Telepresence to Support Research Experiences for Undergraduates

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The Inner Space Center at the University of Rhode Island.
(Photo courtesy of Ocean Exploration Trust)

The Concord Consortium

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Project overview

The Transforming Remotely Conducted Research through Ethnography, Education, and Rapidly Evolving Technologies (TREET) project explored ways to provide undergraduate research opportunities using telepresence. Funded by the National Science Foundation, TREET provided opportunities for scientists and undergraduate students to engage in their own authentic deep sea research – from a distance. Students developed research plans, collected data remotely, interacted with the scientific community as parts of a shore-based team guiding an oceanographic research cruise, and conducted post-cruise data analysis. Advances in technologies have made such research possible and open up new paths to future opportunities for undergraduate research.

During the spring of 2014, eight scientists, eight undergraduate students from three different academic institutions, three educational researchers, and an ethnographer participated in a hybrid seminar (with both scheduled synchronous events and asynchronous online discussions) that introduced telepresence, the capabilities of the E/V *Nautilus* and the remotely operated vehicle (ROV) *Hercules*, and the locations of the research sites in the Caribbean. In September of 2014, Nautilus set sail to explore and collect data with a full complement of personnel on board the ship plus a group of scientists and undergraduate students on shore directing many of the research operations. Following the fall cruise and during the spring of 2015, TREET participants continued the research efforts, including distribution of data and discussion and presentation of ongoing analysis.

"Aside from being on the ship, I think telepresence is the best way. It gives you an authentic way of doing research." – Student

Throughout the project, this group reflected on their experiences and shared their thoughts about how telepresence-enabled research could be applied in the future. This paper contains a list of recommendations for anyone who would like to engage undergraduates in remote fieldwork and research through telepresence. Our goal is to define the emerging field of "tele-agency" (i.e., where distant participants are more than spectators, but active agents) as broadly as possible.

We believe future undergraduates should have more opportunities for authentic research and distant fieldwork – from the seafloor to outer space (or anywhere else that is too remote, costly, or dangerous, all of which could make for exciting discoveries!). And we hope that our experiences in TREET provide a valuable jumping-off point for transforming the way remote access engages future undergraduates and scientists alike in authentic research.

Good luck!

P.S. A note about language: Since TREET was conducted in the context of ocean research with remote access from land, we refer often to ship and shore. The ship was the site of the remote fieldwork (which took place even more distantly, thanks to ROVs that are equipped with sensors and other instruments to collect data from the ocean floor). Shore was the "home base" for the undergraduates engaged in research. In future tele-agency fieldwork experiences, "ship" and "shore" may, of course, be entirely different locales.

Figure 1. The Exploration Vessel (E/V) Nautilus at sea. (Photo courtesy of Ocean Exploration Trust)

Figure 2. Students at the Inner Space Center at the University of Rhode Island. (Photo courtesy of Zara Mirmalek)

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Introduction

First, we must start by saying that TREET proved to be successful in many ways, hence our optimism about future undergraduates engaging in research from a distance. There were challenges, too, of course. And the recommendations come from both sides of the spectrum. We have written elsewhere about the experience and student gains. Here, we focus on opportunities to try new approaches in this emerging field.

TREET began with an online seminar for undergraduate students in the spring (January through April 2014), during which time they developed research plans. A two-week research cruise for remote data collection took place in late September 2014, several weeks into the academic year for most of the students and months after the seminar. Data analysis was completed through the fall of 2014 and spring of 2015, and included a follow-up seminar for students to present their analyses to scientists. Each phase of this Research Experience for Undergraduates (REU) included tele-agency, which incorporated both the sense of presence and the act of agency at a distance, though the most immersive part took place during the fieldwork when the Nautilus was at field site in the Caribbean. Many of the recommendations thus focus on the fieldwork.

Telepresence-enabled fieldwork

The fieldwork was one of the most exciting parts of the REU for TREET students. Offering similar opportunities for more students to take part in remote fieldwork can provide multiple benefits – from learning new technologies to meeting practicing scientists, and the chance to direct data collection and research from a remote site. Students engaged in the cruise from the Inner Space Center (ISC) at the University of Rhode Island's Graduate School of Oceanography, which is well equipped for telepresence research and through a smaller Exploration Command Center (ECC) at the Woods Hole Oceanographic Institution. Future undergraduates could be involved in other ocean science telepresence research by logging into a website to interact "live" with a particular cruise dive. Such telepresence is already available, and while it does not afford students the opportunity to be agents at a distance, directing the research, it does give students the chance to experience telepresence technology and may whet appetites for ocean research. Other fields that employ telepresence may expand its use to include undergraduates and empower them to engage in their fields similarly.

TREET was able to piggyback on a scientific data-gathering expedition run by the Ocean Exploration Trust, enabling students to collect their own scientific data at the same time. However, since the cruise took place in late September and early October, TREET students missed classes for over two weeks to participate in the remote data collection. This schedule presented challenges for the students. If future projects require similar coordination with ongoing scientific expeditions, it's important to help students keep academic calendars in mind when planning their REU, including preparatory academic work, remote fieldwork and data collection, and data analysis. Undergraduates don't have the same flexibility as graduate students and need support in thinking about coursework over multiple semesters and mentoring with regard to the impact of schedule on other coursework.

> "I don't think telepresence is going to replace oceangoing projects, but I definitely think there is room for people to be involved from the shore."
> – Ship scientist

If scheduling is flexible, and travel (to telepresence command centers) for remote telepresence fieldwork is required, ideally the work would occur over the summer when it would be less disruptive to students' academic careers. On the other hand, if fieldwork must take place during the academic year, students may not need to participate for the whole duration, but just when "their" science is happening. While the TREET research cruise was nearly two weeks long, for the most part students were directly involved in data collection for their own research only for a matter of days.

"It was definitely tough to come back from Rhode Island and get caught up in all my classes. That was definitely a huge setback." – Student

For REUs to leverage telepresence, universities could create smaller versions of the ISC technologies and tools to support telepresence, such as are available at Woods Hole Oceanographic Institution, for example. Additional remote sites could also be outfitted to support telepresence research. Training courses for professors, ROV pilots, scientists, and crew on telepresence-enabled cruises could help them learn to mentor undergraduate students who are undertaking remote research via telepresence. In these ways, telepresence could become more ubiquitous for supporting undergraduate research experiences in the ocean sciences.

Supporting situational awareness

Students new to research and fieldwork need preparation and training; they also need to understand the role of telepresence. To become tele-agents students need training on the telepresence technology and sophisticated situational awareness regarding the remote work site. Providing such situational awareness will vary based on different contexts. Ideas include showing videos or a virtual tour of the remote site, or, in the case of another ocean-based research project, having students board a ship docked at shore to experience the vessel and the remotely operated vehicle (ROV) firsthand before directing research from a distance via telepresence.

"I think the biggest thing is just explaining how everything works before going in and doing it. More time should be dedicated to what is telepresence, what are we going to see, do, participation in this whole thing, what our roles will be, what we will see at ISC, how we will communicate with people, questions like, 'How does this whole thing actually work?'" – Student

Training scientists to work with undergraduates

TREET students were able to direct the ROV pilots to the research sites and to collect data of interest to their research goals. Being in charge of the data collection was new for the undergraduates, though it proved to be the period where students seemed to gain the most understanding of the nature of science, of the research field site and of the constraints of real-world science. However, while students made decisions from shore for data collection, their choices sometimes happened without

complete understanding or appreciation of local sea conditions, for example, that affected the implementation. This caused some frustration on the ship, which could have been alleviated with clearer communications and lines of command in place.

Scientists and support staff for the research (e.g., the captain and ROV pilots) must also keep in mind that undergraduates have less experience and may need advice, handholding, and mentoring. They should understand the individual student projects and should be coached in communicating with a naive audience.

Community and communication

It's essential to build community since there's a wide group of people supporting the research and working together. Telepresence can help form bonds, especially through videoconferencing technology – as TREET used for the seminars – which allows everyone to see and hear one another from a distance. A face-to-face gathering provides another measure of bonding. Some TREET participants were also able to meet in person at the ISC for the remote fieldwork, though others were already onboard the ship.

"It was definitely frustrating at times trying to communicate with the boat. Because I didn't know what I wanted and I was learning how to do things, and it was nerve-wracking at the same time, because I wasn't sure how to communicate." – Student

"The ability to communicate your desires for data collection from shore to the people controlling the ROV is still mind-blowing to me. And incredibly useful." – Student

For any telepresence-based research project, communication between the home base and the remote research site is critical. While TREET students learned to use multiple communication technologies from headsets to science chat (texting) "on the job" to communicate their research plans and to direct data collection, in future telepresence-enabled fieldwork, explicit direction on using the communication technologies with hands-on training should be provided as early as possible.

"I had an imperfect sense of what was going on back there. We had a schedule of who was going to be on and we kind of had an idea of what was going to take place during the dive, but sometimes it wasn't clear exactly who was at Mission Control. Was it two students or was everyone watching?" – Ship scientist

Students at the ISC could see via one of the camera feeds who was sitting in the "van" (control room) on the ship, which was directing the ROV, but the ship crew did not necessarily know exactly what was happening on shore, or even who was on watch. Broadcasting audio and video in both directions (ship to shore and shore to ship) would have helped all participants in this case. In future remote fieldwork experiences, someone should be charged with reporting who is

"Telepresence could be made far more efficient with the implementation of some structured info that is designed to simply make everyone aware of who's in the room and what's going on." – Shore scientist

"I felt a little disconnected, out of touch with what the goals were. It would have helped when I first came on watch to understand that students on shore needed this and that done. I was out of the loop, one step removed." – Ship scientist

present in each location. Structured information about participants and their roles, plus the overall plan and research agendas should also be provided; solutions can be as simple as having photographs of students with their research plans as well as pictures of all other participants and descriptions of their roles at both sites.

Other telepresence-enabled research models

Each of the undergraduate TREET students who participated in remote data collection by telepresence had his/her own research question and data collection needs. With a short cruise, affected by weather and other unpredictable circumstances (e.g., one tool broke; one dive permit was obtained late), it was difficult to ensure that each student's research needs were being met. There is great value in independent research projects (and each student was able to get data in the end), though other models could also be considered for future REUs.

Students could participate in authentic telepresence-enabled research if the research is part of a larger group goal, for example, one with a lead scientist/mentor overseeing the whole project. In this case, the projects could be closely aligned to professors' projects, with professors or students carving off smaller more focused aspects of the research. Or there could be a pool of projects available to students to achieve scalability while ensuring that students are not merely doing rote tasks, but have ownership over their work. In any case, student projects should be flexible and include back-up plans, since data collection, particularly at a distance, is not guaranteed. In all cases, research projects should be well defined, with feedback from experienced scientists, to use remote data collection time as efficiently as possible.

"There [were too many ship resources focused on one student's needs]. The problem with that is it becomes not scalable. It breaks down very quickly. That means you are limited to have small numbers of students involved at great expense. I think the optimum end result for telepresence is the opposite. Where you want to have as meaningful an experience for as many people as possible because that is where you are going to get the numbers to make it really work." – Ship scientist

Figure 3. Student at the Exploration Command Center at Woods Hole Oceanographic Institution. (Photo courtesy of Zara Mirmalek)

Planning for data analysis

Research includes both data collection during fieldwork and data analysis. Getting processed data proved to be challenging for many of the TREET undergraduates, who had to rely on other scientists and post-doctoral researchers with competing requests and time constraints. This may not be unique to the type of data collected on the TREET cruise. Nonetheless, clear planning and support is necessary to ensure that students get their data as quickly as possible, or research plans should be designed with an experienced mentor who can ensure that the data is easy to retrieve and that mentors know how to process it. Alternatively, if similar, representative data were collected at other times, for example, students could use it to begin training on data analysis or continue ongoing work on analysis with previous data until their data arrives.

Recruiting students

Success in REUs is correlated with the length of the research experience with the most powerful outcomes resulting from extended research experiences. TREET took place over three academic semesters and one summer, though some of the students did not seem to fully comprehend the full extent and length of the REU. Clear preparation and understanding by both the professor and the student regarding the long-term commitment to research is important. TREET included one sophomore, six juniors, and one senior when the program began. Future REUs could include sophomores who would have more time for data analysis and could potentially use their data for a senior thesis. They would also have more time to pursue additional courses in the field (or, alternatively, to explore other academic interests if they learned that this work was not to their liking).

"I'm a senior, wish I'd had this [earlier] and still have a year left. Because if I enjoyed it would have given me time to pursue more into this field." – Student

The future of telepresence for REUs

While we are optimistic about the future, it will take others with imagination to integrate telepresence into more REUs. The TREET cruise was one example that fully realized tele-agency for several undergraduate students, but the project had a tremendous amount of resources from National Science Foundation funding to the donation of ship time from the Ocean Exploration Trust, and the use of facilities at both the University of Rhode Island's Inner Space Center and Woods Hole Oceanographic Institution.

With telepresence, the ocean sciences are one step ahead and could be the beacon for helping other research fields understand what it takes to set up smaller but functional telepresence REUs. Indeed, telepresence seems to be the wave of the future for more science fields as teleconferencing software is becoming more robust. We hope that others will embrace remote fieldwork and include undergraduate students in exciting, authentic research opportunities, and we believe TREET provides groundwork on which to build.

"The acquistion of data was the most difficult part – the lag time between collecting it and actually receiving it was a little troublesome. It delayed everything. And once you start delaying, it gets pushed on the back burner and then other things start coming up."
– Student