# Build That ROV: A Planning Guide for Teachers

ROVs: Experience. Explore. Educate.

| **Grade**: 3-5 | **Subject area:** STEM |
|---|---|
| Objectives<br>Students will be able to:<br>● Understand and apply design thinking principles<br>● Design and build an ROV in teams<br>● Design a research project using the ROV | |

## Curriculum and Standards

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|---|---|
| **Ocean Literacy Principles** | Principle #7: The ocean is largely unexplored. (see framework for this principle)<br>● 7b. Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes.<br>● 7d. New technologies, sensors and tools are expanding our ability to explore the ocean system. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.<br>● 7f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, meteorologists, physicists, animators and illustrators. And these interactions foster new ideas and new perspectives for inquiries. |
| **United Nations Sustainable Development Goal** | Goal 14: Conserve and sustainably use the oceans, seas, and marine resources.<br>● Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries |

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<tr><td>Finland National Curriculum</td><td colspan="3">O7 to guide the pupil to understand the use, significance and operating principles of technological applications in daily life and to inspire the pupils to experiment, invent and be creative together.<br>O4 to encourage the pupil to formulate questions on various topics and to use them as the basis for research and other activities<br>O5 to guide the pupil to plan and carry out small-scale research projects and to make observations and take measurements in versatile learning environments using different senses and research and measuring equipment<br>O6 to guide the pupil to recognise causal relationships, to make conclusions on his or her results, and to present the resilts and research in different ways.</td></tr>
<tr><td>Transversal Competencies</td><td colspan="3">Primary (to be formally assessed):<br>T1: Thinking and learning to learn<br>T4: Multiliteracy<br>T5: ICT Competence<br>Secondary (to be informally assessed):<br>T2: Cultural competence, interaction, self expression<br>T6: Working life competence and entrepreneurship</td></tr>
<tr><td rowspan="2">NGSS (Next Generation Science Standards)</td><td colspan="3">Performance Expectation<br>3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.<br>3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.<br>3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.</td></tr>
<tr><td>Disciplinary Core Idea(s)<ul><li>ETS1.A: Defining and Delimiting Engineering Problems</li><li>ETS1.B: Developing Possible Solutions</li><li>ETS1.C: Optimizing the Design Solution</li></ul></td><td>Science and Engineering Practices<ul><li>Asking Questions and Defining Problems</li><li>Planning and Carrying Out Investigations</li><li>Constructing Explanations and Designing Solutions</li></ul></td><td>Crosscutting Concept(s)<ul><li>Influence of Engineering, Technology, and Science on Society and the Natural World</li></ul></td></tr>
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<tr><td></td><td colspan="2">Suggested NGSS (see below for connections to Finland's curriculum):<br>Grade 3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.<br>Grade 4: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. OR Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.</td></tr>
<tr><td>CCSS (Common Core State Standards)</td><td>Suggested ELA-Literacy<br><br>Grade 3 & 4:<br><br>Research to Build and Present Knowledge<br>● Various standards from this thread can be used to meet the needs of your project</td><td>Suggested Common Core Math<br>Grade 3:<br>● Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects.<br><br>Grade 4:<br>● Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.<br>● Represent and interpret data.<br>● Geometric measurement: understand concepts of angle and measure angles.<br>Mathematical Practices (Grades 3-4):<br>1. Make sense of problems and persevere in solving them.<br>2. Reason abstractly and quantitatively.<br>3. Construct viable arguments and critique the reasoning of others.<br>4. Model with mathematics.</td></tr>
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## Vocabulary and Skills

| Key Terms | | | Key Skills |
|---|---|---|---|
| **ROV Component Terms** | | **ROV Science Concepts** | observation |
| ROV (remotely operated vehicle) | ballast weights | Buoyancy | inference |
| thruster | controller | Newton's 3rd Law of Motion | |
| propeller | | Center of gravity | |
| motor | | Circuits (grade 4) | |
| frame | | Energy conservation (grade 4) | |
| Key terms and skills can be further defined/modified based on specific objectives of the unit and age level of students. The above terms and skills are important for the building and understanding of ROVs, and adapted for grades 3-4. | | | |

**Teacher Background Information: 5E Model**

The 5E model is a constructivist learning cycle that allows creativity and innovation in its structure. It has been chosen as the format for this unit because it offers teachers opportunities to tailor the lesson further to best meet the needs of their students, depending on their background in inquiry learning. The lessons and activities in each of these sections will use a variety of strategies and components of design thinking, project-based learning, and STEM.

The 5E model consists of 5 stages: Engage, Explore, Explain, Elaborate/Extend, and Evaluate.

In the **Engage** stage, the goal is to capture student interest and engage them in the learning that is about to take place. In this stage, you can learn any prior knowledge or misconceptions the students have. There are many different strategies to use in the Engage phase, and it is best to choose an activity to best meet the needs of your students and project.

The next stage, **Explore**, students are exposed to a variety of exploratory, hands-on activities where they can begin to construct their knowledge about the topic. Examples of activities in this stage could include building models, collecting data, and testing ideas.

In **Explain**, students can begin to verbalize their understanding and demonstrate newly learned skills. Additionally, teachers can introduce formal vocabulary, concepts, and skills.

In **Elaborate/Extend**, students begin to construct their knowledge based on their learning in the initial stages. Here they clarify concepts, clear up any misconceptions, and connect learning to experiences from the Engage and Explore stages.
Finally, in the **Evaluate** stage, the instructor evaluates student understanding and proficiency of the concepts explored. Students can also evaluate their own learning. Both formal and informal assessment can be used.

Instructional designers often use the design process, A.D.D.I.E., in order to design their instruction. The stages, which align with the 5E model, include **Analyze, Design, Develop, Implement,** and **Evaluate.**

**Teacher Background Information: ROVs (remotely operated vehicles)**

ROV stands for remotely operated vehicle, and these robots have been used on land and underwater. There are several different types of underwater robotic technology being used around the world. Underwater ROVs are being used in many ways to learn about our oceans.

See “ROV Resources” to learn more about underwater remotely operated vehicles (ROVs) and their uses in oceanographic research. Teachers should use these links as well as their own local resources to learn about marine technology in their local area.

# Project ROV Unit Overview

**DRIVING QUESTION:** How can communities, both local and global, better understand underwater environments through the use of technology?
**SUPPORTING QUESTIONS:** Which communities will you focus on? What local underwater environment will you use? Why is it important to understand and share your understanding about underwater environments with others? How will you utilize underwater robots to guide your research?

This unit overview is written to align with the goals and objectives of Project ROV. Because the design process involves constant analysis and revision at each stage in the process, objectives and highlights have intentionally been left general and with room for additions as the project progresses. Because design thinking and PBL are most effective when tied to student interests, there is freedom in design of the unit plan provided the core objectives and driving questions are met.
This unit plan is a live document that will be updated with changes throughout the project. Teachers can also add comments or suggestions for revision.

ENGAGE/ANALYZE
Teachers: In this initial phase, you will engage your students in ROVs, underwater technology, and the underwater world. There are suggestions in the teacher's guide, however, keep in mind that in order to best engage students, this step should be relevant and tap into students' interests and background. Ideas and suggestions have been provided. Check with your local community for additional resources.

The objectives of the ENGAGE phase are as follows:

Teacher Objectives:

- Familiarize yourself with ROV building process and decide which resources and materials you will use to build ROVs with your students
- Engage students in the topics of the underwater world, research, and technology
- Guide students in understanding what ROVs are and how they are being used in underwater environments

Student objectives

- Explain what an ROV is
- Explain 2-3 ways ROVs are used in underwater environments
- Develop empathy for underwater environments
- Explain the importance of underwater technology
- Create a list of questions (using the QFT or another questioning technique) about ROVs and underwater environments

Additional Resources:

- Engaging students in scientific inquiry: Case studies (Teacher Resource A)
- Getting students to ask questions: QFT and Launch (Teacher Resource B)
- Focus: Using mind maps and timelines to focus students

EXPLORE/DESIGN

Teachers: In this phase, students will be planning the design of their ROVs, in addition to exploring research options when they have built the ROVs. It is important to explore the various types of research available for students, and guide them in designing their research projects.

The objectives of the EXPLORE phase are:

Teacher objectives:

- Be familiar with the design process for building/designing ROVs
- Be familiar with various techniques to help students ask lots of questions
- Be familiar with various types of research
- Guide students in asking lots of questions

Student objectives:

- Read and follow directions and parameters for building ROVs
- Plan a simple design for ROVs
- Draw multiple sketches with labels for ROVs
- Create a list of potential research questions for ROVs

Additional Resources

- Research: Using fieldwork and desk research, helping students understand the type of research

EXPLAIN/DEVELOP

One of the main goals of Project ROV is that it is student driven. By helping students in fine tuning their research questions, you can have a variety of types of research in your classroom. In this phase, students will also build, test, and evaluate the design of their ROVs. An optional extension is to have students design an ROV competition (see ROV resources).

The objectives for the EXPLAIN phase are:

Teacher objectives:

- Guide students in building ROVs
- Guide students in problems solving issues with ROVs
- Design a competition with students to use ROVs (optional)
- Explain the various types of research to students
- Guide students to choose their research questions and types of research
- Familiarize yourself with ways for students to organize their research

Student objectives:

- Build a working ROV
- Test the ROV underwater
- Problem-solve any challenges and take feedback about design from outside communities
- Design a competition with multiple events for your class to use your ROVs (optional)
- Decide on a specific research question for ROVs

Additional Resources

- ROV Resources (Appendix A)
- ROV Building Supplement (Appendix B)

ELABORATE/IMPLEMENT

By this phase, students are now familiar with their ROVs, how they work, and how ROVs are used in real-world oceanographic research. With the research questions they have selected in the previous phase, they will now design their research and decide how it will be shared with their global and local audiences. They will also decide if they will make any changes or modifications to their ROVs as relevant to their research topics.

The objectives for the ELABORATE phase are:

Teacher objectives:

- Guide students in designing and organizing their research
- Teach students about the various types of research
- Teach students about the various ways to share information
- Guide students in the design process to make any modifications to their ROVs

Student objectives:

- Create sketches and prototypes of modified ROV (if necessary)
- Explain how the ROV will be used in your research
- Design and implement research
- Plan how you will share your research and experiment with local and global communities

EVALUATE

Teachers: In this final stage, students will share their research and ROVs with both local and global communities. They will also self-evaluate and be evaluated by their peers and communities.

The objectives for the EVALUATE phase are:

Teachers:

- Guide students in developing ways to share their research with communities
- Develop, with students, a way for communities to provide feedback when reviewing projects
- Evaluate the design process for project ROV

Students:

- Design your sharing of research with local and global communities
- Share your research with local and global communities
- Evaluate your research and ROV design

Potential science standards to tie in with students as they build the ROVs:

| Grade level | NGSS Standard | Finnish Objective | Transversal Competency |
|---|---|---|---|
| 3 | Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. | O15 to guide the pupil in exploring nature, identifying organisms, and habitats, and thinking ecologically as well as to guide the pupil in understanding the structure, vital functions, and development of humans. | T1: Thinking and learning to learn |
| 3 | Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. | | |
| 4 | Apply scientific ideas to design, test, and refine a device that converts energy from one form to another | O17 to guide the pupil in exploring, describing and explaining physical phenomena in daily life, nature and technology and constructing an understanding of the law of conservation of energy | T1: Thinking and learning to learn |
| 4 | Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. (secondary) | | |

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| 4 | Analyze and interpret data from maps to describe patterns of Earth's features.<br>(secondary) | O16 to guide the pupil in geographical thinking, perceiving his/her own environment and the entire world, and practising his/her skills in using maps/other geomedia | T1: Thinking and learning to learn<br>T5: ICT competence |
| 3-5 | 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. | | T5: ICT competence |
| 3-5 | 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. | | T5: ICT competence |