2

Birth of a New Technology

Shawn Frayne


Courtesy of Shane Frayne

Key Concepts
from Previous Chapters

1 Engineering
1 Technology
1 Microenterprise

Now that Amy has told you what engineers do, I'm going to tell you how they do it.

My name is Shawn Frayne, and I work as a research assistant in Amy's laboratory. To be honest, I never really liked school all that much when I was growing up in Tampa, Florida. It never felt like I was learning how to do anything revolutionary. I didn't feel challenged to think in new ways. I took Amy's class on microenterprises during my last year in college, and I finally realized I could use my engineering training to solve problems in important and new ways.

I'm thrilled to still work with Amy even though I've graduated. I joined her class while I was still in school, but, unfortunately, I was a little too late. I had just missed their trip to Haiti!

Courtesy of Shawn Frayne

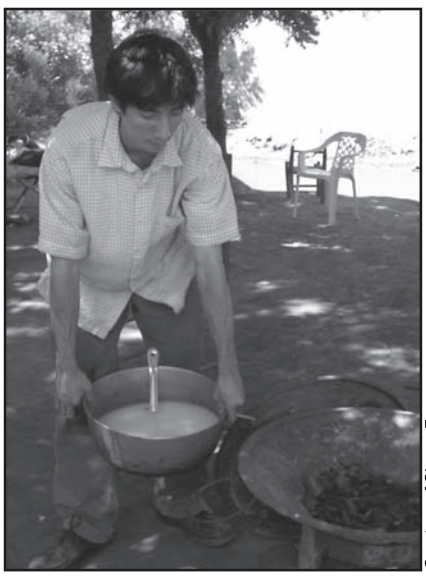
I've heard that it was an incredibly cool trip. Amy and her students traveled to Maissade, a small town about an hour and a half north of Port-au-Prince, Haiti's capital. The town is rural, and most of the people who live there are farmers.

Amy told you about the problems caused by using charcoal as a cooking fuel. I want to tell you how our team used the engineering design process to invent a new cooking technology. People use the engineering design process as a guide to invent just about everything, from paper clips to rocket ships.

When I tell the story of how we developed the technology, it may not sound as if we followed any kind of process at all, but we did. I'll tell the story first, and then I'll describe the steps we took in the design process. Amy's team knew that wood charcoal was contributing to significant problems in Haiti. The team wanted to create a new fuel, one that didn't rely on wood. Although wood was available, it was not plentiful and we wanted to avoid the need to cut down more trees. This new fuel could not make a lot of smoke when burned, because most people cook indoors and smoke fumes can be toxic, especially to children.

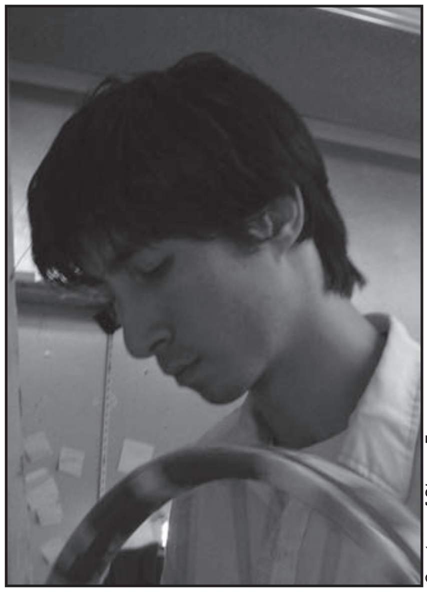
The group arrived with a plan to shred scrap paper and press the shreds into pellets that could be burned. Sounds like a great idea, doesn't it? The team used a heavy press to make the pellets. They spent the first several days in Haiti redesigning the press, so the process would take less time. When the team tried to light a pellet with a match, however, it didn't burn very well at all.

It wasn't until the group returned to MIT—around the same time I joined the project—that we burned the pellets and discovered they didn't burn hot enough to even heat water! We thought about trying to improve the paper pellets, but reconsidered this approach because the scrap paper solution had other drawbacks. The village where the team worked produced very little scrap paper, so the team traveled all the way to Port-au-Prince to get it. Burning pellets just did not fit our plan to develop an appropriate technology, which had to use easy-to-find local materials. We were disappointed, but not discouraged or surprised. That's engineering! Failure is essential to the process. Every failed attempt offers new information that helps in the next try.



Courtesy of Shawn Frayne

We decided to search for other flammable waste products that are easily available in the village. The travelers noticed plenty of sawdust in Maissade. We tried to make pellets from sawdust, but the pellets just crumbled. We needed something to make the sawdust stick together, something we could find in the village. A student from Ghana suggested using a sticky oatmeal-like substance, called cassava flour, that people eat in his country. Cassava is a root vegetable much like a potato, which also grows in Haiti. Haitians make it into a pancake-like dish.


Courtesy of Shawn Frayne

We found some cassava flour, cooked it, mixed it with the sawdust, and then pressed the mixture into pellets using our press. When it dried, the pellets held together. Was this the solution? Not quite. When we lit the cassava-sawdust pellet, it produced even more smoke than wood charcoal did! Another failure, but we had new information to help us get closer to a solution.

Again we searched for plentiful and cheap materials. The team recalled that near the village they'd seen piles and piles of crushed sugar cane, which is left over after the sugar-making process. A lot of sugar cane is grown in Haiti. People there turn the canes into sugar by pressing the juice out of them, then boiling the juice down. After juicing the cane, Haitians often dry some of it to use as fuel for the boiler. Because of this process, we thought the dried sugar cane stalk might make a good fuel. However, we also knew it produced a lot of smoke. Outside, where most Haitians make sugar, the smoke is not a problem. For indoor cooking, we needed a fuel that made very little smoke.

Still, we decided that dried sugar cane stalks, called bagasse, just might work. To solve the smoke problem, we burned the bagasse in a container with very little air. This process burns off a lot of the smoke, so all that remains are lumps of powdery black carbon.

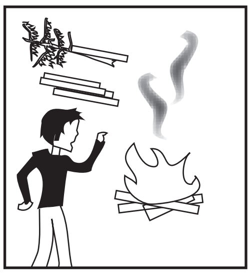

Courtesy of Shawn Frayne

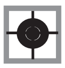
We formed briquettes by cooking cassava paste, mixing the paste with the black carbon powder, and shaping the mixture by hand. The hand-shaped briquettes dried as hard pellets. When we tested them, the charcoal sugar cane pellets burned hot with very little smoke. Finally, we had developed a solution made from locally available materials that burned well and didn't make much smoke. Success at last!

It had taken months of experimenting to find a solution. We felt satisfied we had found something that might work. However, we weren't quite finished. We still needed to test the sugar cane briquettes in the lab to see if the fumes they produce were truly less toxic than wood fumes. We also had to find a faster way to produce the pellets than shaping them by hand. We wanted to make it possible for one or two people to produce enough charcoal briquettes to sell and earn a decent living. Finally, if we overcame these obstacles, we'd need to help some of the Haitian ***entrepreneurs***—creative people willing to try new business opportunities—get access to the raw materials and equipment needed to make the charcoal briquettes. No easy task! I've learned that the technology is an important part of the process, but making the business that gets people that technology is sometimes a greater challenge.

The Engineering Design Process

Our process of developing this technology didn't follow a straight line, but we did follow the steps of the engineering design process. Here are the steps:



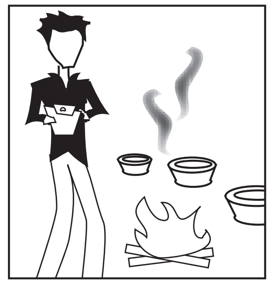


1. Define the problem.

The design process always starts with defining the problem. Before developing a new technology, engineers must try to understand the problem in detail. With this understanding, engineers can decide what features and requirements are necessary for the technology to solve the problem. The requirements include both the criteria or desired features and the constraints or limitations in developing or using the technology. Constraints often include costs, time, and materials.

- **Problem:**
  People in Haiti cut down trees to make fuel, which leads to environmental degradation.
- **Criteria:**
  Provide an environmentally friendly, easy-to-produce alternative to wood charcoal. Provide Haitians the opportunity to develop microenterprises around the technology.
- **Constraints:**
  The solution cannot cost very much to produce and cannot give off toxic smoke when burned. This new technology cannot be made from wood. The fuel must be made of locally available materials.

2. Research the problem.



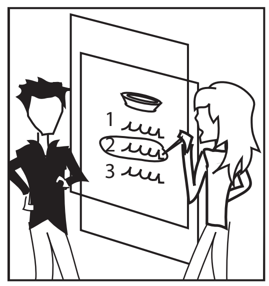
There are many ways to research a problem. Library and Internet research showed us that wood-based fuels contribute to serious ecological problems in Haiti and elsewhere in the world. We did patent research to learn about other people's ideas for solving similar problems, which helped us decide to use a press to make scrap paper into pellets.

When my classmates arrived in Haiti, they did a lot of research on locally available flammable materials by looking around and asking questions. Researching a problem simply means learning all you can about it.

3. Develop possible solutions.

The most creative part of engineering is developing many different ideas for solving a problem. Because individuals often think of unique creative solutions, our team used brainstorming to come up with as many ideas as possible. The team thought of many different ways to improve cooking technologies in Haiti, many of which we didn't even try. Regardless, each idea helped us to better focus on a plan that would work.

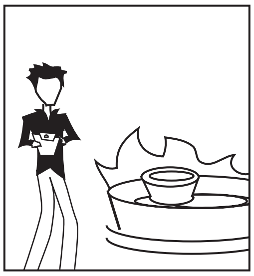
4. Choose the best solution.



No one can tell for sure what will be the best solution, or which technology will work best. But, at some point, an engineer must choose a solution that meets all requirements and test it.

5. Create a prototype.

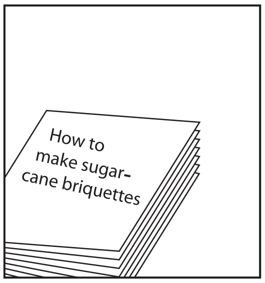
Before engineers commit to a particular solution, they usually develop a prototype. A ***prototype*** is a full-scale working model that tests whether the technology meets the requirements. Prototypes rarely work as expected, but an engineering failure can be a benefit. Our first prototype, the shredded paper pellet, didn't burn well. We learned that we had to use a fuel that burned hotter and more easily. Our second prototype, the sawdust pellet, smoked too much. But the experience with these failures led us to the cassava flour and the invention of the sugarcane charcoal briquettes.



6. Test and evaluate the solution.

To truly crack a problem, the solution must meet all criteria and constraints. Cassava is easily available in Haiti, and the briquettes are easy to produce. We also eliminated the need to use wood, and we tested the briquette's flammability—it burned hot and produced very little smoke.

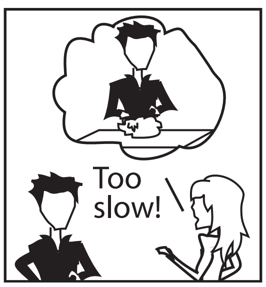
But our team's new cassava briquettes must meet all the other requirements as well. We still need to analyze the fumes in a chemistry lab here at MIT to ensure they are safe to use. If the fumes pass the test, we will need to determine whether entrepreneurs in Haiti can develop microenterprises to profitably produce and sell the briquettes.



7. Communicate the solution.

Another step in the design process is communicating the solution to the people who might use the new technology. We need to work with entrepreneurs in Haiti to describe the benefits of sugarcane charcoal briquettes and discuss how producing them may provide a source of income. This step might be the most important one because an unused technology is no better than an unavailable technology.

Informing entrepreneurs around the world about our charcoal briquette technology is part of my job right now. Amy and I have created a manual that explains how to make the briquettes. We've been distributing it to people Amy knows around the world from her time in the Peace Corps. Some people in the Philippines already have shown an interest in using the technology. I also created a website about this project and others like it. We often return to Haiti to work with entrepreneurs and engineers there to develop the briquette technology further. If our briquettes catch on, we'll help preserve the remaining trees in Haiti—and maybe help some entrepreneurs in Haiti start their own small charcoal-making businesses.

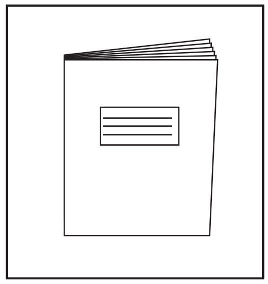


8. Redesign.

As soon as people start using a new technology, they usually find a way to improve it. Making improvements leads to changing how we define the problem, and the engineering design process begins again. If shaping each briquette by hand is too slow, then we need to add the requirement "briquettes must be made quickly" to our original design process. The team will have to research different methods for making briquettes and brainstorm ideas to speed up the production process. After we select the best idea, we'll have to build a prototype and start the other necessary steps in the process over again.

The engineering design process is a cycle. Every time we decide to improve an existing technology, the engineering design process gives us a map to find the solution.

All Steps



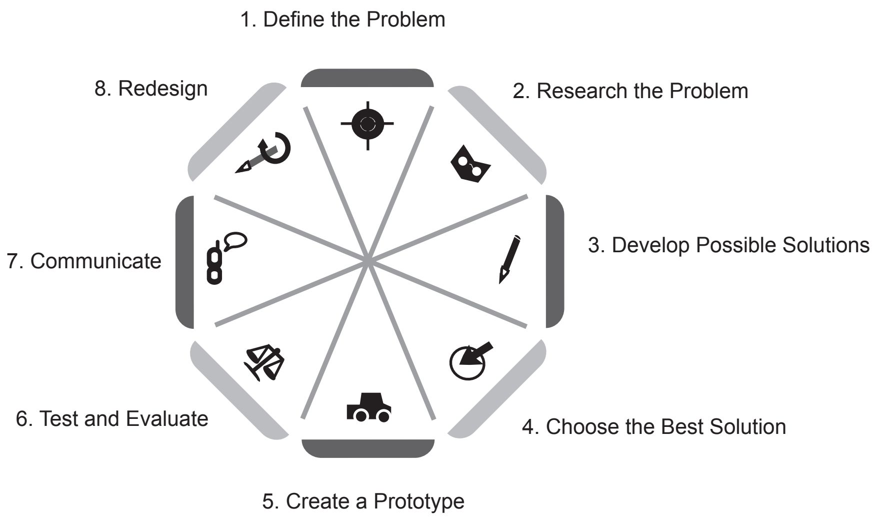
Keep a notebook. Working engineers find it helpful to write each step of the engineering design process in notebooks. The purpose of the notebook is to keep all ideas in a single place, whether documenting an observation or testing methods and results. The engineer or the team can retrace each step in the process by consulting this one source.

Is it always necessary to follow each and every step of the engineering design process as if it were a recipe? No! Our team's failure with the paper pellet made us go back to the first step and continue our research. At each step in the process, an engineer must decide either to go back or move forward toward a successful solution.

For a long time, I had always wanted to take on this type of project—one where we would work as partners with people from around the globe, to invent something that makes a difference—but until I started working with Amy, I wasn't sure it was really possible. Fortunately, as part of her class at MIT, Amy has shown many students like me how the greatest technologies of the 21st century will show up on a small farm in Haiti, not just in the local mall. I'm lucky to be a part of some of those technological breakthroughs, starting with the sugarcane charcoal briquettes.

The Engineering Design Process

Define the Problem	Describe criteria and constraints.
Research the Problem	Learn all that you can about the problem.
Develop Possible Solutions	Brainstorm creative solutions.
Choose the Best Solution	Choose a solution that best meets your requirements.
Create a Prototype	Make a working model.
Test and Evaluate	Test the solution and evaluate its success.
Communicate	Explain your solution.
Redesign	Suggest improvements to your solution.



Criteria: the desired elements of the final product

Constraints: limitations to the design or the design process

What's the Story?

1. What is the engineering design process?
2. Did Shawn's team follow the steps of the design process in order?
3. What's the difference between criteria and constraints?
4. How many prototypes did the team build? How many were successful?
5. Think about Shawn's response to his first failure. Was he surprised? What do engineers think about failure? How is this different from the way most people think about failure?
6. Why is communicating the solution an important step? What happens to technologies that are not communicated?

Connecting the Dots

7. Amy Smith says that engineers use science to develop new technologies. At which point in the design process did the team use science in developing their new technology?
8. Why was it critical to use materials that were cheap and easy to find for a new cooking technology in Haiti?

What Do You Think?

9. Your principal just hired you to help solve a problem for your school. Students are sneaking off campus for lunch because they are so unhappy with the food choices at the school cafeteria. The principal has budgeted only $1,000 to solve the problem, and she really wants it solved this academic year.

   How would you use the engineering design process to develop a solution to this problem? Write two or three sentences for each step detailing how you would accomplish it.

   Step 1: Define the problem, criteria, and constraints.
   Step 2: Explain how you would conduct your research.
   Step 3: Brainstorm at least three possible solutions.
   Step 4: Describe how you would choose the best solution.
   Step 5: Indicate how you would create a prototype.
   Step 6: Show how you would test your solution.
   Step 7: Explain how you would communicate your solution.
   Step 8: Describe how you might improve or redesign your solution.