Oh, The Places You'll Go… To Do Science with ROAVEE

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Target Grade: 10th-12th, STEM and Engineering

Time Required: 6-12 weeks project

- This lesson is a project that the students will most likely work on outside of the classroom. The teacher may choose how much class time to devote to project work and how long the project will last during the semester.

Standards

Next Generation Science Standards (NGSS):

- HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Lesson Objectives

Students will be able to:

- Use a systematic approach to answer scientific and investigative questions.
- Work collaboratively to design a vehicle that can be maneuvered and navigated through remote operation on land and water.
- Analyze the effectiveness of a design and refine the design to optimize functionality.
- Apply their design to solve a real-world problem.

Central Focus

Over the course of many weeks, students will create a Remotely Operated Amphibious Vehicle for Environmental Exploration (ROAVEE) by utilizing the engineering design process. During this project, students will collaborate on a design and create a product to test. Each group will be assigned a different section of the engineering design process for the ROAVEE. The class will test the final product and collect and analyze data in multiple environments.

Key Terms: engineering, groups, developing, 3D printing, robotics, physics, CAD, project, makerspace

Background Information

Students will be broken up into 5 teams, each with unique responsibilities in the design process. This project will be completed mostly outside of the classroom. The team's work happens chronologically, and each team cannot start work until the team before is finished. Thus, the teacher can assign groups based on the students' schedules if necessary. The teacher can also implement benchmarks for each group to achieve to ensure that the work is getting done on time.

Students must be familiar with the following before completing this project:

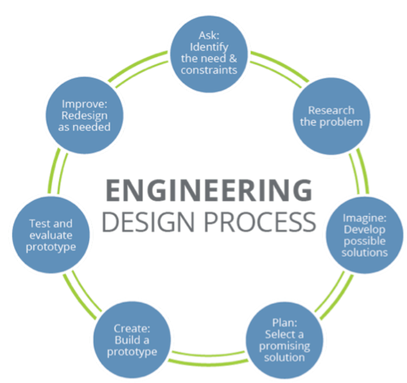
- Creating CAD files or other files for a 3D printer
- Using 3D printers
- Using Vernier lab tools
- Basic principles of physics to aid in the design of the vehicle

The teacher must also have knowledge of using 3D printers and all lab tools. The teacher should also familiarize themselves with the materials in the VEX Robotics kit. Since the students must use this kit, it may be a good idea to go through the contents of the kit with the students to familiarize them with their available supplies.

The teacher should know how UV radiation and pH levels correspond to air and water quality:

- pH refers to the acidity levels of the water. A pH score of 0-6 is acidic, 7 is neutral, and 8-14 is basic. Water with a pH of less than 6.5 may be contaminated with pollutants and is unsafe to drink.
- Lower amounts of UV radiation in the air can indicate lower air quality since air pollution reduces UV radiation in the atmosphere.
- The teacher should emphasize that these measurements alone are not conclusive, but they can be indicators.

Students should be aware of the engineering design cycle prior to this lesson. These steps include the following: Define the Problem, Collect Information, Brainstorm Solutions, Develop a Solution, Build a Prototype, Present Your Ideas to Others for Feedback, Test and Redesign. The process is never truly complete, as there can always be additional improvement. Students also need to be aware of the safety precautions in using some of the makerspace materials. It is advisable that the teacher does not introduce new tools in this lesson, but instead uses only the tools students are familiar with already, as a safety precaution.



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Materials

- 3D Printer
- CAD software for STL files
- 2 Vernier LabQuest (2 devices)
- 2 Vernier water probes (pH sensor, temperature sensor)
- 2 Vernier air probes (radiation sensor)
- 1 VEX Robotics kit
- Common hand tools (e.g., hammer, screwdriver)
- Power tools (e.g., drill, power saw)
- *Dear Physics Students* letter
- *Objectives and Goals* handout
- Notebook
- Small Camera (about the size of a GoPro)

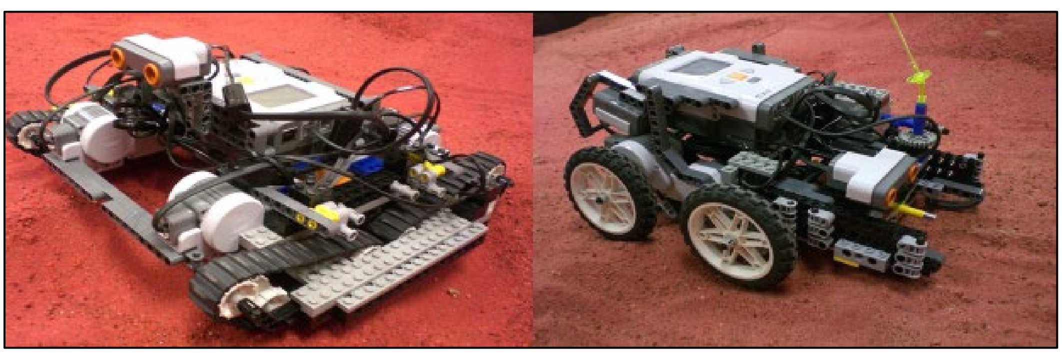
Instruction

Project Introduction

- Students will be placed in five small groups.
- Each group will be given the *Dear Physics Students* letter.
  - The letter will explain the problem, the task, and the goal of the ROAVEE machine.
  - Problem: They need a way to collect data from their Vernier LabQuest 2 in outside places they cannot physically reach to analyze air and water quality.
  - Task and goal: The students will be asked to design a ROAVEE to achieve the goal of taking measurements in outside environments that cannot be easily accessed by people.
- Ask students, "Why is it important to know our air and water quality?"
- Have half of the students research how UV radiation and temperature relate to air pollution. Have the other half research how pH levels and water temperature relate to water pollution. The class can then have a discussion about how these measurements can help them determine air and water quality.
  - Temperatures can be compared to average temperatures in years before.
  - UV radiation and pH can be compared to healthy levels.
- *Activity:*
  - Each group is responsible for a different section of the engineering design process. They will be given a description and a list of objectives they must complete:
  - The Vehicle Design group is responsible for the overall design of the vehicle, ensuring all the necessary features are present.
  - The Vehicle Modeling group will create computer files and 3D print any new parts necessary for the design.

  - The Vehicle Construction group is responsible for synthesizing the design and the materials into a working vehicle.
  - The Vehicle Testing group will perform tests to see if the vehicle is working appropriately and able to collect data. They must solve any remaining problems with the vehicle.
  - The Vehicle Data Analysis group is responsible for collecting and analyzing the data. The analysis must include graphs and a determination of the accuracy and significance of the data.
- As a class, the students will design a ROAVEE that will accommodate two LabQuest 2 devices, 4 probes, and a camera.
  - One LabQuest 2 will collect data in the air on UV radiation. The other will collect data in water on pH and temperature.
  - Each group will be accountable for a different step of the engineering process.
- Students will be working on this project at different times. For example, the first two weeks the Vehicle Design team will be meeting and working. The next two weeks, the Vehicle Modeling team will meet, etc. This may require students to collaborate outside of the classroom.
- As part of the introduction, the teacher can show videos or photos of example ROAVEE machines to give the students an idea of what the final product can look like. Some example pictures are provided below. This ROAVEE is land-only, so the students should be reminded that their robot must travel over land and water.

Examples of a ROAVEE machine (from Mission to Mars):



Design and testing process:

- The students can have both in and out of class time to work on their project.
- Throughout the students' design process, they should keep a detailed log of any meeting, communication, or development within their group in their lab journals.
  - All entries must include date, time, team members present, length of meeting, and a detailed description of what was discussed and any progress.

- The student's log should also include any questions the student might have throughout the design and testing process.
- Have each group give a progress report to their class once they have made some headway on their portion of the project. For instance, if each group gets 2 weeks to complete their parts, have them do the progress report after week 1.
  - The progress reports will keep the entire class informed about each group's work and help create cohesion across the groups.
  - Other students can give input and potential ideas for their classmates' work.
- Once the students have finished their portion of the project, they will give a final report in their presentation about their work to the class, and they will write a short summary of what they learned and how their group completed their assigned responsibilities.

Project Closure:

- Have the whole class respond to the following prompts to reflect on the project and then lead a class discussion about their responses:
  - What is one thing you will remember from this project?
  - What was the most difficult part of this project?
  - How did you overcome a challenge during this project?
  - How could this project be used to improve the lives of your community?
  - What other data could be used to better understand air and water quality?

Differentiation

- Students with disabilities
  - Students may use speech-to-text technologies throughout this lesson to record their ideas.
  - Multiple means of representation are available during this project, including drawings, writing, and discussions.
  - Students may complete the final reflection in different forms: writing, video, presentation, etc.
  - Students can choose to type notes on Word or Google doc instead of a notebook to provide multiple students access to the document at any time.
- English Language Learners
  - Students may use online translation technology throughout the lesson.
  - Provide students with articles and worksheets in their L1.
  - Provide students with vocabulary sheets.
  - Group students with peers who are familiar with supporting them.
- Advanced Learners
  - Task these students with the responsibility of sharing any important information from their group with the other groups.

- Have these students research methods of improving their design.
- Ask these students to reflect on ways to improve their vehicle in the reflection or what they would do differently.

Assessment

Formative assessment:

- The teacher will monitor each group to ensure progress towards established goals and objectives.
- The teacher will review the journal logs of each group on a weekly basis to assess progress.
- *Progress report*

Summative assessment:

- Students will write a review and score each group member on a scale 1-10 for effort and involvement. This will assess individual participation within each group.
- Final presentation of teamwork.
- The teacher will use the student's final reflection discussion to assess the students' final understanding of the project.

Oh, the places you'll go…with ROAVEE!

Dear Students,

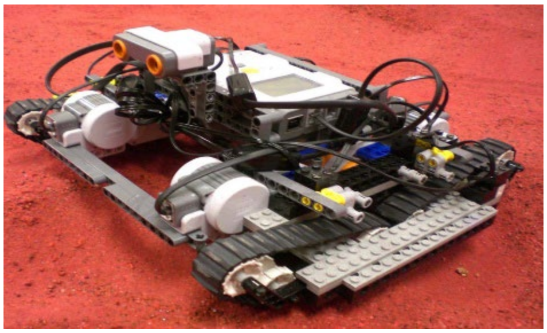
Welcome to your ROAVEE design project. As you read the title, you probably saw something very familiar but are wondering what this has to do with a Physics project. If you are one of the miniscule number of kids who have not had the pleasure of reading the Dr. Seuss classic book, *Oh, The Places You'll Go!*, let me explain the connection between the book and this project. Books by Dr. Seuss have become time-tested literary treasures that have impacted generations upon generations of children. Why is this the case? Well, even though he uses comical characters and language that is yuzz-a-ma-tuzz, diffendoofer and well, sometimes, murky-mooshy, Dr. Seuss's books tap into a child's inherent yet vitally important sense of curiosity, inquiry, adventure and a can-do belief – qualities that will also be critical to your success in this project.

I am sure that there are probably three questions you are anxious to ask. The first question is, **where are the places I will go to do science?** In short, you will go to a lab, but not the lab in the classroom, rather the lab outside. Wait, we don't have a lab outside! If we did, **why do we have to stay inside rooms to do our labs**? The lab outside that I am referring to is not technically a lab but it is definitely a place where science can be done. I am talking about the outdoors, the environment. From the air that we breathe, to the water that we drink, and the soil that we plant seeds, science is everywhere and waiting to be explored which leads me to the second question: **Why are we being assigned a special project to conduct science outside?** While it is true that we could take something as simple as a Vernier LabQuest 2 equipped with a host of probes outside to explore the environment around us, how exactly would you collect data in the middle of a lake, or in a drainage tunnel, or perhaps in an area that is hard for a person to access? This is where ROAVEE comes in. ROAVEE is an acronym that stands for **Remotely Operated Amphibious Vehicle for Environmental Exploration**. ROAVEE will make it possible for us to make these measurements in areas that are not easily accessible. ROAVEE is a vehicle that will be able to navigate terrain AND be able to reach the middle of a lake – hence the term Amphibious.

What will we have access to for constructing ROAVEE? You will have everything you will need to construct the robotic vehicle in the VEX Robotics kit and all of the additional mechanical and electrical components you will need. Using the kit and available components, you, working in five small groups, will work on specific aspects of the engineering process to develop and create ROAVEE. ROAVEE will be designed to accommodate two LabQuest 2 devices – one LabQuest 2 equipped with two sensor probes directed upward to collect data in air on UV

B radiation and relative humidity and a second LabQuest 2 with two sensor probes directed downward to collect data in water on pH and temperature. In addition, a camera will be mounted on the vehicle to provide real-time video footage of each expedition.

Five separate groups will be formed with each group working on a specific aspect of development of ROAVEE. These groups are Vehicle Design, Vehicle Modeling, Vehicle Construction, Vehicle Testing, and Vehicle Data Analysis. To give you a general idea on how to proceed, the photo on the left is an example of a past project. The project was entitled Mission to Mars in which students had to construct a Mars Rover using Legos to navigate across a Martian terrain. The class will have a total of 6 weeks to fully complete this project. Refer to the *ROAVEE Design Team Goals and Objectives Sheet* to see your individual group's goals and objectives. Let's begin designing!



ROAVEE DESIGN TEAM

Goals and Objectives Sheet

VEHICLE DESIGN

Your group is responsible for designing the vehicle and incorporating the necessary features.

- ☐ Ensure unimpeded motion on terrain while maintaining center of balance.
- ☐ Ensure uniform flotation and navigation in water.
- ☐ Ensure accommodations for both land and water navigation.
- ☐ Ensure IR sensors are positioned to be remotely controlled and can contact both air and water.
- ☐ Apply a housing unit that will protect the experimental equipment from the elements.

VEHICLE MODELING

Your group will take the information from Vehicle Design and develop a design of a working prototype.

- ☐ Ensure all major components/aspects of the vehicle are connected such that the land and water navigation is a working unit.
- ☐ Develop a blueprint design that demonstrates the working operation of all components of ROAVEE.
- ☐ Create CAD files for any new parts and 3D print these components.

VEHICLE CONSTRUCTION

Using the prototype, your group will bring the vehicle to life.

- ☐ Ensure your group has all equipment and parts needed for construction.
- ☐ Ensure all parts are safely cut and sized.
- ☐ Design a platform that allows for efficient collection and visualization of data.
- ☐ Ensure all mass, size, and dimension measurements are appropriate for operation.
- ☐ Construct the vehicle.

VEHICLE TESTING

Your group will perform multiple test on the vehicle to determine its efficiency on both land and water.

- ☐ Design and perform different tests for the vehicle.
- ☐ Identify and document all tests' success/failure.
- ☐ Address each failure and what may have caused it.

VEHICLE DATA ANALYSIS

After successful testing of the prototype, your group will construct three full-scale missions.

- ☐ Determine how easy it is for all 4 probes to take measurements.
- ☐ Develop graphs for each data set.
- ☐ Collect and report both raw and processed data.