We are not yet in a technological age. Students use technologies in many forms without a thought of where they came from or how they differ from each other. For example, is a lump of clay an example of technology? Most students would probably answer an emphatic “No” to this question. However, a lump of clay is a design tool that is used to solve human problems. The picture above shows a full-sized car created completely out of clay. In the process of developing a car, designers often create a model out of clay to get feedback from potential customers. Clay used in this way is clearly a form of technology that helps the designers determine what shape the car should be.

The process of designing technologies to solve practical problems has been a hallmark of human civilization since the dawn of time. Our current use of the term “technology” has lost track of this deeper meaning. We tend to reserve the term for electronic devices such as computers or mobile phones that...

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The term “technology” as used today is less a matter of making things and more about using things.

Above: The Tesla Model S crafted entirely out of clay. Students will find this link to creative automotive design with clay eye-opening:
http://luciano63.hubpages.com/hub/Sculptural-car-design
Photo credit: Wikimedia Commons: Steve Jurvetson.

by Brian Hartman and Larry Flick
we use every day. In fact, technology has a much broader meaning that students would benefit from understanding. Students’ lack of understanding of this topic was borne out in a study (ITEA/ITEEA, 2002) that explored young adults’ (age 18 to 29) understanding of the meaning of the word “technology.” Fifty-six percent of the respondents saw “computers and the internet” as the primary meaning for the word technology. For those who had this view, it is clear that their understanding of the meaning of technology is limited.

The National Academies of Engineering (NAE) defined technology as, “The process by which humans modify nature to meet their needs and wants.” This expansive view of technology includes ancient technologies such as the ramp as well as more recent technologies such as airplanes. The development of these technologies spans many thousands of years of human history. This view is in contrast to those of middle school and high school students surveyed in 1989 (Bame and Dugger). Over 60% of those surveyed thought that technology was a recent development (or couldn’t answer the question). This survey is additionally disturbing because more than three quarters of the students reported that they were taking or had taken technology education courses.

A study of U. S. adults (Rose, Gallup, Dugger, & Starkweather, 2004) found that over 90% viewed technology as being primarily related to computers, cell phones, and the internet. While these results are not surprising given the recent explosion of information-technology-based innovations, they highlight a general myopathy about what technology is. Despite this basic misunderstanding about technology, the 2004 survey found that 98% of participants believed that a broad view of technology should be taught to students of all ages. STEM classes have an opportunity to open student thinking to technology in all its forms.

How do we move students toward a more productive understanding of technology? In a report on technology, NAE (2002) identified three misunderstandings of technology that can be used as motivators for student learning. First, consumers are not able to make informed decisions about the benefits and risks of the technologies they use. Second, if the general population does not understand technology, it will be unable to make logically sound decisions at the ballot box (such as whether oil fracturing should be allowed). Finally, leaders at every level (from small business to large corporations) will make poor technology decisions that impact their companies and society. Technology is a vector toward the future, and each of these points helps students envision their future.

When STEM classrooms open student thinking to technological design and materials like shoes, cars, and appliances, teachers can nudge students towards seeing themselves as makers and not just takers. Certainly “high tech” items such as mobile phones and computers will continue to be important in the future, but the students of today are motivated to think about more pressing problems than whether to use Instagram™ or Snapchat™. These same devices open the students’ world to seeing important challenges, such as finding new energy sources and reducing pollution, that require an appreciation of technology as an expression of human ingenuity directed at solving important problems.

Both Standards for Technological Literacy (STL), (ITEA/ITEEA, 2000/2002/2007) and the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013) offer instructional tools and guidance about technology that develops understandings not readily apparent in today’s society. ITEEA offers 20 standards that are valuable for structuring and integrating instruction across the STEM disciplines. They provide developmentally appropriate guidance for understanding technology. NGSS links science to engineering and technology as well as mathematics. Together these documents support instruction across the STEM fields that can bring STEM teachers together in a coordinated effort to bring a 21st Century understanding of technology to today’s youth.

An enlightened view of technology will enhance the lives of students and lead to a better future. Consumers treat many forms of technology as “throwaways” with “planned obsolescence.” For example, buying a new model and throwing the old one away may be good for a corporate bottom line, but it does not benefit consumers. Such behavior likely increases the cost of the basic
service with no real change in functionality. With a deepened knowledge of technology, students can live in better harmony with their surroundings and be less of a slave to economics of technology hype. They can be wiser about sustainability, more aware of the nature and use of chemicals, able to make better decisions about their own nutrition, and be wiser consumers.

Changes in Word Meaning

The word technology has not always been linked to computers and other “smart” devices. A search of the New York Times from 1851-1899 (New York Times Archival Database) shows that in the 1800s the word “technology” was not used to describe advanced devices as it is today. The word “technology” was not used to reference any of the new inventions of the day such as electric lights, telephone, or a motion picture camera. Instead, technology in the 19th century was synonymous with the fabrication and building trades. Understanding technology meant that you could fabricate an engine or craft a cabinet. This usage is closer to the meaning of the Greek word “Techne” meaning art or skill (Merriam-Webster, 2003).

As an example of this use of the word technology, the initial goal for founding the Georgia Institute of Technology shows this focus on the practical arts. In 1888, the first two buildings constructed for the new school were the shop building and the academic building. The shop building included everything needed to teach students the trade of metalworking: blacksmith, machine and metal shops (Georgia Tech Living History Program). Georgia Institute of Technology’s original school seal had an anvil as the school icon to celebrate its focus on metalworking.

The term “technology” as used today is less a matter of making things and more about using things like personal electronic devices. How did this change occur? Heavy use of the term “high technology” in the 1980s may be responsible for the common misunderstanding that computers are the sole representation of technology. A 1996 Seattle Times article (Boswell & McConaghy, 1996) described high technology as electronic equipment and computer systems such as those developed by the small company Microsoft. Over the years, it seems that common usage has dropped the prefix “high” from “high technology” and has left the definition of technology as electronic equipment.

Classroom Exercises

The second author presented math and science teachers with a list of items based on a broad definition of technology: tools and practices deliberately employed as natural (rather than supernatural) means for attaining clearly identifiable ends (Richter, 1982). This list was largely based on a feature story in the October 18, 1999, Engineering News Record, “125 Years of Innovation” (see table at upper right).

The classroom, sports, and art items were selected to broaden examples to contemporary culture. The scales created by the math and science teachers were created using the Thurstone Paired Judgment method (see Sidebar below). The interval scale shows relative distances between items that indicate groupings or separations depending on how different or similar the teachers felt the items were on the characteristic of “technology.” Creating an interval scale involves some cumbersome manipulation of ratings.

While all of these items are technology in the broadest sense of the word, the teachers saw the computer and air conditioning (among others) as best representing “technology.” Teachers rated sculpting clay and professional sports as least representative of technology. This provided a provocative basis for a discussion about the meaning of “technology.”

**Examples of Technology**

<table>
<thead>
<tr>
<th><strong>Description of Example</strong></th>
<th><strong>Selected Items</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Element of modern</td>
<td>Sports car</td>
</tr>
<tr>
<td>transportation system</td>
<td></td>
</tr>
<tr>
<td>Type of tool</td>
<td>Power drill</td>
</tr>
<tr>
<td>Engineered materials</td>
<td>Plywood</td>
</tr>
<tr>
<td>Systems in buildings</td>
<td>Air conditioning systems</td>
</tr>
<tr>
<td>Environmental systems</td>
<td>Running water</td>
</tr>
<tr>
<td>Contemporary computing</td>
<td>Cell phone</td>
</tr>
<tr>
<td>equipment</td>
<td></td>
</tr>
<tr>
<td>Classroom equipment</td>
<td>Pencil</td>
</tr>
<tr>
<td>Process for creating art</td>
<td>Sculpting clay</td>
</tr>
<tr>
<td>Modern sport that has</td>
<td>Professional football</td>
</tr>
<tr>
<td>become an entertainment</td>
<td></td>
</tr>
<tr>
<td>product</td>
<td></td>
</tr>
</tbody>
</table>

**Louis L. Thurstone** developed the method of paired comparison in 1928 to order concepts on a single dimension (such as importance or interest). Prior to this time, ratings of this type had been conducted by asking participants to rank items according to their views. Thurstone recognized that the human mind isn’t able to keep the entire list in memory, causing participants to be inaccurate in their ranking. He resolved this issue by asking participants to compare each item with every other item and mark the one that was most like the dimension under research. By comparing each item with every other item, Thurstone resolved the issue of accuracy in rank-ordering exercises. His approach could accurately place each item on the scale without succumbing to the limitations of human short-term memory. See [http://thesesproject.org/technology/](http://thesesproject.org/technology/) for more details on the Thurstone scale and results of the teacher study referenced above.
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Is a road a technology?

Teachers can lead students through a similar approach with no computation to stimulate a deeper understanding of technology. Ask students to determine which of the technologies listed in the table (previous page) most represent the meaning of this term. Using a sorting technique that simulates the Thurstone Scale, you can create a scale based on student perceptions as the basis for discussion. To prepare students for this activity and discussion, they can spend time at the website for Science & Engineering in the Lives of Students (http://TheSELSProject.org) watching a video or examining one or more of the activities. A worksheet on the site can be used to lead the sorting activity. Students individually compare each type of technology that they then sum to determine the final rank order of technology items. Instruct students to compare each pair of technologies and check the box. Using a classroom tally, teachers can determine what words the students have prioritized as most like technology and least like technology. This summary can be used as a springboard to initiate discussions about what really represents technology.

The activity was piloted in multiple schools, and the teachers developed a list of questions for leading the discussion:

- What are key differences between those items at the top of the list versus those at the bottom? (A think-pair-share activity is an effective way to get the discussion started.)
- What are key similarities?
- Describe a problem that specific items were designed to solve. [Guide discussion to items up and down the scale]
- Can you describe something you made or did to solve a problem at home or in your life? [e.g., how to leash a dog in the yard so that it doesn’t get tangled; arranging hooks and shelves in your room so that you can find things or so that you have the best performance of your speakers; crating things in your backpack so that the phone doesn’t get damaged…]
- How is a practice (e.g., traffic laws) like a concrete piece of technology (e.g., backpack)?
- How is a specific kind of material (e.g., spandex) like a mechanical device (e.g., power tool)?
- How is technology different than natural products (a stick, for example)?
- What do you think the latest technology would have been in the following eras: Stone Age, Bronze Age, Iron Age?
- What human problem does the wheel solve?
- Why do you think electricity was not used in human inventions until recently?
- Most people don’t view a road as a technology. Why do you think that is so?

Following the discussion, groups of students can create their own lists of technologies that span the range of tools, practices, materials, and systems that capture their understanding of technology. Students could start with a list of technologies commonly available in technology labs such as: hammer, nail, pencil, screwdriver, hand saw, table saw, 3D printer, CNC router, pencil. This activity could assist in connecting hands-on laboratory work with technology tools to the larger meaning of technology. Using the templates provided in this paper, students can also conduct their own surveys, comparing results across classrooms, between genders, and between ages. They will find it interesting to ask their parents to complete the same survey after which they can combine the results within the class and discuss what it means.

Technology is a confusing concept for students to understand. In a school setting, technology often refers to instructional technologies such as electronic whiteboards, tablets, and laptop computers. Students begin to associate the word technology with these highly technical devices instead of developing a more broad understanding of the word. The activity presented in this article helps students to see technology as something that encompasses the entire built world. Not only are mobile phones considered technology, but cups, spoons, and even modeling clay are a tool to solve a human problem. With this increased understanding of technology, students will be better prepared to make technological decisions and may be inspired to pursue careers in a technology or engineering field.
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References


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