

Grand Challenges Engineering Solutions

Companion Lesson to X-STEM All Access Episode "[Engineering With Purpose](#)"

Grade/ Grade Band: High School		Topic: Engineering
Brief Lesson Description: Students will explore their ideas about what engineering is and then consider the National Academy of Engineering's Grand Challenges as complex problems to be solved. They will break down this complex problem into smaller, more manageable problems that could be solved with engineering using decomposition as a strategy.		
Performance Expectation(s): NGSS ETS 1-2: Design a solution to a complex, real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.		
Specific Learning Outcomes: -Students can explain how the Engineering Grand Challenges are complex problems -Students can develop a list of five or more subproblems that must be solved in order to solve a given engineering grand challenge -Students can rank the importance of solving subproblems in order to solve a complex problem		
Narrative / Background Information		
Prior Student Knowledge: <ul style="list-style-type: none"> No prior knowledge required–this is an introductory lesson into the engineering design process and breaking down complex problems into simpler problems. 		
Science & Engineering Practices: Construction Explanations and Designing Solutions: Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progress to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories. <ul style="list-style-type: none"> Design a solution to a complex, real-world problem based on scientific knowledge, student generated sources of evidence, prioritized criteria, and trade off considerations. 	Disciplinary Core Ideas: ETS1.C: Optimizing the Design Solution: <ul style="list-style-type: none"> Criteria may need to be broken down into simpler ones that can be approached systemically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. 	Crosscutting Concepts: No CCC are identified for this specific performance expectation.
Possible Preconceptions/Misconceptions: <ol style="list-style-type: none"> Students may believe that engineering is based on solutions rather than problems. This is caused by students' experience seeing devices/inventions created by engineers without focusing on what problem these devices solve. Students may believe that engineering is merely building/fabrication rather than a system approach used to solve a variety of problems. Beginning engineering students often view problems as simple to solve. As they develop expertise, they are able to find and scope problems at more complex depths of understanding. 		
LESSON PLAN – 5-E Model		
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions: <p><i>"What is an engineer?"</i> Have students begin this lesson by creating their own definition to this question. Have them use the Stand up-Hand Up-Pair Up strategy to share with another student. Next, generate a class definition based on student ideas.</p> <p>Show the video "What is Engineering?" After watching the video, ask students <i>"Do we need to make any adjustments to our class definition based upon this video? Why or why not?"</i> Make any needed adjustments and ensure that the shared definition includes solving problems as a key component.</p> <p>Next, have students work with a partner to generate a list to answer the question, <i>"What problems are engineers currently trying to</i></p>		

solve?" After giving pairs five minutes, generate a class list of problems. If students have similar problems, point out these similarities.

Explain that today our goal is to learn about engineering as a field and consider how engineers solve problems.

Watch the X-STEM Video "[Engineering with Purpose: Lt Col Cassandra McCloud](#)" During the video, have students make a list of problems that Lt Col McCloud has solved or worked on during her career. After the video, have students discuss what kinds of problems were discussed.

Ask students "**Can engineering solve all types of problems?** Why or why not?" (Students should come to the conclusion that not all problems can be solved by engineering. Examples of non-engineering based problems could include social problems.)

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

Explain to students that today engineers are trying to solve many problems. In 2008, the National Academy of Engineering identified fourteen complex problems that must be solved called the engineering grand challenges. Show the [Grand Challenges for Engineering Video](#).

After watching the video, have student discuss the following prompts in small groups:

1. Would you classify the problems in this video as simple or complex? Why?
2. Which of these problems do you think is most important to solve? Why?
3. How would you approach starting to solve one of these grand challenges? Explain the steps you would take.

EXPLAIN: Concepts Explained and Vocabulary Defined:

Each of the Engineering Grand Challenges is a very complex problem. In order to solve them, engineers must break them down into smaller, more manageable problems. One method to do this is called decomposition.

Have students read the article "[Decomposition in Computational Thinking](#)".

After reading the article, ask students to write a summary explaining how this strategy works. Then ask them to explain "**how this strategy could help engineers break the grand challenges down into smaller, more manageable problems?**"

ELABORATE: Applications and Extensions:

Students will now break up into small groups. Each small group will select one of the following Engineering Grand Challenges to focus on:

1. Make Solar Energy Economical
2. Engineering Better Medicines
3. Restore and Improve Urban Infrastructure
4. Develop Carbon Sequestration Methods
5. Provide Energy from Fusion
6. Provide Access to Clean Water
7. Manage the Nitrogen Cycle

Students will then research this challenge and complete the first [Student Handout](#) to decompose this problem into subproblems. (Front of handout)

After completing their graphic organizer, have students share their subproblems with another student from a different group. After sharing their findings, have the partner set rank the subproblems from most important to solve (#1) to least important to solve (#3) together. (This is question one on the student handout. Then, have students complete question #2 to see the relationship between solving subproblems and the complex problem.

EVALUATE:

Formative Assessment: Formative assessment problems throughout the lesson are ***bold and italicized***. Use student responses to these questions to help teach/reteach ideas as the lesson progresses.

Summative Assessment: Have students complete question #3 on the student handout to assess their understanding of how solving subproblems improves the likelihood that the overarching problem will be solved.

Elaborate Further / Reflect: Enrichment:

Once completing this lesson, students may use this skill/strategy as a beginning stage of long term engineering/problem solving projects.

SOCIAL EMOTIONAL LEARNING ACTIVITY

CASEL Competency Addressed: Self Awareness

During the X-STEM video, Lt Col McCloud discussed how standardized tests such as the ACT and SAT are challenges that require training, just

as runners train for a marathon. Today we are going to create a training plan to help you think about how to use this advice from Lt Col McCloud.

First, have students share what they currently do to study for tests in classes they are taking. Create a class list on the board of these strategies. Next, ask students which of these strategies can also be used to prepare for standardized tests. Remove any that are not helpful.

Next, show the video "[Facing Standardized Tests](#)". After the video, ask students what stuck out to them and why.

Next, tell students that today their goal is to come up with strategies to help prepare for standardized tests. Have students break into partners and assign each group one of the sections from the [Khan Academy General SAT Strategies Page](#). Each set of partners needs to read their assigned page and create a one page poster with how to use that tip to prepare/succeed on the SAT Test. Then have each pair present their tip to the class.

After sharing, connect your students to locally available resources to help them prepare for standardized testing.

INTERDISCIPLINARY CONNECTIONS/IDEAS

Social Studies: This lesson plan can be repurposed for students to look at breaking down the UN Sustainable Development Goals (SDGs) into smaller problems. The same decomposition strategy outlined above can be used.

Computer Science: Students can explore how decomposition is used in the field of computer science by completing this [decomposition lesson](#).



Lesson Created by Jess Noffsinger

For questions please contact info@usasciencefestival.org