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Scaling Up Success: Using MATE's ROV Competitions to Build a Collaborative Learning Community that Fuels the Ocean STEM Workforce Pipeline

PD/PI Name:

- **Jill M Zande, Principal Investigator**
- **Candiya Mann, Co-Principal Investigator**
- **Deidre Sullivan, Co-Principal Investigator**

Recipient Organization:

Monterey Peninsula College

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Submitting Official (if other than PD\PI):

- **Jill M Zande**
- **Principal Investigator**

Submission Date:

08/01/2016

Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)

Jill M Zande

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Accomplishments

* What are the major goals of the project?

The information included within this report covers the period from July 1, 2016 through May 15, 2017.

Our ITEST Scale-Up project, *Scaling up Success: Using MATE's ROV Competitions to Build a Collaborative Learning Community that Fuels the Ocean STEM Workforce Pipeline*, expands the best practices that we identified, based on evaluation data and regional reporting, as most effective in reaching, engaging, and supporting student and teacher participation in STEM. 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. Our hypothesis is that for each additional year a student participates in engineering design challenges such as the MATE ROV competition, their likelihood of going to college increases, their likelihood of declaring a STEM major increases, and their likelihood of entering the STEM workforce increases. The following four goals (and the activities described beneath each) provide the foundation for our work:

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.

1a. Add a SCOUT+ competition class so students can gradually step up their knowledge and skills.

1b. Create a support system for students who move on to the next grade and find there are no robotics activities.

1c. Provide opportunities for students to interact with working professionals as well as student mentors to support their learning and provide examples of STEM careers.

1d. Document and share inspirational stories of successful students and working professionals to help students visualize themselves in pathways to STEM careers.

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

2a. Develop a continuum of curriculum that is tied to the Next Generation Science Standards (NGSS) and includes online complementary resources.

2b. Develop a progression of ROV "kits" that complement the curriculum.

2c. Designate regional teacher "leaders."

2d. Offer week-long professional development workshops focused on the curriculum and kits.

2e. Offer regional professional development and student-focused workshops.

2f. Increase preparedness of near-to-peer student and industry mentors.

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

3a. Create an online parents' resource center and listserve.

3b. Form regional parental advisory committees that provide feedback and advice.

4. Track students longitudinally to document how participation impacts their education and career path.

4a. Improve our current student tracking system.

4b. Use the videos described under Goal 1d to document student education and career pathways.

The evaluation report for this grant year is included within the supplemental documents.

* What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?

Major Activities:

1a. Add a NAVIGATOR (SCOUT+) competition class. Sixteen of the 20 U.S.-based regional competition programs received ITEST funding this year: Carolina, Coastal Carolina, Florida, the Great Lakes, the Mid-Atlantic, Monterey, New England, Northern Gulf Coast, Ohio, Oregon, Pennsylvania, the Pacific Northwest, Puerto Rico, Shedd Midwest, Southeast, and Wisconsin. Nine of those regionals offered a NAVIGATOR class; all nine plan to offer it again in Year 5. One regional is thinking about adding it next year. The remaining six regionals reported that they did not (and do not plan to) offer it because currently there is no demand.

1b. Create a support system for students. Students and parents looking to start or continue with the ROV competition were connected with the following resources: 1) the regional coordinator nearest them; 2) the new "Getting Started with MATE Underwater Robotics" section of the MATE web site; 3) MATE's bank of online instructional materials, including building instructions, curriculum modules, how-to videos, and technical reports from previous competitions; 4) the MATE store for access to ROV kits, practice boards, and more; 5) the mission fly-throughs and safety inspection tutorials; and 6) access to MATE's online forums, which include a technical help and competition FAQs board. In addition, this year we conducted Facebook Live events where we walked viewers through the mission props for each competition class and allowed them to ask questions along the way. We also gave regional winning teams a look at "what to expect in Long Beach." These were popular with teams as well as regional coordinators; a number of them noted this within their ITEST regional reports. While no formal survey was conducted this year to assess user satisfaction and usage of the online resources, comments shared via post-competition surveys indicate that parents found the resources to be helpful. (See the Year 4 Evaluation Report for further details.)

1c. Provide opportunities for students to interact with mentors. Fourteen of the 15 regionals that participated in ITEST reported connecting teams with mentors. The mentors

were industry professionals; high school, community college, university, or graduate students; or teams mentoring other teams. Regionals facilitated connections in creative ways; for example, one hosted an “Ask an Expert” class and a “Virtual Engineer Mentor” unit, and connected middle school teams with the high schools that their students feed into to help make the transition a smooth one. Another engaged returning competition students to mentor teachers starting new teams. All 15 regionals utilized industry professionals as mentors, judges, or technical support during the competition events.

1d. Document and share inspirational stories. The video highlighting the 2016 MATE international competition includes a number of student interviews where the students describe the impact that the competition has had on their education and careers choices (see https://vimeo.com/184585932).

We organized a MATE competition alumni panel discussion and Q&A during the 2017 MATE international competition. Seven alumni participated, answering prepared questions such as:

- What innovation on your Competition ROV are you most proud of (or team accomplishment)?
- What is your most memorable competition or ROV building-related experience?
- How did this experience influence your education and career path?
- What advice would you give to someone at this competition?

In addition, footage collected during the 2017 international ROV competition is currently being compiled a summary video highlighting the event. This video, as well as the recording of the alumni panel, will be released later this fall. We plan to organize another alumni panel during the 2018 international competition.

Further, we developed and started disseminating a monthly electronic newsletter in December of 2016. Features include “Share Your MATE Journey,” which highlights competition alumni student success stories. The newsletter is currently distributed to a contact database of 13,345 individuals; links to current and past issues are also posted to the MATE web site (see www.marinetech.org/mate-newsletters/).

2a, 2d, and 2e. See **What opportunities for training and professional development has the project provided?**

2b. Develop a progression of ROV kits. We continued to improve the four ROV kits that support a progression of learning: 1) AngelFish (REV 2) (simple electronics); 2) PufferFish (REV 6) (simple-intermediate electronics) (REV 7 to be released 9/1/17); 3) TriggerFish-Analog (intermediate electronics) (REV 3 to be released 9/1/17); and 4) TriggerFish-Digital with microcontrollers (intermediate electronics with computer programming) (improved design to be rebranded and released October-November 2017). The TriggerFish-Analog control system underwent a major redesign in 2016. The new design was beta tested in 2017 and will be released in September. This design moves all of the components to one printed circuit board (PCB) for a more compact and streamlined appearance. Everything is now housed in a durable watertight control box with a detachable tether. We also increased the ruggedness of the design to aid in reusability.

The TriggerFish-Digital also underwent major design changes in 2016-17 and will now have Bluetooth capabilities and two relay switches; this kit will be rebranded as the Barracuda and will be released by November. The Barracuda can be controlled via a smart phone (if desired) and the relay switches allow for the addition of more advanced tools such as robotic arms. The TriggerFish-Analog can easily be upgraded to the Barracuda by replacing the PCB and adding additional components; again, the kit was designed with the progression of learning in mind.

A description of these ROV kits can be found here www.marinetech.org/store/. The new designs will be posted to the site as they become available for purchase.

We provided (at no cost) 193 ROV kits along with lab packs, textbooks, and building supplies to the 15 regionals that participated in ITEST activities in Year 4 to support their teacher workshops and student outreach. In addition to the kits provided through ITEST, we sold 779 ROV kits and 278 textbooks this past year. Two hundred eighty-two PufferFish circuit boards were also purchased to rebuild "old" PufferFish control systems.

A great deal of time and testing has gone into the development of our kits, not only to enhance the learning experience, but also to maximize production efficiency. We continue to update and improve these kits with new versions, but the foundational technology will continue to remain the same for the foreseeable future.

The four kits support the student learning objectives outlined in the MATE Underwater Robotics student learning outcomes document www.marinetech.org/files/marine/files/Curriculum/PufferFish/MATE%20UWRobotics%20Learning%20Objectives_16.pdf . These learning objectives provide knowledge and skills in engineering design (aligned with the Next Generation of Science Standards) along with electrical, mechanical, physical science, and computer science knowledge and skills. These knowledge and skill areas are foundational to robotics and automation that are vital to every sector of the U.S. economy. The ROV design and building experience, coupled with the comprehensive competition experience, produces well-rounded students that are conversant in project management (including managing failure), teamwork, communication (oral and written), leadership, entrepreneurship, and the application of technology and science to solve real-world problems.

In addition to the ROV kits and textbooks, we offer a variety of other materials, such as camera waterproofing kits, simple circuits kits, lab packs, and replacement parts for all of our ROVs, through the SeaMATE store. A new addition in the fall of 2016 was the Spanish Galleon Competition Kit. This kit includes a competition manual, prop building instructions, a teacher's guide, and assessments (i.e. scoring rubrics). Not all teachers and students can or plan to participant in a MATE competition. Further, if a regional competition cannot accommodate multiple teams per school, a school runoff may be required. The Spanish Galleon kit is designed to provide a competition experience to all students, whether or not they are able or intend to attend a MATE event.

One of the major barriers to participation, outlined in the 2015 I-Corps for Learning study, was lack of access to easy-to-order materials from a single vendor that would accept school purchase orders. We have devoted considerable time and effort to increasing ease of access and to scaling our store operations; we will continue to enhance the online ordering experience with better documentation and product photos.

2c. Designate regional teacher "leaders." Eleven of the 16 regionals participating in ITEST had at least one local teacher leader; several had more than one. These teacher leaders led or assisted with professional development workshops and student outreach; mentored other teachers in starting ROV programs at their schools; connected teachers and students with industry and student mentors; helped teams decipher the MATE competition manuals and fielded questions about participating in the event; presented at conferences and workshops; and/or participated on regional advisory committees. We will continue to encourage regional coordinators to utilize teachers experienced with ROV design and building and the MATE competition as resources for themselves and other teachers in their regions.

(Continued under Key Outcomes or Other Achievements)

Specific Objectives:
See **What are the major goals of the project?** above.

Significant Results:

Over the course of Grant Year 4, our project:

- Supported 16 regionals with ITEST funds.

- Held a regional coordinators meeting where 18 coordinators representing 17 regions attended in person, with 3 additional coordinators (representing 2 additional regions) attending via teleconference.

- Offered a NAVIGATOR competition class in 9 regions.

- Continued progress towards creating a multi-year student support system that consists of professional development instructional resources, mentors, parents, and more. In last year's report, we redefined this goal: that the overall number of multi-year participants will increase by at least 10% each year over the duration of the grant.

  From Year 1 to Year 2, the number of multi-year students increased from 1,345 to 1,537, an increase of 14%. From Year 2 to Year 3, the number of multi-year students increased from 1,537 to 2,016, an increase of 32%.

  From Year 3 to Year 4, the number of multi-year students increased from 2,016 to 2,118, an increase of only 5%. We did not reach our goal.

*Note: Again this year, we used registration data, rather than post-competition surveys, for these numbers because registration data is more comprehensive (i.e., more students register via the Active system than complete post-competition surveys).

- In our analysis of post-competition surveys, we did find several statistically significant differences between the first year and multi-year competition participants. For example, multi-year participants were statistically significantly more likely to report their participation in the ROV program resulted in higher levels of awareness of and interest in pursuing 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.

- Provided students with access to student and industry mentors in all 16 regions that participated in ITEST this year.

- Produced a summary video highlighting the 2016 international ROV competition (see https://vimeo.com/184585932) as well as a video highlighting the 2016 Monterey Bay regional ROV competition (and the SCOUT and NAVIGATOR class teams; see https://vimeo.com/170548699), In addition, collected footage during the 2017 international competition that is currently being compiled into a video highlighting that event.

- Offered 4 ROV kits that complement MATE instructional resources as well as other building materials and resources (e.g., soldering practice board).

- Eleven regions utilized teacher leaders as resources for coordinators and other teachers. Several of these regions had more than one teacher leader.

- Offered 1 workshop that provided 60 hours of professional development to 20 participants.

- Offered 20 regional professional development “teachers only” and 170 “teacher-student” workshops that provided an average of 12 hours of instruction to 501 teachers. Taking into account the teachers’ participation in competition events and the number of hours increases to more than 20.

- Offered 223 “student only” and 170 “teacher-student” regional workshops, such as topic-specific hands-on instruction, information sessions, and pool practice days, that engaged more than 7,300 students; 1,472 in an after school setting, 2,106 during school, and 3,762 as part of a community organization or event. More than 2,400 of those students attended regional ROV competitions.

- Provided mentors with access to information and resources to support their role in the classroom and streamline communication. In the post-competition survey,*** among the teachers who indicated that a mentor came to their site (N=64), 94% percent noted that their mentors were adequately prepared to help them and their students through the ROV design and building process.

- Surveyed*** 283 parents attending 14 competition events and engaged 49 as members of regional advisory committees. It is estimated that more than 50 parents participated in regional professional development workshops; countless others attended community-wide events where regional partners exhibited. In addition, directed parents to our online resources, including the "Getting Started with MATE Underwater Robotics" section (see www.marinetech.org/getting-started/) and invited them to join our e-mail listserves to support their involvement and improve communication.

- Fifty-eight organizations, 407 industry professionals, and 138 others (e.g. community members) supported the grant activities. The activities were also supported by 89 high school, 32 community college, 97 university undergraduate, and 27 graduate students as well as 24 community college and 59 university faculty members. (While the total number of organizations supporting the work decreased from Year 3 to Year 4, the total number of individuals increased in all categories, with dramatic increases in the number of industry professional (34% increase), university undergrads (45%), and community college and university faculty (380% and 103%, respectively).

- Benefitted from the guidance and oversight of 12 regional advisory committees (that include, among other members, a total of 50 parents).

- Twelve regionals held advisory committee meetings, either in-person or via teleconference call or webinar, or collaborated with members in smaller groups in order to gather feedback to help improve and steer the future direction of their regional programs.

- Continued to use Active to collect both team and student competition registration information. Used this data, along with post-competition surveys, to help us to determine 1) how many students were involved for multiple years and 2) how their long-term participation influenced their interest in pursuing STEM courses and careers.

- Continued to improve the utility of MATE web resources and used social networking tools to increase communication and collaboration. For example, we hired a new media and communications specialist (via the MATE grant) to develop a comprehensive social media strategy (FB, Twitter, Flickr, YouTube, etc.). This has resulted in increased "likes" and engagement on Facebook and Twitter (defined as the number of times people engaged with posts through likes, comments, shares, replies, retweets, etc.). For example, on July 27, 2017 the competition Facebook page had 6,260 "likes," an increase of more than 1,400 "likes" from the same date last year; our engagement rate (defined as the number of engagements divided by the number of page likes/followers multiplied by 100) on FB averaged 7.40% from January to July 2017, with a maximum rate of 32.35% during June (and the international ROV competition).

- Maintained a live videostream from the Long Beach City College during the 2017 international competition (see www.marinetech.org/live-videostream/ for video archives) and used two Twitter (#MATE2017 and #MATEROV) to communicate with the public; from

January through July, our highest Twitter engagement was in June, with an engagement rate of 18.90% (the average over that time period was 8.76%). We also livestreamed the entire awards ceremony (see our competition FB page for a recording). OpenROV, Blue Robotics, and Teledyne Marine supported the livestream with equipment (ROVs, underwater cameras) and personnel. OpenROV is co-founded by former MATE competitor Eric Stackpole. In addition to Eric, the company employs other former MATE competition students, as does Blue Robotics.

- Disseminated information about the ROV competition program via 100+ publications and more than 32 conferences, meetings, and workshops, including the National Science Teachers Association and National Marine Educators Association's annual conferences.

- Used surveys and other instruments to evaluate progress and increase effectiveness and impact.

***NOTE: The 2017 international competition survey results are NOT included in this report.** They will be shared in our Year 5 annual report.

Key outcomes or Other achievements:

(Continued from Major Activities)

2f. Increase preparedness of student and industry mentors. Regional coordinators continued to engage high school, undergraduate, and graduate students as well as community college and university faculty, industry professionals, and community members as mentors and volunteers at workshops and competition events. More than 870 students, faculty, industry professionals, and community members supported grant activities this year. Through the regional coordinators, mentors also had access to the information and training modules reported in Year 1 as well as the online resources described under "**What was accomplished under these goals?" 1b**.

The results of the 2016 post-competition teacher survey speak to mentor preparedness. For 26% of the post-competition teacher survey respondents (N=243), a classroom/club mentor came to their site to help their teams. The majority of those teachers (94%) indicated that their mentors were adequately prepared to help them and their students through the ROV design and building process.

3a. Create an online parents' resource center. The Parent Resource Center page is located within the competition section of the MATE web site (see www.marinetech.org/parent-resource-center/). The resource center includes a "welcome" note targeted to parents as well as links to information and resources. It also includes links to the "Gallery" page that contains videos from the international and regional competitions. Recently added are links to information such as competition timeline and costs, student learning objectives for ROV building, and "Getting Started with MATE Underwater Robotics," a section aimed at helping newcomers navigate finding information (e.g. what kit to purchase, what competition class to enter, etc.) on the MATE web site.

A document with highlights of 2016 evaluation data and alumni survey results that demonstrate the positive impact of the program is also located on the resource center; a document with highlights of the 2017 evaluation data will be added in September.

- **3b. Form regional parental advisory committees.** Twelve of the regions participating in Year 4 ITEST have advisory committees. Nine of those include at least one parent; eight of those nine include two or more parents. In addition to parents, the advisory committees include staff of the lead organization, industry members, parents, teachers, and/or students. Twelve regionals held advisory committee meetings, either in-person or via teleconference call or webinar, or collaborated with members in smaller groups in order to gather feedback to help improve and steer the future direction of their regional programs. We will continue to encourage all regional coordinators to assemble advisory committees and to utilize these committees for guidance and feedback on regional activities.

  4a. Improve our current student tracking system. Again this year we used Active, a low-cost, commercially available system, to collect both team and student competition registration information. We used the student registration data to determine that 40% of the student registrants had competed for multiple years.

  See the Year 4 Evaluation Report for further details; also see **Changes in approach and reason for change** as well as **Actual or Anticipated problems or delays and actions or plans to resolve them** for information on how we are using this data in our work with the and the National Student Clearinghouse Washington State Education Research Data Center.
  4b. Use the videos described under 1d. See 1d above.

* What opportunities for training and professional development has the project provided?

2a. Develop a continuum of curriculum. In 2016 we started to transition our educational resources to Google Slides for quick and easy updating. We also started using the Canvas Learning Management System for learning resource dissemination; this system provides much greater control over who is and how they are using our educational resources.

We currently have five active courses in Canvas; there is one course for each competency/ROV kit level plus the Diving into Underwater Sensors and Arduino course. In addition to better control, this system allows us to respond to participants' questions far more efficiently because it retains a log of the questions and answers within its discussion board. The Canvas courses are currently available to individuals who participated in our workshops during this past year; to date, 400 educators are enrolled in one or more of these courses.

These courses contain quizzes and worksheets. We are just beginning to pilot "spin-off" or "clone" courses, where educators can add their students to the courses and we can better understand and

monitor student performance. We are working with Dr. Min Li to design, pilot, and assess the psychometric quality for the courses' pre- and post- tests.

2d. Offer week-long professional development workshops. The seventh annual ITEST Summer Institute, Introductory Level ROV Building: The PufferFish ROV, took place July 10 -17, 2016 at MPC. This institute introduced participants to the PufferFish ROV control system. Participants learned the fundamentals of engineering design, project management, and ROV building and experienced a variety of hands-on science, technology, and engineering activities that can be integrated into a class or afterschool activity to reinforce foundational knowledge and skills. Along with MATE staff, two engineers (one mechanical, one electrical) co-taught the institute to ensure that best engineering design practices were applied to all building activities; the instruction followed the format of the NGSS for engineering design. Instructional materials from this institute can be requested via a password for a Canvas login to the course. Ninety-five percent of the teachers rated the usefulness of the workshop as excellent, one as good.

We offered the online workshop Diving into Underwater Sensors and Arduino for the second year. Forty-two participants enrolled in this 30-hour course that covers the hardware and software development environments for sensor interface and programming. After learning the basics of Arduino programming, the participants built and collected digital data from six sensors commonly used in the underwater environment. See www.marinetech.org/files/marine/files/Workshops/Diving%20into%20Sensors%20Course%20Outline.pdf for the course outline.

The goal of sensors course is to provide a foundation for the hardware and software required to migrate to the digital TriggerFish (now renamed Barracuda) ROV. This course was inspired and designed based upon feedback from workshop participants on new skills and information they would like to learn from both our ITEST and ATE grant-funded work. This course is funded, in part, with program income generated from SeaMATE store sales.

2e. Offer regional workshops. Twenty "teacher-only" professional development workshops and 170 "teacher-student" workshops were offered to a total of 953 teachers and parents/community members; the following is a breakdown by grade level:

Grade 3-5: 68; Grade 6-8: 226; Grade 9-12: 150; postsecondary: 14; Informal educators: 43; Other (e.g. parents): 452

The workshops ranged from ½-day ROV design and building activities (where the focus was on frame design, motor placement, and buoyancy) to multi-day events (where the focus was building control boxes). The number of hours of instruction for each teacher ranged from 2 to 40; the average was 12. The workshops were offered during school, after school, on weekends, in the evening, and/or during the summer.

Two hundred twenty-three "student only" and 170 "teacher-student" workshops were offered to 7,340 students. Of these students, 2,106 were impacted in an in-school setting, while 1,472 and 3,762

were impacted in an after school setting or as part of a community organization/event, respectively. The following is a breakdown by grade level:

Grade 3-5: 1,209; Grade 6-8: 1,938; Grade 9-12: 1,248; postsecondary: 59; Other (e.g. home school not defined by grade level or community event where grade levels are not known): 3,782

(NOTE: Some students were reported in more than one category – i.e., grades 9-12 and "other.")

The workshops covered topics from basic ROV design and building to simple electronics and AngelFish and PufferFish ROV kit assembly. Information sessions, pool practice days, and "demo nights," among others, were also offered. The number of individual student contact hours ranged from 1 to 50; the average was 16.

All 16 regions that participated in ITEST reported that they used MATE's ROV kits in their workshops; all of these regions reported that the kits were helpful. Twelve regions reported that they used the Canvas online course management system; 13 used the instructions for kit assembly. One regional noted that several teachers who attended a workshop wrote suggestions for how to improve the layout of the instructions on their post-workshop surveys; we will review those suggestions and make the necessary improvements in Year 5. Twelve regions reported that they used the practice boards, 7 used the simple circuits kits, and 6 used the new Spanish Galleon mini-competition kit. Ten indicated that they used the MATE textbook as a resource for themselves and their teachers.

Comments from regional coordinators about the support they received from MATE included:

The [online resources] are very useful because students and teachers have the resources available 24/7 and they can review what I taught in the workshops during the week. – Puerto Rico regional coordinator

The practice boards continue to be an effective tool for teachers and students who are first-time solderers to learn and practice the technique. – Shedd Midwest regional coordinator

* How have the results been disseminated to communities of interest?

Between the MATE Center, its regional partners, and ROV competition participants, well over 100 abstracts, journal papers, newspaper articles, web sites, television news stories, and other publications featured ITEST grant activities. Examples of these are included within the products section of this report.

In addition, between the MATE Center and its regional partners, information about the ITEST project was presented at more than 30 conferences, meetings, community events, workshops, and other events. These included the following:

- National Marine Educators Association Conference, held June 25 – July 1, 20-16 in Orlando, FL.

- Georgia Southern University STEM Fest, September 26, 2016, Statesboro, GA

Society of Manufacturing Engineers, January 27, 2017, Cherry Hill, NJ

- Oceanology International North America, February 14-16, 2017, San Diego, CA.

- Ohio Educational Technology Conference, February 14-16, 2017, Columbus, OH.

- Underwater Intervention Conference and Exhibition, organized by the Marine Technology Society's ROV Committee and the Association of Diving Contractors International and held February 21-23, 2017 in New Orleans, LA.

- Alabama Science Teachers Association, March 7-8, 2017, Birmingham, AL.

- Wisconsin Society of Science Teachers Convention, March 17-19, 2017, Milwaukee, WI

- Marine Science Day at Hatfield Marine Science Center, April 8, 2017, Newport, OR.

- American Alliance of Museums (AAM) Annual Conference, May 6-9, 2017, Phoenix, AZ

See also **Significant results** for information about our use of social media.

* What do you plan to do during the next reporting period to accomplish the goals?

During the next reporting period (Grant Year 5) we will:

- Support 16 or more regional partners with ITEST funds.
- Hold a regional coordinators meeting to build community and increase regional fidelity, among other goals.
- Continue to add a NAVIGATOR competition class to regionals, based on the regional demand and feedback from stakeholders.
- Compare Year 3 to Year 4 to determine 1) if we have improved multi-year competition participation by 5% (and, if not, dive deeper into the data to interpret why) and 2) what other statistically significant gains multi-year participants have made compared to first-year participants.
- Continue to provide students with access to student and industry mentors who are well-prepared to support learning and provide career guidance.
- Document 2-4 student success stories via video (interviews during the competition) and an additional 3-6 success stories via the MATE electronic newsletter and use these stories for evaluation purposes.
- Continue to clone (producing copies of) the PufferFish Summer Institute course in the Canvas content management system so that educators can adapt and deliver the content directly to their students in a way that best meets their needs and allows them to monitor student performance. We plan to enhance the course with new instructional videos. We will work with Dr. Min Li to design, pilot, and assess the psychometric quality for the courses' pre- and post- tests.

- Continue to improve our ROV kits (we will be releasing version 3 of the TriggerFish-Analog kit in September 2017 and the TriggerFish-Digital rebranded as the Barracuda by November 2017) and continue to create additional materials to enhance student learning.

- Continue to encourage MATE regionals to identify and utilize regional teacher leaders to function as resources for coordinators and other teachers.

- Offer 1 workshop that provides 60 hours of professional development to at least 20 participants, including middle and high school teachers and regional coordinators.
- Offer at least 20 regional professional development workshops that provide an average of 10 hours of instruction to 400 teachers.
- Offer an additional 200 regional workshops, such as topic-specific hands-on instruction, information sessions, and pool practice days, to 4,000+ students.
- Work with regional coordinators to add to the current mentor information and training to support their role in the classroom and streamline communication.
- Continue to engage and increase the number of parents in grant activities and continue to add to the resources and information included with the Parent Resource Center. Direct parents to our online resources and invite them to join our e-mail listserves to support their involvement and improve communication.
- Increase the number of organizations, industry professionals, and others as well as high school, community college, university undergraduate, and graduate students and community college and university faculty supporting the grant activities.
- Continue to encourage regionals to create and meet with regional advisory committees to provide guidance and oversight.
- Use the student competition registration system in conjunction with the post-competition surveys to determine 1) how many students are involved for multiple years and 2) how their long-term participation influences their interest in pursuing STEM courses and careers.
- Improve the organization and utility of MATE web resources and continue to use social networking tools to increase communication and collaboration.
- Use surveys and other instruments to evaluate progress and increase effectiveness and impact.

Please also see the **Major Activities, Key Outcomes or Other achievements,** and the **What opportunities for training and professional development has the project provided?** sections.

Supporting Files

	Filename	Description
(Download)	Student Description Input 2016_MATE underwater robotics competition.pdf	Description of AMNO & CO and two other ROV consideration for the White House Science Fair.
(Download)	ITEST 2015-2016 Evaluation Report 7-29-16.pdf	Year 3 Evaluation Report.

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Products

Books

Book Chapters

Inventions

Journals or Juried Conference Papers

Licenses

Other Conference Presentations / Papers

Other Products

- *Audio or Video Products.*
  The 2015 competition video summarizes the 2015 international competition event, which took place June 25-27, 2015. The video is housed on both the MATE Center's YouTube and Vimeo accounts and can be accessed here https://vimeo.com/161073555
- *Audio or Video Products.*

  Dauphin Island hosts Northern Gulf Coast ROV Compeition - http://local15tv.com/news/local/dauphin-island-hosts-northern-gulf-coast-rov-competition

- *Audio or Video Products.*

  Highlight video of the 2016 MATE Mid-Atlantic regional ROV competition - https://www.youtube.com/watch?v=rkNPR2-Nec8#action=share

- *Audio or Video Products.*
  Highlight video of the 2016 MATE Monterey Bay regional ROV competition, featuring student interviews - https://vimeo.com/170548699
- *Audio or Video Products.*

  Meet Brother Rice High School's Underwater Robotic, Edmund MK 2.5 - https://www.dnainfo.com/chicago/20160318/mt-greenwood/meet-brother-rice-high-schools-underwater-robot-edmund-mk-25

- *Audio or Video Products.*
  Meghan Abella-Bowen and & Darlease Montiero (MATE Advisory Board member and ROV team mentor) are interviewed on the Fall River “Full STEAM Ahead” cable program where we discuss MATE and VEX - https://www.youtube.com/watch?v=81PMfTpUUeY
- *Audio or Video Products.*
  National Publics Radio *Here and Now* - http://www.disl.org/news/article/nprs-here-and-now-features-disl-research
- *Audio or Video Products.*

  Podcast on ByteMarks by Burt Lum - Episode 405: MATE ROV - June 1, 2016

- *Audio or Video Products.*

  Podcast on Civilbeat by Burt Lum - Civil Geeks: Taking Robotics into Uncharted Waters

- *Audio or Video Products.*
  Recording of the 2016 MATE international ROV competition livestream video from the William's Pool, collected by OpenROV, a company that manufactures a low-cost, open source ROV for exploration - https://www.youtube.com/watch?v=Gvp5R0p9fWM
- *Audio or Video Products.*

  TV news coverage on WTOC.com - Students take part in underwater ROV competition

- *Audio or Video Products.*
  The following videos of student interviews (with compelling testimonials) from the 2015 MATE international ROV competition can be found on both the MATE Center YouTube (https://www.youtube.com/user/MATECenter/videos) and Vimeo Channels (https://vimeo.com/user14545135):
  - Highlight video on YouTube and Vimeo
  - RANGER class champions on YouTube and Vimeo
  - Teamwork rocks! on YouTube and Vimeo
  - Students rise to the challenge on YouTube and Vimeo
  - So much to learn on YouTube and Vimeo
  - Career choices on YouTube and Vimeo
- *Audio or Video Products.*

  Video Footage from a Team in Stockbridge, MI:

  https://www.youtube.com/watch?v=cCEqJtjquWo

  https://www.youtube.com/watch?v=SteEfrcnT6M

  https://www.youtube.com/watch?v=ZgL2Ya6-muU

  https://www.youtube.com/watch?v=7ablW4KhorU

- *Audio or Video Products.*

  Video for News 3 TV - Underwater Robotics Competition at ODU

  http://wtkr.com/2016/04/30/annual-rov-competition-at-odu/

- *Educational aids or Curricula.*
  Building instructions, instructional resources, and other activities that complement the ROV kits we developed - see http://www.marinetech.org/curriculum/.
- *Educational aids or Curricula.*
  ROV kits, practice boards, and more building resources - see http://www.marinetech.org/store/ for a description of the kits, boards, and other resources.
- *Educational aids or Curricula.*

We used the Canvas online course management system to host all of the presentations, assignments, and quizzes delivered as part of our 2016 PufferFish Summer Institute. We can send an invitation to view the course upon request (e-mail to dsullivan@mpc.edu).

- *Data and Research Materials (e.g. Cell lines, DNA probes, Animal models).*

NOTE: The Year 4 evaluation report is included within the Supplemental Documents.

1. During negotiation, additional information was requested regarding the data management plan to ensure how products of the research (reports, instruments, and data) would be made accessible to other researchers.

Action 2D: Please what was accomplished during Year 4 pertaining to the work you proposed in your responses, including:

o sharing of evaluation reports, evaluation instruments, de-identified data sets, and website analytics at the project website and ITEST's STEM Learning Resource Center.

If the goals/objectives were not fully accomplished during Year 4, please include what changes will be made to your plan and timeline to achieve these goals/objectives.

Our Year 3 annual and evaluation reports have been submitted to STELAR; our 2015-2016 post-competition survey instruments have been posted to our project's page on ITEST STELAR web site.

The web page http://www.marinetech.org/itest currently contains project and evaluation reports from our ITEST Strategies work and Years 1-3 of our ITEST Scale-Up (Year 4 will be posted upon completion and NSF approval).

The 2014-2017 survey instruments, 2014-2016 survey results (2017 survey results will be posted upon completion of final analysis), and information on how to obtain datasets and web site analytics data are also included there. Visitors to the MATE web site can find instructions on how to access this information on the "about MATE" page (see http://www.marinetech.org/about/); once they have created a login, they can access the information.

- *Announcement.*

Announcements of the Pennsylvania Regional Competition were posted on these websites:

http://philadelphia.eventful.com/events/mini-maker-faire-make-c-/E0-001-088090873-6@2015110616
http://www.philasciencefestival.org/
http://www.schoolius.com/school/731351216951985/T+E++Harrington+Middle

- *Blog.*

Breaking Waves

MATE ROV compeition in North Bend this Weekend
- http://blogs.oregonstate.edu/breakingwaves/2016/04/28/mate-rov-competition-in-north-bend-this-weekend/

- *Blog.*

  Central Orgeon Coast Now

  Volunterring for the Statewide ROV Compeition on April 30th
  - https://centraloregoncoastnow.com/tag/oregon-regional-mate-rov-competition/

- *Blog.*

  Chief Education Office

  Volunteering for the statewide ROV Competition on April 30
  - http://education.oregon.gov/volunteering-for-the-statewide-rov-competition-on-april-30th/

- *Blog.*

  LADC-GEMM

  Remotely Operated Vehicles: another technology - http://www.ladcgemm.org/remotely-operated-vehicles-another-techonology/

- *Blog.*

  Oregon Coast STEM Hub

  ROV Displayed at Aquarium - http://blogs.oregonstate.edu/oregoncoaststem/2015/11/19/rov-displayed-at-aquarium/

- *Blog.*

  Oregon Coast Stem Hub

  Students Dive into STEM in Statewide Underwater Robotics Compeition
  - http://blogs.oregonstate.edu/oregoncoaststem/2016/05/04/2016-rov-competition/

- *Blog.*

  Unsinkable Girl Scouts - http://gscccblog.blogspot.com/2016/05/unsinkable-girl-scouts.html

- *Facebook Page.*
  https://www.facebook.com/OregonCoastSTEM/
- *Facebook Page.*
  https://www.facebook.com/OregonRegionalMATEROV/
- *Facebook Page.*
  DISl/MATE ROV Program - https://www.facebook.com/groups/DISL.ROV.Program/
- *Initiative Newsletter.*

  2016 Dauphin Island Sea Lab ROV Teacher Workshop
  - http://education.gulfresearchinitiative.org/2016-dauphin-island-sea-lab-rov-teacher-workshop/

- *Newsletter.*

Norfolk Naval Shipyard and Mid-Atlantic Regional Maintenance Center Employees Volunteer for STEM Event

- *Newsletter.*

  Scientists put ROV Technology in Hands of Teachers and Students
  - http://gulfresearchinitiative.org/scientists-put-rov-technology-in-hands-of-teachers-and-students/

- *Newsletter.*

  Series of Newsletters on Oregon Coast STEM Hub - http://oregoncoaststem.oregonstate.edu/hub-happenings

- *Newsletter.*
  Troop 481 Takes Third at Mid-Atlantic Regional Robotics Contest - http://tidewaterbsa.com/ek-electronic-knapsack-may-17-2016/
- *Online Article.*

  Oregon Coast Aquarium

  Students' Underwater Robot Return to Aquarium after Trip Abroad - http://aquarium.org/students-underwater-robot-returns-to-aquarium-after-trip-abroad/

- *Online News Article.*

  Oregon Coast Daily News

  Students Dive into STEM in Statewide Underwater Robotics Competition
  - http://oregoncoastdailynews.com/2016/05/02/students-stem-underwater-robotics-competition/

- *Online Newsletter.*
  Dauphin Island Sea Lab - http://skimmer.disl.org/

  March 2016, Volume 57, Number 3

  May 2016, Volume 57, Number 5

- *Online Newsletter.*

  PAST Innovation Lab

  Underwater Robotics Workshop - https://pastinnovationlab.org/posts/2016/03/

- *Online Newsletter.*

  Past Innovation Lab

  2016 MATE ROV Buckeye Regional was Amazing! - https://pastinnovationlab.org/posts/2016-mate-rov-buckeye-regional-was-amazing/

- *Shedd Storify.*

https://storify.com/SheddLearning/shedd-aquarium-rov-regional-competition-2016

https://storify.com/SheddLearning/rov-club-event

- *Twitter Feeds.*

  @SheddLearning

  @shedd_aquarium

  #SheddROV

- *Twitter Page.*

  @roboticcrusader video link for Robotic's time lapse

Other Publications

- Margaret Blackwell (2016). *Carrollton High School Represents Southeast At MATE's International ROV Competition*. Web article on GPB media. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- MJ Connell (2016). *DISL hosting annual robotics competition April 22-24*. Online article - http://lagniappemobile.com/disl-hosting-annual-robotics-competition-april-22-24/. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Elizabeth Thomson (2016). *Guest Post: An Out-of-This-World Experience at the MATE International Underwater Robotics Competition*. Article for PLTW. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Kurt Yeager (2016). *Highway 68 ROV Club Wins Again*. Newspaper article - Off 68. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Rebecca Crookes (2016). *Houston bound: Tech School underwater robotics team wins regional competition*. Online article for the News Courier - http://www.enewscourier.com/news/houston-bound-tech-school-underwater-robotics-team-wins-regional-competition/article_5ffda5b8-0e58-11e6-9403-fb1c03c023fe.html. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Miriam Cresswell and Savannah Williamson (2016). *Limestone County students win underwater robotics competition*. Online article on Tech Alabama. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Shelby West (2016). *MARMC Volunteers Judge Underwater Robotics Competition*. Online article - http://www.navy.mil/submit/display.asp?story_id=94536. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Shelby West (2016). *MARMC Volunteers Judge Underwater Robotics Competition*. Online article - http://www.militaryspot.com/news/marmc-volunteers-judge-underwater-robotics-competition. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Jill Zande (2015). *MATE's 2015 Underwater Robotics Competition: Students Challenged to Brave Arctic Waves and Ice*. Servo. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

- Jill Zande (2016). *MATE's 2015 Underwater Robotics Competition: Students Challenged to Brave Arctic Waves and Ice*. ROVPlanet. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Dave Herndon (2016). *Melvindale ROV team will be head to international tournament after winning qualifier*. News Article for The News-Herald - http://thenewsherald.com/articles/2016/05/01/news/doc57255f1cbd066935263798.txt. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Herndon (2016). *ROV team ready to tackle international competition*. News Article for The News-Herald - http://thenewsherald.com/articles/2016/05/06/news/doc572bb311b4109205992665.txt?viewmode=fullstory. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Mary Kaull (2016). *RPS 205 students build underwater remote vehicle in Shedd program*. Online article - http://www.rrstar.com/article/20160324/BLOGS/303249999. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Kim Cheek-Stanley (2016). *Robotics is the rage thanks to innovative teacher*. The Time of Northwestern Indiana Article - http://www.nwitimes.com/news/local/lake/crown-point/robotics-is-the-rage-thanks-to-innovative-teacher/article_3e20bb6c-9846-5186-a08a-f241bd8f1674.html. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- N/A (2016). *SeaTech program and unknown #s for AMNO & CO going to White House Science Fair*. Newspaper article for the Skagit Valley Herald. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Kera Wanielista (2016). *Skagit Sea-Tech Teams Compete in International ROV Competition*. Newspaper article in Skagit Valley Herald. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Kathy Routliffe (2016). *St. Francis Students Gain Skills While Creating Underwater Robot*. Article for the Chicago Tribune - http://www.chicagotribune.com/suburbs/wilmette/news/ct-wml-st-francis-underwater-robotics-tl-0107-20160104-story.html. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Andrew Mundhenk (2016). *Students form underwater robotics team*. Online news article on blueridgenow.com. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Michael Gagne (2016). *Students' robots go for test dive in Fall River Boys and Girl Club Pool*. News Article for The Herald News - http://www.heraldnews.com/article/20160201/NEWS/160209621. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- John O'Connor (2016). *Teachers Train in Underwater Robotics*. Article and Video on postguam.com. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Lauren Traut (2016). *Team Vector Advances to International Competition*. Online article - http://patch.com/illinois/lemont/team-vector-advances-international-competition-0. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Roger Mari (2016). *U.S. Coast Guard hosts underwater robotics competition*. TV news coverage with web article. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- N/A (2016). *Underwater Robot Competition Offers Impressive Display of Technical and Design Skills*. Web article on Gray's Reef. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Patents

Technologies or Techniques

Thesis/Dissertations

Websites

- http://nauticus.org/programs-activities/professional-development-workshops

  Professional Development Workshop Page

- http://www.decaturdaily.com/news/limestone_county/limestone-underwater-robotics-team-captures-regional-win/article_d9cde784-e6f7-51e1-8a7d-950840ba8620.html

  Decator Daily

- *Aptos Excels in MATE Underwater Robotics*
  http://www.growing-up.com
  Web article by Suki Wessling - *Cooperation Through Competition*
- *Cooperation Through Competition*
  http://growing-up.com
  Web article by Suki Wessling - *Growing Up*
- *MATE Center Announces Winners of 2015 International ROV Competition*
  http://www.rovplanet.com
  Web article for *ROV Planet*
- *MATE ROV*
  http://oahu.marinetech2.org
  Hawaii Underwater Robotics
- *MATE ROV Oregon Regional Website*
  http://oregon.marinetech2.org
- *Oregon Coast STEM Hub*
  http://oregoncoaststem.oregonstate.edu
- *ROV Programs - Dauphin Island Sea Lab*
  http://www.disl.org/educational-programs/onsite-programs-k-12/school-year-programs/rov-programs/
- *STEM Oregon*
  http://stemoregon.org/april30th-oregon-mate-rov/
- *Salinas School Flooded with ROV Applicants*
  http://www.thecalifornian.com
  Web article by Robert Robledo - *The Salinas Californian*
- *Sciences Put ROV Technology in Hands of Teachers and Students*
  http://gulfresearchnitiative.org

Gulf of Mexico Research Initiative

- *Skidaway Marine Science Day is Full of Family Fun*
  http://blog.visitsavannah.com
  Blog posting - *Visit Savannah*. 21 October 2015
- *Skidaway Marine Science Day to Feature New Sea Turtle Display*
  http://www.skio.uga.edu

  Skidaway Institute of Oceanography

- *Underwater Robotics Program*
  http://www.sheddaquarium.org/Learning-Experiences/Educators--Classrooms/Classroom-Clubs-and-Competitions/Underwater-Robotics/

  Video and article

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What other collaborators or contacts have been involved?

The MATE regional competition network includes programs in Canada, Hong Kong, Scotland/UK, Russia, Egypt, Turkey, and – new in 2017 - Indonesia. While the organizations that coordinate MATE programs in these regions do not benefit directly from ITEST grant funds, they do leverage the ITEST-supported activities and products. They also share their best practices and lessons learned with the competition network. These organizations (and the points of contact at each) are listed below:

Paul Brett, Marine Institute of Memorial University of Newfoundland and Labrador, St. John's, NL, Canada

Mike Duggan and Peter Oster, Nova Scotia Community College, Halifax, NS, Canada

Robin Bradbeer and Paul Hogan, Pearl Technologies, Ltd., Hong Kong as well as Philip Chui, Institute of Engineering and Technology, Hong Kong

Graeme Dunbar, John Still, David Howie, and Steve Allardyce, The Robert Gordon University, Aberdeen, Scotland

Sergey Mun, The Center for Robotics Development, Maritime State University, Vladivostok, Russia

Mahmoud Abdel Aziz, Hadath for Innovation and Entrepreneurship, Cairo, Egypt

Dr. Ihab El-Aff, EngTechs Engineering & Technology, Izmir, Turkey

Dhadhang SBW, Sekolah Robot Indonesia, Surabaya, Indonesia

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Impacts

What is the impact on the development of the principal discipline(s) of the project?

A number of prior reports have identified significant problems in educating, recruiting, and retaining U.S. workers for scientific, technological, and operational careers. Such workers are critical for building and operating much of the nation's infrastructure and for sustaining growth and innovation. The lack of appropriately educated workers is especially pronounced in ocean fields, such as deep water ocean exploration; the engineering of specialized tools and instruments for remote, harsh environments; and the management and use of ocean resources (particularly, renewable resources). The graying trend in the marine workforce adds to the urgency of educating new technical professionals that will adapt and excel in the rapidly advancing ocean workplace.

Workforce studies previously conducted by the MATE Center and funded by the Office of Naval Research identified more than twenty STEM-based ocean occupations that are currently limiting the growth of ocean industries because of the lack of qualified personal. At the top of the list are the following occupations: electronics/marine technicians; engineers (electrical, mechanical, civil/structural); and computer scientists (software application developers, computer programmers, hardware developers).

However, these are not “just” engineers, technicians, and computer scientists; these are professionals that understand ocean applications within their field. For example, ROV technicians in support of ocean operations must have an understanding of ocean science in addition to engineering and computer science since all commercial ROVs possess computer-controlled systems and must be maintained, repaired, and modified in remote locations far from port. These skills sets are transferable to almost every sector of the economy that uses robotics, automation, and computer-controlled systems.

Every year, the ocean attracts thousands of students to pursue degrees in biology because that is a discipline that most students associate with ocean careers. However, the opportunity and compensation in ocean-related engineering, technology, and computer science fields is much greater than the biological sciences. Combining STEM education with ocean applications via the MATE ROV competition network provides students with a pathway to achieve their goals, including the gainful employment that is so critical to engaging students from economically disadvantaged environments. For the ocean occupations in greatest need of qualified individuals, the early education and career preparation is similar. This includes applied math, critical and creative thinking, and design and innovation, which, during the competitions, are presented in an engaging environment that simulates the high-performance workplace.

What is the impact on other disciplines?

Covered above under "What is the impact on the development of the principal discipline(s) of the project?"

What is the impact on the development of human resources?

The work of this project supports the development of a diverse ocean STEM workforce, outlining and allowing students to see a career pathway from upper elementary school to middle and high school to college and into the workplace. It is also providing valuable workplace experience; all of the ROV kits funded by this grant are assembled, packaged, and shipped by community college students (Please see the ACCOMPLISHMENTS section for details.)

The findings of the alumni survey demonstrate the impact on workforce development. This survey, which was launched in June 2015, gathered data on students' education and employment. Four hundred thirty-two student alumni responded. A sampling of results is presented below; for additional details, please see the Year 3 (last year's) Evaluation Report.

- 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%).

We plan to launch a second competition alumni survey during Year 5, employing new strategies (e.g., social media, the newly created MATE Alumni LinkedIn Group) for reaching more past participants.

What is the impact on physical resources that form infrastructure?

Progress on the MATE workshop continued, with additional space secured for inventory, all of which improved the working environment for the community college students who assemble the MATE ROV kits (see the "MATE store" referenced in ACCOMPLISHMENTS).

What is the impact on institutional resources that form infrastructure?

Nothing to report.

What is the impact on information resources that form infrastructure?

Nothing to report.

What is the impact on technology transfer?

The MATE ROV kits are sold through our SeaMATE online store (www.marinetech.org/store/). In addition to the kits provided through ITEST, schools, camps, museums, and parents across the country are also buying kits directly from us; from July 1, 2015 to June 30, 2017, we sold more

than $430,000 worth of ROV related items (ROV kits, textbooks, and ROV supplies).

What is the impact on society beyond science and technology?

Through the impacts described under ACCOMPLISHMENTS, the work of this project is helping to prepare and create a more scientific- and technology-literate society.

Please also see the Leveraging ITEST Activities/Funding, Using ROVs Outside the Competition, Broader Impacts on Teachers and Institutions sections of the Year 4 Evaluation Report.

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Changes/Problems

Changes in approach and reason for change

In our grant proposal, we set a goal to improve multi-year participation (as a percentage of total students) by 5% a year over the duration of the grant. After three years of evaluating the data, we realize that the way that we defined that goal did not take into consideration the full picture. As the competition network continues to expand, by definition, it draws in new, first-time competitors. For example, between Year 1 and Year 2, we added 1 new regional program and between Year 2 and Year 3, we added 3 new regional programs. So, while the percentage of multi-year students declined slightly from Year 1 to Year 2 (42% in Year 1 vs. 40% in Year 2), the number of multi-year students increased from 1,345 to 1,537, an increase of 14%. And, while the percentage of multi-year students declined slightly from Year 2 to Year 3 (40% in Year 2 vs. 38% in Year 3), the number of multi-year students increased from 1,537 to 2,016, an increase of 32%.

In last year's annual report, we proposed a revision to that goal: that the overall number of multi-year participants will increase by at least 10% each year over the duration of the grant.

From Year 3 to Year 4, the number of multi-year students increased from 2,016 to 2,118, an increase of only 5%. However, we have a very likely explanation for this.

In 2016 and prior years, the answer choices to the question "how many years have you participated in the MATE competition?" were:

- This is my first year!

- 1

- 2

- 3

- 4

- 5

Etc.

We recognized that there could be some confusion on which choice is most appropriate for a first-year, first-time student - i.e., do you answer this is my first year or 1? So, in 2017, we revised the answer choices to:

- This is my first year!

- 2

- 3

- 4

- 5

Etc.

This revision likely accounts for the smaller increase in overall multi-year students from Year 3 to Year 4.

NSF's expectation is that the scope of activities will include elaborations and/or revisions that are discussed in pre-award negotiations. The Annual Report and Evaluation Report submitted do not specifically address several NSF questions/ requests and PI elaborations/revisions that were included in the pre-award negotiations.
During negotiation, additional information was requested about the mechanism by which implementation fidelity (or adaptation) of the ROV intervention across regions would be documented.
Action2B1: Please clarify what was accomplished during Year 3 pertaining to the work you proposed in your responses, including:

- conducting face-to-face observations of a subset of the regional efforts.

In Year 4 we were not able to conduct face-to-face observations of any regional contests. (Note: One Co-PI attends the Pacific Northwest regional each year; the PI and other Co-PI coordinate the Monterey regional contest.)

However, we did hold a regional coordinators meeting at Monterey Peninsula College January 16-17, 2017. Twenty-four people attended, including 18 coordinators representing 17 of our current 30 regional competitions, MATE staff, and the ITEST evaluator. Three additional coordinators joined via teleconference line.

The overarching goal of the meeting was to strengthen the MATE competition community as well as to discuss strategies for sustainability, especially in light of the fact that we are entering our 5th and final year of ITEST funding. During the meeting we presented several ‘’revenue streams" that could potentially help to take the place of grant funds. In addition, during the meeting we 1) debriefed the 2016 competition season and provided a preview of 2017 mission tasks, including props; 2) shared best practices and lessons learned; 3) discussed changes and improvements for next year; and 4) provided professional development on a sensor that is serving as a 2017 competition "prop." Our

evaluator also shared the results of the 2016 competition surveys and summarized the results of the 2015 alumni survey.

We believe that these discussions and activities, especially those that involved consensus (e.g., agreeing on a registration fee structure), encouraged buy-in (e.g., determining mission tasks), and strategized about how to sustain the network in the absence of grant funding, will further help to build community and increase regional fidelity across the network.

We are planning to hold another regional coordinators meeting in 2018, our final year of ITEST funding.

Action 2B2: Please clarify whether you have you have considered or established any mechanism for studying the artifacts from the professional development and/or competition experiences for assessing implementation across regions in the event observations were not conducted?

See Action 2B1.

Actual or Anticipated problems or delays and actions or plans to resolve them

NSF's expectation is that the scope of activities will include elaborations and/or revisions that are discussed in pre-award negotiations. The Annual Report and Evaluation Report submitted do not specifically address several NSF questions/ requests and PI elaborations/revisions that were included in the pre-award negotiations.
During negotiation, additional information was requested about the instruments and processes used to collect outcome data and the technical quality of those instruments, with the clear purpose of moving the research/evaluation beyond self-report.
Action 2A: Please clarify what was accomplished during Year 3 pertaining to the work you proposed in your responses that intended to:

- improve the internal consistency of existing surveys by adding questions and standardizing the question constructs;

  Again, in Year 4, we worked with Dr. Min Li to improve the consistency and validity of the four existing post-competition surveys: student, instructor, parent, and judge/volunteer. Please see the Methodologies section of the attached Year 4 Evaluation Report for a detailed summary of the work carried out by Dr. Li.

- compare survey data against students' NSC data to provide an additional form of survey validation;

  Please see the Year 4 Evaluation Report for information regarding our work with the National Student Clearinghouse (NSC) and Washington State Education Research Data Center (ERDC).

- employ 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

In Year 4, we continued our work with Dr. Min Li on the alignment study of competition scoring rubrics. The alignment study focuses on how the scoring (i.e. "coding") categories can be mapped back to (1) the competition manual in terms of how the students are mentored or guided and (2) the standards from the engineering proportion of the NGSS, 21st Century Skills, and College Readiness documents.

Dr. Li used the marketing display, technical documentation (report), and product presentation scores that student teams received from judges during the 2016 events to investigate inter-rater reliability. The data file included the IDs of judges so that a generalizability study could be performed to examine whether judges evaluated the teams consistently or not. Please see the Year 4 Evaluation Report for details from Dr. Li on the study, results, and analysis.

We revised the information presented in the 2017 competition manual and the marketing display rubric, technical documentation, and presentation rubrics based on Dr. Li's findings. We will continue to work with Dr. Li to conduct a similar alignment study on these rubrics in Year 5; again, we will revise the rubrics based on her results as well as on feedback from the judges who used them during this competition season.

We did not conduct our validity studies to decide whether scores assigned by judges are comparable to Dr. Li's evaluation. We will conduct those studies in Year 5.

Please the Methodologies section of the Year 4 Evaluation Report for a detailed summary of Dr. Li's work, results, and plans for continued analysis in Year 5.

- design, pilot, and assess psychometric quality for NGSS-aligned pre-post knowledge tests (and for the above competition scoring), with the assistance of Dr. Min Li.

  Please see "What opportunities for training and professional development has the project provided?" 2a and the Year 4 Evaluation Report.

  During negotiation, additional information was requested regarding other study designs that might be employed, such as interrupted time series design and/or use of state longitudinal data, to collect more reliable estimates of the average impact of the intervention.
  Action 2C: Please clarify what was accomplished during Year 1 pertaining to the work you proposed in your responses, including:
- employing the "modified time series design" that included one pretest of knowledge and attitudes, several interim knowledge tests (quizzes at the end of each module), post- and follow up tests of knowledge and attitudes with possible triangulation with competition scores.

  Please see "What opportunities for training and professional development has the project provided?" 2a and the Year 4 Evaluation Report.

Changes that have a significant impact on expenditures

Nothing to report.

Significant changes in use or care of human subjects

Nothing to report.

Significant changes in use or care of vertebrate animals

Nothing to report.

Significant changes in use or care of biohazards

Nothing to report.

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Special Requirements

Responses to any special reporting requirements specified in the award terms and conditions, as well as any award specific reporting requirements.

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