Who Are Engineers and What Do They Do?

Lesson Authors

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Standards and Benchmarks (see page 12)

Lesson Description

In this lesson, students learn about various types of engineering and the investments in human capital necessary to become engineers. First, they speculate about the types of engineers involved in building the International Space Station. Next, they work in pairs, select a field of engineering, and conduct research to determine (i) the type of work engineers in this field do and (ii) the types of investment in human capital required to have a career in this field. Finally, they learn about the 14 Grand Challenges for Engineering in the 21st Century identified by the National Academy of Engineering. They work with a partner and conduct research to learn about one of the grand challenges and share what they learned with the class.

Grade Level

9-12

Personal Finance Concepts

Careers/Planning

Economics Concepts

Human capital

Investment in human capital

Time Required

2 class periods

Essential Question

How do engineers help people?

Objectives

Students will be able to

- identify various fields of engineering as career options;
- define human capital and investment in human capital;
- explain the types of investment in human capital required to pursue a career in engineering; and
- explain how engineers contribute to the well-being of people.

Materials

- Visuals 1 and 2
- Handout 1, copied and cut apart to provide one strip for each pair of students (There are 14 strips, each with a different type of engineering. Copy additional strips as needed.)
- Handouts 2 and 3, one copy of each for each student
- Bag or container in which to place the strips cut from Handout 1

Preparation

- Place the cut-apart strips from Handout 1 into a bag or container.

Procedure

Day 1

1. Explain that this lesson will help students begin to explore careers in engineering.

2. Display *Visual 1: International Space Station*. Ask students what fields of engineering were involved in planning and constructing the International Space Station (ISS). Allow a few minutes for students to think about this. Then begin selecting students and asking them to identify fields of engineering they think were involved in the project. (*Answers will vary but may include electrical engineers, aerospace engineers, mechanical engineers, and civil engineers.*)

3. After some students have had a chance to suggest a field of engineering, explain the following:
    - Electrical engineers were involved with the power system for the ISS.
    - Computer engineers were involved with the control systems and computers aboard the ISS.
    - Mechanical and aerospace engineers were involved with the maneuvering systems.
    - Biochemical engineers were involved with the hydroponics systems.
    - Environmental engineers were involved with the life-support systems.
    - Architectural engineers were involved with the modular design.
    - Ceramic engineers were involved with the fuel cells and solar panels.
    - Mining engineers were involved with extracting specialized construction materials for the ISS.
    - Geological engineers were involved with sensing equipment for imaging Earth's surface.
    - Petroleum engineers were involved with the raw materials for creating polymers and fuels for the ISS.
    - Metallurgical engineers were involved with the aluminum and titanium alloys needed for the structural components of the ISS.
    - Nuclear engineers evaluated the radiation hazards associated with the ISS.

4. Explain that engineers are problem solvers. An accomplishment such as the ISS doesn't happen in isolation. It requires the skills of many people working as a team. Engineers use hard skills such as math, science, and written and oral communication skills along with soft skills such as collaboration, management, and judgment to create things and implement solutions to make the world a better place.

5. Explain that becoming an engineer requires investment in human capital and planning.

6. Define **human capital** as the knowledge and skills that people obtain through education, experience, and training.

7. To become engineers, people must make investments in human capital. **Investment in human capital** is the effort people put forth to acquire human capital. This effort includes education, training, and experience.

8. Tell students that they are going to determine the types of investment in human capital people who want to be engineers must make beginning in high school and then through college.

9. Divide the class into pairs of students. Have each pair draw an engineering slip (from *Handout 1: Types of Engineering*) from the container.

10. Tell students that in order to plan and make the investment in human capital necessary to become engineers, they must learn more about specific types of engineering.

11. Distribute a copy of *Handout 2: Careers in Engineering* to each pair of students. Instruct the pairs to work together to complete Handout 2 by going to the websites noted on the handout (and below). Explain that they will share the information about their assigned field with the class. Allow time for students to work.
    - *Bureau of Labor Statistics Occupational Outlook Handbook*; http://www.bls.gov/ooh/
    - Discover-e, Engineering Careers: http://www.discovere.org/discover-engineering/engineering-careers
    - National Academy of Engineering Grand Challenges for Engineering in the 21st Century: http://www.engineeringchallenges.org/

12. Have student pairs share the information they found. As students share, create a list of commonalities for most/all of the engineering fields.

13. Discuss the following:
    - What content or course work is common across all fields of engineering? (*Math, sciences, and computer technology*)
    - What other skills do engineers need? (*Written and oral communication skills, creativity*)

Stop here if you are teaching this lesson over 2 days.

Day 2

14. Explain that in March 2015, more than 120 U.S. engineering schools gave a letter of commitment to President Barack Obama. In that letter, these schools pledged to graduate a minimum of 20 students per year who are specially prepared to lead the way in solving large-scale problems, with the goal of training more than 20,000 formally recognized "Grand Challenge Engineers" over the next decade.

15. Display *Visual 2: Grand Challenges for Engineering*. Explain that the National Academy of Engineering (which is part of the National Academies of Science, Engineering, and Medicine) have identified 14 grand challenges. Discuss the following:

    - Why is solving these problems so important? (*Answers will vary.*)
    - Explain that solving these problems will lead to new technology and new and better ways of producing goods and services. Changes such as these typically lead to economic growth (a sustained rise in a nation's production of goods and services). Historically, economic growth that raises per capita output (measured as real GDP per person) has been a vehicle for alleviating poverty and raising standards of living.

16. Divide the students into small groups or pairs and assign each group one grand challenge listed on Visual 2.

17. Distribute a copy of *Handout 3: Solving Grand Challenges* to each small group or pair. Instruct the student groups/ pairs to visit the National Academy of Engineering website noted on the handout (http://www.engineeringchallenges.org/challenges/8965.aspx), read the information associated with the challenge they were assigned, and answer the questions on the handout. Explain that they will be responsible for presenting information about their assigned challenge to the class. Allow time for students to work.

18. Distribute a piece of chart paper and markers to each group/pair of students. Instruct them to prepare a visual to help them explain their grand challenge to the rest of the class. Allow time for students to work and then have groups/pairs share the information about their grand challenge.

19. After students have presented, discuss the following:

    - Might you be interested in solving any of these problems and why? (*Answers will vary.*)

Closure

20. Review the key concepts in the lesson by discussing the following:
    - Describe engineers. (*Problem solvers*)
    - Name some types of engineering. (*Accept answers based on the types of engineering careers students studied in the lesson.*)
    - What is human capital? (*Knowledge and skills people obtain through education, experience, and training*)
    - What is investment in human capital? (*The effort people put forth to acquire human capital, including education, training, and experience*)
    - What types of investments in human capital are required to pursue a career in engineering? (*Pursue a college degree in engineering, gain hands-on experience through internships, complete licensing requirements, and receive on-the-job training*)
    - How do engineers contribute to the well-being of people? (*They solve problems and develop new technology and new and better ways of producing goods and services.*)

Assessment

21. Choose among the following assessments:
    - Have small groups of students develop videos explaining their grand challenge. Within the video they must address these questions:
        - Which types of engineers might be involved in solving the challenge?
        - What specific human capital do these types of engineers need?
        - How will solving the grand challenge help people/society?
    - Have each pair of students write a tweet—140 characters or less—describing the engineering career they learned about.
    - Have students post a photo on Instagram or other social media with a tagline explaining how the picture relates to engineering.

Visual 1: International Space Station

Visual 2: Grand Challenges for Engineering in the 21st Century

1. **Advance personalized learning**
2. **Make solar energy economical**
3. **Enhance virtual reality**
4. **Reverse-engineer the brain**
5. **Engineer better medicines**
6. **Advance health informatics**
7. **Restore and improve urban infrastructure**
8. **Secure cyberspace**
9. **Provide access to clean water**
10. **Provide energy from fusion**
11. **Prevent nuclear terror**
12. **Manage the nitrogen cycle**
13. **Develop carbon sequestration methods**
14. **Engineer the tools for scientific discovery**

Handout 1: Types of Engineering

Aerospace Engineering	**Agricultural and Biosystem Engineering**
Biomedical Engineering	**Chemical Engineering**
Civil Engineering	**Computer Engineering**
Electrical Engineering	**Environmental Engineering**
Industrial Engineering	**Manufacturing Engineering**
Materials Engineering (Includes Metallurgical, Ceramic, and Welding Engineering)	**Mechanical Engineering**
Nuclear Engineering	**Petroleum Engineering**

Handout 2: Careers in Engineering

Directions: Visit the following websites to answer the questions below about your assigned field of engineering.

- *Bureau of Labor Statistics Occupational Outlook Handbook*; http://www.bls.gov/ooh/
- Discover-e, Engineering Careers: http://www.discovere.org/discover-engineering/engineering-careers
- National Academy of Engineering Grand Challenges for Engineering in the 21st Century: http://www.engineeringchallenges.org/

Field of engineering assigned: _____

1. What do people with jobs in this field do?

2. What is the work environment for this field?

3. What is the human capital required for this field?

4. Are their special licenses required for this field? If so, what are they?

5. What is the median income for this field?

6. What investments in human capital should someone interested in becoming an engineer make while in high school?

Handout 3: Solving Grand Challenges

Directions: Visit the following website to answer the questions below about your assigned grand challenge: http://www.engineeringchallenges.org/.

Grand challenge assigned: _____

1. Why is solving this problem important to people?

2. How does solving this problem contribute to the well-being of people/society?

3. What types of engineers might be involved in solving this problem, and how might they be involved?

4. Is this a problem that interests you? Why?

Standards and Benchmarks

Voluntary National Content Standards in Economics

Standard 15: Investment in factories, machinery, new technology, and in the health, education, and training of people stimulates economic growth and can raise future standards of living.

- Grade 8, Benchmark 3: Technological change results from an advance in knowledge leading to new and improved goods and services and better was of producing them.
- Grade 12, Benchmark 3: Investing in new physical or human capital can increase future productivity and consumption, but such investments require the sacrifice of current consumption and entail economic risks.

National Standards for Financial Literacy

Standard 1: Income for most people is determined by the market value of their labor, paid as wages and salaries. People can increase their income and job opportunities by choosing to acquire more education, work experience, and job skills. The decision to undertake an activity that increases income or job opportunities is affected by the expected benefits and costs of such an activity. Income is also obtained from other sources such as interest, rents, capital gains, dividends, and profits.

- Grade 8, Benchmark 1: Careers are based on working at jobs in the same occupation or profession for many years. Different careers require different education and training.
- Grade 8, Benchmark 2: People make many decisions over a lifetime about their education, jobs, and careers that affect their incomes and job opportunities.
- Grade 8, Benchmark 3: Getting more education and learning new job skills can increase a person's human capital and productivity.

Common Core State Standards: English Language Arts

Reading: Informational Text

- Key Ideas and Details

  CCSS.ELA-Literacy.RI.11-12.1: Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.

  CCSS.ELA-Literacy.RI.11-12.3: Analyze a complex set of ideas or sequence of events and explain how specific individuals, ideas, or events interact and develop over the course of the text.

- Integration of Knowledge and Ideas

  CCSS.ELA-Literacy.RI.11-12.7: Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.

- Craft and Structure

  CCSS.ELA-Literacy.RI.11-12.6: Determine an author's point of view or purpose in a text in which the rhetoric is particularly effective, analyzing how style and content contribute to the power, persuasiveness, or beauty of the text.

Common Core State Standards: Literacy in History/Social Studies, Science, and Technical Subjects, Grades 6-12 History/Social Studies

History/Social Studies

- Key Ideas and Details

  CCSS.ELA-Literacy.RH.11-12.1: Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.

- Integration of Knowledge and Ideas

  CCSS.ELA-Literacy.RH.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

  CCSS.ELA-Literacy.RH.11-12.9: Integrate information from diverse sources, both primary and secondary, into a coherent understanding of an idea or event, noting discrepancies among sources.