SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Build a Submarine Part 4 **Grade 8 – Fluids**

Lesson Plan

Assessment	AFL, model, worksheet
Cross-curricular	

Big Ideas

- Fluids are an important component of many systems.
- Fluids have different properties that determine how they can be used.

Learning Goals

- Build a powered submarine.
- Understand how a submarine can use the properties of a fluid to propel itself through it.
- Figure out how to stabilize the submarine.

Specific Expectations:

2.1 follow established safety practices for using apparatus, tools, and materials
2.7 use appropriate science and technology vocabulary

Description:

This is **lesson four** in a five-lesson unit on fluids. The unit uses submarines as a framework on which to build knowledge and conduct experiments. This lesson focuses on building a second submarine that can propel itself.

Materials/Resources:

Build a Submarine Part 4 Experiment Worksheet, Reference Images
2L pop bottles (one per group)
Cordless drill with very small drill bit
Paper clips
Scissors (to cut through a plastic bottle)
Plastic beads
Rubber bands
Skewers or chopsticks (1 per group ideally)
Needle nose pliers (if possible)
Bottle caps with a hole drilled into them that just fits a paperclip

Safety Notes:

Be careful while cutting and drilling plastic bottles.

Introduction

Prep

- Teacher may want to drill a hole in each bottle cap and in the bottom of each bottle ahead of time, as this could be dangerous for students to do themselves.

Recap

- We built a submarine that can sink and rise.
- By adding or taking away air you change the buoyancy of the submarine.
- If you did not have a chance discuss the changing pressure with depth you can do so now as well:
- We can't take our submarine to greater depth but here is a fun video showing a diver doing exactly this: https://www.youtube.com/watch?v=cHf9eWRd_bc
- The submarine was not able to move forward/backward. How do subs move?

Today's project

- Submarines use propellers to move. The propeller could be powered by a diesel engine or atomic power (which heats up steam to drive turbine)
- We are going to modify our sub from yesterday (or build a new one) by adding our own engine. A rubber band!

Action

Building a Powered Submarine

Students build a powered submarine today. There are two options here. They can start from scratch with a new bottle or they can modify the submarine they built yesterday. We suggest they modify the existing sub to save on materials. We will need to move the location of the air hose however as we will attach the propeller to the cap of the bottle.

If you wish you can print the following instructions for students, as it is broadly what we are following for this activity and presents the construction in a nice graphic way: http://www.howtoons.com/?page_id=48.

Note: Their suggestion of adding a stabilizer is unnecessary as the bottle will never spin when it has enough weight inside to make it neutrally buoyant (if you don't use two knives it would be almost completely full of water).

- Drill a hole into plastic cap (or teacher may want to do this ahead of time for students). The hole should be just big enough that you can thread a paperclip through. Follow all safety procedures!
- Make the propeller:
    - Cut a 2L pop bottle in half (pinch a piece of it first to make it easier to cut).
    - Make a cut along each high and low ridge of the bottom of the bottle to within about 1'' of the centre.
    - Cut off every second "flap" you've created (see reference image).
    - Poke a hole into the centre of the propeller.
    - Straighten a paperclip and thread it through the bottle, a bead, and then the propeller.

    - Make a second hole in the propeller (off centre) and thread the paper clip through it (bend paper clip with needle nose pliers if necessary).
- Attach rubber band (your engine) inside submarine:
    - Drill a hole into the bottom of the bottle that will be your submarine.
    - Insert a half-straightened paper clip through the hole from the inside (tape the paper clip to a skewer). You should have a "hook" in the bottom of your bottle now. Bend the paperclip toward the bottle on the outside so it can't slide back in.
    - Hook a rubber band on the paper clip inside the bottle (tape one end of the rubber band to a skewer so it holds well). Stretch out the rubber band by pulling the skewer back out until you can hook it onto the paperclip that is attached to the cap (and propeller)
    - Screw on the cap.
- Buoyancy control:
    - Make a hole into the top of the bottle that just fits a straw/air hose (opposite where you already have two large holes for water to enter – if you are reusing the bottle from the last day).
    - Tape on the airline or straw so it is as watertight as possible and you can blow air into the bottle (or suck it out).
    - Make sure the sub is still weighted down with two knives inside the bottle. Otherwise, you won't be able to sink it.
    - Fill the bottle with an amount of water and submerge it. Adjust water level until the submarine is neutrally buoyant. You'll notice that without a weight inside you have to fill it almost to the brim.

Testing the submarine- surface then underwater.

- Surface test:
    - Wind up the propeller and hold it (it will take a lot of winding – you want it to actually move).
    - Place the submarine in your water tank.
    - Let go of propeller. What happens?
        - The sub should start moving. You MAY notice that the bottle also starts spinning a bit if you have NO weight inside.
        - Do real submarines have to worry about starting to spin? (Yes they do!)
            - Real submarines actually have a stabilizer attached to them. We have to make sure that it's easier for the propeller to spin rather than the sub itself!
- Underwater test:
    - Wind up propeller again and place the sub in the water
    - Suck out enough air to make the sub sink.
    - Release propeller. If it moves backwards try winding up the propeller in the opposite sense.
- Does the submarine move as well? (likely not – discuss that there is extra friction from the fluid surrounding the bottle. Water is a LOT denser than air – and you know that even in air you feel a lot of resistance when you go fast (e.g. driving a car or biking).

Consolidation/Extension

Discussion:

- What did we learn doing this experiment?
    - Propellers in water work just as they do in air. Each blade has a pitch (angle) that makes it push water behind it when it turns. This creates a forward (or backward) force.
    - The more dense a fluid is the greater the resistance it offers something that moves in it (the propeller for example spins much faster when you just let it go in the air, then underwater).
        - The water has higher VISCOSITY.
        - Its density is greater as it has more particles per given volume than air (particle theory of matter).
    - A propeller has to spin only fairly slowly compared to air to make an object move. This is because water, a liquid, is much less compressible than air, a gas. Due to this the water can't as easily "flow around" the blades as they sweep through – creating a much greater force at lower propeller speeds.