Creative Lessons To Open Classrooms & Minds To The World.

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With
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Secondary STEM Lesson Plan
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LESSON PLAN TITLE

Sustainable Cities

DESIGNERS

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SUMMARY AND RATIONALE

In this lesson, students will design solutions to make cities more sustainable. As there are multiple targets within this goal, high school students will be given choice as to their grouping, scope, and approach to creating a working prototype using an engineering design process.

GRADE

Secondary STEM

TIME FRAME

Three weeks (50-60 minutes each class with optional extension time)

SUBJECTS

Science
Math
CTE (Career, Technology, Engineering)

STANDARDS

UN Sustainable Development Goal #11: Sustainable Cities and Communities
• Target Goal 11.7: Provide universal access to safe, inclusive and accessible, green and public spaces, particularly for women and children, older persons and persons with disabilities
• Competencies:
  › Systems Thinking
  › Strategic
  › Collaboration
  › Integrated Problem-Solving

UNDERSTANDING

• With half of humanity (3.5 billion people; estimated 5 billion by 2030) living in urban areas, global communities will need to work together to ensure that these cities are sustainable.
• Equal access to fresh, nutritious, affordable food is often lacking in urban areas, impacting people's overall health and wellbeing. Some cities are addressing this issue by creating community gardens, which have additional benefits for the environment.

ESSENTIAL QUESTIONS

• How can we design solutions to improve urban quality of life?
• How can we optimize urban infrastructures to minimize the impact of cities on human health?
• How can we ensure access fresh, nutritious foods for all?
INSTRUCTIONAL GOALS

Design solutions to identified challenges to sustainability in their community.
- Identify community stakeholders and laws/regulations applicable to the problem.
  › Be able to contact local community organizers and officials to navigate existing infrastructure.
- Identify the necessary components to a sustainable city (including affordable housing, green spaces, accessible transportation systems, cultural and natural heritage sites, and air quality and waste management).
- Use a decision matrix (or decision-making process) to objectively prioritize the challenges of a community to focus resources on the most needed areas.
- Apply the science and mathematics principles behind urban infrastructures, spaces and gardens to create prototypes to improve conditions.
- Conduct quality tests (water, air, soil, heavy metals, etc.) to determine baseline statistics for the targeted community.
- Analyze the carrying capacity/the max population that can be sustained by local/global resources.

STUDENT LEARNING OBJECTIVES

I. By the end of the Sustainable Cities project, students will be able to identify sustainability problems specific to urban areas.
  › A. Percent of students correctly defining sustainability issues on post-KAP survey
  › B. Percent change in students’ rubric scores in technical content
  › C. Percent change in students’ rubric scores in creating a decision matrix

II. By the end of the Sustainable Cities project, students will create solutions to the challenges associated with sustainability in urban areas and quantify their improvements.
  › A. Number of prototypes created to address identified sustainability problems
  › B. Percent reduction in sustainability indicator (water, air, carbon, and/or energy), as selected by student group
    1. Significant sustainability progress is 30% or higher of positive change.

III. By the end of the Sustainable Cities project, students will be able to see themselves as change agents for problems in sustainability.
  › A. Percent change in students agreeing or strongly agreeing with the belief that they have the knowledge and skills to solve sustainability problems, as measured in pre and post-project KAP Surveys.

ASSESSMENT

FORMATIVE ASSESSMENT

Students will be required to keep a project journal to record daily progress, respond to teacher prompts, and to complete a reflection activity upon conclusion of their presentations. Teachers may grade each journal entry on a scale (for example 1-3; 1-5; 1-10), based on the level of detail, and/or read journal entries when meeting with groups, as a daily check-in conversation starter.

Journal ~ Daily Check-in Questions

<table>
<thead>
<tr>
<th>Today’s Date:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Today my group completed (or worked on) this task/step:</td>
<td></td>
</tr>
<tr>
<td>Questions/concerns I have after today’s work:</td>
<td></td>
</tr>
<tr>
<td>Our plan for the next project working day:</td>
<td></td>
</tr>
</tbody>
</table>
Journal ~ Final Reflection Activity

<table>
<thead>
<tr>
<th>Which group’s presentation (not your own) best met the challenge posed by our three essential questions? Provide specific evidence for your choice.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinking about your own group’s solution/product, what are the next steps that need to be taken to implement your idea to address the challenges of sustainable cities?</td>
</tr>
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</table>

**SUMMATIVE ASSESSMENT**

Teacher will assess student work by using the NGSS Engineering Practices Rubric. Students will also be using this rubric as one of their self-assessment tools. (See rubric below.)

Additional assessment option: For a more personalized learning experience, one option for final grading is to have the students create their own rubric with Rubistar once they have identified the deliverable they will create. There are simple frameworks that they can select and modify for their specific deliverable (prototype, website, etc.), and students can easily submit to the instructor for approval.

**NGSS ENGINEERING PRACTICES RUBRIC**

| STUDENT (S): ________________________ |
| DATE: ____________________ |

<table>
<thead>
<tr>
<th>ENGINEERING PRACTICE (NGSS)</th>
<th>BEGINNING</th>
<th>PROGRESSING</th>
<th>PROFICIENT</th>
<th>ADVANCED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining problems</td>
<td>We understood the design problem.</td>
<td>We understood the design problem. We attended to some of the constraints of the problem. We used some science knowledge to limit possible solutions.</td>
<td>We had a good understanding of the design problem. We attended to multiple criteria and constraints. We used science knowledge to limit possible solutions.</td>
<td>We had an exceptional understanding of the design problem and could clearly articulate it. We attended to multiple criteria and constraints and understood the relationships between them. We used science knowledge and could clearly articulate the science behind our design.</td>
</tr>
<tr>
<td>Planning and carrying out the investigation</td>
<td>We collected data on the performance of our prototype under at least one condition.</td>
<td>We collected data on the performance of their prototype under more than one condition.</td>
<td>We collected data on the performance of our prototype under a range of conditions. We evaluated the accuracy of our data collection method(s).</td>
<td>We collected significant amounts of data under a wide range of conditions. We improved the accuracy of our data collection methods.</td>
</tr>
<tr>
<td>Analyzing and interpreting data</td>
<td>We collected some performance data of our prototype.</td>
<td>We collected performance data on our prototype using a single trial. We analyzed the performance data of the single trial.</td>
<td>We collected performance data of our prototype using multiple trials. We analyzed the performance data from multiple trials. We considered the limitations of data collection and analysis.</td>
<td>We collected some performance data of our prototype using multiple trials. We analyzed data on the performance of our prototype using multiple trials. We created and/or used different tools to improve precision and accuracy of the data.</td>
</tr>
<tr>
<td>Designing solutions</td>
<td>We completed a design project, engaging in the design cycle, to construct and implement a solution.</td>
<td>We completed a design project, engaging in the design cycle, to construct and implement a solution that met specific design criteria and constraints.</td>
<td>We completed a design project, engaging in the design cycle, to construct and implement a solution that met specific design criteria and constraints. We optimized performance of a design.</td>
<td>We creatively used the engineering design process to implement a solution that exceeded specific design criteria and constraints. We optimized performance of a design. We applied and could clearly articulate many scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system.</td>
</tr>
<tr>
<td>Obtaining, evaluating, and communicating information</td>
<td>We described our solution in writing or through oral presentations.</td>
<td>We described our solution using scientific and technical information in writing or through oral presentations.</td>
<td>We described our solution using clear and accurate scientific and technical information in writing or through oral presentations.</td>
<td>We creatively described our solution using clear and accurate scientific and technical information in writing or through oral presentations.</td>
</tr>
</tbody>
</table>
**SEQUENCE OF ACTIVITIES**

**OPENER/MOTIVATOR**

a. Prior to launching the project, students will take a brief KAP (knowledge, attitudes, and perceptions) survey to determine their pre-existing knowledge and beliefs about sustainability, challenges in urban areas, and the extent to which they believe they can design solutions to urban problems.

b. Kickoff video & total class discussion: https://www.bbc.com/reel/video/p06sbtzz/tricks-from-the-most-densely-populated-city
   
   i. What is the value of having green spaces within a city?
   
   ii. How does the video show examples of people creating local solutions to a global problem?

c. Optional activity - read NPR Article (as a class), “And This is How We Stopped Climate Change” and have students discuss their impressions.

**CORE ACTIVITIES**

a. Speed brainstorm: Whole class brainstorm on what problems exist in cities - gallery walk - each subtopic of SDG 11 is written on chart paper and students move from paper to paper as instructed, writing either a question they have about the topic or an idea for a solution. Students may not repeat an idea or question already on the paper. This allows for rapid generation of ideas and piling on, without the judgment students sometimes feel in groups.

b. After brainstorming rounds are complete, students move freely to read other ideas around the room and then stand near the target that they most want to work with. (Alternatively, students may create a decision matrix in which they rank each target based on number of ideas, their personal interest, feasibility of a solution within three weeks, etc.).

c. In groups based on target/solution interest, students will use the PMIEF Project Management Framework to define their problem, plan their class time, and narrow the scope of their problem to one community. Teacher will help students identify available resources and refine their problem statement to reflect the scope of their problem.

If working collaboratively with a global partner, students will complete the defining and planning documents in tandem and refer back to their targeted city.

d. Students will conduct research related to the problem statement and selected community and ensure that their proposed solutions are sustainable and appropriate for that community. (This may be the students’ own community or a community with which they have a connection.)

e. Based on student groups’ planning documents, students will create a reference design, test their prototype, and make quantifiable improvements to their reference design until it meets the criteria they established previously.

   i. Optional activity: If students have access to Solidworks (CAD software), they can quantify the sustainability improvements of their project, and earn a Certified Sustainability Associate credential. See teacher references.

f. Depending on the size of the class and availability of resources, teacher may elect for all students to work jointly on one project, or to have multiple projects occurring concurrently.

**CORE ACTIVITIES**

g. Students will present their solutions to an authentic audience, including the community for which the solution has been proposed. After presenting, students will be given feedback and will complete a reflection activity in their project journals to consider what their next steps should be.

h. Students will complete a post-project KAP survey to determine what effect the project has had on their knowledge, attitude, and perceptions of their capacity to affect change regarding sustainable cities.

i. Students will complete a self-assessment, using the NGSS Rubric for Engineering Design. (Rubric is adapted to meet specific needs of this project.)
RESOURCES FOR STUDENTS

- United Nations SDG website - Goal #11 Sustainable Cities and Communities
  https://www.un.org/sustainabledevelopment/cities/
- Newsela article “What is Sustainability?” - Good introduction, overview, and connection to STEM:
  https://newsela.com/read/lib-sustainability-overview/id/37905/
- Good article for stimulating discussion on possible sustainable cities:
  https://www.npr.org/sections/goatsandscada/2019/03/11/688876374/its-2050-and-this-is-how-we-stopped-climate-change
- “Vertical Farming is Here” (TEDxYouth - speaker Dickson Despommier - The Greenhouse Project: Science and Sustainability for K-12)
  https://www.youtube.com/watch?v=-ydeazX2W6M
- “How a Rooftop Farm Feeds a City” (TEDxUdeM - speaker Mohamed Hage)
  https://www.youtube.com/watch?v=kSQm09twKEE

RESOURCES FOR TEACHERS

- Project Management for Youth Framework: https://pmief.org/ (Excellent resources on teaching project management either within the PBL framework or traditional project management terminology).
- Asia Society STEM Modules for Building Global Competencies: http://www.core101.org/login/index.php (Requires free registration; 10 modules designed to help teachers facilitate globally-focused projects with students. There is a wealth of resources in their toolkit for this purpose)
- Practical Action: A wealth of resources on design challenges, background on global sustainable development projects, and lesson plans.
  https://practicalaction.org/
- Rubistar: Great rubric generator for instructors who do not have set rubrics for their curriculum (and a great way for high school students to have a voice in how they will be graded; if they have to create a rubric for their final grade)
  http://rubistar.4teachers.org/index.php
- Solidworks Sustainability: For schools using Solidworks as their CAD program, there is an add-on tool that allows students to quantify improvements to energy, carbon, air, and water. For schools that do not have access to Solidworks, students can still be credentialed as a Certified Sustainability Associate by studying the online module (https://www.solidworks.com/sustainability/sustainable-design-guide/ch1-introduction-terminology.htm) and scoring 80% or higher on the Sustainability exam.
- Global Cities: https://www.globalcities.org/ One option for students to work collaboratively with another school (intended for middle school students)