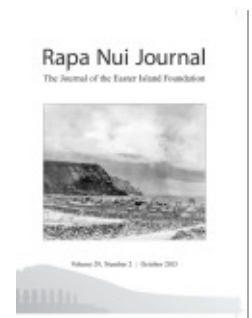




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Engineering and renewable energy

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Rapa Nui Journal, Volume 29, Number 2, October 2015, pp. 52-55 (Article)

Published by University of Hawai'i Press

DOI: <https://doi.org/10.1353/rnj.2015.0015>

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Introduction

For the past twelve years, Terevaka Archaeological Outreach (TAO) has offered educational programs for young people in the Rapa Nui community – focusing on the study and conservation of cultural resources. In 2014, local community leaders suggested that in addition to the successful archaeological outreach program, the island would benefit from an educational program that introduced young people to engineering and technology. During the ensuing ten months, we developed a hands-on engineering curriculum to be implemented in Spanish for a small group of high school students participating in the TAO 2015 program.

Since the inception of TAO, our most general goals have been to promote education and conservation on Rapa Nui. The engineering curriculum we piloted this year, with its theme of renewable energy, was a natural extension of our past focus on cultural resources –

a parallel curriculum devoted to the conservation and sustainable exploitation of natural resources. Students applying to the 2015 TAO program elected to participate in either the engineering or the archaeology track, with seven participants opting into each of the two groups. Each group had its own set of activities and projects (see “Terevaka Archaeological Outreach (TAO) 2015 field report: Archaeology, conservation, and toponymy” in this edition of the *Rapa Nui Journal*).

For two weeks, TAO students and staff lived and worked together, camping on land provided by Explora Hotel and Mike Rapu. In addition to the activities and projects specific to the two tracks, the entire TAO cohort participated together in a number of excursions, activities, hiking trips, and a series of eight evening lectures by experts on the island’s history, geology, wildlife, and archaeology (see Figure 1). The immersive nature of the program, and the sense of community it fosters among the participants, enables



Figure 1. TAO students and staff visit Ahu Akahanga.

students to accomplish a tremendous amount over the course of the two-week period and to make substantial progress on the projects they take on during the program. The program ended with a final presentation, hosted by Explora, where the student participants in the program presented their work to members of the local community.

Engineering Curriculum

Our ultimate aspiration for the engineering curriculum is to foster curiosity about science and technology in a new generation of leaders who will be grappling with questions about the island's energy and resource needs in the future.

The main challenge was to design a set of "lessons" that would be interesting to a group of students with no prior exposure to engineering, and relevant to the theme of sustainable development within the Rapa Nui community. To this end, each of the twelve roughly three-hour lessons included a significant hands-on component, so that students were working together to design, disassemble, reassemble, build, improve, and tinker with a variety of systems and machines (Figure 2).

The goals for these lessons were to instill in the students:

1. An understanding of the engineering design process.
2. Curiosity about the natural and mechanical world.
3. Experience working with tools to solve mechanical problems.
4. An understanding of the energy and resource needs of Rapa Nui.
5. Confidence in their ability to design and implement solutions to real-world problems.
6. Experience using mathematics to engineer solutions to real problems.



Figure 2. Students Tahira Tuki and Katalina Isla ignite a miniature hot-air balloon as part of a lesson on heat and pressure.

Beginning with the first project, which was to design and build paper airplanes, students worked to understand and implement the engineering design process (identify the problem, do background research, brainstorm possible solutions, choose a promising solution, build a prototype, test the prototype, redesign and improve the current iteration).

We talked extensively about the connections of the students' projects to Rapa Nui, and in particular about the energy and resource needs of the island. We visited the power plant run by SASIPA (www.sasipa.cl), where the plant's operators gave the students a tour of the facility's diesel generators (Figure 3). Students spent a half-day at the Museo Antropológico Padre Sebastián Englert (www.museorapanui.cl) in the museum's library doing research on the island's energy consumption, diesel generators, and alternative energy sources (e.g., wind power, solar power) in preparation for an afternoon debate between two groups of students on the energy future of the island.

Another project, motivated by the island's need for clean, fresh water, spanned two days and allowed groups of students to design and build a small-scale desalination system. Students initially developed and tested a prototype constructed from pie tins and plastic that used heat from the campfire at the communal campsite to convert salt water to fresh water. The teams then switched to a solar powered desalination design after testing revealed that the first apparatus did not stand up well to the heat of the fire.

After learning about different forms of energy and methods of converting energy from one form to another, each pair of students created hand-powered generators capable of lighting an LED bulb using a rotating magnet and a coil of copper wire. Students discussed the process (the changing magnetic field induces current in the copper coils). They then disassembled an old bicycle and attached it with a belt to an electric scooter motor so



Figure 3. TAO students visit the SASIPA power plant on Rapa Nui (left-to-right): Tahira Tuki, Tea Belen, Kamilha Haunani, Kiara Icka, Katalina Isla.

that pedaling the bicycle cranked the motor, generating even more current to power an incandescent bulb and an electric blender (and were rewarded for their hard work with pedal-powered smoothies, see Figure 4). The bicycle-powered generator that the students put together created electricity by a process fundamentally similar to that used by the diesel generators the students had seen in action in their tour of SASIPA, where burning diesel rather than human power was used to provide the energy to create the electricity. The amount of work required by the students to pedal the bicycle and power a single light bulb gave them a visceral sense of the sheer amount of energy, and diesel fuel, required to meet the island's power needs.

We discussed the principles by which wind generators operate, and students worked to understand the mathematical formula used to calculate their efficiency (see Figure 5). TAO students were also then able to calculate the velocity at the tips of the turbine's blades (over 100 mph for commercial wind turbines). Finally, the students used what they had learned about generating electricity from mechanical energy by using electromagnetic induction to design and build a prototype wind generator using only parts salvaged from the recycling yard on the island (see Figures 6 & 7). Students worked together to brainstorm and sketch a design for the prototype, cut turbine blades from a salvaged plastic tub, connected a gearbox from an old washing machine to a motor from another old washing machine using a belt taken from an abandoned car, and mounted the entire apparatus on a plank of

scrap wood. As they found with the scooter motor in the bicycle generator project, the motor serves as a generator when an external power source – in this case the wind – is used to turn the crank. The resulting machine was not able to produce electricity using wind power alone (the size and strength of the turbine blades was not sufficient for the amount of wind at ground level), but it was successful in the more limited sense that it did produce electricity when the turbine was turned by hand, and with more time the students could have succeeded in building a working wind generator.

Reflection

Our goals in developing an engineering component to the TAO program were to introduce high school students on Rapa Nui to the engineering design process, to allow these students to participate actively in exploring science and technology, and to encourage them to think deeply about the island's energy needs and natural resources. Our belief going into this project was that these goals were closely aligned with the longstanding mission of TAO to promote education, outreach, and conservation on Rapa Nui.

The seven students who elected to participate in the engineering program ranged in age from 14 to 19 years old, and included five girls and two boys. To assess the success of the engineering curriculum, we administered an evaluation quiz as a pre-test on the first day of the program, and had the students answer the same questions on the final day, after two weeks of



Figure 4. Engineering instructor Matt Petney helps students Tahira Tuki and Eduardo Arancibio in the assembly of the bicycle generator.



Figure 5. Student Akivi Nahoe (right) works with instructor Omar Monares to assemble and test different blade designs with model wind turbine kits.



Figure 6. Student Kamilha Haunani at work in the construction phase of the wind turbine project.



Figure 7. The wind turbine designed and assembled entirely from recycled materials by TAO students.

working with their peers and the engineering program staff. All seven of the engineering students saw their scores improve on the post-test relative to the pre-test, and their feedback on the anonymous evaluation form we collected from each of them about the engineering program was overwhelmingly positive. Students cited the projects they worked on, the evening talks, the excursions, and the time they spent making new friends as positive aspects of the program, and all seven students indicated that they would like to come back next year if they had the opportunity. We found the engineering curriculum to be an ideal complement to the traditional archaeology curriculum, and that students benefited greatly from an immersive experience working on hands-on engineering projects while exploring the island's natural and cultural resources in excursions.

Acknowledgments

TAO 2015 was truly a community effort. Many individuals on the island, including staff at Explora, the Museo Antropológico Padre Sebastián Englert,

SASIPA, and Rapa Nui's recycling yard, contributed their time to the program. We had a number of excellent guest speakers – see “Terevaka Archaeological Outreach (TAO) 2015 field report: Archaeology, conservation, and toponymy” in this issue of the *Rapa Nui Journal* for a list – who volunteered to give evening lectures, and more than sixty members of the community attended the students' final presentation at Explora. The Arizona Wind for Schools program and KidWind donated equipment, and the Center for International Education at Northern Arizona University provided scholarships that were used to purchase the remaining materials for the engineering projects. Mount Holyoke College provided funding to offset expenses of program interns Julia Godinez and Erin Mullin. Marae Cabañas donated the bicycle for the bicycle generator project; the recycling yard allowed us free access to any old equipment we could find; and Explora provided meals, transportation, accommodations, and a venue for the final presentation.