Uncovering Student Ideas about Engineering and Technology

HIGH SCHOOL
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STEM20
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Framing Questions for This Session:

• How does this book fit into the *Uncovering Student Ideas* series?

• Why focus on engineering and technology?

• What are some of the key ideas about engineering and technology included in this book?

• What can we learn by examining students’ responses?
Formative assessment probes are assessment *for* learning rather than assessment *of* learning; and—often it is assessment *as* learning!
Eliciting Students’ Ideas

Students’ initial ideas are used to build a bridge from where the student is to where the student needs to be to understand and use core ideas and practices.
Four Key Questions

1) What is technology?

2) What is engineering and why is it important?

3) Who engineers?

4) How is engineering done?
1) What is technology?

Probe 1
How would your students answer this question?

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**Surrounded by Technologies**

Reggie: It looks like we have only cold sandwiches today—I heard the cafeteria had a problem. It sure would be simpler if there was no more technology. Then, things would just work right all the time.

Ebony: Are you joking? If there was no more technology, the lights would go out too, so we couldn’t see what we were eating.

Tishon: That’s not all. We wouldn’t even be eating these cold sandwiches, because bread is a technology.

Reggie and Ebony: Huh? What do you mean by that, Tishon?

Do you agree with Tishon that “bread is a technology”?

___ Yes, I agree with Tishon.  ___ No, I disagree with Tishon.

Explain your thinking. How did you decide whether bread is a technology?
1) What Is Technology?

**Purpose:** Elicit students’ understanding of technology.

**Explanation:** There are no wrong answers. But the best answer is Tishon’s who understands that people made the bread, so it is a technology.

**Research:** Several studies have shown that most people think of technology as only mechanical or electrical devices.
1) What Is Technology?

Probe 1 Key Ideas

• Technologies are all of the ways that people have changed the natural world to meet their needs, including products, processes, and systems.

• We live in a world in which we are surrounded by technologies.

• Engineering is a process of solving problems by improving or inventing new technologies.
1) What Is Technology?

Takeaway #1

We live in a world of technologies!

Surrounded by Technologies

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Do you agree with Tishon that “bread is a technology”?

___ Yes, I agree with Tishon. ___ No, I disagree with Tishon.

Explain your thinking. How did you decide whether bread is a technology?
2) What is Engineering and why is it important?

Probe 3
How would your students answer this question?

What’s the Purpose of Technology?

Five friends were talking about new and improved technologies. They each had a different idea about why technologies are always being developed.

Bijou: I think technologies are developed to make life easier for everyone.

Eve: I think technologies are developed to meet people’s need for clean water, food, and shelter.

Franco: I think technologies are developed to make the world a better place for people, plants, and animals.

Marisol: I think technologies are developed for all the reasons you said.

Hal: I disagree with all of you. I think technologies are developed for a different reason than what you all said.

Who do you agree with the most? __________________ Explain your thinking.
2) What is Engineering and why is it important?

**Purpose:** Find out what your students think about engineering and its importance.

**Explanation:** The best answer is Marisol’s, that technology makes life easier, helps people meet basic needs and make the world a better place.

**Research:** Studies show that the more students understand the value of engineering, and its relevance to their lives and their communities, the more interested they become in the subject, especially for girls and youth of color.

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- **Marisol:** I think technologies are developed for all the reasons you said.
- **Hal:** I disagree with all of you. I think technologies are developed for a different reason than what you all said.

Who do you agree with the most? _________________ Explain your thinking.
2) What is Engineering and why is it important?

Probe 3 Key Ideas

- Engineering can help people solve problems and meet their needs.
- Engineering can help to preserve and improve the environment.
- Engineering can make a better world for people and animals.

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Who do you agree with the most? ____________________ Explain your thinking.
2) What is Engineering and why is it important?

PROBE 11 Key Ideas

• Engineers design solutions to problems that deeply affect people, including some that save lives.

• Engineers nearly always work in teams, often including people from a wide diversity of professions.
2) What is Engineering and why is it important?

Takeaway #2

Engineers make a better world!

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**Working Together to Save Lives**

An artificial heart is an example of technology saving lives. It shows that engineers and scientists often work in teams of people with many different skills. Put an X next to any professions that might be valuable for teams developing artificial heart technology.

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Explain your thinking. Why do engineers and scientists work with others?
Four Key Questions – Big Ideas

1) What is technology?

2) What is engineering and why is it important?

3) Who engineers?

4) How is engineering done?
A note about developing this book: we didn’t just “write” it – we “engineered” it!

An Engineering Design Process view of the book:
- Define:
  - daily life - engineering “magic” is everywhere
  - friendly language
  - diversity of characters and scenarios
- Design:
  - modular architecture
  - themes > probes > support
- Optimize
  - iterated and improved multiple cycles
TOC - Modular Architecture

Section 1: What Is Technology?
Key Ideas Matrix
Teaching and Learning Considerations
1. Surrounded by Technologies
2. Is It a Technology?
3. What’s the Purpose of Technology?
4. How Do Technologies Change?
5. Block Diagrams
6. Technology, System, or Both?
7. Systems Within Systems

Section 2: What Is Engineering?
Key Ideas Matrix
Teaching and Learning Considerations
8. Who Engineers?
9. Who Can Become an Engineer?
10. Team Players?
11. Working Together to Save Lives
12. How Are Science and Engineering Similar?
13. Is Engineering Creative?
14. Reasons for Success

Section 3: Defining Problems
Key Ideas Matrix
Teaching and Learning Considerations
17. An Engineering Design Process
18. How Do Engineers Solve Problems?
19. What’s the Problem?
20. Who Needs It?
21. Is It an Engineering Problem?
22. Criteria and Constraints
23. Pizza Problem

Section 4: Designing and Testing Solutions
Key Ideas Matrix
Teaching and Learning Considerations
24. Brainstorming
25. Engineering and Nature
26. Is It Affordable?
27. What Is a Product’s Life Cycle?
28. Engineer’s Models
29. Picking the Best Solution
30. Designing With Math and Science
31. Testing for Success
32. Making It Better
3) Who Engineers?

Probe 9
How would your students answer this question?

Who Can Become an Engineer?

Tanya: My neighbor told me that anyone can become an engineer.

Anna: That’s definitely true. My sister is an engineer, but when she was young she was only interested in history and community service. In high school, she learned that engineers solve real problems in society, so she became a civil engineer to work on affordable housing.

Marisol: That’s exciting! I can become an engineer and solve real problems! I heard that engineers need science and math so now I see why they’re such valuable classes.

Leon: Anyone can become an engineer, even if they don’t study science and math. You can learn science and math after you become an engineer.

Who do you agree with more—Marisol or Leon? _______________ Explain why you agree.
3) Who Engineers?

**Purpose:** Determine if students understand that anyone can become an engineer if they are willing to learn and help others.

**Explanation:** The best answer is Marisol’s since she understands that anyone can become an engineer, and that engineers use math and science.

**Research:** On a national test of science and technology literacy, girls scored higher than boys. However, relatively few girls choose to become engineers.
3) Who Engineers?

Probe 9 Key Ideas

• Engineering as a profession is open to people with a wide variety of interests and capabilities.
• Engineers design products, processes, and systems that meet people’s needs.
• Engineering requires scientific and mathematical thinking.
3) Who Engineers?

Takeaway #3

Everyone Engineers!

Who Can Become an Engineer?

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Who do you agree with more—Marisol or Leon? ________________ Explain why you agree.
4) How Is Engineering Done?

Probe 23
How would your students answer this question?

Pizza Problem

Business has been slow at Claire’s Pizza Place. Claire thinks a better pizza will increase sales. She asks for help from a team of students from an engineering class at a local school. The team volunteers its time helping businesses with design projects. The student team visits Claire to learn about the pizza design project. After the meeting, the students have a discussion to share different ideas on improving the pizza and attracting more customers:

Meena: I know what we should do. Let’s put chocolate and other kinds of candy on the pizzas. People like candy and they like pizza. That combination will be a winner!

Cybil: Let’s design a new kind of sauce. That is what gives pizza its taste.

Deven: We should talk with as many people as possible to find out what they like and don’t like about pizza.

Asami: Let’s see what the other pizza places in town are doing. We can find out what kind of crust, sauce, and toppings people like best, and how much those pizza places charge.

Who do you think has the best idea? ______________ Explain why you think it is the best idea.
4) How Is Engineering Done?

**Purpose:** Find out students’ ideas about how to research a problem.

**Explanation:** The best answer is Deven’s. Talking with potential customers will help the students find out what they like and don’t like and identify criteria and constraints.

**Research:** Researchers have found that beginning designers often try to skip the research phase and start generating solutions right away. Sometimes they get attached to their first idea and have a hard time considering other solutions.
4) How Is Engineering Done?

Probe 23 Key Ideas

• Research can be done many ways, such as physical and digital searches, conducting scientific investigations, interviewing clients, and studying how similar problems have been solved in the past.

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4) How Is Engineering Done?

Probe 20 Key Ideas

• Defining the problem to be solved is the first step in engineering design.

• Identifying a “client” is necessary to be clear about whose needs the solution must meet.
Once a problem is solved the work is not done. **Optimization** involves further tests and improvements to find the best possible solution.

Many different methods can be used to optimize a design.
Takeaway #4

Engineering is a lifelong skill!
Book Takeaways - Four Big Ideas

1) What is technology?
   Takeaway #1: We live in a world of technologies!

2) What is engineering and why Is it Important?
   Takeaway #2: Engineers make a better world!

3) Who engineers?
   Takeaway #3: Everyone engineers!

4) How is engineering done?
   Takeaway #4: Engineering is a lifelong skill!
1) Engagement - an equation for ALL students: $E = 5 \text{ C’s}$
   • Compassion
   • Curiosity
   • Creativity
   • Commitment
   • Careful (contraction of CareFull = Compassion!)
   = Engineering

2) Assessment *FOR* Learning & Assessment *AS* Learning

3) Start from Students’ Daily Lives – and Your Own!
2 T’s - a parting Thought and Thank you

“Any sufficiently advanced Technology is indistinguishable from Magic” - Arthur C. Clarke

“Any sufficiently advanced Teaching is indistinguishable from Magic” – a grateful student

The Uncovering Student Ideas in Engineering & Technology book has a powerful blend of recipes, but the magic only comes alive when YOU use it in your teaching!
Questions? – we love them!

USIE&T Probes are all about “what’s on your mind”

Download a sample chapter – Probe #20 - Birdhouses!
https://static.nsta.org/pdfs/samples/PB455Xweb.pdf