

# PLASTIC POLLUTION PBL

PROBLEM/PROJECT BASED LEARNING

CULTURALLY RESPONSIVE

EQUITABLE AND INCLUSIVE



N A P E

National Alliance for  
Partnerships in Equity

Plastic is everywhere, and we often use it and toss it without thinking twice. However, most plastics are not biodegradable. Plastics in our landfills last hundreds of years and filter dangerous chemicals into our groundwater. Many plastics aren't disposed of and travel through streams and rivers into our oceans, harming wildlife. Over time, plastics break down into ever smaller pieces, known as microplastics. People inhale microplastics through the air, consume them through food and water, and even absorb them through the skin. Plastic pollution affects everyone, but vulnerable populations are at greater risk. Recycling can help reduce plastic production and plastic waste, but it isn't enough!

**In this lesson, students learn about the life cycle of plastics and the impact of plastic pollution and then choose a project to both acquire and apply new knowledge.**

We've designed this STEM-focused lesson plan to be problem- and project-based<sup>1</sup>, culturally responsive<sup>2</sup>, equitable, and inclusive for every student<sup>3</sup>. If you'd like to learn more about these types of instruction, we encourage you to read [NAPE's toolkits](#). Review the [Ensuring Equity in PBL Reflection Tool](#) and the [Rubric for Equitable STEM Curricula](#) at the end of this document.

The lesson plan follows the 5E Model of Instruction<sup>4</sup> with five phases: Engage, Explore, Explain, Elaborate, and Evaluate. The constructivist learning exercises are student-focused, engaging students in curiosity-driven inquiry, hands-on activities, and career investigation.

**You can adapt the lessons for students in grades 3 to 12 by integrating appropriate science and math concepts and tasks.**

NAPE strives to create equitable learning environments where each student thrives and receives an education that prepares them to earn a living wage. We provide data-driven research, training, and evaluation to transform education and workforce systems at the individual, institutional, and system levels. We approach our work of broadening opportunity and success where equity and identity intersect to include gender, race, culture, disability, and socioeconomics.

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ENGAGE

EXPLORE

EXPLAIN

ELABORATE

EVALUATE

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# Unit Overview

## POTENTIAL STANDARDS

### MATH (COMMON CORE)

- ◆ Elementary School » Measurement & Data (MD)
- ◆ Middle School » Statistics & Probability (SP)
- ◆ High School » Modeling (M+)

### SCIENCE (NGSS)

- ◆ Earth and Human Activity (MS-ESS3-1, HS-ESS3)
- ◆ Ecosystems: Interactions, Energy, and Dynamics (MS-LS2, HS-LS2)
- ◆ Engineering Design (MS-ETS, HS-ETS)

## STUDENT LEARNING OBJECTIVES

Depending on the activities chosen, the student learning objectives can include:

- ◆ Discover STEM careers related to plastic pollution
- ◆ Recall key characteristics of plastic and plastic waste
- ◆ Survey and graphically model personal and household plastic use
- ◆ Analyze the impact of litter on the local environment
- ◆ Apply learning in a PBL activity of the student's choosing
- ◆ Create a solution for reducing plastic waste

## MATERIALS

- ◆ Students or teacher will need Internet access to show videos and access readings
- ◆ Students may need various supplies for their chosen project; however, we encourage you to keep the supplies required to an accessible limit.
- ◆ Projection or display device for PDF slides
- ◆ Print outs of student worksheets

# Key Terms

**CLIMATE CHANGE:** Climate change describes a change in the average conditions — such as temperature and rainfall — in a region over a long period of time.

**ECOSYSTEM:** An ecosystem is a geographic area where plants, animals, other organisms, and weather and landscape work together to form a bubble of life.<sup>5</sup>

**ENVIRONMENTAL IMPACT:** Environmental impact is the effect of human activity on the environment.

**MICROPLASTICS:** Microplastics are extremely small pieces of plastic debris in the environment resulting from the disposal and breakdown of consumer products and industrial waste.

**POLYMER:** A polymer is a substance with a molecular structure consisting chiefly or entirely of a large number of similar units bonded together, e.g., many synthetic organic materials used as plastics and resins.

**SINGLE-USE PLASTIC:** Single-use plastics are goods made primarily from fossil fuel-based chemicals (petrochemicals) and are meant to be disposed of right after use—often in mere minutes. Single-use plastics are most commonly used for packaging and service ware, such as bottles, wrappers, straws, and bags.

**VULNERABLE POPULATIONS:** Vulnerable populations are groups and communities at a higher risk for poor health as a result of the barriers they experience to social, economic, political and environmental resources, as well as limitations due to illness or disability.<sup>6</sup>

## WARM-UP

- ◆ Make a list of everything you've used in the last 24 hours that is made of or includes plastic.
- ◆ Circle each item that you've already thrown away.
- ◆ Put a star next to each item you'll probably throw away or stop using within the next 12 months.

## WATCH

[\*What really happens to the plastic you throw away - Emma Bryce\*](#)

## WATCH GUIDE<sup>7</sup>

**Print the student worksheet and show the slide with the answers after the video.**

The chains that ultimately form plastic are known as:

- Monomers
- Polymers\*\**
- Oil and gas molecules
- Plastic fibers

Leachate is produced as:

- Rainwater absorbs water-soluble compounds in layers of trash\*\**
- Plastic flows into ponds and streams
- Toxic waste is emptied into ponds and streams
- Metal comes into contact with water

Marine animals are impacted by ocean plastic because:

- Ocean Plastic is full of toxins
- Ocean Plastic traps them, and when they eat plastic, it can starve them\*\**
- Ocean Plastic takes up space in their natural habitat
- Ocean Plastic kills their food, meaning they're left with nothing to eat

What's one way we can reduce plastic's impact on the environment?

- By burying it
- By burning it
- By shredding it into pieces
- By recycling it\*\**

Most plastics don't biodegrade.

- True\*\**
- False

How do fossil fuels provide energy?

- ◆ Fossil fuels are burned in order to provide energy. Power plants burn fossil fuels to provide electricity, and car engines burn fuel to convert chemical energy into mechanical energy. When fossil fuels are burned, they release fumes, smoke, and carbon that pollute the environment.

- ◆ How long will it take bottle 1 to decompose?
- ◆ Where did bottle 2 end up?
- ◆ Why is birds eating plastic bad for them and us?
- ◆ What happens to bottle 3?
- ◆ Which bottle do you think had the best ending? Why do you think that?

## DEMONSTRATE

Using an internet connected browser, open the [Plastic Tracker](#). **Enter your zip code and see where the plastic goes!**

This interactive map is a tool to illustrate the fate of floating plastic 20 years from now, should you lose it today from your location or anywhere else in the world. Where will it go? How probable is it that it will reach the ocean? This tool will give you a possible answer to these questions and show you just how far plastic can travel from its starting point.

## READ

Invite students to read the article about the United Nations Report that revealed plastic pollution disproportionately affects marginalized groups, or vulnerable populations. Have them discuss what they learned in small groups.

[Plastic pollution disproportionately hitting marginalized groups, UN environment report finds](#)

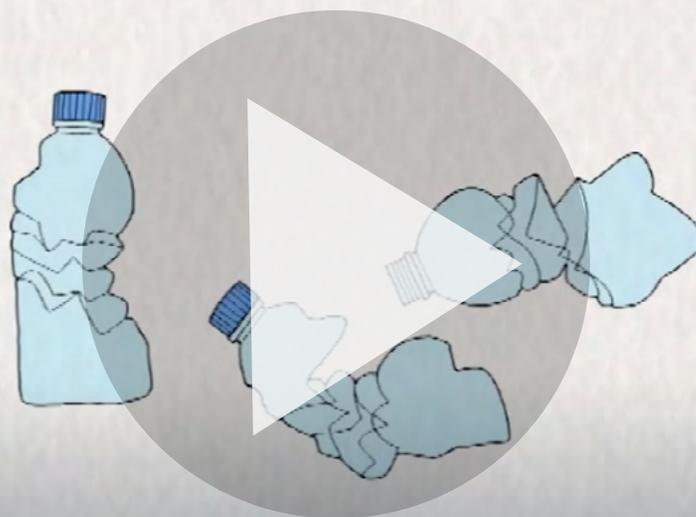
## REFLECT & DISCUSS

- ◆ Why is it important to reduce plastic use?
- ◆ Why is it important not to litter?
- ◆ What is the impact of single-use, landfill-bound, and littered plastics on the environment?
- ◆ What stories have you heard about the impact of plastic on humans, animals, and the environment?
- ◆ How might your plastic use affect the oceans and its ecosystems?
- ◆ What have you heard about or perhaps tried in your household to reduce the use of plastic?
- ◆ What questions do you have about plastics and their impact on the environment and vulnerable populations?

## EXTENSION EXERCISES

- ◆ Have students draw or map the life cycle of plastics.
- ◆ WATCH: [A brief history of plastic](#)
- ◆ WATCH: [What are microplastics?](#)
- ◆ Illuminate the socio-environmental and socio-ecological impacts of increased production and use of plastics on vulnerable communities and their ways of life. Topics might include environmental discrimination, brownfields and landfills, food sourcing for marginalized and indigenous communities, etc.
- ◆ Discuss the human impact of fossil fuel gathering/use on communities affected by mining, fracking, and drilling.

1. Make a list of everything you've used in the last 24 hours that is made of or includes plastic.
2. Circle each item that you've already thrown away.
3. Put a star next to each item you'll probably throw away or stop using within the next 12 months.



This is the story  
of three plastic bottles,



0:08 / 4:06



The chains that ultimately form plastic are known as:

- ◆ (b) Polymers

Leachate is produced as:

- ◆ (a) Rainwater absorbs water-soluble compounds in layers of trash

Marine animals are impacted by ocean plastic because:

- ◆ (b) Ocean Plastic traps them, and when they eat plastic, it can starve them

What's one way we can reduce plastic's impact on the environment?

- ◆ (d) By recycling it

Most plastics don't biodegrade.

- ◆ (a) True

How do fossil fuels provide energy?

- ◆ Fossil fuels are burned in order to provide energy. Power plants burn fossil fuels to provide electricity, and car engines burn fuel to convert chemical energy into mechanical energy. When fossil fuels are burned, they release fumes, smoke, and carbon that pollute the environment.

1. How long will it take bottle 1 to decompose?
2. Where did bottle 2 end up?
3. Why is birds eating plastic bad for them and us?
4. What happens to bottle 3?
5. Which bottle do you think had the best ending? Why do you think that?



Go to the Tracker: [theoceancleanup.com/plastic-tracker](https://theoceancleanup.com/plastic-tracker)



**United  
Nations**

**UN News**

Global perspective Human stories

UN ENVIRONMENT REPORT FINDS PLASTIC POLLUTION DISPROPORTIONATELY HITTING MARGINALIZED GROUPS

- ◆ The impacts of plastics on marginalized populations are severe, and exist at all stages of the production cycle, from extracting raw materials and manufacturing, through to consumption and disposal, according to the report.
- ◆ Plastic waste not only endangers the livelihoods of those relying on marine resources, it also causes a raft of health issues for people who consume seafood infested with toxic micro and nano plastics.
- ◆ Women, in particular, suffer from plastic-related toxicity risk, due to higher aggregate exposure to plastics at home and even in feminine care products.
- ◆ Differences in gender, social roles, and political power in regulating plastic use and health standards place women at high risk of miscarriages and cancer, further exacerbating gender-related disparities overall.
- ◆ Aggravated by the COVID-19 pandemic, plastic waste has become a major part of the global pollution crisis, along with biodiversity loss and climate change, representing a triple emergency that must be tackled by strong and effective action plans, says UNEP.

<https://news.un.org/en/story/2021/03/1088712>

1. Why is it important to reduce plastic use?
2. Why is it important not to litter?
3. What is the impact of single-use, landfill-bound, and littered plastics on the environment?
4. What stories have you heard about the impact of plastic on humans, animals, and the environment?
5. How might your plastic use affect the oceans and its ecosystems?
6. What have you heard about or perhaps tried in your household to reduce the use of plastic?
7. What questions do you have about plastics and their impact on the environment and vulnerable populations?

# PLASTIC POLLUTION ENGAGE WORKSHEET

## WATCH GUIDE

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- True
- False

How do fossil fuels provide energy?

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## REFLECTION & DISCUSSION

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- ◆ Why is it important not to litter?
- ◆ What is the impact of single-use, landfill-bound, and littered plastics on the environment?
- ◆ What stories have you heard about the impact of plastic on humans, animals, and the environment?
- ◆ How might your plastic use affect the oceans and its ecosystems?
- ◆ What have you heard about or perhaps tried in your household to reduce the use of plastic?
- ◆ What questions do you have about plastics and their impact on the environment?

## ACTIVITY

Depending on the objectives you need to reach, consider allowing students to do multiple activities. Try our [Google Sheets Sample Tracker](#) (Tracker requires a Google log-in, then select “make a copy” from the file menu).

### SINGLE-USE PLASTIC TRACKER

Track your plastic use for one week. (Can be modified to [waste audit](#).)

- ◆ Depending on the grade level, have students create tables or bar charts. Students can group items by bottles, bags, to-go containers, etc. Students could also convert bar charts to line graphs if comparing use by time, for example. Another extension would be to have them collect all plastic items and weigh the bag(s) at the end of a determined period.
- ◆ **Resource:** [Single-Use Plastics 101](#)
- ◆ **Reflection:** What did you notice? What did you learn about your self and your habits?

### LITTER TRACKER

Tally observations of litter for one week.

- ◆ Depending on the grade level, have students create tables, bar charts, or heat maps. What kind of litter do they see, where is it, and how frequently do they see it? Students can identify where litter is likely to enter into the water system by using satellite maps, and then predict how the trash will travel to the ocean. (If it is safe to do so, and using proper equipment, you can teach students to dispose of trash they find in their surroundings. Please provide adequate safety instructions and guidelines for supervision.) Extensions: ecosystems, systems thinking, etc.
- ◆ **Reflection:** What did you notice? What did you learn about your environment?

### IMPACT INVESTIGATION

Explore the impact of plastic waste on vulnerable populations. Investigate the potential effects of plastic pollution on marginalized persons – here and abroad. This might include financially, environmentally, and health.

### STUDENT’S CHOICE

If students can identify a similar type of activity that still meets the objectives, allow them to present their idea to you for approval.

## EXTENDED LEARNING

- ♦ Read [Confronting Ocean Plastic Pollution](#).
- ♦ Read the full report, [From Pollution to Solution: A global assessment of marine litter and plastic pollution](#)
- ♦ Read [Plastic pollution disproportionately hitting marginalized groups](#)

## PRESENT

Have students present their findings, models, and reflections from their activity to the class.





**WATCH OR READ**

"Breaking the Plastic Wave," a global analysis using first-of-its kind modeling, shows that we can cut annual flows of plastic into the ocean by about 80% in the next 20 years by applying existing solutions and technologies. No single solution can achieve this goal; rather, we break the plastic wave only by taking immediate, ambitious, and concerted actions.

WATCH: [Breaking the Plastic Wave | Pew](#) or

READ SUMMARY REPORT: [Breaking the Plastic Wave: Top Findings for Preventing Plastic Pollution](#)

**NOTE TAKING CHALLENGE**

What are 8 interventions that can solve 80% of the plastic problem?

- ◆ *Reduce plastic production.*
- ◆ *Substitute paper and compostable materials.*
- ◆ *Design products and packaging for recycling.*
- ◆ *Expand waste collection rates in middle- and low-income countries.*
- ◆ *Increase mechanical recycling.*
- ◆ *Develop plastic-to-plastic chemical recycling.*
- ◆ *Build facilities that don't allow plastic to leak out.*
- ◆ *Reduce plastic waste exports.*

**READ**

Have students read or introduce the key concepts in: [Pollution to Solution](#)

**READING GUIDE**

1. What percentage of total marine waste is plastic? *(85%)*
2. Without urgent action, the estimated 11 million metric tons of plastic currently entering the ocean annually will \_\_\_\_\_. *(Triple in the next twenty years.)*
3. This would mean between 23 and 37 million metric tons of plastic flowing into the ocean every year by 2040. Convert metric tons to pounds! *(50,706,320,303 and 81,571,037,008)*
4. Marine litter and plastic pollution are problematic for many reasons. List at least 3. *(Can be a number of things from the article)*
5. How is plastic pollution harmful to humans? *(Environmental health is inextricably linked to human health. People are inhaling microplastics through the air, consuming them through food and water and even absorbing them through the skin.)*
6. Are the impacts of plastic pollution felt equally around the world? *(No. Plastic pollution affects vulnerable populations globally, not just in industrialized countries like the U.S. Wealthier countries produce more plastic waste, which all too frequently flows into countries where waste management is the least sophisticated.)*
7. Why are plastics a problem for our climate? *(Plastic is predominantly produced from oil and gas, both of which are fossil fuels. The more plastic we make, the more fossil fuel is required, the more we intensify the climate crisis in a continual negative feedback loop.)*
8. What is the singular goal? *(Reduce the use of unnecessary, avoidable and problematic plastics, and stop their flow into our lakes, rivers, wetlands, coasts and seas.)*

**EXTENSION**

Split students into groups to create what they think would be an effective way to execute one of the eight interventions that solve 80% of plastic problems.



Each year roughly 11 million metric tons of plastic flow into the ocean on our current

# What are 8 interventions that can solve 80% of the plastic problem?

- ◆ *Reduce plastic production.*
- ◆ *Substitute paper and compostable materials.*
- ◆ *Design products and packaging for recycling.*
- ◆ *Expand waste collection rates in middle- and low-income countries.*
- ◆ *Increase mechanical recycling.*
- ◆ *Develop plastic-to-plastic chemical recycling.*
- ◆ *Build facilities that don't allow plastic to leak out.*
- ◆ *Reduce plastic waste exports.*

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6. Are the impacts of plastic pollution felt equally around the world? *(No. Wealthier countries produce more plastic waste, which all too frequently flows into less developed countries where waste management is the least sophisticated.)*
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8. What is the singular goal? *(Reduce the use of unnecessary, avoidable and problematic plastics, and stop their flow into our lakes, rivers, wetlands, coasts and seas.)*

# PLASTIC POLLUTION EXPLAIN WORKSHEET

## NOTE TAKING CHALLENGE

What are 8 interventions that can solve 80% of the plastic problem?

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.



*Breaking the  
Plastic Wave*

## READING GUIDE

1. What percentage of total marine waste is plastic?
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7. Why are plastics a problem for our climate?
8. What is the singular goal?



*From Pollution  
to Solution*

**ORGANIZE**

- ◆ Describe the project options on the following page and allow students to identify which is most interesting to them.
- ◆ Create teams of 4 based on their project interest. Follow best practices for grouping.
- ◆ Introduce professional practices like collaboration, communication, presentation, creativity, and quality.

**PROJECTS**

**PLASTIC REDUCTION:** Research and brainstorm ways to reduce your personal and household plastic use. Develop, implement, and track a plan for [reducing plastic use](#). Compare data with your original data set from the **EXPLORE** activity. **Extension:** Consider having students predict the probability of success, or predict how much less waste will be created over time.

**ANTI-LITTER CAMPAIGN:** Research [effective litter reduction campaigns](#). What made them effective? Create a campaign for your school or community to reduce litter. Use the data collected to inform your messaging. Set goals and track the impact of your campaign.

**RECYCLED PLASTICS:** Research and brainstorm uses of recycled plastics. Research examples of 3 different kinds of products that use recycled plastic. Describe the creative ways entrepreneurs are using recycled plastics. Make a list of more products you think recycled plastics could be turned into. **Extension:** Engineer a prototype of a product that could be created with recycled plastics. **Bonus:** [Brands](#) like Adidas, Patagonia, Rothy's and Tumi, among many others, have products made from recycled products. Learn about [plastic bricks in Kenya](#).

**(ADVANCED) MICRO-PLASTICS ANALYSIS &/OR REPORT:** Depending on your access to waterways and lab tools students can do a variety of experiments to test for micro-plastics, or students can research work that other students have done and write a report on their findings.

Example Labs:

- ◆ [Florida Microplastics Awareness Project](#)
- ◆ [Microplastics Beach Walk Activity](#)

News of Student Micro-plastics Research

- ◆ [Students Research Microplastics and Their Not-So-Micro Environmental Impact](#)
- ◆ [Microplastics and the quality of water in my Western N.C. hometown](#)
- ◆ [Cornell students design robot to collect microplastics from beaches](#)
- ◆ [ERAU students Design Autonomous Robot to Clean Microplastics from Beaches](#)

project options continued...

**ENVIRONMENTAL JUSTICE:** Plastic pollution disproportionately affects marginalized communities and communities living in close proximity to plastic production and waste sites, constituting an environmental injustice, according to a report by the United Nations Environment Programme (UNEP) and environmental justice non-governmental organisation, Azul. The report, *NEGLECTED: Environmental Justice Impacts of Marine Litter and Plastic Pollution*, calls for the recognition of communities affected by plastic waste and their inclusion in local decision making.<sup>8</sup> “Environmental justice means educating those on the frontlines of plastic pollution about its risks, including them in decisions about its production, use, and disposal, and ensuring their access to a credible judicial system,” said UNEP Executive Director, Inger Andersen.

For this project, students can read the report and then research environmental justice issues **in their community** related to plastic or other types of waste. Examples could include impact of plastic pollution on sea turtles, “Shingle Mountain” in Dallas, Texas, research on local watershed concerns, etc. The final product of the project could be an article for a school or local paper, or some other awareness building tool.

**STUDENT’S CHOICE:** If students can identify a similar type of activity that still meets the objectives, allow them to present their idea to you for approval.

## POTENTIAL TOPIC EXTENSIONS

- ◆ Water cycle
- ◆ Ocean circulations
- ◆ Ecosystems

## CLARIFY

- ◆ Formatively assess student progress.
- ◆ Identify misconceptions and opportunities to provide clarity and additional instruction and evidence.
- ◆ Encourage students to conduct additional investigations to reinforce new skills.

## FEEDBACK

How teachers provide feedback to students can have a profound effect on their achievements, attitudes, and motivation, including self-efficacy. Students are more likely to be successful when they receive effective feedback and are held accountable for reaching their goals. Even if they are highly motivated to reach goals, feedback allows students to evaluate their progress and the strategies they use. Effective feedback increases self-efficacy while ineffective feedback can lower achievement.

## INTENTIONS

|               |                           |
|---------------|---------------------------|
| Useful        | Is feedback needed?       |
| Asset-focused | Are you encouraging?      |
| Sincere       | Is feedback constructive? |

## TIMING

|           |                               |
|-----------|-------------------------------|
| Readiness | Are students ready to listen? |
| Timely    | Has too much time passed?     |
| Frequent  | Can you follow up soon?       |

## DETAILS

|               |                             |
|---------------|-----------------------------|
| Specific      | What are the facts?         |
| Initial Steps | What can students build on? |
| Next Steps    | What can students do next?  |

## STRATEGY

|                    |                                    |
|--------------------|------------------------------------|
| Growth-minded      | Progress not perfection!           |
| Prompt             | Questions help uncover answers.    |
| Praise the process | Emphasize effort to drive results. |

## TONE

|                   |                                       |
|-------------------|---------------------------------------|
| High Expectations | Express rigorous standards.           |
| Confidence        | Do students know you believe in them? |
| Trust-Building    | Prioritize your relationship.         |

### INCLUSIVE FEEDBACK REMINDERS

- *To whom is feedback offered?*
- *What types of feedback are offered?*
- *Is feedback consistent?*
- *Is feedback equitable?*
- *Is feedback oriented in an asset-based mindset?*

# PLASTIC POLLUTION PROJECT OPTIONS

**PLASTIC REDUCTION:** Research and brainstorm ways to reduce your personal and household plastic use. Develop, implement, and track a plan for *reducing plastic use*. Compare data with your original data set. Extension: Consider having students predict the probability of success, or predict how much less waste will be created over time.

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*Brands* like Adidas, Patagonia, Rothy's and Tumi, among many others, have products made from recycled products. Learn about *plastic bricks in Kenya*.

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Example Labs:

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News of Student Micro-plastics Research

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- ♦ [ERAU students Design Autonomous Robot to Clean Microplastics from Beaches](#)

**ENVIRONMENTAL JUSTICE:** Plastic pollution disproportionately affects marginalized communities and communities living in close proximity to plastic production and waste sites, constituting an environmental injustice, according to a report by the United Nations Environment Programme (UNEP) and environmental justice non-governmental organisation, Azul. The report, *NEGLECTED: Environmental Justice Impacts of Marine Litter and Plastic Pollution*, calls for the recognition of communities affected by plastic waste and their inclusion in local decision making.<sup>9</sup> "Environmental justice means educating those on the frontlines of plastic pollution about its risks, including them in decisions about its production, use, and disposal, and ensuring their access to a credible judicial system," said UNEP Executive Director, Inger Andersen.

For this project, read the report and then research environmental justice issues **in your community** related to plastic or other types of waste. Examples could include impact of plastic pollution on sea turtles, "Shingle Mountain" in Dallas, Texas, research on local watershed concerns, etc. The final product of the project can be an article for a school or local paper, or some other awareness building tool.

**STUDENT'S CHOICE:** If you can identify a similar type of activity that still meets the objectives, present your idea for approval.

## PRESENT

Invite students to present the process and outcome of their projects.

Consider inviting relevant engineers, scientists, community members, and decision makers to listen to and evaluate student presentations. This is especially important if there is a possibility that the student recommendations can be implemented to solve a real campus or community problem. A real-world context raises the bar from project based to problem based.

## REFLECTION

- ◆ How will you raise public awareness and take action against the global crisis of plastic pollution?
- ◆ What solutions do you propose to help monitor and minimize the effects of plastic pollution in our oceans?

## RUBRIC

Create a rubric for students to evaluate their work and their collaboration with their teammates. This will vary based on the grade level and the integrated STEM concepts you incorporate.

## Additional Resources

- ◆ [\*End Plastic Waste by TEDed\*](#)
- ◆ [\*TEDx Talk by Van Jones, The economic injustice of plastic\*](#)
- ◆ [\*NEGLECTED: Environmental Justice Impacts of Marine Litter and Plastic Pollution\*](#)

### Complementary Lessons

- ◆ [\*The Great Pacific Garbage Patch\*](#)
- ◆ [\*The Plastisphere: Plastic Migration and Its Impacts\*](#)
- ◆ [\*Investigating the Properties of Plastic and its Effects on the Environment\*](#)
- ◆ [\*NGSS Lesson for Middle School: An Ocean of Plastics\*](#)
- ◆ [\*Plastic, Plastic Everywhere!\*](#)
- ◆ [\*Measuring School Sustainability\*](#)
- ◆ [\*Ecorise\*](#)

## OVERVIEW

Help students connect what they've learned in this PBL to STEM Careers. As you complete each part, encourage students to reflect on the listed jobs. If they learn of new jobs, add them to the list. You may want to keep a shared list.

**Print or share the 2-page worksheet with the students.**

## ACTIVITY OPTIONS

- ◆ Individual reflection
- ◆ Think-pair-share
- ◆ Large group discussion
- ◆ Jig-saw

## REFLECTION PROMPTS

1. Based on what we learned in this plastic pollution PBL unit, which STEM careers sound interesting? Why?
2. What other types of STEM jobs can you identify related to plastics and reduction of plastic pollution?
3. Select one of the careers on the list, or another one you identifies and search the Internet. What can you learn and share with your classmates? Try searching the Bureau of Labor Statistics Occupational Outlook Handbook or Sciencebuddies.org.
4. STEM professionals are essential to our health, happiness, and safety. They are creative and collaborative problem solvers that make a world of difference and help shape our future. What kind of difference would you like to make on the world when it comes to plastic pollution and the impact of it on vulnerable populations?
5. Imagine being one of the listed STEM professionals. How might you approach solving an issue related to plastic pollution?

# EXPLORE STEM CAREERS

## ACTIVITY WORKSHEET

### *DID YOU KNOW?*

STEM professionals are essential to our health, happiness, and safety. They are creative and collaborative problem solvers that make a world of difference and help shape our future.

Engineering is involved in all plastic and alternative plastic development as well as the processes related to waste management, recycling, and plastic removal from the oceans. Here are a few examples of engineering careers related to plastic pollution:

- ♦ **CHEMICAL ENGINEERS** design environmentally friendly, sustainable, and recyclable materials for packaging. Chemical engineers apply the principles of chemistry, biology, physics, and math to solve problems that involve the production or use of chemicals, fuel, drugs, food, and many other products.
- ♦ **POLYMER ENGINEERS** create plastics. Understanding plastic and its properties may help polymer engineers create more environmentally-friendly plastics and/or develop methods to clean up plastics.
- ♦ **ENVIRONMENTAL ENGINEERS** identify potential hazards in the environment. Examples include: evaluating water supplies and treating water resources for drinking, using mechanical and chemical processes to remove toxic and biotic pollutants, developing technologies for landfills to collect methane from compostable materials and use it to generate electricity.
- ♦ **MATERIALS ENGINEERS** develop, process, and test materials used to create various products, from computer chips, aircraft wings and biomedical devices to golf clubs and shoes. They study substances (metals, ceramics, plastics, composites, nanomaterials and more) to create new materials that are safer for the environment. They also help select materials for specific products and develop new ways to use existing materials.
- ♦ **HYDRO ENGINEERS** support design engineers for ocean clean-up systems, perform hydrodynamic calculations and simulations and communicate the results to agencies tracking progress.

1. Based on what we learned in this plastic pollution PBL unit, which STEM careers sound interesting? Why?
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3. Select one of the careers on the list, or another one you identifies and search the Internet. What can you learn and share with your classmates? Try searching the Bureau of Labor Statistics Occupational Outlook Handbook or Sciencebuddies.org.
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5. Imagine being one of the listed STEM professionals. How might you approach solving an issue related to plastic pollution?

# Best Practices for Groups

Rosser<sup>10</sup> identifies important considerations for teachers when creating groups:

1. **Size:** Team sizes should typically range from 3 to 6, depending on the nature and objectives of the task, with 4 being an ideal size for most projects.
2. **Ability:** Teams, particularly in K-12 classrooms, should have a heterogeneous mix of ability.
3. **Gender and Race:** Teams with only one student from a marginalized ethnic, racial, or gender group on a team can be isolating and create a negative experience for the student, especially in a nontraditional class or major. When possible, at least two students from a marginalized group should be on a team. If a student represents underrepresented groups from both gender and race, their placement should be carefully considered to ensure they are on a team with students from both groups.

## ADDITIONAL STRATEGIES:

- ◆ Help students see themselves as a team rather than a divide and conquer style working group.
- ◆ Establish a tool to help students evaluate each other and help them learn to manage interpersonal conflicts.
- ◆ Use a solid, detailed collaboration and teamwork rubric.
- ◆ Suggest or co-create group norms for how the teams will operate. ([Example](#))
- ◆ Avoid and discourage gender or racialized norms associated with content, presentation style, and roles on the team.
- ◆ Use effective feedback strategies that guide and facilitate students rather than directing and telling them.
- ◆ Encourage students to celebrate the struggle, find their own answers, and persist when they face challenges.

# Ensuring Equity in PBL Reflection Tool

As problem- and project-based learning (PBL) gains popularity in STEM classrooms, and as the disparity of women and students of color in many STEM disciplines remains the same, specific strategies can be applied to PBL to improve equity and access. This tool is designed to assist educators in reflecting on their current practice and enacting changes to make PBL more equitable and to ensure every student's potential to be successful. This tool can also be used to evaluate and administer equitable and effective STEM projects/PBL lessons in other classrooms.

|  | Reflection   | Action   |
|--|--|--|
| <b>My PBL project is student-centered.</b>   |  |  |
| <b>Student agency:</b> Providing opportunity for students' personal agency on assignments and grading has been correlated to motivation and intellectual development.  | How can you increase personal agency? (consider topics, projects, and grading)   | Write down one specific step you can take to increase student agency.  |
| <b>Scaffolding:</b> Providing students with appropriate support can help lead them to success and build self-efficacy. Consider students' Zone of Proximal Development (ZPD) and include supports that encourage further understanding.  | How can you best determine students' ZPD? What supports are needed to scaffold student learning?                           | Create a plan to pre-assess students' knowledge or skills in an upcoming lesson and identify scaffolds that will support their learning. |
| <b>My PBL project fosters an equitable team-learning environment.</b>  |  |  |
| <b>Intentionally selecting teams:</b> Having only one ethnic or gender minority in a group can be isolating and create a negative experience for the students, especially in a non-traditional major or career choice. Teachers should form teams that have at least two students from an underrepresented group together. | How do you organize teams? What do you consider when forming them? Are there aspects of diversity you are not considering? | Identify and gather the information you need and create teams with at least two students from underrepresented groups together.          |

|   | Reflection  | Action  |
|---|---|---|
| <p><b>Rotating roles:</b> Student roles within a team may be limited to gender or racial stereotypes. Allowing students to choose their role initially provides them with some level of comfort. It is important to then require students to rotate roles so that students learn new skills and are not limited by gender or racial norms.</p>  | <p>How do you assign roles? Do you ask students to rotate their role? What can you do to support students in roles that are challenging?</p>                            | <p>Create a system so that students move from comfortable to challenging roles. List challenges that you anticipate students to have and create supports to help overcome those challenges.</p> |
| <p><b>Reflect on and celebrate diversity:</b> Providing teams with the opportunity to reflect on and value the contributions of each team member can build collaboration within teams. Ask students to evaluate and discuss their contributions to help individuals see their own and others' value on the team.</p>  | <p>How can you foster reflection and celebration of diversity within teams?</p>   | <p>Build team reflection activities into your PBL lesson that help students recognize the value of individuals and benefits of diversity within their team.</p>                                 |
| <p><b>Monitoring team discourse and roles:</b> Monitoring discourse and interactions within teams can help teachers become aware of and interrupt inequities that occur between students. Listen for conversations that may make a student feel uncomfortable, identify instances where privilege plays a role in decisions or roles, and monitor the actual roles students are enacting, regardless of official roles.</p> | <p>What should you be doing and listening for when facilitating PBL among teams?</p>  | <p>Create a system to monitor and interrupt inequities within teams. Compile resources to help you respond appropriately to inequitable behavior.</p>   |
| <p><b>Assessment:</b> Gender norms and race dynamics can be present in peer reviews. Grading systems for team projects should be carefully planned and articulated to students at the beginning of the project. Teachers should consider a combination of individual contributions and peer evaluations, as well as giving students agency in the grading format or process.</p>  | <p>How are students assessed for their work? Does the assessment represent individual or team work? How does your assessment system align with learning objectives?</p> | <p>Identify your learning objectives and align them to appropriate assessments. Include evaluations that can counterbalance peer reviews, which may be inequitable.</p>                         |

| My PBL project centers around authentic, relevant contexts.  |  |   |
|--|--|---|
| <p><b>Social impact:</b> When PBL is delivered within a real-world context and has social impact, it is more interesting to all students.</p>  | <p>Is the project situated in a real-world context that highlights social impact and application? (consider driving questions and authentic audiences)</p> | <p>Change the project to focus on a real-world context that has social impact and to include an authentic audience.</p>   |
| <p><b>Culturally relevant:</b> Cultural values can influence how students relate to PBL lessons. Teachers should consider the content that is studied and how it is studied to ensure its alignment with the cultural norms represented in the classroom.</p>  | <p>Does the focus of the project recognize or conflict with the cultural values of the students? What other approaches could be used?</p>                  | <p>Identify the cultural values of your class and develop content and approaches that are in alignment.</p>   |
| <p><b>Lived experiences:</b> A project that is situated in an unfamiliar context for students will not be motivational. In contrast a project that stems from students' own culture, identity, and lived experiences (particularly those not often represented in the classroom) will be engaging.</p> | <p>Is the project relevant to students' own lives and creates opportunities to incorporate lived experiences?</p>  | <p>Get to know your students. Take a student interest inventory and create opportunities to understand your students' lives.</p>  |
| <p><b>Socioeconomic relevancy:</b> Projects should not require technologies or material to which students do not have access. Projects should not require students to already have mastered soft skills, which should be taught along with content.</p>  | <p>Does the project require students to use materials from home or work on the project outside of class?</p>   | <p>Revise the project to only require provided materials and be considerate of working time outside of class.</p>   |
| <p><b>Gender norms:</b> Gender norms can limit the way that females or males participate in a project. Be mindful of gender norms associated with content, presentation style, and roles on the team.</p>  | <p>Is the project presented in a way that encourages all students to participate? What gender norms are implicit in the project?</p>                       | <p>Look for hidden, gendered assumptions in the lesson. Monitor student roles and create systems that require all students to participate equally in meaningful ways.</p> |

# Rubric for Equitable STEM Curricula

Through thoughtful action, we can create equitable environments that encourage, facilitate, and accelerate every student’s success in STEM. Based on NAPE’s Explore STEM Careers and Explore Nontraditional Careers Toolkits, this rubric helps you **assess, adjust, and activate** changes to create more equitable and inclusive STEM curricula.



For a more comprehensive evaluation of STEM programs, access NAPE’s STEM Equity Program Evaluation Rubric.<sup>11</sup>

|  | 1<br>INEQUITABLE   | 2<br>STATUS QUO   | 3<br>EQUITABLE  |
|--|--|---|---|
| <p><b>Positive career messaging</b></p> <p>1) STEM professionals are creative and collaborative problem-solvers.</p> <p>2) STEM careers are essential to our health, happiness, and safety.</p> <p>3) STEM careers make a world of difference, and help shape the future.<sup>12</sup></p> | <p>Positive STEM/CTE messaging is <b>missing</b> from the communication, design, and implementation.</p> <p><i>For example: STEM is for the elite math and science students, and creativity is ignored.</i></p>                            | <p>Positive STEM/CTE messaging is <b>additive</b>, yet not fully integrated into the communication, design, and implementation.</p> | <p>Positive STEM/CTE messaging is fully <b>integrated</b> into the communication, design, and implementation.</p>   |
| <p><b>Diverse representation</b></p> <p>This includes images, scholars, speakers, authors, role-models, videos, game characters, etc.</p>  | <p>Only the <b>normative population</b> is represented.</p> <p><i>For example: an all white or Asian male panel of engineers, or there are only women in nursing posters.</i></p>  | <p>Representation is mostly normative with the exception of one <b>tokenized individual</b>.</p>                                    | <p>Representation is <b>diverse across gender, race, socio-economic status, ability, etc.</b></p>   |
| <p><b>Multiple work<sup>13</sup> and cultural values<sup>14</sup></b></p>  | <p>Only individualistic cultural values and extrinsic work values are included. Collectivist and other work values are <b>missing</b>.</p> <p><i>For example: the nature of the intervention is competitive, with no social value.</i></p> | <p>Collectivist cultural values and social/intrinsic/prestige work values are <b>additive</b>, yet not fully integrated.</p>        | <p>Collectivist cultural values and social/intrinsic/prestige work values are fully <b>integrated</b> with normative individualistic and extrinsic work values.</p> |

|  | 1<br>INEQUITABLE   | 2<br>STATUS QUO   | 3<br>EQUITABLE   |
|--|--|---|--|
| <p><b>Accessible to every student</b></p> <p>This includes scheduling, cost, physical requirements, culture/climate, etc. In addition, are all components accessible to people with visual, hearing, and physical impairments?</p> | <p><b>Many barriers exist</b> to access, opportunity, and participation. Inadequate efforts are made to eliminate barriers.</p>                      | <p>While some efforts to eliminate barriers are in place, and progress has been made, <b>barriers still exist</b> to access, opportunity, and participation.</p>                    | <p><b>No known barriers exist</b> to access, opportunity or participation.</p> |
| <p><b>Challenges gender norms and stereotypes</b></p>  | <p>Gender norms and stereotypes are <b>perpetuated</b>.</p>  | <p>Gender norms and stereotypes are <b>not challenged</b>.</p> <p><i>For example: Girls or women consistently write the report or presentation, because "girls are neater."</i></p> | <p>Gender norms and stereotypes are <b>challenged</b>.</p>                     |
| <p><b>Challenges racial norms and stereotypes</b></p>  | <p>Racial norms and stereotypes are <b>perpetuated</b>.</p>  | <p>Racial norms and stereotypes are <b>not challenged</b>.</p> <p><i>For example: Asian students are assigned the math portion because "Asians are good at math."</i></p>           | <p>Racial norms and stereotypes are <b>challenged</b>.</p>                     |
| <p><b>Challenges socio-economic status (SES) norms and stereotypes</b></p>   | <p>SES norms and stereotypes are <b>perpetuated</b>.</p>   | <p>SES norms and stereotypes are <b>not challenged</b>.</p>   | <p>SES norms and stereotypes are <b>challenged</b>.</p>                        |
| <p><b>Challenge ableist norms and stereotypes</b></p>  | <p>Ableist norms and stereotypes are <b>perpetuated</b>.</p> <p><i>For example: Students in wheel chairs are discouraged from welding class.</i></p> | <p>Ableist norms and stereotypes are <b>not challenged</b>.</p>   | <p>Ableist norms and stereotypes are <b>challenged</b>.</p>                    |

|  | 1<br>INEQUITABLE   | 2<br>STATUS QUO   | 3<br>EQUITABLE  |
|--|--|---|---|
| Encourages career exploration outside of norms | Students are <b>not encouraged</b> to explore careers outside of norms.                      | Students are <b>passively encouraged</b> to explore careers outside of norms.   | Students are <b>actively and directly encouraged</b> to explore careers outside of norms.<br><br><i>For example: Students are personally invited and encouraged to consider nontraditional careers.</i> |
| Encourages college AND career readiness        | <b>Only four-year college</b> pathways are represented as acceptable post-secondary options. | Some two-year college, certificate, and apprentice pathways are included, but <b>implicitly presented as secondary</b> to four-year college pathways. | Two-year college, certificate, apprentice, and four-year college pathways are included, and presented as <b>equally valuable post-secondary options</b> .   |

# Endnotes

- 1 Brown, M., Thompson, J., & Pollock, M. (2017). Ensuring Equity in Problem Based Learning. NAPE. Gap, PA.
- 2 Brown, M., Martin, J., Davis, M. & Pollock, M. (2018). Eliminating Barriers through Culturally Responsive Teaching. NAPE. Gap, PA.
- 3 Pollock, M. (2022). Explore STEM Careers, 3rd Edition. NAPE. Gap, PA.
- 4 5E Model of Instruction: <https://ngss.sdcoe.net/Evidence-Based-Practices/5E-Model-of-Instruction>
- 5 <https://education.nationalgeographic.org/resource/ecosystem>
- 6 Definition from the National Collaborating Centre for Determinants of Health, St. Francis Xavier University in Antigonish, Nova Scotia
- 7 Quiz Source: [https://ed.ted.com/on/ZRH1NmA?theme\\_id=cleanup#review](https://ed.ted.com/on/ZRH1NmA?theme_id=cleanup#review)
- 8 <https://www.unep.org/news-and-stories/press-release/plastic-pollution-environmental-injustice-vulnerable-communities-new>
- 9 <https://www.unep.org/news-and-stories/press-release/plastic-pollution-environmental-injustice-vulnerable-communities-new>
- 10 Rosser, S. V. Group work in science, engineering, and mathematics: Consequences of ignoring gender and race. *College Teaching* 46, 82-88 (1998).
- 11 STEM Equity Program Evaluation Rubric: <https://napequity.org/stem/stem-equity-project/imstem/stem-equity-program-evaluation-rubric/>
- 12 STEM Messaging  
National Academy of Engineering. 2008. Changing the Conversation: Messages for Improving Public Understanding of Engineering. Washington, DC: The National Academies Press. <https://doi.org/10.17226/12187>.  
See also NAPE's Explore STEM Careers Toolkit: <https://napequity.org/product/stem-toolkit/>  
Watch a quick overview here: <https://www.youtube.com/watch?v=wJp4Cte6ZMU&t=682s>
- 13 Work Values  
Learn more: <https://nape.courses/topic/stem-4-1-agenda-2/>  
See also NAPE's Explore STEM Careers Toolkit: <https://napequity.org/product/stem-toolkit/>  
Watch a quick overview of work values here: <https://www.youtube.com/watch?v=wJp4Cte6ZMU&t=964s>
- 14 Cultural Values  
Watch a video "Individualism vs Collectivism: Why it Matters in the Classroom" [https://youtu.be/5mIGIS\\_OblE](https://youtu.be/5mIGIS_OblE)