# HEAT ISLAND PBL

PROBLEM/PROJECT BASED LEARNING

CULTURALLY RESPONSIVE

EQUITABLE AND INCLUSIVE

NAPE
National Alliance for Partnerships in Equity

Buildings, cars, and concrete, oh my! As populations increase and cities expand, green spaces shrink. We need green spaces to absorb stormwater and reduce the heat swells in cities. An urban heat island occurs when a city experiences much warmer temperatures than nearby rural areas. The difference in temperature between urban and less-developed rural areas is dependent on how well the surfaces in each environment absorb and hold heat. This effect impacts air quality and, ultimately, people's health.

**In this PBL, students learn about urban heat islands and ways to reduce heat, such as green roofs, and then choose a project to both acquire and apply new knowledge.**

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.

We've designed this STEM-focused lesson plan to be problem- and project-based[1], culturally responsive[2], equitable, and inclusive for every student[3]. 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[4] 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.**


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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:

- Explain the urban heat island effect and how it is created and measured
- Describe the effects of urban heat islands
- Identify ways in which we can reduce the effects of urban heat
- Compare and contrast the impact of building materials on temperature
- Apply learning in a PBL activity of the student's choosing
- Create a solution for reducing heat island effect

## MATERIALS

- Students or teacher will need Internet access to show videos and access readings
- Projection or display device for PDF slides
- Print outs of student worksheets

Students may need various supplies for their chosen project; however, we encourage you to keep the supplies required to an accessible limit.

- Thermometers (paper, glass, or infrared)
- Foil
- Sponge
- Glossy white cardstock
- Black cardstock (or loose roof shingles if available)

# Key Terms

**ALBEDO:** Albedo is the fraction of light that a surface reflects. If it is all reflected, the albedo is equal to 1. If 30% is reflected, the albedo is 0.3. The albedo of Earth's surface (atmosphere, ocean, land surfaces) determines how much incoming solar energy, or light, is immediately reflected back to space. This can have an impact on climate.

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

**CITY GRID:** In urban planning, the grid plan, grid street plan, or gridiron plan is a type of city plan in which streets run at right angles to each other, forming a grid.

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

**GREEN ROOF:** A green roof is planted vegetation on top of a human-made structure. Layers of vegetation must be planted over a waterproofing system.

**HEAT ISLAND:** An urban heat island occurs when a city experiences much warmer temperatures than nearby rural areas. The difference in temperature between urban and less-developed rural areas is dependent on how well the surfaces in each environment absorb and hold heat.

**IMPERVIOUS SURFACE:** Impervious surfaces are surfaces that allow little or no stormwater infiltration into the ground. A related word, impermeable means not allowing fluid to pass through.

**STORMWATER:** surface water in abnormal quantity resulting from heavy rain or snowfalls.

**URBAN AREA:** Urban area can refer to towns, cities, and suburbs. An urban area includes the city itself and the surrounding areas. Most inhabitants of urban areas have nonagricultural jobs. Urban areas are very developed, meaning dense human structures such as houses, commercial buildings, roads, bridges, and railways.

**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.[5]

# Part 1: Engage

20m

## WARM-UP

- If it were a hot summer day, where would you go outside to cool off? Why?

## EXERCISE

Share the images of people walking barefoot on different surfaces and invite students to review and reflect on the provided prompts.

Prompt students with the following:

- Think about the times you have walked on these surfaces during a hot, summer day. What was the experience like?
- On what surfaces have you noticed a difference between the temperature of the surface and the air?

## REFLECT & DISCUSS

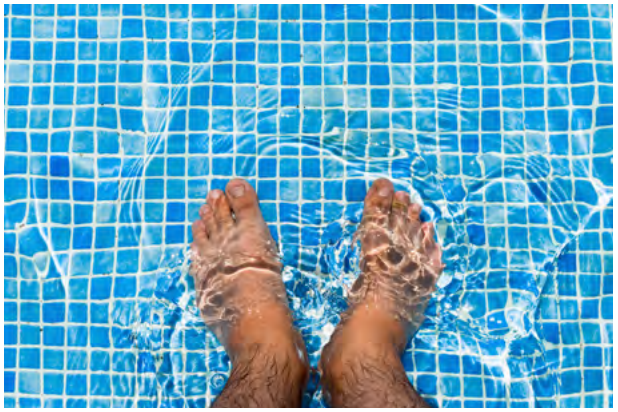
- Why are some surfaces hotter than the others?
- What would happen if you had more hotter surfaces than cooler surfaces in an area like a city?






If it were a hot summer day, where would you go **outside** to cool off? Why?



- Think about the times you have walked on these surfaces during a hot, summer day. What was the experience like?
- On what surfaces have you noticed a difference between the temperature of the surface and the air?
- Why are some surfaces hotter than the others?
- What would happen if you had more hotter surfaces than cooler surfaces in an area like a city?

# Part 2: Explore

30m + HW

## ACTIVITY

Depending on the objectives you need to reach, consider allowing students to do one or both of the activities. Instructions on how to measure surface temperatures will vary based on the instruments you have available. Simple Internet searches can assist you or students in identifying protocols and procedures. You may also add an element of student choice to the two activities by allowing them to choose a temperature instrument. Try our *Google Sheets Sample Tracker* (Tracker requires a Google log-in, then select "make a copy" from the file menu).

### SURFACE TEMPERATURE:

Invite students to explore and record surface temperatures during a warm sunny day. Students will require safe access to grass and pavement. Other options can include gravel, wooden decks, pavers, etc. Encourage them to make hypotheses first and then compare and contrast the results. They can record various details like time of day, weather conditions, surface type, ambient temperature, surface temperature, nearby shade, wind, etc.

- **Extend the lesson:** Students can track and graph temperatures over time. They can make predictions, and do statistical analyses, too.
- **Reflection**: What did you notice from your data and observations? How can human activities and construction impact surface temperatures?

### BUILDING MATERIALS:

Have students identify several locations to observe temperatures. Have them document the building materials used, structures, and conditions. (consider breezeways, building height, construction materials, reflections from glass, temperature feel, etc.) First, have them hypothesize before documenting their observations.

- **Extend the lesson**: You can measure light reflectance value if you have access to a spectrophotometer.
- **Reflection**: What did you notice from your data and observations? How can human activities and construction impact surface temperatures?

### 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.

## PRESENT

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

# SURFACE TEMPERATURE

## EXPLORE WORKSHEET

| Date/ Time | Surface Type<br>grass<br>dirt/mud<br>concrete<br>gravel<br>pavers/stones<br>wood<br>metal<br>shingle<br>other | Surface Descrip-tion & Location | Weather Condi-tions | Ambient Tem-perature | Hypothesis of Tem-perature Reading | Time thermometer placed (START) | Time thermometer read (END) | Total Time of Reading | Surface Tem-perature |
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# BUILDING MATERIALS
## EXPLORE WORKSHEET

| Date/ Time | Surface Type<br>grass<br>dirt/mud<br>concrete<br>gravel<br>pavers/stones<br>wood<br>metal<br>shingle<br>other | Surface Descrip-tion & Location<br><br>Covered or shad-ed?<br><br>Building Height? | Light Reflec-tance Value | Weather Condi-tions<br><br>Ambient Tem-perature | Hypothesis of Tem-perature Reading | Time thermometer placed (START) | Time thermometer read (END) | Total Time of Reading | Surface Tem-perature |
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# Part 3: Explain

30m

**WATCH**

*Why It's Usually Hotter In A City | Let's Talk | NPR*

**WATCH GUIDE**

What is thermal vision?

a. A technique in which a person can see heat radiating from the surface of structures.
b. *A technique in which an infrared camera is used to measure temperature variations on the surface of a structure*
c. A technique used by scientists to measure air quality during the summer.

What is heat island effect?

- *Heat islands are urbanized areas that experience higher temperatures than outlying areas*

Which **does not** contribute to heat island effect (HIE)?

a. Building materials
b. Cars
c. People running air conditioning
d. *Green roofs*
e. Building height

What **does not** reduce HIE?

a. *Dense City Grids*
b. Green space
c. Light colors

Which causes more deaths per year?

a. *Heat*
b. Tornadoes
c. Hurricanes
d. Floods

**WATCH**

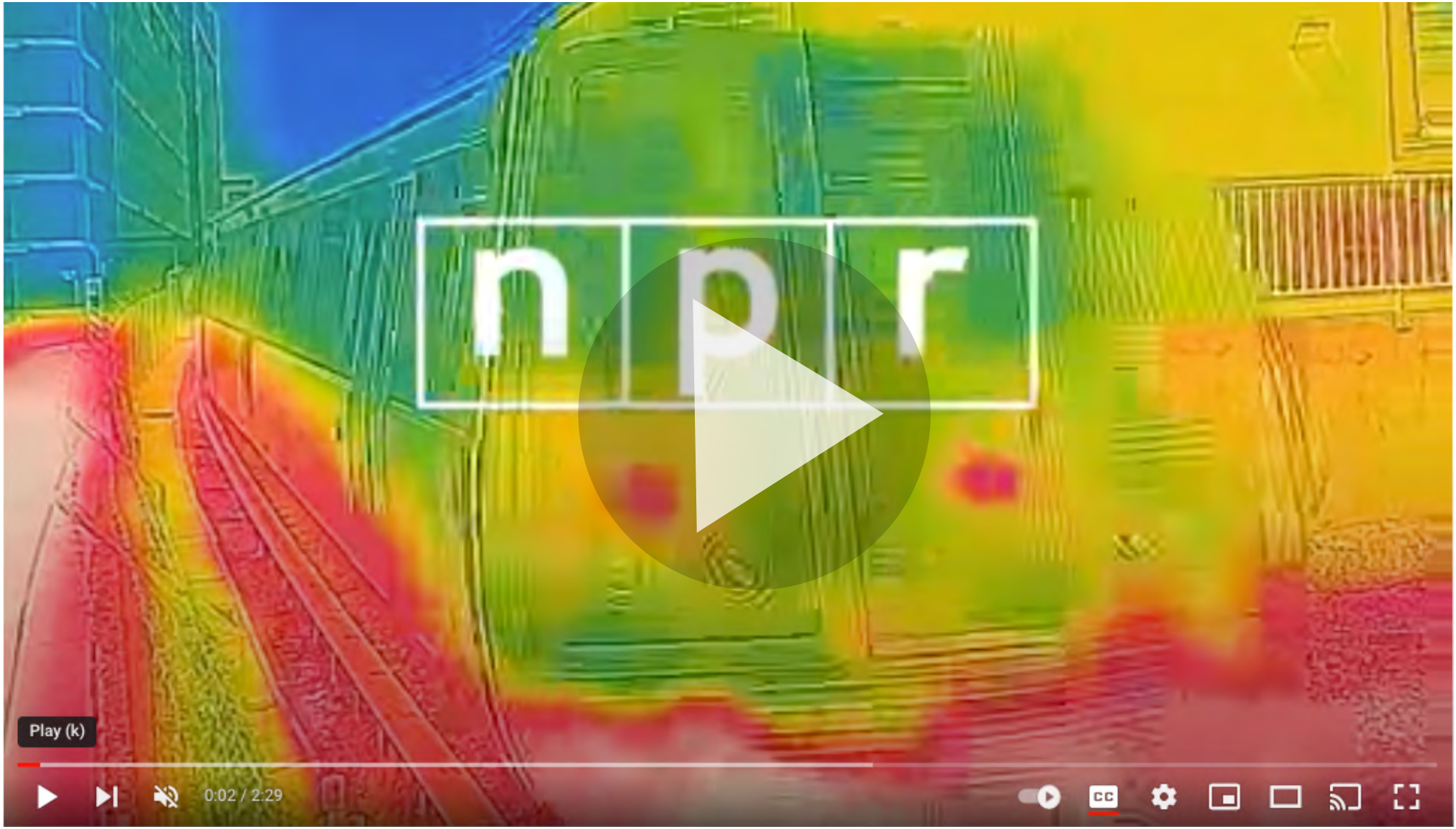
*How Green Roofs Can Help Cities | NPR*

**REFLECT & DISCUSS**

- Have you ever seen a green roof before? What did you notice?
- What did you learn from your investigations that might be explained from what you learned in the video?
- What are the benefits of adding green space like green roofs, bioretention spaces and rain gardens to urban areas? What kinds of issues might they affect?
- Where do you think a good location would be for a green roof in your community?

**OUTCOMES EXTENSION**

- Review or invite students to read *Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts*, and discuss the impacts of climate change on four socially vulnerable groups. For this unit, you could limit focus to chapters 4 & 5 related to temperature.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1. Have you ever seen a green roof before? What did you notice?

2. What did you learn from your investigations that might be explained from what you learned in the video?

3. What are the benefits of adding green space like green roofs, bioretention spaces and rain gardens to urban areas? What kinds of issues might they affect?

4. Where do you think a good location would be for a green roof in your community?

Climate change affects EVERYONE and indicators project many impacts like the urban heat island effect will worsen.

*But individuals will not EQUALLY experience these changes.*

A recent EPA report improves our understanding of the degree to which four socially vulnerable populations in the United States— defined based on income, educational attainment, race and ethnicity, and age may be more exposed to the highest impacts of climate change.

EPA. 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. U.S. Environmental Protection Agency, EPA 430-R-21-003.

## Table 4.1 – Social Vulnerability and Temperature Mortality

| CATEGORY | DEFINITION |
|---|---|
| **Low Income** | Neighborhoods in the U.S. and Canada where poverty rates are relatively higher have been found to experience elevated temperature mortality impacts.[13] Individuals without health insurance—a condition which may be more common for low-income populations—have also been found to experience higher rates of temperature mortality impacts.[14] |
| **Minority** | Studies have found higher temperature mortality rates among many minority populations, including Black and Hispanic populations.[15] |
| **No High School Diploma** | There is a paucity of research on the relationship between one's education and impacts from exposure to extreme temperatures. However, one study found higher temperature mortality among individuals working in outdoor occupations (agriculture and resource extraction),[16] industries where some workers may be more likely to lack a high school diploma. |
| **65 and Older** | Older individuals have higher baseline mortality rates and are more susceptible to the negative health consequences of heat exposure, in part due to the exacerbation of heat stress on pre-existing cardiac conditions.[17] |

## Table 5.1 – Social Vulnerability and Labor

| CATEGORY | DESCRIPTION |
|---|---|
| **Low Income** | Workers with low income levels may experience more hardship associated with reduced pay from lost labor hours.[9] Low income may also be associated with lack of access to insurance or healthcare, making these individuals more vulnerable to the potential health effects of heat exposure. |
| **Minority** | There is a lack of research on the link between minority status and labor impacts from extreme temperatures. However, individual racial and ethnic identity has been strongly associated with heat-associated morbidity and mortality in the U.S.[10] |
| **No High School Diploma** | There is a lack of comprehensive literature on the link between educational attainment and labor impacts from extreme temperature. However, as described in Appendix E, those with no high school diploma make up significant percentages of workers in the agriculture sector (31%) and construction sector (19%). |
| **65 and Older** | Older individuals are more susceptible to the negative health consequences of heat exposure.[11,12] |

# PLASTIC POLLUTION EXPLAIN WORKSHEET

## WATCH GUIDE

*Why It's Usually Hotter In A City*

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## REFLECT & DISCUSS

*How Green Roofs Can Help Cities*

1. Have you ever seen a green roof before? What did you notice?

2. What did you learn from your investigations that might be explained from what you learned in the video?

3. What are the benefits of adding green space like green roofs, bioretention spaces and rain gardens to urban areas? What kinds of issues might they affect?

4. Where do you think a good location would be for a green roof in your community?

# Part 4: Elaborate

40m + HW

## ORGANIZE

- Describe the project options below 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

### SCHOOL/CAMPUS HEAT ISLAND REDUCTION:

Create a plan to reduce heat island effect for your school/campus. Start with data to inform why it is beneficial. This can include maximizing green space, reducing impervious surfaces, changing the color of surfaces, recommending a change in materials, planting rain gardens and green roofs, etc. Consider costs, constraints, and potential savings.

**Resources**

- *Reduce Urban Heat Island Effect*
- *Bioretention areas*
- *Rain gardens*

### GREEN ROOF PROPOSAL:

Identify a location in your school or community that is a good candidate for a green roof. Clarify why it is a good candidate, and the problem it will solve for the building owners and the broader area. This could be an advanced math exercise doing calculations to estimate energy savings over time.

**Resources**

- *Mini Green Roof Lesson Plan*
- *Let's Put Green Roofs on Schools and Help Students and Teachers*
- *Sustainable Design and Green Roofs*

### EXTREME HEAT OR GREEN SPACE PUBLIC AWARENESS CAMPAIGN:

Research extreme heat public awareness campaigns, or campaigns for green spaces to reduce heat island effect. What made them effective? Create a campaign for your school or community on the causes and health implications of extreme heat, especially for vulnerable populations, and specific strategies to reduce the impacts on climate change. Use data to inform your messaging. Set goals and track the impact of your campaign.

### 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.

## 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.

## Here are the components of effective feedback

### 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?*

# HEAT ISLAND PROJECT OPTIONS

## SCHOOL/CAMPUS HEAT ISLAND REDUCTION:

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## STUDENT'S CHOICE:

If you can identify a similar type of activity that still meets the objectives, present your idea for approval.

# Part 5: Evaluate

40m

## 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 heat island effects?
- What solutions do you propose to help monitor and minimize the effects of heat island effects in our communities?

## 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

### Complementary Lessons

- *Measuring School Sustainability*

# STEM Careers Activity

15m

## 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.

## OPTIONS

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

## REFLECTION PROMPTS

- Based on what we learned today, which STEM careers sound interesting? Why?
- What other types of STEM jobs can you identify?
- Select one of the careers 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.
- Imagine being one of the listed STEM professionals. How might you approach solving an issue related to the urban heat island effect?

# 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.

There are many STEM careers related to solving the issues of the urban heat island effect. Here are a few examples:

- ARCHITECTS blend art and science, designing structures for people, such as houses, apartments, schools, stores, malls, offices, places of worship, museums, sports stadiums, music theaters, and convention centers. Their designs must take into account not only the structure's appearance, but its safety, function, environmental impact, and cost.

- CAD TECHNICIANS (computer-aided design) combine art and engineering to prepare the technical drawings and plans from which everything in the world is made—from toys to toasters, houses to hoses, satellites to sewer systems. CAD technicians are essential to designing and constructing all human-made products around you.

- CIVIL ENGINEERS work to improve travel and commerce, provide people with safe drinking water and sanitation, and protect communities from earthquakes and floods. If you turned on a faucet, used a bathroom, or visited a public space (like a road, a building, or a bridge) today, then you've used or visited a project that civil engineers helped to design and build. Civil engineers

- ENERGY ENGINEERS or Energy Systems Engineers deal with energy efficiency, energy services, facility management, plant engineering, environmental compliance, sustainable energy and renewable energy technologies.

- ENVIRONMENTAL ENGINEERS use the principles of engineering, soil science, biology, and chemistry to develop solutions to environmental problems.

- ATMOSPHERIC AND SPACE SCIENTISTS investigate weather and climate-related phenomena to prepare weather- and climate-related phenomena for the public.

- COMPUTER AND INFORMATION SCIENTISTS conduct research in the field of computer and information science that improve our ability to understand changing weather conditions.

- APPLICATIONS SOFTWARE DEVELOPERS develop and modify computer applications software that is used to communicate with satellites and people using satellite data.

# Best Practices for Groups

Rosser[6] 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 |
|---|---|---|
| **My PBL project is student–centered.** | | |
| ***Student agency:*** 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. |
| ***Scaffolding:*** 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. |
| **My PBL project fosters an equitable team–learning environment.** | | |
| ***Intentionally selecting teams:*** 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 |
|---|---|---|
| *Rotating roles*: 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. | 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? | 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. |
| *Reflect on and celebrate diversity:* 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. | How can you foster reflection and celebration of diversity within teams? | Build team reflection activities into your PBL lesson that help students recognize the value of individuals and benefits of diversity within their team. |
| *Monitoring team discourse and roles:* 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. | What should you be doing and listening for when facilitating PBL among teams? | Create a system to monitor and interrupt inequities within teams. Compile resources to help you respond appropriately to inequitable behavior. |
| *Assessment:* 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. | How are students assessed for their work? Does the assessment represent individual or team work? How does your assessment system align with learning objectives? | Identify your learning objectives and align them to appropriate assessments. Include evaluations that can counterbalance peer reviews, which may be inequitable. |

| | Reflection | Action |
|---|---|---|
| **My PBL project centers around authentic, relevant contexts.** | | |
| ***Social impact:*** When PBL is delivered within a real-world context and has social impact, it is more interesting to all students. | Is the project situated in a real-world context that highlights social impact and application? (consider driving questions and authentic audiences) | Change the project to focus on a real-world context that has social impact and to include an authentic audience. |
| ***Culturally relevant:*** 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. | Does the focus of the project recognize or conflict with the cultural values of the students? What other approaches could be used? | Identify the cultural values of your class and develop content and approaches that are in alignment. |
| ***Lived experiences:*** 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. | Is the project relevant to students' own lives and creates opportunities to incorporate lived experiences? | Get to know your students. Take a student interest inventory and create opportunities to understand your students' lives. |
| ***Socioeconomic relevancy:*** 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. | Does the project require students to use materials from home or work on the project outside of class? | Revise the project to only require provided materials and be considerate of working time outside of class. |
| ***Gender norms:*** 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. | Is the project presented in a way that encourages all students to participate? What gender norms are implicit in the project? | Look for hidden, gendered assumptions in the lesson. Monitor student roles and create systems that require all students to participate equally in meaningful ways. |

# 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.*[7]

| | 1<br>INEQUITABLE | 2<br>STATUS QUO | 3<br>EQUITABLE |
|---|---|---|---|
| **Positive career messaging**<br>1) STEM professionals are creative and collaborative problem-solvers.<br>2) STEM careers are essential to our health, happiness, and safety.<br>3) STEM careers make a world of difference, and help shape the future.[8] | Positive STEM/ CTE messaging is **missing** from the communication, design, and implementation.<br>*For example: STEM is for the elite math and science students, and creativity is ignored.* | Positive STEM/ CTE messaging is **additive**, yet not fully integrated into the communication, design, and implementation. | Positive STEM/CTE messaging is fully **integrated** into the communication, design, and implementation. |
| **Diverse representation**<br>This includes images, scholars, speakers, authors, role-models, videos, game characters, etc. | Only the **normative population** is represented.<br>*For example: an all white or Asian male panel of engineers, or there are only women in nursing posters.* | Representation is mostly normative with the exception of one **tokenized individual**. | Representation is **diverse across gender, race, socio-economic status, ability, etc.** |
| **Multiple work[9] and cultural values[10]** | Only individualistic cultural values and extrinsic work values are included. Collectivist and other work values are **missing**.<br>*For example: the nature of the intervention is competitive, with no social value.* | Collectivist cultural values and social/ intrinsic/prestige work values are **additive**, yet not fully integrated. | Collectivist cultural values and social/ intrinsic/prestige work values are fully **integrated** with normative individualistic and extrinsic work values. |

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

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

# 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 Definition from the National Collaborating Centre for Determinants of Health, St. Francis Xavier University in Antigonish, Nova Scotia

6 Rosser, S. V. Group work in science, engineering, and mathematics: Consequences of ignoring gender and race. College Teaching 46, 82-88 (1998).

7 STEM Equity Program Evaluation Rubric: https://napequity.org/stem/stem-equity-project/imstem/stem-equity-program-evaluation-rubric/

8 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

9 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

10 Cultural Values

Watch a video "Individualism vs Collectivism: Why it Matters in the Classroom"https://youtu.be/5mIGIS_ObIE