Plastic Seas
Nurdle Know-How
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The curriculum for EarthEcho Expedition: PlasticSeas was created by expedition fellows in collaboration with EarthEcho International. The STEM design challenges represent a compilation of experiences and materials gathered on this week-long journey that included a visit to Queenscliff Marine Discovery Centre on the edge of Swan Bay, an ecologically important wetland, a gull bolus dissection at Melbourne Zoo, and workshops at Sustainability Victoria, the government department tasked with making the Australian state of Victoria a more sustainable place. The “Nurdle Know-How” curricular guide was developed to teach middle school students about one of the many ways in which plastic pollution can end up in our rivers and oceans.

Students examine the nature of the problem and work collaboratively to create solutions to the issue of nurdles becoming evermore present in our oceans. Nurdles are small plastic resin pellets which are used to make many of the plastics we use everyday. Unfortunately, they end up where they are not supposed to and cause a wide range of problems. Nurdle Know-How is a series of activities that will ultimately prepare students to design and build a nurdle capture system to clean up their local bay, harbor, or coastal waters.

We have provided pre-design challenge activities so students have the knowledge base to understand the complexity of the problem and its impact on the environment. During EarthEcho Expedition: PlasticSeas, we took an in-depth look at the state of Melbourne Australia’s Port Phillip Bay. While every ecosystem has its unique concerns, the issue of marine pollution threatens coastal communities across the globe. This point was exemplified when Expedition Fellows conducted a microplastic audit with the staff from Port Phillip Ecocentre. Microplastics are what many plastic products break up into and often resemble the nurdles that they were originally made from.

Nurdles may be small individually, but in large numbers they cause large problems. This curricular guide empowers students to make a difference through following the Engineering Design process.
LEARNING OBJECTIVES

After completing this unit students will be able to:

a. Understand that nurdles are small plastic pellets made up of polymers that originate from crude oil.
b. Understand that nurdles are the starting material in plastics manufacturing.
c. Explain how nurdles get into the environment.
d. Discuss how nurdles impact the marine environment.
e. Explore how to separate nurdles from other materials.
f. Design and build a nurdle capture system which can:
   1. Remove nurdles from beach sand, or
   2. Stop nurdles from entering drains at plastic factory production sites, or
   3. Catch nurdles being discharged into a river or a creek before they enter the major waterways and get to the bay.
g. Prepare and deliver a pitch to a potential investor.

ENGINEERING CONNECTION

Nurdles are a real problem, though not one that most people are aware of. Manufacturers all around the world—thousands in just the USA and Australia—buy nurdles as a raw material to be melted down to manufacture a wide range of plastic products. Engineers are involved in all steps of the process from plastic product design, to materials management, to the actual manufacturing and distribution, as well as recycling of the product. The fact that nurdles are small and lightweight make them profitable for transportation, but easy to lose and really hard to clean up or track when spilled. Exploiting the differences between the properties of the pollutant and the environment is a key principle required to solve this challenging problem. Engineers around the world try and solve problems like this through a range of strategies, and an essential understanding for students is that solving it often requires a combination of several approaches and systems. The complexity of the nurdle challenge is a great introduction to the design thinking that engineers use to make the world a better place.

Image Reference:
STUDENT LOGBOOK

Throughout this process students will be required to keep a journal of their activities. Share the outline below with your students to have them create their logbook:

CONTENTS (Chapters 2-10)

1. TITLE PAGE (DESIGN YOUR OWN)
   - TEAM NAME
   - TEAM MEMBERS

2. WHAT ARE NURDLES?
   - Do you know? How did you find out? Fill in the table below:
     - PMI (PLUS-MINUS-INTERESTING)
     - Plus (How are they useful?)  Minus (Why are they a problem?)  Interesting (What else have you learned?)

3. BRAINSTORMING PAGE (THE WHAT-IF?)
   - How might the problem of nurdles in the environment be solved? What ideas do you have? Anything is possible...

4. DETAILED PLANNING PAGES (THE PLAN)
   - ...well, perhaps not everything! :) Write down your best SMART goal! Now plan your process carefully for the best possible result!

5. CONSTRUCTION NOTES (THE BUILD)
   - How will you go about putting it together? Who will be responsible for troubleshooting to ensure your build goes smoothly?

6. TESTING NOTES (THE PROTOTYPE)
   - Does it work? What problems have you encountered?

7. MODIFICATIONS AND REDESIGNS (THE TWEAK)
   - What needs to change?
   - How will you effect the change?
   - Does the change improve the model? If not,
   - Try again!
8. FINAL DESIGN (THE MODEL)
   • Sketch out or take a picture of your model and put it here for reference.

9. MARKETING PLAN (THE PITCH) Refer to the student worksheet.

10. REFLECTIONS (THE LEARNING JOURNEY)
    • Congratulations on all you have learned and created throughout this unit of work! It’s time now to pause and reflect: What has been the most enjoyable and inspiring aspect of this unit? How well did your group work as a team? Are there things you would do differently next time? How do you feel about what you have achieved individually? What have you learned from your failures and successes? Write away!

SMART Goals
Graphic Organizer

<table>
<thead>
<tr>
<th>Specific</th>
<th>What do you want to accomplish?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurable</td>
<td>How will you know when you have accomplished your goal?</td>
</tr>
<tr>
<td>Achievable</td>
<td>What steps must you take to accomplish this goal?</td>
</tr>
<tr>
<td>Relevant</td>
<td>What makes this goal worth accomplishing? How will accomplishing this goal help you? Explain.</td>
</tr>
<tr>
<td>Timely</td>
<td>When will the goal be accomplished or when will you check if you have accomplished your goal?</td>
</tr>
</tbody>
</table>
As part of the EarthEcho Expedition Fellows’ experience on Expedition: PlasticSeas, we visited St. Kilda beach in Victoria, Australia. It was in the morning and the beach had been raked just a few hours earlier, in order to remove any rubbish. The beach looked clean to the naked eye, however when we got down on our hands and knees and sifted through the sand we found many pieces of plastic and, more shockingly, a large number of nurdles. This finding inspired our group of teachers to find out more about nurdles - what they are, where they come from, and what we can do about them.

What is a nurdle?
A nurdle is a small, plastic pellet, which is used as the starting point to make the plastics that we use every day. Nurdles are made from petroleum products (oil). The nurdles are transported to factories where they are melted and then molded into the many different plastic products that we use. They can be 1mm - 5mm in size, about the same size as a lentil.

How do nurdles get into the ocean?
When being transported to the factory by truck, nurdles can spill and be lost to the environment. Nurdles can be lost at sea when being transported by container ships and enter the ocean environment. They can also enter the waterways from plastic factory runoff, going down drains into creeks and rivers and ultimately, ending up in the sea. They can be blown around by wind and moved by waves so that they wash up on beaches.

Why are nurdles an issue?
Marine animals often mistake nurdles as prey or as a source of food (they look an awful lot like fish eggs) and they will eat them. The animals fill their stomachs with these and other plastic products and can ultimately starve to death with a stomach full of plastic!

Nurdles are also harmful as they attract toxins to their surface. These are also ingested by the animals and can cause serious harm.

Nurdles will never break down completely - they will just break up into smaller and smaller pieces that are more and more easily ingested by many marine animals.
Nurdle Lesson References:

• **A great introductory video and lesson idea can be found here:** The nurdles quest for domination video [https://www.youtube.com/watch?v=KpVpJsDjWj8](https://www.youtube.com/watch?v=KpVpJsDjWj8) (4:54 duration)
• Full lesson ideas: [https://ed.ted.com/lessons/the-nurdles-quest-for-ocean-domination-kim-preshoff](https://ed.ted.com/lessons/the-nurdles-quest-for-ocean-domination-kim-preshoff)

Additional Nurdle Reference Websites:

• Boomerang Alliance: [https://www.boomerangalliance.org.au/nurdles](https://www.boomerangalliance.org.au/nurdles)
• News articles:
LESSON 1: NURDLES: WHERE ARE THEY? LITTER AUDIT

Time Requirements:
- Class discussions and web search: 30-50 mins
- Clean up and litter audit - within school grounds or local beach/river/wetland location. (1-3 hours depending on the location for the audit and any transit time required.)
- Reflection following the litter audit (30 mins-1hr)

Materials:
- Internet access
- Data collection sheets
- Containers, buckets, or bags
- Gloves and pick up tools

Begin with a general discussion of how much litter each person in the class generates on an average school day. Students can first make a personal list, then compare and tally with a small group, then with the class. Have students guess how many items of litter they might find in the school yard. Discuss the different ways litter is collected and disposed of in the community. What happens to the litter that isn’t collected? Explain that often we litter without realizing or noticing, and that this litter can float into the waterways and then to the ocean.

Introduce the various groups at work in the community that clean up the accidental litter. These may include: city councils, volunteer groups, Scouts, Sea Shepherd Marine Debris, etc.

Introduce one of the following websites:
Australian Teachers: (from https://www.tangaroablue.org/about-us/faq.html)

The Australian Marine Debris Initiative (AMDI) is a national network of over 40,000 volunteers and partners, coordinated by Tangaroa Blue Foundation, focused on reducing the amount of marine debris washing into our oceans.

The objectives of the Australian Marine Debris Initiative are:
- Removing marine debris from the marine environment.
- Ongoing monitoring programs.
- Collecting scientific data on the type of debris found.
- Tracking the debris back to the source wherever possible.
- Working with stakeholders to find strategies (Source Reduction Plans) to prevent marine debris occurring in the first place.
• Working with partners to divert marine debris, in particular plastics, from landfill.
• Providing education resources and presentations on the marine debris issue to increase understanding and awareness.

Schools in Australia can get involved in the AMDI by adopting a section of beach and committing to ongoing removal and monitoring of marine debris at this site. If your school wants to join the AMDI, they can provide you with beach clean-up materials and education resources to help with learning about marine debris and conducting an AMDI clean-up. You can also request a school visit for presentations, workshops and to support your school with beach clean-up events. Please let EarthEcho International know if you are planning a clean-up event to contribute to the AMDI Database at info@tangaroablue.org.

The AMDI Database is a great opportunity for students to collect, report, analyse and compare results of other clean-up sites over time. It is free to utilise once you have agreed to the data use agreement.

Find out here which schools are already involved in AMDI activities across Australia. On the Tangaroa Blue Foundation resources webpage you can find the following AMDI resources to help your school get involved:
• Marine Debris Education Kit
• Data Sheet for clean-ups
• Manual “How to run a beach clean-up”
• Identification manual for marine debris
• Fact sheets
• Previous reports
• Source Reduction Plan.

Below is an infographic of some of the data collected by Tangaroa Blue in Australia.
The data sheet can be accessed via the following link: https://www.tangaroablue.org/resources/data-sheet.html
Data can also be entered electronically on the the website: https://www.tangaroablue.org/database.html

If required, a modified data sheet can be used: https://docs.google.com/document/d/1l_cQgkixB4SO3-nHKs9ZsMmUxArAFwmE0cE30uAxDs/edit?usp=sharing

US Teachers:
(from https://oceanconservancy.org/trash-free-seas/international-coastal-cleanup/cleanswell/ )

**Real World Connections:** Expansion could include how the compiled data is being used in actual policy action to provide clear information about how plastics are impacting upon the environment. Interested students may choose to do further research into the reduction of plastic in the environment from various pressure groups (e.g. Plastic-free Victoria Alliance in Australia), work on legislative change at various levels in their state or nationally, or presentation of a litter reduction policy at their school.

**Litter Audit (1-3hrs)**
Have students choose a site around the school that needs a clean up, and decide on the boundaries. You will need to acquire permission from administration and parents, and ensure that safety measures are put in place. Students should be supplied with gloves and collection containers and follow any local guidelines. Clean Up Australia Day may supply bags and other support. You might also contact your local council or volunteer group to assist with running the event.
Prior to the clean up, students should become familiar with the data sheet and/or the database they will be using. Students should be put into teams with an adult (teacher or volunteer) and one person should be assigned the role of recorder, to tally the litter as it is collected.

Tangaroa Blue Foundation has many resources available to assist teachers in the carrying out of an audit.

Visit their page to find out about: https://www.tangaroablue.org/resources.html
- how to carry out an audit
- how to identify the items collected
- various education kits to support teachers

Clean Swell is an app that allows your students to track their own litter audit. Visit their page to find out about:
- how to carry out an audit
- how to identify the items collected
- various documents to support teachers, including pre, during, and post audit
https://oceanconservancy.org/trash-free-seas/international-coastal-cleanup/cleanswell/

After selecting a suitable site, within school grounds or local beach/river area, students can be divided up into groups for sampling.
- Ensure samples are randomly selected within the area to be audited

**Wrap Up**
Reflection upon audit. (30 minutes-1hr)
Following the litter audit take time to reflect with the students upon their findings. Students can use their audit sheets to help direct their reflection.

Possible guiding questions that could be used for individual and class reflections:
- Which type of litter was the most abundant?
- Which type of litter was the least abundant?
- What percentage of items were plastic in composition?
- Were there any patterns in the type and distribution of the litter that was collected?
- Did other groups see similar results? (if comparing different sites or if two or more classes involved on different days?) If using a site that has been used before what previous data exists? Are there any patterns?
- Were nurdles a common litter item? If so what percentage of the items were nurdles?
- What surprised you about the litter audit?
- What does the litter make you conclude about human behaviours and litter?
- What goals or future projects do you have now that you have recorded data for a particular site?
<table>
<thead>
<tr>
<th>Bolus ID Number:</th>
<th>Date:</th>
<th>Group Members:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Name of Bird species (if known)

Photo of specimen prior to dissection
(*include a ruler for scale when taking the photo*)

<table>
<thead>
<tr>
<th>Length of Bolus (mm)</th>
<th>Width of Bolus (mm)</th>
<th>Mass of Bolus (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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## Items found in Bird Bolus

<table>
<thead>
<tr>
<th>Natural Prey/Organic material</th>
<th>Overall Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Photo of Natural Prey/Organic Material</strong> (include a ruler for scale when taking the photo)</td>
<td></td>
</tr>
<tr>
<td><strong>Inorganic Material – recognizable plastics - i.e. bottle tops, toys, pegs</strong></td>
<td><strong>Inorganic Overall Mass</strong></td>
</tr>
<tr>
<td><strong>Photo of Inorganic Material</strong> (include a ruler for scale when taking the photo)</td>
<td></td>
</tr>
</tbody>
</table>
Plastic Fragments according to size: non-recognizable broken up plastics (place a count for each category)

<table>
<thead>
<tr>
<th>Size</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (&lt;10 mm)</td>
<td></td>
</tr>
<tr>
<td>Medium (&lt;20 mm, &gt; 10mm)</td>
<td></td>
</tr>
<tr>
<td>Large (&gt;20 mm, &lt;50 mm)</td>
<td></td>
</tr>
<tr>
<td>Extra Large (&gt;50 mm)</td>
<td></td>
</tr>
</tbody>
</table>

Plastic Fragments Overall Mass

Photo of Plastic Fragment Materials (include a ruler for scale when taking the photo)

Other Non-Natural Items – i.e fishing line, fishing hooks

Other Non-Natural Items Overall Mass

Photo of Non-Natural Items (include a ruler for scale when taking the photo)
<table>
<thead>
<tr>
<th>Totals</th>
<th>Mass</th>
<th>Total Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inorganic/Plastics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional Comments About the Dissection:
LESSON 2: CHEMISTRY OF NURDLES

Time requirements:
- Reading and discussion of text (20 - 25 min)
- Viewing video clips and discussion (20 - 25 mins)
- Hands-On Activity (20-25 mins)
- Quiz (5 mins)

Background
Nurdles are small plastic pellets that weigh approximately 20 milligrams each. They are the starting material in plastics manufacturing. A plastic water bottle is most likely to have started out as a collection of nurdles that is heated to become liquid and shaped into a hollow bottle using a technique called extrusion blow molding.

Nurdles themselves are composed of polymers, either polythene or polypropene. These polymers originate from crude oil or natural gas. Once crude oil is extracted from the ground it is piped and transported to a refinery where it undergoes fractional distillation. The collected fractions can be either used directly or processed further into petroleum products, such as polymers that make nurdles.

Fractions of crude oil are chemically known as hydrocarbons. Hydrocarbons are compounds containing the elements carbon and hydrogen only. Atoms of carbon and hydrogen combine through the sharing of their valence electrons to form covalent molecules. Ethene and propene are examples of hydrocarbons formed when certain fractions are subjected to a process called cracking. Cracking is used to convert larger, less useful, hydrocarbon molecules into smaller and more useful ones. Ethene and propene are two very important chemicals needed by the plastics industry. To convert ethene and propene monomers into polymers they undergo a process called addition polymerisation. In addition polymerisation, one of the covalent bonds in the double bond is broken and a new single covalent bond is formed, which links the monomers together to form a long chain polymer.

Drilling for Crude Oil and Natural Gas off shore and on shore drilling

Fractional Distillation separating the mixture of crude oil into similar sized molecules.

Cracking of larger fractions to make ethane and propene.

Polymerization of ethane and propane monomers to make the polymers: polyethane and polypropene.

Polymer pellets - nurdles - used in extrusion blow moulding to make plastic products.

Ethene monomers

\[ \text{Polymerisation} \]

Polythene Molecule

\[ \left( \begin{array}{c}
\text{CH}_2 \\
\text{CH}_2
\end{array} \right)_n \]

Polyethene polymer

Propene monomers

\[ \text{Propene} \]

\[ \left( \begin{array}{c}
\text{CH}_3 \\
\text{CH}_2
\end{array} \right)_n \]

Poly (Propene)

Polypropene polymer
Video Resources to show students (if desired).
1. Fractional Distillation:
   - https://www.youtube.com/watch?v=KCs1F_44dy4
   - https://www.youtube.com/watch?v=PYMWUz7TC3A&list=PLleayStacpLiiFyuo-IU3hB4mNsIairAj

2. Hydrocarbon Cracking:
   https://www.youtube.com/watch?v=Xsqlv4rWnEg

3. Polymerisation of ethene:
   https://www.youtube.com/watch?v=sk6h4oaArE0

4. Polymerisation of propene and chloroethene:
   https://www.youtube.com/watch?v=nz1ucI6gCIg

5. Plastic processing overview:
   https://www.youtube.com/watch?v=qn16JtE_vLc

**A Practical Activity: **Modeling addition polymerization using plasticine.

**Objective:**
This activity is hands-on and allows students to use simple models to show their understanding of how ethene undergoes addition polymerization to form chains of polythene. Students could use Claymation/Movie software to create a motion picture that show how ethene monomers join to form the polyethene polymer chains.

**Materials:**
Modeling clay (black for carbon, white for hydrogen)
Toothpicks

**Safety:**
Modeling clay should not be ingested. Toothpicks have sharp ends and can be blunted.

**Method:**
1. Roll black clay into 8 balls (approx. 3 cm diameter). These represent carbon atoms.
2. Roll white clay into 16 balls (approx. 1.5 cm diameter). These represent hydrogen atoms.
3. Insert 2 toothpicks parallel between two carbon atoms. Each toothpick represents a covalent bond.
4. Insert 2 toothpicks in opposite directions on each carbon atom (add the hydrogen atoms on the ends of the second set of toothpicks)
5. Figure 1. The structure of ethene monomers.

6. Figure 2. This image shows that the double bond breaks. The two covalent bonds that make the double bond are not equal in strength. The weaker of the two (the pi bond) breaks and the stronger covalent bond (the sigma bond) remains attached between the two carbon atoms. The monomers are referred to as Intermediates in this phase.

7. Figure 3. In addition polymerization a new single covalent bond forms between the carbon atoms of neighboring monomers.

8. Figure 4. The length of the polyethene chain is variable and is stopped when end groups (or terminal groups) are added. These are shown as brown colored balls. The terminal group is selected from a number of different atoms.

9. Students could move their respective polymer chains closer together and parallel to each to illustrate a model of High Density Polyethene (HDPE).
LESSON 3: NURDLE CAPTURE DEVICE STEM CHALLENGE

Engineering Design Process

STEP 1
INVESTIGATE: Identify the Problem

STEP 2
INVESTIGATE: Identify Criteria and Constraints

STEP 3
PREPARE: Possible Solutions and Generate Ideas

STEP 4
PREPARE: Research the Possibilities

STEP 5
PREPARE: Select an Approach/Prototype/Solution

STEP 6
ACT: Build a Model or Prototype

STEP 7
REFLECT: Refine the Design

STEP 8
DEMONSTRATE: Share with Others and Community
Primary Engineering Objectives of Nurdle Know-How Lesson:
The concept of this STEM challenge is to use the design process to engineer a nurdle capture system which can do one of 3 things:

1. Remove nurdles from beach sand, or
2. Stop nurdles from entering drains from plastic factory production sites, or
3. Catch nurdles being discharged into a river or a creek before they enter the major waterways and get to the ocean

Materials:
• Recycled or repurposed materials work best here. They can be provided by either teacher or students. Creativity with purpose is the focus.
  • Examples: Netting from citrus, gripper mats, placemats, woven baskets, fabric (different types), fly screen, tulle, beach toys, etc.
• Packaged nurdles can be purchased at craft supply stores to investigate in class
• Sand for beach groups
• Plastic storage bins for river groups
• Student handouts

Lesson Notes for Teacher:
• Possible student design outcomes for reference: it could be anticipated that students will create a vacuum to clean the floor, a net to clean the water, and a sieve to clean the sand. Creativity is key!
• Safety concerns - Make sure no loose nurdles escape!
Nurdles are small plastic pellets which are used in the manufacturing of plastic products. However, sometimes they are mishandled and create litter with specific environmental challenges. Their small size makes them easier to re-shape into new products, but makes them difficult to clean up.

What if they spilled...
- On a concrete floor?
- In the water (river or bay)?
- Or washed up on the beach?

**TASK:** Design a nurdle catcher to work in one of the situations listed above

**Pre-investigation** - Students will explore the characteristics of plastic resin pellets. This can be structured or semi-structured as students explore the density, size, shape, buoyancy, solubility, etc. of the pellets.

**Materials** - Recycled or repurposed materials work best here. They can be provided by either teacher or students. Creativity with purpose is the focus. *Netting from citrus, gripper mats, placemats, woven baskets, fabric (different types), fly screen, tulle, and beach toys are all possibilities.*

**Design Cycle** - There are many interpretations of the design cycle in various degrees of complexity. The design cycle below features most of the steps of the EarthEcho cycle in a simplified manner.
Design Cycle:

- **Plan** Consider the properties of the nurdles and how you will separate them. Identify the chosen context and any environmental factors. Describe and draw the planned gadget.
- **Build** your prototype. Keep a logbook of problems & solutions, possible challenges, great ideas, and extensions.
- **Test** your device. Does it do what it should do? How well does it meet the criteria listed below? How could it improve?
- **Evaluate** Report on your project (and evaluate at least one other).

**Criteria**

- Your gadget should be effective (does it do the job intended?)
- Your gadget should be efficient (quick). Does it take 10 minutes to get each nurdle?
- Your gadget should be scalable (The prototype will be small, but could it be bigger to deal with bigger areas?)
- Your gadget should be durable (Is it reliable or does it break easily or require frequent repairs?)
- Your gadget should be sustainable (Can you make it out of recycled or repurposed materials?)
- Your gadget should cause minimal disruption to the environment.

**Rubric & Gadget Testing**

**SCENARIO 1: Beach setting** Each group is given 1/4 of playground sand and one tablespoon of nurdle, mixed together. In one minute, and using their device (not picking them out), how many did they extract?

**SCENARIO 2: River setting** Each group is given a plastic storage bin with water and one tablespoon of nurdles. In one minute, and using their device (not picking them out), how many did they extract?

**SCENARIO 3: Concrete floor setting** (if a group has chosen this). Each group is given an area of concrete floor taped off in a one square meter area. One tablespoon of nurdles is dispersed on the area. In one minute, and using their device (not picking them up), how many did they extract?

**NOTE:** Each of these tasks can be differentiated by adding other non-desirable media to the mix, i.e., put shells in with the sand, gel beads in the water, or sawdust on the concrete floor. It becomes a more difficult and selective task to get the nurdle, not the other items.
### SELF-ASSESSMENT RUBRIC

<table>
<thead>
<tr>
<th></th>
<th>Innovation Expert</th>
<th>Sustainability Superstar</th>
<th>Environment Apprentice</th>
<th>Eco Guard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effectiveness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>How many of the nurdles did you extract?</em></td>
<td>100% (almost all)</td>
<td>90% (almost all)</td>
<td>60% most</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>They are elusive!</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>How quick was it?</em></td>
<td>Really quick, with extra time</td>
<td>Medium</td>
<td>Slow</td>
<td>Very slow!</td>
</tr>
<tr>
<td><strong>Scalable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Could you make your prototype in a bigger size?</em></td>
<td>Easy</td>
<td>Maybe</td>
<td>Possible</td>
<td>One of a kind</td>
</tr>
<tr>
<td><strong>Durable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Did it require fixing or adjusting during the test?</em></td>
<td>Minor adjustments to improve</td>
<td>Some medium repairs required</td>
<td>Major repairs/rebuild but it held</td>
<td>Major repairs/rebuild but we kept at it!</td>
</tr>
<tr>
<td><strong>Recycled materials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Is it created with recycled/repurposed materials</em></td>
<td>Entirely</td>
<td>Mostly</td>
<td>Some recycled materials</td>
<td>Didn’t use any</td>
</tr>
<tr>
<td><strong>Minimal disruption</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Did your device work with minimal disruption to the surrounding?</em></td>
<td>Completely undisturbed</td>
<td>Some disturbances required a little extra effort</td>
<td>Clean, but no major upheaval</td>
<td>Major upheaval</td>
</tr>
</tbody>
</table>
**Strengths & Weaknesses**
Student can self-evaluate and peer evaluate with the rubric above. This will highlight the strengths and weaknesses of their design.

**Extension Thinking Questions**
1. On the factory concrete floor - will the reclaimed nurdles be reusable, or are they excessively dirty? Could they be reused and not wasted?
2. In the water - will your nurdle net be harmful to fish? Could you make it fish-friendly?
3. At the beach - What if the beach is sandy or rocky? Will your gadget work on any beach strata?
4. Could it be autonomous? What challenges would there be and how will you overcome these?
Use the rubric below to assess the overall unit of work on nurdles, or modify a criteria to assess one component/lesson of the nurdle unit.

<p>| NURDLE CAPTURE CHALLENGE TEACHER ASSESSMENT RUBRIC |
|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| <strong>Above standard</strong>                            | <strong>At standard</strong>                               | <strong>Below standard</strong>                              | <strong>Well below Standard</strong>                                        |
| <strong>Nurdle Knowledge</strong>                         | Explanations by all group members indicate a clear and accurate understanding of the properties of nurdles and the environmental impacts they cause. | Explanations by all group members indicate a relatively accurate understanding of the properties of nurdles and the environmental impacts they cause. | Explanations by several members of the group do not illustrate much understanding of the properties of nurdles and the environmental impacts they cause. |
| <strong>Brainstorming – Problems and Solutions</strong>   | Students identify more than 4 barriers/problems that need to be overcome and suggest reasonable, insightful solutions. | Students identify at least 4 barriers/problems that need to be overcome and suggest reasonable, insightful solutions. | Students identify fewer than 3 barriers/problems that need to be overcome and suggest some insightful solutions. |
| <strong>Design Plan</strong>                               | Plan is detailed with clear measurements and labelling for all components, with reference to chosen context. | Plan is neat with clear measurements and labelling for most components, with reference to chosen context. | Plan does not show measurements clearly or is otherwise inadequately labelled, does not reference chosen context. |
| <strong>Construction/Modification of Prototype</strong>    | Appropriate materials were selected. Clear evidence of troubleshooting, testing, and refinements based scientific principles. | Appropriate materials were selected. Clear evidence of troubleshooting, testing, and refinements. | Inappropriate materials were selected. Little evidence of troubleshooting, testing, or refinement. |</p>
<table>
<thead>
<tr>
<th>Function of Prototype</th>
<th>Prototype functions extraordinarily well, removing all nurdles and causing minimal disruption to the environment.</th>
<th>Structure functions well, removing most nurdles and causing minimal disruption to the environment.</th>
<th>Structure functions pretty well, removing some nurdles, causing minimal disruption to the environment, but deteriorates under stress.</th>
<th>Fatal flaws in function, failure to remove nurdles, and causing some disruption to the environment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logbook</td>
<td>Logbook provides a complete record of planning, construction, testing, modifications, reasons for changes. Self evaluation rubric completed with reflection on strengths and weaknesses.</td>
<td>Logbook provides a complete record of planning, construction, testing, modifications and reasons for modifications. Self evaluation rubric completed with some reflection included.</td>
<td>Logbook provides quite a bit of detail about planning, construction, testing, modifications, and reasons for modifications. Self evaluation rubric completed.</td>
<td>Logbook provides very little detail about several aspects of the planning, construction, and testing process. Incomplete self evaluation rubric.</td>
</tr>
<tr>
<td>Presentation/ Pitch</td>
<td>Team gave a strong presentation of its solution to the challenge and showed clear understanding of the science concepts and design process, with precision and efficiency as the goal of their nurdle capture system.</td>
<td>Team gave a good presentation of its solution to the challenge and showed some understanding of the science concepts and design process, with precision and efficiency as main goals of their nurdle capture system.</td>
<td>Team gave a basic presentation of its solution to the challenge and showed a basic understanding of precision and efficiency as goals in the creation of the nurdle capture system.</td>
<td>Team gave a weak presentation of its solution to the challenge and showed little understanding of a precise and efficient nurdle capture system.</td>
</tr>
<tr>
<td>Working with Others</td>
<td>Worked well together. All team members shared ideas and stayed on task. Group did not have to adjust deadlines or work responsibilities.</td>
<td>Worked well together. Usually used time well throughout the process. Group did not have to adjust deadlines or work responsibilities.</td>
<td>Some team members were occasionally off task. Some adjustments of work responsibilities were needed to meet deadlines.</td>
<td>Most team members were often off task and not cooperating or participating fully. Group had to adjust deadlines or work responsibilities.</td>
</tr>
</tbody>
</table>
Wow, what a journey we have been on so far! We learned about nurdles: what they are, where they come from, and where they end up. We know that nurdles in the environment create many problems, and we have researched and designed potential solutions. We are engineers and problem solvers!

Now, to get our ideas into the public sphere and get them working, we need support!

So, the next step is to present your design and prototype to an audience. This will require clear verbal and visual communication. Bear in mind that YOU are the expert in your product, but you may need to explain some things in a way that ensures EVERYONE can understand it. Your audience may include:

- **Financial backers and investors:** they will want to know things like how much it might cost to produce, where the resources will come from, and whether it can earn a profit somewhere down the line.
- **Government representatives and legislators:** they will want to know if it is safe to use, who you expect to use it, and whether it will have benefit to the community.
- **Community members:** they will want to know why it is a good thing to support, and how it will help them enjoy a better lifestyle and ensure a clean future for their children.

So much to consider! By now you have worked with your team for a while, and you will know who is best at which kind of work. You will need someone to introduce the team; someone to demonstrate the model; someone to ‘pitch’ the idea, and someone to keep everyone organized.
### Student Presentation Planner

<table>
<thead>
<tr>
<th>TASK</th>
<th>Team members</th>
<th>Supplies needed</th>
<th>Timeframe</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Leader</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Presentation Writer</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrate/ troubleshoot prototype</td>
<td></td>
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<td></td>
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<tr>
<td>Props and set up</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speakers</td>
<td></td>
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</tbody>
</table>

Once you have decided who does what, it's time to plan your pitch.
Instructions for Elevator Speech

Imagine you step into an elevator and the president of your country is there and says, “What’s on your mind?” At most, you have about 7 floors that you will be traveling on the elevator together. That means about 12 seconds and 20 words per floor to tell him or her your important information. That’s your “elevator speech.”

Be prepared: Know your key points—what you care about, what needs to happen, what you will do, and what others can do. Use short sentences that convey vivid images. Make solid eye contact. Mean what you say and say what you mean. Always tell who you are, the organization or school you represent, mention this is part of the EarthEcho International’s Expeditions Program, and always have an “ask” at the end.

Philippe Cousteau’s Elevator Speech

1ST FLOOR: Did you know water is the most important substance on the planet?

2ND FLOOR: Water connects every being to one another—from drinking to energy production.

3RD FLOOR: Water is becoming the cause of the greatest crises of our century.

4TH FLOOR: Our organization, EarthEcho International, launched EarthEcho Expeditions to involve students in protecting our most important resource.

5TH FLOOR: Youth are mitigating the impacts of using the ocean as a long-term carbon sink by planting native trees and blue carbon projects.

6TH FLOOR: Our everyday choices in our homes, schools, and businesses can add up to a significant impact.

7TH FLOOR: Are you ready to help? Here’s what you can do... (Hint: The ASK! Always have an idea about how the person you’re talking to can get involved.)

Things to consider:
What makes a good sales pitch?

- https://www.youtube.com/watch?v=IPYeCltXpxw

Here is a pro-forma to help you write a persuasive speech. Your speakers can deviate from the script when you actually present it, but it’s a good way to make sure you cover everything, and make a solid case for your product.

Supporting documents for speeches

How did you do? How will you know? You need some feedback!

Here is a link to a pro forma for responding to a speech. Ask your classmates to respond to your speeches when you practice them, so you can add more persuasive techniques and go bigger and better! This is also a great listening task for your peers - test them on their knowledge of your product!
LEARNING OBJECTIVES RUBRIC

Use the rubric below to assess how students have demonstrated the knowledge obtained for each learning objective.

<table>
<thead>
<tr>
<th>Learning Objective</th>
<th>Demonstrated in written notes</th>
<th>Demonstrated in discussion with teacher</th>
<th>Demonstrated with a model or diagram</th>
<th>Demonstrated within presentation</th>
<th>Not demonstrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand that nurdles are small plastic pellets made up of polymers that originate from crude oil.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand that nurdles are the starting material in plastics manufacturing.</td>
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</tr>
<tr>
<td>Explain how nurdles get into the environment.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discuss how nurdles impact the marine environment.</td>
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</tbody>
</table>
Explore how to separate nurdles from other materials.

Design and build a nurdle capture system.

Prepare and deliver a pitch to a potential investor.

**Enhancement task:**
- Make your speech into a dramatic performance.

**Extension task:**
- Make a film showing how your device was developed and how it works. This could be in the form of an advertisement, a documentary, or a public service announcement.
- Quiz - this could be on paper or using Kahootz. Develop a set of questions about nurdles and your device to test your classmates.

**Scaling:**
This could be done via the examples of expected performance used e.g. a simple presentation video example for year 5s, a more sophisticated one for older students.
Design and Technologies - content description

Levels 5 and 6

Technologies and Society - Investigate how people in design and technologies occupations address competing considerations, including sustainability, in the design of solutions for current and future use (VCDSTS033).

Technologies Contexts: materials and technologies specialisations - Investigate characteristics and properties of a range of materials, systems, components, tools, and equipment and evaluate the impact of their use (VCDSTC037).

Creating Designed Solutions - Investigating: Critique needs or opportunities for designing, and investigate materials, components, tools, equipment, and processes to achieve intended designed solutions (VCDSCD038).

• Generating: Generate, develop, communicate and document design ideas and processes for audiences using appropriate technical terms and graphical representation techniques (VCDSCD039).
• Producing: Apply safe procedures when using a variety of materials, components, tools, equipment and techniques to produce designed solutions (VCDSCD040).
• Planning and Managing: Develop project plans that include consideration of resources when making designed solutions (VCDSCD042).

Levels 7 and 8 http://victoriancurriculum.vcaa.vic.edu.au/level7

Technologies and Society - Examine and prioritise competing factors including social, ethical, economic, and sustainability considerations in the development of technologies and designed solutions to meet community needs for preferred futures (VCDSTS043). Investigate the ways in which designed solutions evolve locally, nationally, regionally, and globally through the creativity, innovation, and enterprise of individuals and groups (VCDSTS044).

Technologies Contexts: materials and technologies specialisations - Analyse ways to create designed solutions through selecting and combining characteristics and properties of materials, systems, components, tools, and equipment (VCDSTC048).

Creating Designed Solutions: Investigating - Critique needs or opportunities for designing and investigate, analyse, and select from a range of materials, components, tools, equipment, and processes to develop design ideas (VCDSCD049).
• Generating: Generate, develop, and test design ideas, plans, and processes using appropriate technical terms and technologies including graphical representation techniques (VCDSCD050).

• Producing: Effectively and safely use a broad range of materials, components, tools, equipment, and techniques to produce designed solutions (VCDSCD051).

• Planning and Managing: Use project management processes to coordinate production of designed solutions (VCDSCD053).
NEXT GENERATION SCIENCE STANDARDS:

**MS-PS1-3 Matter and its Interactions**
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

**MS-ESS3-3 Earth and Human Activity**
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

**MS-ETS1-1 Engineering Design**
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

**MS-ETS1-2 Engineering Design**
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

**MS-ETS1-3 Engineering Design**
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

**MS-ETS1-4 Engineering Design**
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

REFERENCES