According to the United Nations Population Fund, the world population reached 7 billion as of October 31, 2011. That's a 4 billion increase in the last 50 years and a 1 billion increase in the last 12 years. And, with more people living longer, the strain on our natural resources is tremendous.

No profession is better positioned to address the challenges that come with the burgeoning world population than engineering. In fact, a committee of the National Academy of Engineering recently developed a list of Grand Challenges for Engineering in the 21st Century—a list that includes a number of goals that relate directly to ensuring the sustainability of our resources. For example:

- Make solar energy economical.
- Provide energy from fusion.
- Develop carbon sequestration methods.
- Manage the nitrogen cycle.
- Provide access to clean water.

This classroom poster guide is designed to help you engage students in exploring some of the ways in which engineers can contribute to meeting the challenges we face today and ensure that our world can continue to support its inhabitants—and their 7 billion dreams…and counting.
National and Common Core Standards

The activities in this guide address the following National Education Standards that are incorporated as part of the STEM curriculum in science and technology, and Common Core standards in mathematics. The application of these standards will vary with the presenter and the challenges chosen to be addressed by students.

National Science Education Standards

■ Abilities of technological design.
  • Identify a problem or design an opportunity.
  • Propose designs and choose between alternative solutions.
  • Evaluate the solution and its consequence.
  • Communicate the problem, process and solution.

National Standards for Technological Literacy

■ Technology and Society. Students will develop an understanding of the effects of technology on the environment.
  • The alignment of technological processes with natural processes reduces negative impacts on the environment.

■ Design. Students will develop an understanding of the attributes of design.
  • The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design, refining the design, creating or making it, and communicating processes and results.

Common Core Standards for Mathematics

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Activities and Grade Level

This guide can be used with middle school and/or high school students, and adapted as needed. The activities are meant to build on one another as they delve deeper into the engineering design process.

Presentation Tips

You will need to make copies of the presenter and teacher background material as well as the activity masters and review everything with the teacher before asking him or her to display the poster in the classroom for student reference. Activities two and three are intended for the teacher to use as a classroom follow-up to your presentation.

Activity 1: Engineering for the Billions

Goal: To introduce students to the types of global challenges that engineers will be solving to enable a sustainable future for the world’s population

Time Required: Approximately 45 minutes

Objectives

Students will:

■ Learn about the role engineers can play in supporting sustainable development
■ Identify a key challenge they believe will affect the world
■ Be introduced to how the engineering design process can enable problem-solving
■ Consider which engineering disciplines might be most effective in addressing the challenge they identified

Before you begin your presentation, make sure that the poster is displayed in the classroom. Start by asking students to imagine what they would do if, as a class, they only had one electrical outlet to power all their devices. Tell them that engineers solve problems like this by using their creativity and teamwork to find practical solutions. Some problems, however, involve people all over the world. Introduce this activity with a discussion of the term sustainable development and the impact of the world population on sustainability, a concept that is defined as finding a better way for humans to live and to use the natural systems that provide the essentials for our survival—clean air and water, healthy soil, and a stable climate. To do that, we must live in ways that do not erode the ecological and social systems upon which we depend.

In Part 1 of the activity, talk with students about the roles that engineers can play in addressing the global challenges that will arise in the future. If possible, cite examples from your personal experience or the experience of colleagues in having previously met and solved challenges of this type.

Review the five Grand Challenges listed on the activity master and ask the class to make additional suggestions, then have students vote on the one challenge students think is most critical. If time permits, you might want to suggest some of the websites listed on the next page to help students form their opinions. Refer to the poster and the steps in the engineering design process as the way that engineers solve any problem, regardless of its nature. Give students an overview of how they might follow the process in addressing the challenge they voted on.

In Part 2, refer to the poster again and review the various engineering disciplines listed. Engage students in suggesting which disciplines they think might be the key players in addressing the challenge they selected when applying the various steps of the design process.

Note: As an alternative, you can provide the teacher with the list of websites in advance and ask that students do their research and consider their choice of the biggest challenge prior to your visit. This will allow you to use your time with students to more fully consider examples of how engineers have developed or could develop solutions to address global challenges.
Students will:

Objectives

Presenters Resources

The National Engineers Week Foundation website (www.eweek.org) contains a wealth of information and ideas, including examples of many engineering solutions.

An address by the president of the National Academy of Engineering focuses on preparing the next generation of engineers (www.nae.edu/Activities/Events/AnnualMeetings/19611/53074.aspx).

Activity 2: Engineering by Design (Teacher Follow-Up)

Goal: To learn more about the engineering design process and about the roles that various engineering disciplines can play in addressing the critical challenges facing our planet

Time Required: Approximately 45 minutes

Objectives

Students will:

- Review the steps in the engineering design process as they might apply to another of the global challenges they identified in Activity 1
- Assume the role of an engineer working in one of various engineering disciplines and identify how that discipline might use the skills associated with it toward solving that challenge

This activity is intended as a teacher follow-up to the material presented by the engineer in Activity 1. In Part 1, ask students to vote on and choose another of the global challenges they previously identified in Activity 1. Review the steps in the engineering design process as they might apply to solving this new challenge.

In Part 2, refer students again to the classroom poster and ask them to speculate as to which engineering disciplines might be involved in solving this challenge. For example, if they have chosen equitable food distribution to countries where hunger is a problem, do they think that a nuclear engineer might be able to develop new ways of irradiating food in order to ensure its safety while in lengthy transits through difficult climatic conditions? Or would a new kind of air transport perhaps enable food to be more readily accessed in especially difficult geographical terrain, and thereby require the skills of an aerospace engineer?

Now divide students into teams that represent the various engineering disciplines they cited and prompt them to identify how they think their discipline might contribute to solving the challenge. For example, would a systems engineer be the most likely candidate to re-engineer an electrical distribution grid needed in an underdeveloped country? If so, what skills would he or she need? Be sure to allow sufficient time for each group to make their presentation, and encourage them to think expansively. Emphasize that solid teamwork is a vital component regardless of the challenge being faced.

Activity 3: Engineering a Solution for a Greener World (Teacher Follow-Up)

Goal: To follow the steps in the engineering design process to further detail what various disciplines can do to solve a global challenge

Time Required: Approximately 45 minutes

Objectives

Students will:

- Do research to gain more background on the global challenge chosen by the class in Activity 2
- Continue in their role as a team engineer from their specific discipline in Activity 2 to list and choose solutions; plan, make, test, and evaluate a prototype (if time permits); or, alternatively, describe how they would follow the engineering design process steps as if they were real engineers addressing that challenge

In Part 1, keep students grouped in their discipline teams and give them time to do research on the challenge the class chose to address in Activity 2. Alert them to research previous ideas that might not work, and what alternatives might be suggested as a result. This might point them in a new direction for solving the challenge.

In Part 2, have students follow steps 3 and 4 of the engineering design process by brainstorming solutions to the challenge and then choosing one solution as their best idea. Then have them follow steps 5 and 6 of the process by either making, testing, and evaluating a prototype if time permits and if it applies to their recommended solution, or by writing a report that outlines these same steps.

Note: To extend the activity, students might develop a final report that consolidates the recommendations of each team. If the engineer presenter has offered it as an option, arrange to send student recommendations to him or her for possible feedback and comment.
Engineering for the Billions

Goal: To introduce students to the types of global challenges that engineers will be solving to enable a sustainable future for the world's population.

Introduction: According to the United Nations Population Fund, the world population reached 7 billion as of October 31, 2011. That's twice the number of people there were just 44 years ago. And the prediction is that, 14 years from now, there will be 1 billion more people sharing our planet!

Each of those 7 billion people has a dream for a better life. A key to enabling those dreams lies in making sure that needed resources are available for all to use. This in turn is related to the concept of sustainable development, defined by the United Nations World Commission on Environment and Development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” In other words, sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability is important to making sure that we have and will continue to have the food, water and other resources to protect human health and the environment. Engineers are playing, and will continue to play, a critical role in creating solutions to challenges associated with sustainability. If you become an engineer, you could actually be responsible for helping people achieve their dreams!

In this activity, you will vote on the one most important challenge you think faces our world today, and then consider how the engineering design process, along with various engineering disciplines, would help to find a solution to that challenge.

Instructions: Use the space below to list your nominations for critical global challenges to be met. Then use the information provided by your presenter to consider which engineering disciplines might work on the various steps of the engineering design process to help solve the challenge your class voted on as the most important.

Part 1. Review the challenges listed to the right and add others you think are also important:

Grand Challenges for Engineering in the 21st Century

- Make solar energy economical.
- Provide energy from fusion.
- Develop carbon sequestration methods.
- Manage the nitrogen cycle.
- Provide access to clean water.

Now follow your presenter’s instructions to vote on your choice for the greatest challenge.

What challenge did the class end up selecting?

Part 2. Consider the various engineering disciplines shown on the poster. Using the engineering design process, which disciplines do you think would be most involved in solving the specific challenge voted on by the class? List each discipline in the chart below.

<table>
<thead>
<tr>
<th>Engineering Discipline Involved</th>
<th>What These Engineers Might Do</th>
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Now list the disciplines—as many as you think apply—next to the steps of the engineering design process below. Use more paper if needed.

Step 1: Identify the need or problem (or, in this case, the global challenge. You have already done this, above.).

Step 2: Do research.

Step 3: Develop possible solutions.

Step 4: Choose the best possible solution.

Step 5: Plan and make a prototype.

Step 6: Test and evaluate the prototype.

Step 7: Present the solution.

Step 8: Redesign.

Key Term

- Sustainability—the concept that everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can coexist.

To learn more about the important role engineers will play in achieving sustainability, go to www.engineeringchallenges.org/cms/7126/7356.aspx.
Goal: To learn more about the engineering design process and about the roles that various engineering disciplines can play in addressing the critical challenges facing our planet.

Introduction: According to the National Engineers Week Foundation, “Engineers use their imagination and analytical skills to invent, design and build things that matter. They are team players with independent minds who turn ideas into reality.” Stop and take a careful look around your classroom. Just about everything has been engineered in some way. But regardless of what challenge they are working to solve—even global challenges that affect sustainability—all engineers use the same basic design process. They may use different words to describe it, but it’s still the same!

In this activity, you will choose another critical global challenge and, using what you learned from your engineer presenter, consider which engineering disciplines might be involved in solving it. Then you will work as a team of engineers in one of those disciplines to get more “hands-on” experience in identifying your discipline’s role in solving the challenge.

Instructions: Vote on and select another of the global challenges you previously identified as a class. Review the steps in the engineering design process below, then form teams of engineering specialists with your classmates representing specific disciplines designated by your teacher. Finally, write how you think your discipline might contribute to finding a solution to the challenge.

Part 1. From the list of global challenges your class previously identified, select another challenge that you think is critically important. Which challenge did your class select?
_______________________________________________________
_______________________________________________________
_______________________________________________________

Now review the steps below and think about how they would apply to solving the new challenge your class just voted on.

Steps in the Engineering Design Process
Step 1: Identify the need or problem.
Step 2: Do research.
Step 3: Develop possible solutions.
Step 4: Choose the best possible solution.
Step 5: Plan and make a prototype.
Step 6: Test and evaluate the prototype.
Step 7: Present the solution.
Step 8: Redesign.

For another view of the engineering design process, check out www.sciencebuddies.org/engineering-design-process/engineering-design-process-steps.shtml.

Part 2. As a class, look at the list of engineering disciplines listed on the classroom poster. Repeat the type of analysis you conducted with your engineer presenter and list the engineering disciplines below that you think might be involved in problem-solving this new challenge:

Step 1. Challenge to be solved: __________________________
Step 2. __________________________
Step 3. __________________________
Step 4. __________________________
Step 5. __________________________
Step 6. __________________________
Step 7. __________________________
Step 8. __________________________

List the engineering discipline that your team has been assigned in solving this challenge.
_______________________________________________________
_______________________________________________________

In what ways do you think that your discipline can help find a solution? Write your ideas below. Use the other side of the paper if you need more room.
_______________________________________________________
_______________________________________________________
_______________________________________________________
_______________________________________________________
_______________________________________________________
_______________________________________________________
_______________________________________________________

Now be prepared to present your team’s ideas to your classmates!

Key Term
■ Design process—a series of steps that lead to the development of a new product or system
Goal: To follow the steps in the engineering design process to further detail what various disciplines can do to solve a global challenge.

Introduction: You may wonder how the scientific method that you’ve learned about in science class is related to the engineering design process. Scientists use the scientific method to make predictions that they then test through hypotheses. Engineers use the engineering design process to solve problems. With an ever-expanding global population, coupled with the challenges of creating a sustainable world that can accommodate future growth, the engineering design process gives engineers an important template for tackling real-world problems.

In this activity, you will now get more in-depth on the global challenge the class voted on by doing research as a team member of the engineering discipline you previously represented. Then you will follow the remaining steps in the engineering design process as if you were a real engineer charged with the task of creating a solution to that challenge.

Instructions: First do in-depth research on the challenge from the perspective of the engineering discipline your team represents. Then, follow the engineering design process by refining your idea and either (1) suggesting or making and testing a prototype of an object you think might help your idea work, or (2) create a final team report for consideration and feedback.

Part 1. As you do your research, use the back of this paper to make notes and to record the URLs of the sites where you found the information. Be sure to research the previous ideas for solutions that might not work, and what alternative ideas might now arise that could give you a lead on a new approach.

Steps in the Engineering Design Process
Step 1: Identify the need or problem.
Step 2: Do research.
Step 3: Develop possible solutions.
Step 4: Choose the best possible solution.
Step 5: Plan and make a prototype.
Step 6: Test and evaluate the prototype.
Step 7: Present the solution.
Step 8: Redesign.

Part 2. Follow steps 3 and 4 of the engineering design process by brainstorming new solutions. What solution do you think will work best?

Now follow steps 5 and 6 by either making, testing, and evaluating a prototype of an object that will support your idea or writing a team report that outlines these processes if you had the space, time, materials, etc., to actually follow these steps. Use the following planning guide:

Our team will:
1. □ Make, test, and evaluate a prototype of:
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________
   or
2. □ Write a report outlining these processes.

If you choose 1:
■ Materials Needed:
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________
■ Testing Process/Results:
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________
■ Evaluate the Results/Recommended Next Steps:
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

If you choose 2:
Use another sheet of paper to write a team report that describes the materials you would use, the testing process you would follow, the results you might expect, and what your recommended next step(s) would be if you either did or did not experience the results you anticipated.

Key Terms
■ Engineering—the application of scientific and mathematical principles to practical ends such as the design, manufacture and operation of efficient and economical structures, machines, processes, and systems
■ Engineering discipline—a specific field of engineering. The majority of undergraduate engineering degrees (about 98%) are awarded in a specific discipline.

For information on engineering disciplines and careers at Lockheed Martin, go to www.lockheedmartin.com.
According to the United Nations Population Fund, the world population has reached 7 billion. Wait, 7 billion and 1, 7 billion and 2, 7 billion and 3...! That is a lot of people, and it creates a lot of challenges—challenges that can be solved by engineers.

And the key to solving those challenges is the engineering design process!

1. Identify the need or problem.
2. Do research.
3. Develop possible solutions.
4. Choose the best possible solution.
5. Plan and make a prototype.
6. Test and evaluate the prototype.
7. Present the solution.
8. Redesign.