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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

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Accomplishments

* What are the major goals of the project?

The information included within this report covers the period from September 1, 2014 through June 30, 2015.

Note: In January 2015, we received an NSF I-Corps for Learning grant to assess the need to scale up our ROV kit production and understand the resources, curriculum, and professional development that educators desired. The I-Corps grant came at a critical stage in our ITEST grant; it allowed us to evaluate the value of what we are proposing through interviews of more than 100 educators and parents.

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 evaulation 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. Eleven of the 17 U.S.-based regional competition programs received ITEST funding this year: Carolina, Florida, the Mid-Atlantic, Monterey, New England, Oregon, Pennsylvania, the Pacific Northwest, Shedd Midwest, Southeast, and Wisconsin. Four of those regionals offered a NAVIGATOR class (three regionals offered a NAVIGATOR class in Year 1); all four plan to offer it again in Year 3. One regional plans to add it next year, while another is considering it. The remaining five 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) MATE's bank of online instructional materials, including building instructions, curriculum modules, how-to videos, and technical reports from previous competitions; 3) the MATE store for access to ROV kits, practice boards, and more; and 4) access to MATE's online forums, which include a technical help and competition FAQs board. In June 2015, we conducted a survey to assess user satisfaction and usage of the online resources. Eighty-nine percent (N=90) of respondents indicated that the resources were excellent or good; the majority of respondents indicated that the resources were accurate (90% excellent or good), effective learning aides (82%), accessible (70%), clear (74%), and complete (73%). (See the Year 2 Evaluation Report for further details.)

1c. Provide opportunities for students to interact with mentors. Eight of the 11 regionals that participated in ITEST connected 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. The coordinators of the three regionals that did not explicitly report connecting teams with

mentors served as mentors themselves. All of the regionals utilized industry professionals as judges during the competition events.

1d. Document and share inspirational stories. The videographer covering the 2015 international competition filmed three engineering (sales) presentations and interviewed ~30 students on 10 different teams. During their interviews, the students discussed their experience with the competition and their future education and career goals, among other topics. These videos are currently being prepared for posting on MATE's Vimeo channel (https://vimeo.com/user14545135). In addition, this footage will be coupled with the countless hours of footage collected for the videostream to create a summary video highlighting the 2015 international event. This video will be released later this fall.

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

2b. Develop a progression of ROV kits. By October 2015, we will offer four ROV kits to support a progression of learning: 1) AngelFish (simple electronics); 2) PufferFish (simple-intermediate electronics); 3) TriggerFish *Analog* (intermediate electronics); and 4) TriggerFish *Digital* (intermediate electronics with computer programming). A great deal of time and testing has gone into the development of the kits, not only to enhance the learning experience, but to maximize production efficiency.

Over the past two years, numerous upgrades and enhancements have been made to the PufferFish kit. These revisions have not only improved the kit, but also increased its complexity. As a result, we feel that it is necessary to reintroduce the AngelFish kit, with some improvements to its toggle switches and wiring. The AngelFish will be in full scale production by October 2015.

This summer (2015) we are adding a digital control to the TriggerFish kit by incorporating a programmable microcontroller (e.g. an Arduino). Future TriggerFish ROVs kits will be offered with either analog or digital controls; teachers and students who currently have analog controls can easily upgrade to digital. This will help tremendously in advancing the skill level of students.

In addition, the TriggerFish will now come with a motor simulation board. This board allows for the testing of the control system without having to attach the frame and motors. It provides students with the ability to develop software "offline" and detached from the ROV. This allows teachers to manage their classrooms to mirror engineering practices in industry. One group can develop software and at the same time, another group can build the ROV and motor system. Once both are complete, the two systems can be integrated together. Finally, the simulation board allows students to continually refine their programming (independently of the ROV) and provides them with a backup if there is a system failure.

One of the greatest barriers to participation expressed by the teachers interviewed during I-Corps was the difficulty in buying materials. To help remedy this, we will be offering

additional modular add-ons (cameras and sensors) to the kits as well as lab packs (e.g. materials to build a simple switch).

We provided approximately 300 ROV kits to the regionals that participated in ITEST activities in Year 2 to support their teacher workshops. In addition to the kits provided through ITEST, a number of regionals purchased kits (at their expense) to run additional workshops. Schools, camps, museums, and parents across the country are also buying kits directly from us; to date (July 10, 2015) we have sold more than $280,000 worth of ROV kits. All the kits are packaged and shipped by community college students, providing them with valuable work experience and income.

2c. Designate regional teacher "leaders." Ten of the 11 regionals participating in ITEST had at least one local teacher leader. 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.

(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 2, our project:

1. Supported 11 regional partners with ITEST funds.
2. Offered a NAVIGATOR competition class in 4 regions; 1 more plans to add it in 2015.
3. Continued progress towards creating a multi-year student support system that consists of professional development instructional resources, mentors, parents, and more. While we did not reach our goal to improve multi-year competition participation from Year 1 to Year 2 by 5% (36% (N=1442) in 2014 vs. 39% (N=1419) in 2015), there were several statistically significant differences between the first year and multi-year competition participants. For example, multi-year participants reported that their participation in the ROV program resulted in higher levels of awareness of and interest in STEM careers, gains in interest in taking STEM courses, improvements in STEM knowledge and skills, increased 21st Century skills, and the receipt of awards, honors, and new educational and career opportunities.
4. Provided students with access to student and industry mentors in 8 regions.
5. Collected footage at the 2014 international competition and produced a summary video highlighting the event (see https://vimeo.com/114297278). In addition,

collected footage at the 2015 international competition that included interviews with ~30 students. With the work of I-Corps, we were not able to produce professionally-formatted videos documenting student successes; this will be addressed in the coming year.

6. Participated in the NSF I-Corps program in an effort to assess the needs and desires of the MATE customer base.
7. Offered 3 ROV kits that complement MATE instructional resources. A fourth kit is currently in development.
8. Designated teacher leaders in 10 regions to function as resources for coordinators and other teachers.
9. Offered 1 workshop that provided 60 hours of professional development each to 22 participants.
10. Offered more than 18 regional professional development workshops that provided an average of 10 hours of instruction to more than 270 teachers. Taking into account their participation in student workshops, such as pool practice days, and competition events, and the number of hours increases to 25.
11. Offered 70 regional workshops, such as topic-specific hands-on instruction, information sessions, and pool practice days, that engaged more than 4,000 students, 1,285 in an after school setting, 789 during school, and 2,109 as part of a community organization or event.
12. Recruited new mentors and provided mentors with access to information and resources to support their role in the classroom and streamline communication.
13. Surveyed 346 parents attending competition events and engaged 17 as members of regional advisory committees. Fifty parents participated in regional professional development workshops; countless others attended community-wide events where MATE regional partners exhibited. In addition, directed parents to our online resources and invited them to join our e-mail listserves to support their involvement and improve communication.
14. Sixty-two organizations, 223 industry professionals, and 90 others (e.g. community members) supported the grant activities. The activities were also supported by 276 high school, 45 community college, 68 university undergraduate, and 10 graduate students as well as 10 community college and 41 university faculty members. Please see the supplemental documents for a letter from an industry professional expressing his perspective on the ROV program.
15. Benefitted from the guidance and oversight of 11 regional advisory committees (that include a total of 17 parents).
16. Held eight regional advisory committee meetings; regions that did not hold formal meetings collaborated with members in smaller groups.
17. Used Active, a low-cost, commercially available registration system, 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. (See bullet #3 above.)

18. Launched a survey of competition "alumni" in June 2015 to measure the impact of the competition on their education and career. As of this writing, 432 student alumni over the age of 18 had completed the survey. The survey will remain open through September 2015, in an attempt to collect responses from alumni who may have limited access to (or choose not to access) e-mail over the summer.
19. Continued to improve the utility of MATE web resources and used social networking tools strategically to increase communication and collaboration and document successful strategies. For example, we posted weekly to the competition FB page; this increased to several times a day during the international ROV competition. On July 10, 2015 this page had 3,542 "likes;" on July 10, 2014 it had 1,526. We believe that our increased frequency of posting over the last year contributed to this significant increase. In addition, we included a running Twitter feed (#2015MATEinternational) alongside the live videostream from the 2015 international competition (see www.marinetech.org/live-videostream/ for the page set-up); the hashtag was referenced in 367 tweets.
20. Used surveys and other instruments to evaluate progress and increase effectiveness and impact.

Key outcomes or Other achievements:

(Continued from Major Activities)

2f. Increase preparedness of student and industry mentors. Regional coordinators continued to reach out to and engage new mentors; the total number of high school and college students, industry professionals, and community members supporting grant activities grew from 629 in Year 1 to 825 in Year 2 (11 regionals participated in ITEST both years).

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**. Based on the results of the online survey, users found these resources complete, accurate, accessible, and effective.

The results of the 2015 post-competition teacher survey speak to mentor preparedness. For 22% of the post-competition teacher survey respondents (N=298), a classroom/club mentor came to their site to help their teams. The vast majority of those teachers (89%) 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. In June 2015, we created a specific "Parent Resource Center" page within the competition section of the MATE web site (see www.marinetech.org/parent-resource-center/). (We will add links to the Parent Resource Center on our store, curriculum, and other appropriate web site pages by August 31, 2015.) The resource center includes a "welcome" note targeted to parents as well as links to information and resources described in the Year 1 annual report. It also includes links to videos from the international and regional competitions. (Note that these are resources

that also support students, teachers, and industry mentors seeking information on how to participate, so many are also found on other pages of the MATE web site.) By August 31 we will add highlights of evaluation data that demonstrate the positive impact of the program.

As for gauging parents' reaction to our online resources, the MATE Center's I-Corps for Learning grant required us to interview 100 "customers." (Note that these interviews were done prior to the creation of the parent resource center page.) When asked during what resources he found most helpful for moving his team from the SCOUT to the NAVIGATOR competition class, one parent listed the online curriculum resources, instructions, and videos that support the building of the MATE ROV kits. This same parent noted that the technical reports from previous competitions that are posted on the MATE web site were most helpful in moving his team from NAVIGATOR to RANGER the following year.

However, another parent commented the difficultly navigating the MATE web site to find the resources he was seeking His comments underscore the importance of placing this information in one central location – a Parent Resource Center.

3b. Form regional parental advisory committees. All 11 of the regions participating in ITEST have advisory committees. Seven of those include at least one parent; five of those seven include two or more parents. The majority of the advisory committees grew out of the stakeholders' meetings that each regional was encouraged to hold prior to developing their plan of activities; these committees include industry members, parents, teachers, and/or students. Eight of the 11 regionals held advisory committee meetings in Year 2; those that did not reported collaborating with members in smaller groups.

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 data, along with post-competition surveys, to determine that 39% of the student registrants had competed for one or more years. We also found that multi-year participants reported that their participation in the ROV program resulted in higher levels of awareness of and interest in STEM careers, gains in interest in taking STEM courses, improvements in STEM knowledge and skills, increased 21st Century skills, and the receipt of awards, honors, and newproduct educational and career opportunities. See the Year 2 Evaluation Report for further details; also see **Actual or Anticipated problems or delays and actions or plans to resolve them** for information on how we using this data in our work with the Washington State Education Research Data Center (ERDC) and the National Student Clearinghouse.

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. The I-Corps opportunity helped us define the value propositions of our customer base in a very through and systematic way under the guidance of a cadre of educational entrepreneurs. We interviewed 103 current and potential customers that were teachers, school administrators, and parents. Before we started I-Corps, we believed that the teachers wanted a complete curriculum tied to standards; it was under that mindset that we crafted our ITEST proposal. However, we were surprised to discover that the majority of our current customers who are teachers are not very interested in a complete curriculum. The majority said that they "create their own curriculum" by pulling information from a wide variety of resources. They are much more interested in online resources that they can adapt to support their activities, robotics kit materials that are easy to purchase, and formally-recognized, professional development in a hybrid format (online and in person). Please see the attached PDF that highlights the new insights acquired during the I-Corps process that are profoundly influencing our current and future ITEST work.

How the 2014 workshop participants implemented the summer institute instructional resources further confirmed this. Instructional materials were adapted and altered to fit into a variety of courses and club activities.

Based on these findings, we are looking at how we offer professional development as well as enhancing our online store offerings. We will continue to develop instructional resources (PPT presentations, labs, and activities), but we will be putting greater emphasis on expanding our professional development to accommodate more teachers and assessing the learning of participants **(see 2d below).**

2d. Offer week-long professional development workshops. 2d. Offer week-long professional development workshops. The fifth annual ITEST Summer Institute, *Introductory Level ROV Building: The PufferFish ROV*, took place July 27 –August 3, 2014 at MPC. This institute introduced participants to the PufferFish ROV. Participants learned the fundamentals of ROV building (e.g. structure, power, propulsion, control, tools) 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. Two engineers (a mechanical and electrical) co-taught the institute with MATE staff to ensure that best engineering practices were applied to all building activities; the instruction followed the format of the NGSS for engineering. Instructional materials from this institute can be found here www.marinetech.org/pufferfish-rov-curriculum/. All 22 participants (18 teachers and four informal educators) rated the usefulness of the workshop as excellent. The next PufferFish summer institute will take place July 26 – August 2, 2015; 22 teachers, informal educators, and regional coordinators will participate.

The number of workshop applications we receive greatly exceeds the number of participants we can handle. Based on this and our I-Corps findings, we decided to offer an online workshop "*Diving into Sensors*." Sixty-three participants are currently 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 will build and collect digital data (and convert analog to digital data) from six sensors commonly used in the underwater environment. To see the course outline:

www.marinetech.org/files/marine/files/Workshops/Diving%20into%20Sensors%20Course%20Outline.pdf. The goal of this course is to provide a foundation for the hardware and software required to migrate to the digital TriggerFish ROV.

In Year 3, we plan to offer additional professional development via short online courses. In addition, teachers have asked for videos, not written lessons, that their students can follow. Further, producing written lessons with pre and post-tests proved challenging since the teachers wanted to implement learning activities in their own way to meet their desired objectives. Instead, our plan is to offer additional online courses that include pre- and post-tests that will allow us to assess student learning directly.

2e. Offer regional workshops. Each of the 11 regions that participated in ITEST offered both professional development for teachers and workshops focused on students. All total, 18 professional development workshops were offered to 272 teachers; the following is a breakdown by grade level:

Grade 3-5: 16; Grade 6-8: 86; Grade 9-12: 96; postsecondary: 5; Informal educators: 11; Other (e.g. parents): 58

The workshops ranged from ½-day ROV design and building activities (where the control boxes are pre-built so that the focus is on frame design, motor placement, and buoyancy) to multi-day events (that covered simple electronics and building the control box of the PufferFish kit). The number of hours of instruction for each teacher ranged from 3 to 20; the average was nearly 10. The workshops were offered during school, after school, and/or on weekends.

Each of the 11 regions also offered student-focused workshops. All total, 70 workshops were offered to 4,192 students. Of these students, 1,285 were impacted in an after school setting, while 789 and 2,109 were impacted in school and as part of a community organization or event, respectively. The workshops covered topics from basic ROV design and building to simple electronics and PufferFish and TriggerFish 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 25; the average 7.

Ten of the regions used MATE's ROV kits and/or practice boards as the focus of their workshops; all ten regions reported that the kits were helpful. One region offered a suggestion for improving the way that switches are attached to the printed circuit board; another suggested creating additional training videos for advanced features as well as including a SID (system integration diagram) with the kits. These suggestions and additions will be addressed in Year 3. Eight regions reported using MATE's on-line curriculum or videos; 8 reported using the instructions for kit assembly.

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

The practice boards have been an effective tool for first-time soldiers – teachers and students alike – to practice the technique. We plan to continue to use them in the future. – Shedd Midwest regional coordinator

Teams appreciate having a starting point to begin training their pilots and designers while having a resource to continue to expand their knowledge. – Wisconsin regional coordinator

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

Between the MATE Center, its regional partners, and ROV competition participants, more than 80 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 40 conferences, meetings, community events, workshops, and other events. These included the following:

- Oceans Conference and Exhibition, organized by the Marine Technology Society and the Institute for Electrical and Electronics Engineers Oceanic Engineering Society and held September 14-19, 2014 in St. John's, NL, Canada.

- Annual COASTALearning Symposium, held October 9-10, 2014 in Newport, OR.

- Boys Scouts of America's STEM-o-palooza, October 18, 2014, Chicago, IL

- Connect STEM Partnership Networking Event, October 30, 2014, at Bridgewater State University in Bridgewater, MA.

- Environmental Educators Alliance Outdoor Learning Symposium, November 13, 2014, in Hampton, Georgia.

- Expanding Your Horizons, held November 22, 2014, at Hartnell College in Salinas, CA.

- National Science Teachers Association Regional Conference, December 3-6, 2014, in Long Beach, CA.

- Underwater Intervention Conference and Exhibition, organized by the Marine Technology Society's ROV Committee and the Assocation of Diving Contractors International and held February 10-12, 2015 in New Orleans, LA.

- Wisconsin Society of Science Teachers Convention, held March 5-7, 2015, in Wisconsin Dells.

- Philadelphia Science Festival, April 24 – May 2, 2015.

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

During the next reporting period (Grant Year 3) we will:

- Support 11 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 2 to Year 3 to determine 1) if we have improved multi-year competition participation by 5% 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 at least 5 student success stories in professionally-formatted videos and create at least 10 more videos of student interviews for evaluation purposes.

- Develop online instructional videos with pre and post-tests built in to assess faculty and student learning.

- Continue to improve our PufferFish and TriggerFish ROV (analog and digital) kits, update and reintroduce our AngelFish kit, and continue to create additional sensors and tools that can be added to these kits.

- Continue to 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 10 or more hours of instruction to 300 teachers.

- Offer an additional 100 regional workshops, such as topic-specific hands-on instruction, information sessions, and pool practice days, to 600+ 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 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.

- Add to 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.

- 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.

- Continue to improve the utility of MATE web resources and use social networking tools to increase communication and collaboration. This will include increasing the use of Twitter.

- 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	Uploaded By	Uploaded On
(Download)	ITEST 2014-2015 Evaluation Report FINAL 7-17-15.pdf	Evaluation of Innovative Technology Experiences for Students and Teachers (ITEST) 2014-2015 Grant Activities For The Marine Advanced Technology Education (MATE) Center report.	Jill Zande	07/17/2015
(Download)	NSF-MATE_6-2015.pdf	Letter to NSF from an industry professional expressing his perspective of the ROV program.	Jill Zande	07/17/2015
(Download)	19_SeaMATE_ICORPS.pdf	Final MATE I-Corps for Learning presentation.	Jill Zande	07/17/2015
(Download)	MATE UWRobotics Learning Objectives.pdf	MATE underwater robotics learning objectives.	Jill Zande	07/17/2015

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Products

Books

Book Chapters

Conference Papers and Presentations

- Jill Zande (2015). *Challenging Students to Engineer ROVs for Extreme Environments*. MATE ROV Competition 2015. New Orleans. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Deidre Sullivan (2015). *Underwater Intervention*. International ROV Cirriculum Focused on 2-Year Colleges. New Orleans. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Inventions

Journals

Licenses

Other Products

- *Audio or Video Products.*

  10th IET/MATE Hong Kong Underwater Robot Challenge 2015 highlights this MATE regional competition, which took place in Hong Kong April 18-19, 2015. It can be accessed here – see www.youtube.com/watch?v=Wsdnf-E4gtA&feature=youtu.be

- *Audio or Video Products.*

  2014 MATE Pacific Northwest Regional ROV Challenge highlights this MATE regional competition, which took place in Federal Way, WA, May 10, 2014. It can be accessed here – see https://vimeo.com/94813329

- *Audio or Video Products.*

  ROV Competition Spring 2014 highlights the MATE Northern Gulf Coast regional competition, which took place April 26-27 at the Dauphin Island Sea Lab in Alabama. Ic can be accessed here – see www.youtube.com/watch?v=S4RXs8dCCLQ

- *Audio or Video Products.*

  Small Town, Big Hearth showcases the 2014 MATE international ROV competition, which took place in the small town of Alpena, MI, June 26-28, 2014. It can be accessed here – see https://vimeo.com/108008551

- *Audio or Video Products.*

  The 2014 competition video summarizes the 2014 international competition event, which took place June 26-28, 2014. The video is housed on both the MATE Center's YouTube and Vimeo accounts and can be accessed here - see https://vimeo.com/114297278

- *Audio or Video Products.*

  Underwater Robotics: Learning with Shedd Aquarium showcases the MATE Midwest regional ROV competition program, which is coordinated by the Shedd Aquarium. It can be accessed here – see https://vimeo.com/101316687

- *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 and practice boards - see http://www.marinetech.org/store/ for a description of the PufferFish and TriggerFish kits and soldering practice boards.

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

  NOTE: The Year 2 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 2 pertaining to the work you proposed in your responses, including:

  - 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 2, please include what changes will be made to your plan and timeline to achieve these goals/objectives.

  Our Year 1 annual and evaluation reports as well as the 2014 post-competition survey instruments have been posted to the ITEST STELAR web site.

  The web page http://www.marinetech.org/itest currently contains project and evaluation reports from our ITEST Strategies work and Year 1 of our ITEST Scale-Up. The 2014 survey instruments, de-identified data sets collected from these surveys, and information

on how to obtain 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.

Other Publications

- n/a (2015). *15 Top students from Pearl City compete in the 2015 science Olympiad National Tournament*. Hawaii News Now. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- n/a (2015). *AMNO & CO does it again! ROV team compete internationally*. West Seattle Blog. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
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Patents

Technologies or Techniques

Thesis/Dissertations

Websites

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- *Team Oceanus, Sea-Tech 4-H Club*
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  Underwater Robotics Program from Shedd

- *Washington State 4-H*
  https://www.facebook.com/WashingtonState4H

  Facebook Page

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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 rapidly evolving ocean fields, such as deep water ocean exploration (especially oil and gas); 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 conducted previously 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 (including ROV 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 preliminary 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. To date, 432 student alumni had responded. A sampling of results is presented below; for additional details, please see the Year 2 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.
- Almost three-quarters of the alumni are currently employed (74%).
    - Among the employed alumni (N=320), 73% are currently working a STEM-related job.
    - Among the employed alumni, 14% are currently working a job related to ROVs or other underwater technologies, and an additional 8% have ever worked in a job related to ROVs or other underwater technologies.

What is the impact on physical resources that form infrastructure?

The MATE workshop was updated with new shelving and workbenches, resulting in an improved 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 online store. In addition to the kits provided through ITEST, a number of regional coordinators have purchased kits to run additional workshops. Schools, camps, museums, and parents across the country are also buying kits directly from us; to date (7/10/15) we have sold more than $280,000 worth of ROV kits.

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 2 Evaluation Report.

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Changes/Problems

Changes in approach and reason for change

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 1 pertaining to the work you proposed in your responses, including:

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

The PI/Co-PIs conducted face-to-face observations of three of the 2015 regional contests: Florida, Oahu, and the Pacific Northwest. We used the list of questions/observations developed in Grant Year 1 to assess regional fidelity during these site visits. The list includes the following:

- Volunteers/Judges – How many? Training (pre event and day of briefings)? Did they see the judges' forum? Diversity of people – where do they come from?

- Missions/Props – were they built to specs, disputes?

- Safety Inspections – did the safety inspectors attend the webinar?

- Teachers – how much support before the competition, mentors, practice days, workshops?

- Students – how much time did they spend, in class, club, what was the hardest part, favorite part, learned the most, what do they wish was different?

- Parents – Did they get the information they need? What impact did this have on your child?

The Pacific Northwest regional was evaluated last year; it continues to demonstrate exemplary regional fidelity and MATE "branding." The Florida and Oahu regionals also demonstrated MATE branding; however, the Florida regional did not include any of the engineering and communication components (technical documentation, marketing display, or sales presentation; two of the three are required by MATE), while Oahu was not prepared to provide a power source to the competing teams (MATE requires teams to use the power source it provides). The majority of the judges at the Florida regional were returning volunteers, so were well-prepared for their roles; with a new regional coordinator and lead coordinating organization (U.S. Coast Guard), the Oahu regional's judge preparation was adequate but can be enhanced by sending materials and information to volunteers at an earlier date. There are other examples where

regional fidelity can be improved; we will work with both of these regionals to ensure that they more closely align with MATE in the future.

Based on lessons learned from site visits conducted in Year 1, we provided each regional with MATE brochures and flyers to distribute at their regional workshops and on contest day; these materials were sent last fall/winter, along with the ROV kits that regionals requested for their teacher workshops. We are currently working on new banners for each of the regionals. These banners will be designed so that they are appropriate for use at conferences and community events as well as on contest day.

We are planning a regional competition coordinators' meeting at Monterey Peninsula College in November 2015 (dates TBD). The overarching goal of that meeting is to strengthen the MATE competition community as well as build capacity, since new coordinators/coordinators of new regions are planning to attend. During the meeting we will 1) debrief the 2015 competition season; 2) share best practices and lessons learned; 3) discuss changes and improvements for next year; and 4) provide professional development on the MATE ROV kits and curriculum materials. We believe that these discussions and activities, especially those that involve consensus and encourage buy-in, will further help to increase regional fidelity across the network.

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 2 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;

In Year 2, 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 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;

We launched the competition alumni survey in June 2015. Please see **Significant Results**, bullet #18 for a summary and the Year 2 Evaluation Report for details and information on the results.

Regarding the National Student Clearinghouse (NSC), we have created the student contact information for matching and will send it to the NSC to match and return the higher education follow-up data later this summer. We will then compare the results.

In addition, this past spring we began working with the Washington State Education Research Data Center (ERDC) to assess whether students who participate in the ROV competition are more likely to pursue STEM education and careers than a matched group of students. The plan for moving forward is defined below by the ERDC. The estimated date of completion is September 30, 2015.

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

- 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 2, we revised the competition marketing (poster) display scoring rubrics based on feedback that we received from the judges who used them during the 2014 competition season as well as on the results of the alignment study that we conducted with Dr. Min Li. The alignment study focused 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.

In addition, Dr. Li used the marketing display, technical documentation (report), and sales (engineering) presentation scores that student teams received from judges during the 2014 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.

We revised the information presented in the 2015 competition manual and the marketing display rubric based on Dr. Li's findings; her work also influenced the creation of the technical

documentation and sales presentation rubrics, which were piloted during the 2015 competition season. We will work with Dr. Li to conduct a similar alignment study on these rubrics in Year 3; we will revise them based on her results as well as on feedback from the judges who used them during this competition season.

In addition, in Year 3 we will conduct a validity study to decide whether scores assigned by judges are comparable to researchers' evaluation.

Please the Methodologies section of the Year 2 Evaluation Report for a detailed summary of Dr. Li's work, results, and plans for continued analysis in Year 3.

- 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 2 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 2 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.

Nothing to report.

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