EVALUATION OF THE ARCUS POLAR WORKSHOP BUILD AN ROV

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Build an ROV Polar Workshop

Workshop Evaluation Report
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EXECUTIVE SUMMARY

The ARCUS *Build an ROV* workshop was a collaborative, hands-on event that brought together teachers, teacher/mentors, scientists and researchers for three days, July 30-31 and August 1, 2013. The workshop was held at the Monterey Bay Aquarium Research Institute (MBARI) in Monterey, California.

This report presents results of an evaluation of the ARCUS *Build an ROV* workshop. Data was collected in two ways, through online daily feedback surveys and through in-depth interviews conducted by an outside evaluator. Both methods captured the same results, with participants highly satisfied with what they had learned from the workshop, the hands-on activities that had been planned, the presentations and opportunities to share ideas and network with experts in the field and with fellow teachers. All participants have plans to take what they learned back to their schools and implement an ROV project with their students. Projects include building, testing, and collecting data using ROVs. While some teachers came to the workshop with some ROV experience, others did not. For all participants, the workshop provided the training, support, and encouragement from researchers and PolarTREC teachers that ensured a positive experience for teachers of all levels.

Results from the in-depth interviews conducted with participants after the workshop indicated a high degree of satisfaction with the presentations, polar science topics and research presentations, collaboration, and hands-on activities involved with building the ROV and adapting the design to accomplish specific tasks. Participants also expressed appreciation for the lab tours that included a visit to SCINI (Submersible Capable of under Ice Navigation and Imaging), a small, slender vehicle that can fit through a 20 cm hole in the ice, allowing for deployment without heavy drilling equipment and with minimal logistical support[1], boarding the Rachel Carson ship and seeing the ROV aboard, and praised the MBARI facilities as a near perfect setting for holding the workshop.

The overall goals of the workshop were to provide underwater ROV training to teachers, build and test a ROV, and prepare teachers to implement classroom projects around the topics of ROVs and marine polar science. By the end of the workshop, all participants noted they gained the knowledge and confidence to teach students about polar research currently being conducted and to implement ROV projects with their students. Participants cited the collaborative nature of the workshop as a particular strength and strongly praised the presenters and mentor teachers who helped make the workshop a success.

> *"I learned so much! I learned more about how ROVs are being used by researchers throughout the world, how to more authentically incorporate the use of ROVs into my classroom, and how to connect the work with Polar Science."*

[1] Cazenave, et.al, 2011. Development of the ROV SCINI and Deployment in McMurdo Sound, Antarctica. The Journal of Ocean Technology, Sustainable Oceans, Vol 6, No. 3.

INTRODUCTION

Middle School teachers in the Monterey Bay area participated in a three-day Polar Workshop designed to enlighten teachers regarding marine polar science and exploration through the use of remotely operated vehicles, or ROVs. The Polar Workshop was offered as part of a teacher professional development activity that took place July 30-31 and August 1, 2013 at the Monterey Bay Aquarium Research Institute. The workshop was organized by the Arctic Research Consortium of the United States (ARCUS) and provided training for teachers alongside polar scientists and teacher mentors. The overall purpose of the workshop was to teach teachers about marine polar science and technology that could be used with students in classrooms. Teachers were teamed with a polar scientist and with a teacher-mentor for the three-day project.

The goals of the Polar Workshop were: 1) to increase the teachers' content knowledge about the Polar Regions, specifically related to how to teach polar science to their students; 2) to improve the knowledge and skills related to best practices for K-12 science education for both teacher and scientist participants; 3) to increase collaborations between teachers and scientists by fostering new relationships and by mentoring teachers not familiar with Polar Regions; 4) to engage participants in hands-on activities and increase their knowledge of Polar Regions; 5) to increase the contributions of scientists to the broader impacts of their research; 6) to complete a portfolio of STEM related lessons and/or products that can be utilized by classrooms nationwide (e.g. robotics built by students and get tested by polar researchers; post-workshop webinar to share with other teachers, etc.)

This report presents results from a follow-up evaluation of the workshop to determine if the goals of the project were achieved. Workshop evaluations were completed by all fourteen teacher-participants. The evaluation tools appear in Appendix A. This report presents a summary of the results from the evaluation.

EVALUATION METHODOLOGY

The ARCUS Polar Workshop, *Build an ROV*, was evaluated by the Goldstream Group of Fairbanks, Alaska. The workshop evaluation was designed to assess the extent to which the project met its stated goals and objectives.

Evaluation Questions and Indicators

Two tools were developed to collect information from participants that would answer an overall question about the workshop: To what extent does the structure of ARCUS's workshop lead to increased knowledge about best practices and professional collaboration/communication among teachers that can bring change in teachers' practices in the classroom?

1. How is the workshop implemented?
2. Strengths and weaknesses of the workshop implementation?
3. What best practices and content knowledge do teachers learn from their participation?
4. To what extent does the structure of the ARCUS workshop lead to increased collaboration/professional communication among teachers?
5. To what extent does the structure of the ARCUS workshop lead to increased collaboration/professional communication between teachers and researchers?

Daily Feedback Survey

An online survey was disseminated to participating teachers at the end of each workshop day. The survey included the following six questions:

1. Describe in a few sentences what you did during the workshop today. Think about the activities in which you participated, your actions during those activities, and who you worked with during the activities.
2. During the day how much of your time was spent (none, a little bit, some, a lot)
3. During the day how much of your time was spent working with (none, a little bit, some, a lot)
4. Overall, how satisfied were you with the workshop today? (2.a) (not at all satisfied, somewhat satisfied, satisfied, very satisfied)
5. What aspects of the workshop today led you to be satisfied/not satisfied? This question will follow logic based on responses to question 4.
6. What suggestions would you give to Janet and Sarah to improve the workshop tomorrow?

Interview

A post-participation interview was conducted with participating teachers between August 15 and August 31, 2013. The interview included the following six questions:

1. Describe what you did during the workshop (your role during the workshop for a teacher leader). Think about the activities in which you participated, your actions during those activities, and who you worked with during the activities
2. What did you learn during the workshop?
3. How did working with other teachers and researchers help learn the content? Learn about using ROVs with your students?
4. What will you do next as a result of this workshop?
5. What professional gains did you achieve overall?
6. What were the best aspects of the workshop? What would you suggest for improvements?

EVALUATION RESULTS

Results from Daily Feedback Surveys

All teachers who participated in the "Build an ROV" polar workshop completed an online workshop evaluation using a data collection tool developed by Goldstream Group around workshop goals. Questions were both quantitative and qualitative in nature. Results appear in the following tables.

The first workshop evaluation question asked participants to "Describe in a few sentences what you did during the workshop today. Think about the activities in which you participated, your actions during those activities, and who you worked with during the activities." Table 1 presents a summary that highlights the main activities that occurred each day.

Table 1: Participant Summary of Workshop Activities (n=14)

Day One July 30, 2013
*Presentations: listened to outstanding speakers, learned about the current research being conducted in Antarctica, extreme conditions, polar research. *Planning and designing an ROVs: real world application of ROVs, planning an ROV, using ROVs with students
Day Two July 31, 2013
*Hands-on construction of an ROV including the water sample collection bottle *Teamwork and collaboration: brainstorming and constructing the ROV, problem solving *Toured, looked at real ROVs used by MBARI
Day Three August 1, 2013
*Completed construction of the ROVs and tested them out *Collaborated with others on implementation; group discussions *Demonstrations from MATE, presentations from mentor teachers *Visits to labs and SCINI ROV

Types of Workshop Activities. Table 2 presents a summary of the types of activities in which participants were engaged across the three day workshop. Data comes from the daily feedback surveys that participants completed each day. The progression of workshop tasks, from listening and learning to then applying and doing, is evident in the responses found in Table 2.

Results indicate that on Day 1, workshop participants listened to presenters regarding current research being conducted and background information on how ROVs are used in polar research. Of the participants, 71.4% indicated 'a lot of my time' was spent *listening to presentations* on Day 1. In comparison only 14% on Day 1 indicated 'a lot of my time' was spent in the *hands-on activities* (compared to much higher numbers on Days 2 and 3).

Results from Days 2 and 3 show most participants indicated 'a lot of time' was spent in *hands-on work* (85.7% on Day 2 and 69.2% on Day 3) and *problem-solving* (71.4% on Day 2 and 76.9% on Day 3).

Looking at the workshop activities across all three days, participants indicated a higher percent of their time overall had been spent engaged in *discussion with other participants*, *hands-on work such as building the ROV*, and *problem solving.* Survey results show a balance of learning and doing across the three day workshop: 73% of respondents indicated that at least *some of their time* had been spent *listening to presentations* and 69% indicated that either 'a little' or 'some of their time' had been occupied with *reading / reviewing materials*. Collaboration was an important piece of the workshop structure, and is reflected in the responses of nearly 70% of participants who indicated there was time for *collaboration and discussion* with other workshop participants on all three days.

These results address the structure of the ARCUS workshop and describe how the workshop was planned in order to provide teachers with a context and a progression in background knowledge they needed regarding polar research and the use of ROVs in preparation for the hands-on ROV building that followed. In post workshop interviews, these presentation sessions were described as inspiring, motivational, and successful in setting the stage for the activities that followed.

Table 2: Time Spent on Particular Types of Activities (n=14)

Activity		None of my time	A little of my time	Some of my time	A lot of my time
Hands-on work, such as building ROVs or developing lessons plans	Day 1	14.3%	28.6%	42.9%	14.3%
	Day 2	0	0	14.3%	85.7%
	Day 3	0	0	30.8%	69.2%
	Overall	4.9%	9.8%	29.3%	56.1%
Problem solving	Day 1	0	42.9%	35.7%	21.4%
	Day 2	0	0	28.6%	71.4%
	Day 3	0	0	23.1%	76.9%
	Overall	0	14.6%	29.3%	56.1%
Listening to presentations	Day 1	0	0	28.6%	71.4%
	Day 2	0	21.4%	78.6%	0
	Day 3	0	7.7%	84.6%	7.7%
	Overall	0	9.8%	63.4%	26.8%
Reading/reviewing materials	Day 1	35.7%	57.1%	7.1%	0
	Day 2	14.3%	42.9%	35.7%	7.1%
	Day 3	35.7%	50.0%	14.3%	0
	Overall	28.6%	50.0%	19.0%	2.4%
Discussion with other participants	Day 1	0	0	35.7%	64.3%
	Day 2	0	0%	28.6%	71.4%
	Day 3	0	7.1%	28.6%	64.3%
	Overall	0	2.4%	31.0%	66.7%
Other activities	Day 1	16.7%	50.0%	33.3%	0
	Day 2	0	36.4%	54.5%	9.1%
	Day 3	9.1%	27.3%	45.5%	18.2%
	Overall	8.8%	38.2%	44.1%	8.8%

Measuring collaborative work. Table 3 presents results from the daily feedback survey that asked participants to think about, and rate, the amount of time spent working with others during the workshop in three categories: working with the other participants, working with teacher leaders, and working with Stacy Kim's team. Overall, results show the workshop was highly collaborative in nature, with opportunities to work with others throughout the workshop.

Results show that participants spent time each day *working with each other*, particularly on Days 2 and 3 when 85.7% indicated 'a lot of my time' was spent working with other participants. Work with the teacher leaders appears to have increased as the workshop progressed, from 28.6% on Day 1 stating 'a lot of time' was spent working with teacher leaders, to 50% saying so on Day 2 and 64.3% on Day 3.

Results indicate participants spent time working with Stacy's team on all three days, with nearly all indicating they spent 'some of my time' or 'a lot of my time' on each of the three days. The greatest percent of respondents reporting they spent 'a lot of time with Stacy's team' occurred on Day 3.

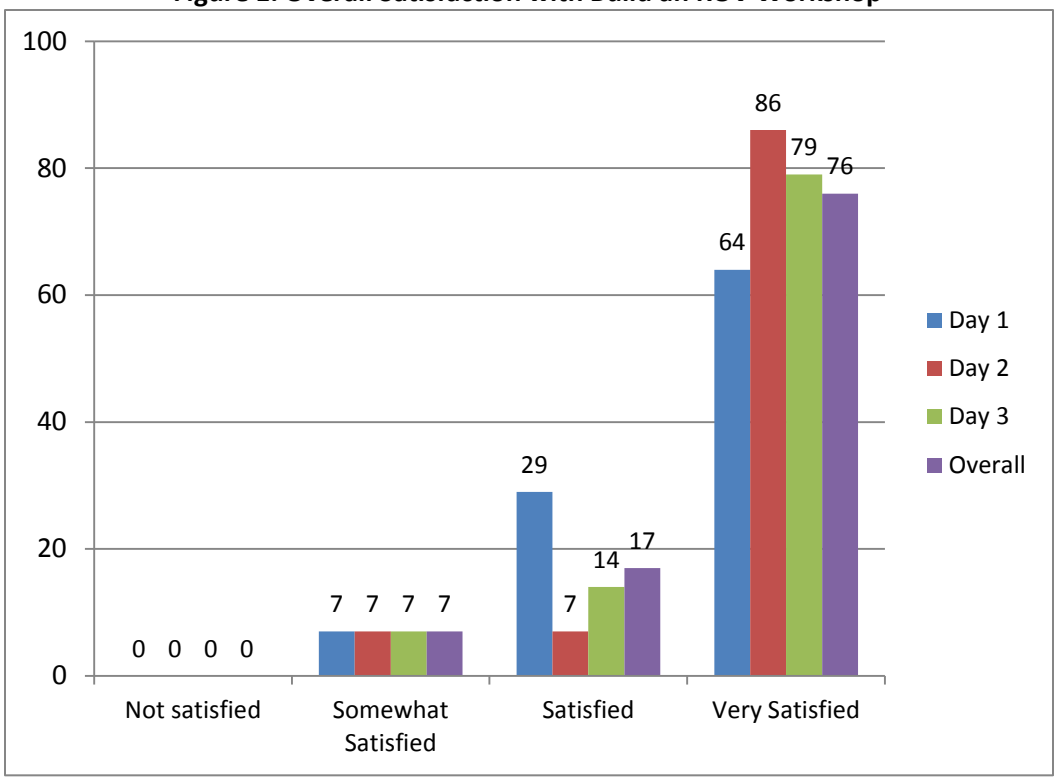
Table 3: Time Spent Working with Others (n=14)

		None of my time	A little of my time	Some of my time	A lot of my time
Working with other participants	Day 1	0	0	57.1%	42.9%
	Day 2	0	14.3%	0	85.7%
	Day 3	0	0	14.3%	85.7%
	Overall	0	4.8%	23.8%	71.4%
Working with teacher leaders	Day 1	7.1%	0	64.3%	28.6%
	Day 2	0	7.1%	42.9%	50.0%
	Day 3	0	7.1%	28.6%	64.3%
	Overall	2.4%	4.8%	45.2%	47.6%
Working with Stacy's team	Day 1	0	7.1%	64.3%	28.6%
	Day 2	0	7.7%	53.8%	38.5%
	Day 3	0	0	50.0%	50.0%
	Overall	0	4.9%	56.1%	39.0%

Overall Satisfaction with the workshop. Participants were asked to respond to the following statement, "Overall, how satisfied were you with the workshop today?" Respondents answered for each day of the survey.

As shown in Figure 1, there was a high level of satisfaction with the *Build an ROV* workshop each day, with 76% of participants overall stating they were "Very Satisfied." The largest percent of participants who stated they were 'very satisfied' came after Day 2, where 86% indicated so, followed by 79% who were 'very satisfied' with the workshop after Day 3.

Figure 1. Overall Satisfaction with Build an ROV Workshop



To follow up with the satisfaction rating, participants were asked to write what they were most satisfied with. Responses appear below for all three days. This section is included to provide ARCUS with information regarding those aspects of the workshop that participants most frequently mentioned as being particularly satisfying each day.

Responses from Day 1

- Knowledge of the research in Antarctica/polar ecology
- Brainstorming our ROV idea with the team/networking with others
- Great information to help with the WHY on ROV's and the opportunity to use them
- New knowledge, resources, and new members of the ocean sciences network
- Sharing of ideas, practicality of incorporating these ideas into classrooms
- The science behind building an ROV
- Real world scenarios for academic buy-in
- Meeting the researchers and teacher leaders, connections
- Logistics of organizing the ROV program
- The collaborative approach, lots of problem solving
- The design process, how the lessons built upon each other

Excellent information, excellent leadership present at workshop, **Participant comment**

Responses from Day 2

- Interesting presentations.
- Great leadership.
- Collaborations between all participants/brainstorming/problem solving/sharing of ideas.
- Help from Stacy's team.
- Networking with teachers who have used ROV in the classroom.
- Watching the team dynamics grow collaboratively; watching the ideas come to life!
- Interesting presentations.
- The hands-on experience and process of building an ROV.
- Coaching and expertise provided along the way, forward progress.
- The people who had great ways to assist and offer ideas.
- Really thinking about how implementing this would look in a classroom.

It felt like a truly collaborative day where we all got to help others, **Participant comment**

Responses from Day 3

- Testing the ROV. Seeing it accomplish the task it was designed to do.
- Seeing the shop where SCINI is worked on – and to see how it is operated out in the field.
- Gaining confidence about teaching ROVs with multiple classes.
- Watching the teams develop and implement a plan and then bring to fruition. Great presentation by MATE.
- Watching the 'A-ha' moments as teachers tested their ROVs

Testing the ROV and seeing it accomplish the task it was designed to do.

Gaining confidence about teaching ROVs.

Vising the SCINI lab.

Participant Comments

successfully! Loved visiting the SCINI lab – made a real life connection I can use.
- Working and sharing with others! Going through the process ourselves. All of the fantastic researchers and support folks on hand!
- I loved that we were able to see the fruit of our labor and the products of other teams. We all worked on something slightly different so it was nice to hear about how they solved some of their own problems that they encountered.
- Today was a great day to see the results of our design and work.

Input on How the Workshop Could be Improved

As part of the workshop evaluation, the survey asked participants to respond to how the workshop could be improved. Many participants were satisfied with the workshops and did not have suggestions for how it could be improved. For those who offered suggestions, responses have been summarized below.

Ideas from Day 1 of the workshop included *more ROV building time, more planning and building on the first day, time to move around and be active on the first day, more highlights and examples of direct curricular application for math and science, types of local school based projects that might be feasible this coming year. One person suggested having a ROV present from the beginning for demonstration.*

Ideas from Day 2 of the workshop included possibly having safety equipment such as goggles when working on building the ROV, and perhaps better work space. One person mentioned pliers would be helpful in future build workshops.

From *Day 3*, only one person made a suggestion, and that was to have an already constructed ROV to work with as well as specific challenges that were related to polar science for us to build for. Mostly the participant feedback included general, positive comments such as the following:

- "I had a great day and an amazing three days with wonderful people."
- "Terrific networking, brainstorming, sharing."
- "Excellent! Well planned, on track, each activity was worthwhile."
- "AWESOME job! Thanks so much for putting all of this together."
- "Let's do more of this!"
- "The three days were a great balance of information and time spent working together and with the ROVs. YOU GUYS ROCK!"
- "Super training, well organized and a joy to be a part of."
- "Love the science talks – those are great. Thanks for everything."
- "I just can't think of an improvement. Everything was well timed and not too strict, and all volunteers and leaders very flexible and knowledgeable."

Responses from In-Depth Interviews

In addition to the input from the daily feedback surveys nine individuals from the workshop completed in-depth follow-up interviews about their workshop experience. The follow-up interviews were conducted in August 2013 by Angela Larson of Goldstream Group. The purpose of the interviews was to collect the teachers' overall impressions of the workshop and to follow up regarding plans or progress with implementing projects in their schools as a result of having participated in the workshop.

A content analysis from the open-ended interview responses resulted in several common themes that defined the structure, content, and benefits to participants as a results of the ARCUS *Build an ROV* workshop:

- Quality of collaboration and networking
- Effectiveness of hands-on activities to support the design, building, and trouble-shooting of the ROVs
- Value of professional gains that resulted from the workshop experiences
- Confidence and ability to move forward with classroom implementation of polar science lessons and building ROVs with students

Additionally, these results from the in-depth interviews mirror the themes that came out of the daily feedback surveys, reiterating a high level of satisfaction with the collaborative activities, excellent presentations, access to expertise, support and encouragement by PolarTREC teacher leaders, and a tremendous amount of satisfaction in designing, constructing, and troubleshooting the ROV.

Participant Description of Workshop Activities. Participants were asked to, "*Describe what they did during the workshop. Think about the activities in which you participated, your actions during those activities, and who you worked with during the activities.*

Participants most frequently mentioned working with other teachers, brainstorming to come up with the design for the ROV, seeking feedback and advice from the scientists and mentors. This collaborative theme was repeated throughout the interviews, clearly an important and influential part of the workshop. Samples of these types of comments include:

> "I worked with other groups and group members as well as researchers and their assistants to learn new strategies for collecting samples, building ROVs, and to learn more about polar science and how to incorporate it into my classroom."

> "The small group was great. It forced us all to jump in. Everyone was very positive. We worked well together and we had a great time. The PolarTREC teachers were the other component that was essential to making this workshop as valuable as it was. They brought the experience. So all of the initial questions that the participants had, they could answer from both knowing it and applying it to what they had already done."

> "Collaboration. Working with other teachers and researchers was great because they did some presentations, then they did a lot of hands-on and problem solving, working through it. Letting the teams come up with their criteria and what they wanted to accomplish with their ROV and how, it's the engineering design process."

Along with the collaboration***, networking*** was also an important theme that will assist teachers with future implementation, and also provided models for classroom strategies.

> "We made new networking contacts with Stacy's team, and I have people now I can email and discuss what we tried, get their suggestions and input."

"Working with the other teachers gave me new insights on new ways to approach questions with students and how to guide their inquiry.

Learning from others (researchers and other presenters) during lectures, presentations, and discussions. Workshop participants cited the amount of knowledge they had gained from the presenters about polar science and current research, use of underwater ROVs in research, and information relevant to building an ROV and implementing ROV projects in classrooms. The impact of having the researchers available as part of the workshop was clearly evident, as shown in the sampling of what teachers described:

"Teachers and researchers gave interesting lectures about ROVs, Antarctic exploration, Antarctic ecosystems, polar science, and bringing scientists into classrooms to collaborate with students."

"I listened to experts present about topics of their field to learn background information that was necessary to the workshop."

"I heard lectures on current polar research, including the technology involved to conduct it. I was introduced to the MATE ROV kits."

"They showed us how to improvise to make fairly complex tools (such as remotely operated "grabbing arms") in quite simple ways (syringe hydraulics) with tools that are readily – and cheaply – available. This will make it much more accessible and possible at the school level."

"The researchers were fantastic. Stacy is really approachable, she's willing to jump in and help. She's got great background information. From working with the PolarTREC teachers as long as she has, I think she has a good feel for the classroom."

"As far as answering wiring questions and design questions and problem solving, they were there the whole time and really helpful and gave great insight. And provides the real life example of what goes on with ROVs."

We were able to work with Stacy Kim and her team and see what they were doing and they gave us lots of insight on how they actually use the SCINI. We even got to visit the lab where they were building the SCINI.

The researchers spoke of some of the challenges they faced in their engineering and design, and it's not that much different as far as how to build the ROV, what kinds of things you need like cameras and sensors, what kind of design you would use. How buoyant or how heavy it would need to be, how deep the waters might be in certain areas. They offered their expertise in the physical science of making these work.

"It was so helpful to have actual researchers, particularly those using ROVs being used within their research, to gain knowledge and experience with how to incorporate such science into my work with students. The experts were there to first give us an overview of their work and experiences with ROVs, then to answer our questions and to assist us in improving ROV/tool design as well as how to make such tasks user friendly for kid levels."

Hands-on Activities. As shown previously in the report (Table 2) the highest ratings from the workshop came on Day 2, when teachers worked in teams to build their own ROV, complete devices that allow the ROVs to accomplish a particular task such as water sample collection. Several comments received from the interviews illustrate this point. Along with the satisfaction of building the ROV, the teamwork and collaboration also come through in the comments regarding the hands-on activities.

> "Working on a team with another teacher and a PolarTREC teacher-leader, we brainstormed ideas, learned to design, build, troubleshoot, and test the ROV."

> "This is a real hands-on, very motivational project to get the kids involved."

> "We actually got PVC pipe, cut it, and learned how to solder the electrical components together on a little board that would be used as a controller, learning what the different parts of the ROV would be. We were provided some specific sets, some kits. It required some design at the beginning, then teams could start building. Very hands-on.

Exploration/enrichment activities. Workshop participants were provided opportunities to tour some of the MBARI facilities, and were highly satisfied with the tours and demonstrations, such as visiting Stacy Kim's lab at the Moss Landing Marine Laboratories, visiting the SCINI, boarding a research ship where the Ventana ROV is stationed, etc. The tours, along with the MBARI facility and location, were mentioned numerous times by the workshop participants.

> "Exploration activities included tours of MBARI and Stacy Kim's workshop, being on the beach at MBARI watching wildlife, and talking with teachers and researchers about experiences. That was fantastic."

In addition to describing what they had done at the workshop, participants were also asked to ***describe what they had learned***. Participants mentioned most frequently the learning regarding the mechanics of building an ROV, more about polar research, but the learning went beyond that. In their own words, here is a sample of participant responses:

> "The roles ROVs play in research, especially Polar research, how to construct a ROV model for use in middle school, some trouble shooting strategies to use when building ROVs, the specific research work that Stacy Kim and her team are doing, the work that is done at MBARI (learned through the tour and staff discussions), and what the MATE program involves. I was not aware of this program before."

> "I learned a lot about Antarctica – the types of research, the living conditions, research conditions, wildlife present. I also learned to design, build, and test an ROV. I learned about creating a water sampling device, how to use sensors to measure temperature, and how to ensure buoyancy. I also learned what other teachers are doing with polar science and ROVs in their own classrooms from the teacher-leaders present. I learned a lot about Stacy's research and what her team has done and will continue to do in the field."

> "We learned quite a bit about polar research through presentations from the builders and managers of the SCINI ROV. We learned about teacher resources and opportunities. We learned how to introduce students to ROVs."

Applying concepts to the classroom. This section answers the question regarding what the participating teachers plan to do as a result of the workshop. Participants were asked to think about activities with students, and future collaboration with other teachers or researchers/scientists. This section is important for determining the impact of the workshop on teachers in regard to their classroom practice as a result of the workshop.

> "I am really wanting to do an ROV workshop next summer with the teachers at our school… maybe partner with the Engineering College here on campus."

> "I received guidance on how to organize an ROV activity back at my school. I learned about polar research."

> "We've been in school for only seven days and I've already talked to my students about my ROV workshop and how they will create ROVs and connect with scientists using ROVs. They are very excited!"

> "They gave us a lot of good ideas. The PolarTREC teachers would show us what they were doing in class with their kids. They had brought examples of ROVs that some of their students had made. And they talked at length about some of the activities and some of the programs they have going on. The materials are easy to get. Interest level for the kids is going to be very high."

> "We are beginning a STEM academy this year and I've already talked with my principal and other teachers about starting an after school club. I brought my ROV back and showed everybody and talked about how we can really do this. My plan is to start with Stacy Kim and her research, then lay down some parameters for the kids to follow, some goals and some tasks. At that point we'll walk through the instruction part of it, the planning and building and engineering and the construction part of it. Work in small groups. Work on funding for some pools, some inflatable pools to use for testing."

> "A next step for me is to find a way to incorporate ROVs into my math curriculum. A big focus for me this year is engineering and design so there will be opportunities to include ROVs, but I need to find a way to scaffold the skills that students will need to be successful. I will also talk to other teachers at my school to gauge their interest and see if there is potential for cross-curricular projects."

> "I next have to decide whether to build ROVs as an afterschool club activity or as part of the regular curriculum in one of my classes. Time will be the major issue. Possible connections with our local Naval Postgraduate School will be explored."

> "I've already spoken to the Safety Marine Officer down at the pier in the city and hopefully we will have an opportunity to take our ROVs out and actually do some sampling, collecting some data."

"We're going to be doing our first field work hopefully at the end of September and put some simple sensors on it: a depth gauge, temperature gauge. We want to have some sort of collection system and may start off with something as simple as a syringe type collection system."

"As a result of this workshop, I already have plans to attend the next level of ROV construction that is offered by the MATE Center. I have plans to incorporate research design (rather than just task-based competition design) into my ROV unit; my students will be designing their own research questions to be investigated through the use of underwater ROV (perhaps an overarching question will be to "map" the local harbor – kids can investigate water temperature, depth, salinity, marine life at different levels, bottom sampling, etc. to develop a complete map of the harbor – or local bay or offshore area. I am also meeting with head personnel at the University of New Hampshire's Leitzel Center and Shoals Marine Lab (located in the Gulf of Maine) to discuss possibilities of having an ROV focus group for middle schoolers out on the islands. Students would conduct a myriad of investigations around the island's waters."

"I have submitted plans to PolarTREC and received my materials stipend, and have submitted a $2,500.00 grant to purchase ROV kits and supporting materials. My engineering students will build ROVs at the end of their electronics unit, after they learn and practice soldering techniques. Student ROVs will be on display at a Fall open house held in the engineering classroom. Students, parents, administrators, community members and the media are invited to the Open House. Lockheed Martin and PolarTREC are acknowledged in my classroom and on my class web page for the training and materials. After the open house event, my sixth grade earth science students will get the parts to design and build an ROV. These students will not solder the electronics, but will still learn engineering skills as they design and test ROVs. ROVs will align with these sixth grade curriculum topics: plate tectonics, earthquakes, ecosystems, and interrelationships of ecosystems. I plan to follow the work of Stacy Kim and her team when they are in Antarctica this year. Students will follow their work, as allowed through web sites and Skype interactions. The ROV kits will be reused from year to year. "

"We've been showing off our ROV at the school. We're getting a new pool installed at our high school so we'll be ready to test them in that."

"There is a teacher who is just about an hour away from me and we have talked about building a relationship around the experiences the kids will be having with the ROVs, sharing the data and the experiences with another classroom of students."

"I've got a project in mind already. My students can build an ROV and take it to a harbor that's about six miles from our school. We will evaluate the local marine life. And leave it up to the kids what kind of information they want to gather, on density and salinity, temperature, pressure, observations of sea life. Leave it up to the kids to decide what project they want to do, based on our study of what ROVs are currently

being used for. Have the kids do research on what's going on in our harbor, such as measuring the amount of erosion taking place each year."

Working with other teachers and researchers. The ARCUS Polar Workshop was collaborative by design. The workshop included polar scientists, researchers, and PolarTREC mentor teachers to work alongside teachers in the Build an ROV workshop. An evaluation question was asked to determine to what extent workshop participants valued the collaboration of the researchers and the PolarTREC mentor teachers and their involvement and contribution to the workshop as a whole. Responses are shown below.

"Working with other teachers helped me learn how ROVs may be successfully used in the classroom. Teachers sharing their experiences with ROVs made me feel more confident that I can successfully use ROVs in my lessons. Working with the researchers was awesome! They were interesting, patient, and encouraging. We learned firsthand how ROVs are used for science, and some of the results that were obtained by use of ROVs."

"Having experts and other teachers was extremely helpful to gain insight and ideas. It was encouraging to see how others have started recently as well, and that each year is different and that each group of students are different. I was also helpful to hear about their experiences and struggles as well. I also learned about the MATE contests."

"Working with other teachers was most helpful because of the firsthand experience it gave me in cooperatively designing and building the ROV. We had to listen to each other's ideas, advocate for our own ideas, and then be willing to compromise where appropriate. Hearing others' experiences with ROVs in their classrooms was also very useful. The researchers gave us valuable context for ROVs that we could share with our students."

"I shared four kits with one of the teachers so she could get started right away. We've decided we're going to start some sort of collaboration between us based mainly on the ROVs. We are going to put the same types of sensors on our ROVs so we can compared exactly different things like depth, temperature and go from there. I'm working with a researcher from Stacy's team on the technology and the cameras."

"By meeting the researchers and getting to know them through the workshop, we now have the opportunity to communicate with them in real time as they conduct their research."

"The researchers were great. We can tell out students that not only did we build this cool little thing and learn about the properties of fluid, electrical circuits, theories and parallels, parts of the standards. But now there's a real world application. We can go onto computers and see actual ROVs that are not much different than this one we just built, gathering research on biotic systems and marine life, oceanography, the geology of the ocean floor, in real time. The application of the learning. The lesson goes from being a cool novelty item to having meaning in real life applications. The researchers guided us in our learning about the ROVs."

> "There are three or four teachers locally that plan to continue collaborating, work with MATE, continue to build ROVs, share ideas in terms of what other teachers have already done, like having the ROVs move up and down freely with the ballasts, working with underwater cameras, those types of things. I would love to have my students go on that website and adopt a scientist. Have our ROV tie into the science fair."

Professional Gains. The ARCUS workshop contributed to professional gains for teachers in several important areas: confidence with ROVs and presenting the project to students, an expanded network of colleagues to rely upon as classroom projects are implemented, and sharing the newly gained knowledge and expertise with fellow teachers at their schools. Again, the theme of collaboration and networking comes through. Some of the interview responses are presented below.

> "I gained confidence in my ability to improve and expand my use of underwater ROVs within the classroom. I learned new skills, I learned new content about ROVs as well as polar research. I made connections with other teachers and expanded my network of collaborators; I have a new group of people with whom to brainstorm, troubleshoot, and integrate ROV and polar related work. Before the workshop, I felt like I was alone in my troubleshooting efforts. Now I have an entire team to work with."

> "I learned how to incorporate unique, hands-on learning and align this with several lessons for different types of classes. Information and skills learned at the workshop will help me apply Common Core Standards (investigation, critical thinking, communicating) and Next Generation Science Standards (NGSS) in my classes. In addition to classroom teaching, I may be working for our school district to develop staff training for implementation of new standards, and developing lessons to comply with NGSS. ROVs will be referred to in these projects."

> "Professionally, I learned a new skill that would be of great interest to my students and school community. I also was able to network with other teachers around the U.S. with similar interests. I was able to connect with local scientists that are eager and willing to work with my students. All in all, I feel that I am better equipped with both knowledge and resources to build ROVs with my students."

> "The workshop brought me new ideas, new materials, new resources, new contacts to bring into our science programs. Getting to go onboard to see a real ROV that is being used as part of research, learning more about how they actually use those out in the ocean and getting a sense of the size of these things."

> "The three biggest things are that I learned firsthand are how to build an ROV and I can do that now with students, including some of the snags and pitfalls you may run into and how to deal with those; we can tap into current research for real world application of what is being done; and with the new science standards, our students can be part of data collection, which is a big part of the standards here in California."

> "We learned from each other some creative ways to have an ROV accomplish different tasks like taking water samples, using a limited set of resources. We learned from some of the wonderful

ROVs that others have created, that were shared by the MATE program that include underwater cameras."

Best aspects of the workshop. Finally, participants were asked in the interviews to sum up their experience at the workshop by thinking about what had been the best aspects. Several of their responses appear below.

"Networking, learning, and fun! It was fantastic to see Stacy's lab, to tour the Rachel Carson boat and see the ROV on board that vessel. It was great to see such different styles of "real-life" ROVs and the reasons behind their design. It was great to help others develop an understanding of how to build ROVs and how to integrate ROV and Polar research into their classrooms."

"The great location. If we were in Iowa, I don't know that it would have had the same effect, no offense to Iowa. But being there, right on the edge of the ocean, to see the wildlife and the surroundings, and we were right next to the harbor that I'm interested in exploring with an ROV. I think number one was the location in terms of inspiring me. The personnel who ran the workshop were excellent. A tremendous variety of people that we got to talk to, other teachers like me who are doing similar things and have already done what I want to do. They were an excellent resource."

"This is one of the best workshops I've attended over my past ten years of teaching. The program was well organized. Our time was well spent. Each day's schedule was thoughtfully arranged to bring variety of activities throughout the day. The time went quickly and pleasantly. The small number of participants was perfect for collaboration and idea sharing. I could get help easily when needed, and always felt that I had access to the many experts in the room. The content and teaching methods were excellent! I've completed four weeks of training for using engineering lessons in a middle school classroom. After these trainings, I still felt unsure of how I would present the material and uncertain that I could assist students fully. After the ROV workshop, I felt confident that I can use ROVs in a middle school classroom to fit a variety of curriculum needs. The setting at MBARI was superb! I love that we broke when whales or wildlife was spotted. The food was excellent. The meals would have been expensive to buy. I appreciate the $300 stipend for materials and that there was no fee for me for the training."

"One was the abundance of experts and their willingness to help and give advice. I also enjoyed the time we spent building ROVs. The hands-on experience was invaluable and will give me the experience needed to help guide my students. Working with all the tools and parts was very helpful as I always imagined that would be a big obstacle to getting started in my classroom, so working with the MATE kits was a great way to reduce that barrier of entry."

"The building of the ROV, seeing the SCINI lab, the contact with the "in the field" researchers and their enthusiasm for their work, and the sharing of experiences and ideas with other teachers."

"The ability to explore and create, to engineer a solution. The workshop was very successful in that way. The whole hands-on, teamwork type of learning. We had a good mixture of learning about science, learning about the engineering, and some of the design constraints, that kind of stuff."

> "The content was right on. This is usable stuff. This is STEM, hands-on, very applicable, and with current research going on, so the content was just phenomenal including the MATE information they exposed us to, with the national and regional competitions with ROVs. The support of the class was outrageous. Stacy's team was just a joy to be around, from an engineering point of view and a background and research point of view. The PolarTREC teachers were just great. They are wonderful people and they have great ideas and they're willing to follow up and help you any way they can. Then you connect that all with the location. There couldn't have been a better location than that."
>
> "I think it was great. I think the idea of bringing in the real science, bringing in scientists that actually use ROVs and then having all the people who are in charge of the design, construction, and building, I think that was huge. It made a big difference. I think the size of the group was perfect. There was enough time to really get to work with somebody and get to know them. I think the idea of teaming people with some sort of experience in the group was real helpful."
>
> "It was well planned out with a balance of building, engineering, trouble shooting, and presentations, instead of having a day and a half of doing ROV and a day and a half full of presentations. It was just really well planned out."

Clearly these responses indicate that participants gained a wealth of knowledge and experience from the workshop. Each spoke of how he or she had been impacted by the project within their own teaching context, and all who were interviewed discussed ways in which the workshop helped and encouraged them to proceed with ROV projects in their classrooms.

Suggested Improvements. The workshop participants were also asked in the interview to give suggestions on how the workshop could be improved. Now that they are back at their classrooms, there were additional suggestions to those that had been received on the daily feedback surveys. Suggestions appear below.

> "It would be nice if everyone went home with an ROV kit, but that would be very generous! Please pass along my thanks to all involved with this workshop."
>
> "A resource that I would have liked to see was a document that listed the suggested items/parts to have in the classroom. This would be helpful as I attempt to seek out the necessary parts to build these kits on my own, to save on cost."
>
> "Maybe just add a little more time for the construction; I think would be super if we could find a way to actually get just a little offshore with the ROVs to see how they would actually work out off the coastline."
>
> "Funding is a big deal, if you could email sources of additional grant money for my ROV program."
>
> "If there is an actual classroom we could visit in the area where ROVs are being built, it would be great to pay them a visit to see how it's working with a group of 12-year-olds, watch firsthand and talk with the teachers."

> "A better way to share out our robots at the end, a better culminating activity with presentations to the other groups and self-evaluation."

For some, it was difficult to come up with any suggestions for improvement. The following comment illustrates a sentiment that was echoed by others and provides an overall summation of the workshop:

> "I thought it was a fantastic workshop. I'm not sure what improvements could be made – it was a great balance of work-time, presentation time, inclusion of experts, and others that have built ROVs with students in the past to help the teachers new to the world of ROVs learn how they can implement/include ROV and polar research within their classroom."

DISCUSSION AND CONCLUSIONS

Results from the evaluation of the ARCUS Polar Workshop, ***Build an ROV***, indicate this workshop was an excellent opportunity for the teachers who participated. Responses from both the online daily feedback surveys and the in-depth interviews indicate a high level of satisfaction in what was learned. Common themes that were repeated by participants regarding the workshop were: opportunities to learn about science, exploration, and research from polar researchers, the PolarTREC teachers and other experts, an opportunity to design and build an ROV, networking and collaboration with scientists, researchers, mentor teachers and other teachers; learning how to apply the project with students in their classrooms, polar research currently taking place and how ROVs are being used in real world situations.

Teachers cited many benefits to having participated in the workshop, the primary benefit being they are excited to take what they learned and experienced in the workshop and get started with building an ROV with students in their classrooms. Professional gains that came out of the workshop were discussions about funding projects like building an ROV, relating the project with Common Core and Next Generation Science Standards, the availability of resources and materials to complete projects like these with students, ways to continue the communication that started at the workshop to ensure continued support and ideas. The ability to communicate with one another, to share successes and discuss improvements, is very important to the teachers to make sure opportunities from the Build an ROV workshop continue on to implementation in classrooms.

Teachers are excited to build an ROV with students in their classrooms and appreciate the contacts they have made through this collaborative event. Some are seeking funding in order to proceed

ARCUS implemented all parts of the workshop as planned and met the learning objectives and workshop goals. Teachers increased their knowledge and understanding of polar research and the use of ROVs in conducting studies in arctic regions. All teacher teams went on to successfully design, build, and trouble shoot an ROV equipped with water sampling capabilities and shared the challenges and successes along with the support and encouragement from teacher leaders.

APPENDIX A: EVALUATION TOOLS

Workshop Daily Feedback Survey

Participant Interview Protocol

Polar Workshop: Build an ROV

Introduction

Thank you for completing this important survey. The goal of this survey is to learn what you thought of today's workshop. The results of this survey will help ARCUS improve future workshops and report the workshop's impact to funders. This survey should take about 10 minutes.

Your responses will be kept strictly confidential and will be combined with the responses of the other participants and used only for the evaluation. Only the project evaluator will see individual responses and no information identifying individuals will be reported under any circumstances.

If you have any questions, please contact Angela Larson, Principal Evaluator at 907-452-4365 or at alarson@goldstreamgroup.com.

1. Describe in a few sentences what you did during the workshop today. Think about the activities in which you participated, your actions during those activities, and who you worked with during the activities

2. During the day how much of your time was spent on the following type of activities?

	None of my time	A little bit of my time	Some of my time	A lot of my time
Hands-on work, such as building ROVs or developing lessons plans	◯	◯	◯	◯
Problem solving	◯	◯	◯	◯
Listening to presentations	◯	◯	◯	◯
Reading/reviewing materials	◯	◯	◯	◯
Discussion with other participants	◯	◯	◯	◯
Other activities	◯	◯	◯	◯

Polar Workshop: Build an ROV

3. During the day how much of your time was spent working with

	None of my time	A little bit of my time	Some of my time	A lot of my time
Other participants	◯	◯	◯	◯
Teacher leaders	◯	◯	◯	◯
Stacy's team	◯	◯	◯	◯

4. Overall, how satisfied were you with the workshop today?

- ◯ not satisfied at all
- ◯ somewhat satisfied
- ◯ satisfied
- ◯ very satisfied

5. What aspects of today's workshop led you to be [Q4]?

6. What suggestions would you give to Janet and Sarah to improve the workshop tomorrow?

Polar ROV Workshop
Participant Interview Questions

1. Describe what you did during the workshop (your role during the workshop for a teacher leader).
    a. Think about the activities in which you participated, your actions during those activities, and who you worked with during the activities.

2. What did you learn during the workshop?
    - Think about building ROVs, using ROVs with students, goal setting polar science/research

3. How did working with other teachers and researchers help learn the content? Learn about using ROVs with your students?

4. What will you do next as a result of this workshop? Think about activities with students, collaboration with other teachers, and/or collaboration with researchers/scientists.

5. What professional gains did you achieve overall?

6. What were the best aspects of the workshop?

7. What would you suggest for improvements?