors, grants and other recognition include the following, as described by the students:

Continuing SMART Grant Support

National Science Foundation has funded our school's STEM Center to build more UROV's for Pacific Ocean use.

STEM Grant for Robotics Class

We've received sponsorships through SolidWorks and other companies, we received a grant, and mentions in distinguished journals.

Provincial Innovation Export Award (2008)

Innovation and Rural Development award in Newfoundland

An Air Force certificate of recognition.

The school received a Scottish engineering award as a result of the ROV and various other technical projects.

Recognized at the Utica Community Schools Board Meeting

June 1st in our town is APIA holiday

Our mayor made March 31st Immanuel Lutheran ROV Day in Alpena

We received a proclamation from the City of Carrollton

Recognized by the Dare County, North Carolina board of education and North Carolina Technical Schools

Featured nationally in a variety of media as a model for expanding the scope of 4-H

Our team and ROV was on the front of last year's course catalog. The local media has covered our team.

New Educational/Career Opportunities for Students

One-third of the students (33%, N=984) stated that their participation in the ROV competition had opened up new educational or career opportunities. Examples of the student opportunities include the following:

- **Scholarships** (i.e., IEEE OES, Marine Technology Society, Northrop Grumman, other ROV and robotics scholarships)
- **University admission** (i.e., Massachusetts Maritime Academy, Marine Institute,)
- **Internships** (i.e., United Airlines, Boeing other engineering internships, MIT, Husky Energy, Great Lakes WATER Institute Undergraduate Research, Northrop Grumman)
- **Employment offers** (i.e., Portsmouth Naval Shipyard, Marport Canada, Underwater Intervention, Oregon Emergency Job Program, Oceaneering)

There was broad agreement across the faculty/mentors that the MATE ROV competition provides a valuable venue for helping to prepare their students for careers in marine science and technology (94%, N=217). Testimonials from students, faculty, and organizational collaborators also support this conclusion. Many students recognized the effect that participating in the competition could have on their career, as evidenced by the following quotations from the 2009 post-competition survey:

*My last work term was with Marport Canada who hired me to work on an AUV.
My experience with the competition was the main reason they hired me.*

I honestly think [MATE ROV competition experience] got me my Internship at United Airlines that I'm starting this fall.

Participation in this competition has given me useful experience that I have successfully leveraged in gaining employment in Engineering companies.

Additional testimonial evidence comes from faculty members who have written letters to MATE, describing the positive impact that competition participation has had on their students' educational and career prospects. Excerpts from several of those emails from the 2009 international competition are below:

[My student] won Columbus Technical Council Student of the Year with this project ... he beat out probably the best 50 kids in the state. Wouldn't of happened without MATE!!

Last year I had 4 of my 12 students get full ride scholarships. One to U of H, one to Texas A&M, two to Balyor. This year I have one who has interviewed with MIT, two juniors who have been accepted in the NASA internship program, and a junior who will be going to the Coast Guard Academy for their summer program. The feedback from all is participation in Underwater robotic made a substantial difference in getting the scholarships. As the word filters down to the students I am getting more recruits who want to be engineers.

New Educational/Career Opportunities for the Faculty and Collaborative Opportunities for Schools

Close to half of the faculty/mentors (46%, N=193) indicated that the competition has opened up new professional or educational opportunities for them as individuals or new collaborative opportunities for their schools. Respondents described several different types of institutional collaboration: 1) between schools and industry, 2) between schools of the same type (i.e., middle schools) and 3) cross-level collaboration among schools (i.e., middle schools, high schools, and community colleges in the same community). Examples of new collaborative opportunities for schools include the following:

We have made a connection to the ocean sciences department at the local university through this year's competition.

My feeder middle school and community college both have programs and we share students.

Partnerships with Lockheed Martin and local middle schools

Partnerships with government agencies and oil industry were developed

Tour planned with Schilling Robotics this summer, connections through fundraising efforts

My state's "Workforce Investment Act" board have provided my students with funds to build an ROV and research a volcanic caldera in Oregon and paid my students to host workshops on ROV building for at-risk high school students.

Examples of new career and educational opportunities for faculty/mentors include the following:

I will be presenting my curriculum work to several hundred administrators this fall, and my underwater material will be part of that.

It has contributed to my progress as a candidate in the Boeing Technical Fellowship program.

[Becoming] aware of the Marine Institute Of Ocean Technology and attending there doing the Ocean Instrumentation program.

Just makes me more well rounded as an educator, and it allows me to do training in very relevant types of activities, which helps engage my students in better ways.

Research Question 3: To what extent did the competition lead to increases in the faculty/mentors' own STEM knowledge?

The ROV competition acted as a venue for the faculty and mentors to increase their own marine science knowledge. Almost all of the faculty/mentors (94%, N=212) stated that working with their students to prepare for the competition contributed to their own knowledge about the real world topic covered in the competition theme: hydrothermal vents in 2008, submarine rescue systems in 2009 and undersea volcanoes in 2010.

Research Question 4: Did participation in the program lead to an increase in the parents' support of their children's interest in STEM careers?

Over time, the MATE Center's evaluation has continued to evolve, responding to shifts in programming as well as new topics of interest among educational researchers. In particular, recent research in the field has stressed the importance of family support in a student's decision to pursue a STEM career. (See Siobhan Bredin et al., *A Summary of the Report on the NSF ITEST Convening: Defining an Afterschool Research Agenda*, June 2010.) In the 2009-2010 MATE Center program-year, parental input was solicited for the first time.

Eighty-one percent (81%, N=159) of the parents surveyed 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. Eleven percent (11%) marked that the program participation did not affect how they picture their child's future, and 9% were not sure.

Conclusions and Next Steps

Overall, evaluation results indicate that the competitions have had a profound effect on both students and faculty. Students report that due to the competition they are more aware of careers in marine science and technology and are more interested in pursuing a career in these fields. The competitions have led to new opportunities for the students, including scholarships, internships, university admissions, and employment. Faculty/mentors report that the competitions have motivated their students to improve their technical skills, as well as their skills in problem solving, teamwork, and critical thinking.

The competitions have had a positive impact on faculty as well. Faculty/mentors report that their involvement in the competitions contributed to their own scientific and technical knowledge and opened new professional and educational opportunities for them, as well as new collaborative opportunities for their schools.

The current evaluation has many strengths, such as the availability of evaluation results that cover a 10-year span, but there is always room for improvement. Planned changes to the evaluation include incorporating embedded assessments of student STEM knowledge and skills, feedback from competition judges and other volunteers, and analyzing the results by demographic factors.