2006-575: ENGINEERING FOR EVERYONE: CHARGING STUDENTS WITH THE TASK OF DESIGNING CREATIVE SOLUTIONS TO THE PROBLEM OF TECHNOLOGY LITERACY

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Engineering for Everyone: Charging Students with the Task of Designing Creative Solutions to the Problem of Technology Literacy

Introduction

The first year Introduction to Engineering course at Smith College, "EGR100: Engineering for Everyone," is designed to be accessible to all students, regardless of background, yet it also serves as the foundation for students who choose to major in Engineering Science. In this course, students are introduced to the engineering design process via "mini-projects" that include mechanical dissections and/or design challenges, as well as a final team-based design project in which they are asked to design an approach to the problem of technology literacy on the Smith campus. In addition, each student completes a thirty hour machine shop module in which she learns how to use all major tools in the shop in the fabrication of her own hand-held tool (a combination hammer and screwdriver). Accompanying these design activities and related discussions on teamwork and creativity are a set of readings and discussions on the philosophical aspects of engineering as a profession in service to humanity and the impact of technology on society [1-5]. Each student writes and revises (twice) a narrative essay in which she explores her evolving sense of what engineering is, as well as how engineering may or may not be an appropriate vehicle for her to impact society in a way that has personal meaning within the framework of her own goals and values [6]. In the present paper, we discuss the implementation and outcomes of the Technology Literacy design project within the context of the Engineering for Everyone course at Smith College.

Background

Technology Literacy, broadly defined by the National Academy of Engineering (NAE), encompasses the three dimensions of (1) knowledge about technology; (2) ways of thinking and acting in relation to technology; and (3) basic mathematical and "hands-on" capabilities utilizing technology [7]. According to the NAE's Committee on Technology Literacy, a technologically literate person should be able to recognize technology as "the entire system of people and organizations, knowledge, processes and devices that go into creating and operating technological artifacts, as well as the artifacts themselves" [8]. Ultimately, "in a world permeated by technology, an individual can function more effectively if he or she is familiar with and has a basic understanding of technology" [9].

The imperative to improve technology literacy in the United States stems from the recognition that our society is becoming increasingly dependent on technology, yet the level of understanding of technology among adults its quite poor [10]. As our reliance on technology increases, so does the need for informed policy-makers and individual members of the voting public who are called upon to make technological choices for themselves and others. There is a particular imperative to improve the technological literacy of women and racial and ethnic minorities as a means towards greater empowerment of these historically under-represented groups within science and engineering in particular, as well as within society as a whole.

As the first and only ABET-accredited engineering program at an all women's college in the U.S., and one of only a handful at a liberal arts institution, the Picker Engineering Program at Smith College is uniquely positioned to play a role in improving technology literacy among

women. The open curriculum of the college presents a challenge in this regard, in that the only common graduation requirement for each student is that she takes a writing intensive course in her first year. The introduction to engineering course, Engineering for Everyone, is designed to be accessible to all students, regardless of background, yet it also provides the framework for those students who choose to major in engineering. Historically, 5-10% of the entering first year class of Smith students enrolls in EGR100, thus, by it very nature, the course itself improves the technological literacy of a subset of the student population.

Learning Objectives of the Course
The educational objectives of the EGR100 course are for a student:

(1) To develop her own views of the nature of engineering;
(2) To develop a sound understanding of the engineering design process, including the ability to reason about function by disassembling and reassembling mechanical systems/artifacts (Mikic section) or designing and assembling mechanical systems (Voss section);
(3) To be able to apply formal design tools and work effectively with others to this end;
(4) To effectively communicate ideas, designs, and analyses orally, visually, and in writing;
(5) To understand the impact of engineering in a global and societal context;
(6) To develop a community of intentional learners.

Methods and Implementation
In preparation for the final project, students read and discuss C.P. Snow's lecture on "The Two Cultures" [1] and discuss how this phenomenon manifests itself today on the Smith Campus as well as in society at large. Following this reading, the class documented and analyzed sketches produced by students majoring (or intending to major) in the humanities, social sciences, or the arts in which they portrayed their relationship to technology and then compared these to sketches produced by students majoring/intending to major in science, math, or engineering ("Perceptions of Technology Mini-Project"). Prior to producing the sketch, each participant was required to produce a concept map on technology. Accompanying the sketch, each participant provided a one-paragraph description of what her sketch was meant to convey about her relationship to technology.

After analyzing and discussing their findings, students then worked in teams for the second half of the semester to design an approach to the problem of technology literacy on the Smith campus, including research into the societal need for such work, particularly at an all women's college structured on an open curriculum. The project was launched with a sixty-person brainstorming session consisting of the thirty students enrolled in EGR100 and thirty students outside of science/math/engineering to generate ideas for the project, as well as to discuss the issue of technology and technology literacy. Teams produced a written and oral proposal and final report, as well as a final prototype or story-board of their chosen solution after working closely with their target 'users' on the Smith campus. All project teams were required to include some form of proof of concept testing of their final designs.

Outcomes

Perceptions of Technology Mini-Project

A total of 28 students from humanities/arts-affiliated disciplines and 28 from science/engineering-affiliated fields completed this assignment. While a fair amount of overlap in the characteristics of the sketches was evident between the two groups, certain features were noted to occur more often in one group versus the other.

Humanities-affiliated students tended to primarily depict the negative aspects of technology (Figures 1 & 2), whereas engineering/science students saw both negative and positive aspects and were more likely to depict a need for balance between the two (Figure 3). Humanities students were also more likely to narrowly depict technology as being solely the domain of computers and electronics (Figure 4), whereas engineering/science students sketched a much broader range of images related to technology, including artifacts and processes related to clothing, medicine, plumbing, personal hygiene, books, laundry, transportation, and communication (Figure 5). As one first-year engineering/science-affiliated student noted in the explanation accompanying her sketch, "technology is not just about electronics, it's also a way of thinking and doing things." It is important to note that all participants in this mini-project were first-semester, first-year college students, thus differences cannot be attributed to extensive college-level engineering and science courses.

Many of the humanities students drew disturbing images expressing a sense of being trapped, confused, and/or frustrated by technology (Figures 6 -9), whereas a large number of engineering/science-affiliated students associated technology with opportunity, creativity, and advancement (Figures 10-14).

Despite this positive association, however, a fair degree of ambivalence was also present in the sketches from engineering/science students regarding their own personal relationships to technology. One image shows a machine pulling in the planet earth on a conveyer belt and releasing something unidentifiable at the other end (Figure 15). The caption reads, "Technology swallows the world and makes it into something new, but I/we don't know what that is or whether it's good or bad."

Another engineering/science-affiliated student writes, "My perception of technology includes the involvement of all humankind in creating solutions to problems… My picture depicts a thought bubble containing some examples of technological advances throughout the ages. A stone tool, one of the earliest inventions, moved humankind forward…. The wheel led to other inventions such as the car. Metal plows improved agriculture and new drugs help cure disease. As time goes on, technology will become [more] important as we are forced to find alternative energy sources." While this student's description is positive, her sketch depicts humankind as a phalanx of black-and-white stick figures, marching, faceless and uniform (Figure 16).

A third student affiliated with engineering/science writes, "In my drawing of what technology means to me I have included numerous pictures of different types of technology. I started my drawing with the most basic technological advance, the fork and knife. From there, I drew other household products, which then lead to other outside technological advances like the car. To show how technology is linked to every part of your life, I chained each item together.

Everything is linked to me, money, and the world." Like the previous student, this one depicted positive associations, and included the words 'creativity' and 'intelligence' in multicolored lettering, yet the connecting "chain" appears ominous and dark: heavy shackles which restrain, rather than link, one item to the next (Figure 17).

Brainstorming Session

After completing the Perceptions of Technology Mini-Project and discussing their observations in class, the students also attended a two-hour workshop with many of the same humanities-affiliated friends who had assisted them with the sketching mini-project. The aim of this session was to discuss different definitions of technology and technology literacy in a "mixed" group of humanities and engineering students, as well as to brainstorm ideas for approaches to improving technology literacy that might appeal to humanities-oriented students.

Five different dimensions of technology literacy emerged from the discussion. To this group of students, technology literacy meant: (1) being able to answer the question 'what is technology' in a sophisticated way; (2) understanding the far-reaching impact of technology on society; (3) knowing how to use technology; (4) understanding how specific technologies actually work; and (5) having a positive attitude towards technology whereby one feels confident and empowered to learn what she needs to know to use to technology to accomplish a personal goal.

The overwhelming message from humanities-affiliated students was that their schedules and lives were too busy to have to "fit in" yet another requirement or unit of educational programming that wasn't directly related to something that they were already interested in, even if they knew that it was in their best interest to do so. The key, these students communicated, would be to approach technology in a stealthy manner, by integrating it seamlessly with their pre-existing interests. For example, a course in art-restoration could contain relevant content on the application of chemistry to the field. A dance class might learn about the physics of a pirouette or grande-jete, or an anthropology or archeology course might study the material science needed to understand the context behind the creation of the material artifacts left behind by ancient civilizations. Art exhibits that provocatively approach the complex interplay between technology and society could be used to draw students into learning about a topic they might not otherwise think to explore. One humanities student suggested a film series over the inter-term break related to technology and its impact on society, and carefully chosen summer reading for incoming first year students related to technology and society. A literature course was proposed based on works of fiction that touch on technology, either directly or indirectly, accompanied by "just-in-time" learning about the specific technologies that were mentioned. Because technology is so pervasive and does impact almost every aspect of our day-to-day lives, it would be possible to create such a technological exploration related to virtually any topic within the humanities and arts. The key to this integration, however, would be the willingness of faculty to cross disciplinary boundaries and collaborate in non-traditional ways.

Final Projects

After brainstorming possible approaches, each team of Engineering students created a system of metrics and a numerical evaluation matrix based on target-user feedback to evaluate the potential effectiveness of their top three design concepts in achieving stated project objectives and constraints. A total of nine projects were developed, with a subset described below.

(1) "iPOD® 101" consisted of an interactive large-scale model of an iPOD®. Internal components addressed the technology behind the workings of the lithium-ion battery, the hard drive, and the MP3 format, as well as props to allow the user to learn about the history and evolution of the iPOD® as an innovative design, and the positive and negative societal impact of iPOD®'s (economic aspects, creation of both community and alienation associated with items conferring class status, the isolation of individuals from the larger community, and the distribution of pornography). The team traveled to several houses (i.e., dormitories) to present their "iPOD® 101" short-course and to field questions, and also presented at Apple® Corporation's community day on campus. User feedback from 25 humanities students found the design successful in that it was engaging and informative, although students were slightly more interested in the societal aspects (21% rated this as their favorite aspect) and design evolution (25%) than they were in the details of how the battery, hard drive, and MP3 storage format work (17%).

(2) "Techno Club" was a technology-based student organization founded by one team whose primary goal was to empower students by providing access and information regarding technology-resources on campus in a non-intimidating manner. The one event that was implemented during the semester was a technology scavenger-hunt where participants were charged with 15 challenges that required them to either use technology or identify technology resources on Campus. The final challenge required that they attend a workshop on how to build a webpage and then create their own webpage to display the results of the scavenger hunt. A total of three teams of four humanities students participated, and a sample webpage can be found at: http://www.geocities.com/mmartinez_32/scav_hunt. A survey of participants indicated that 90% felt that they did not know very much about the technological resources on Campus before the scavenger hunt:100% felt that the Scavenger Hunt had introduced them to many new resources. Those who completed the survey were overwhelmingly positive about their experience with the Scavenger Hunt, stating that it was "surprisingly fun" and would be "great as a class [or house] competition." A larger participation rate would undoubtedly have been reached had the event not been held in the days immediately preceding exam period.

(3) Production of a short film, entitled "Technology is Everywhere." This team attended several workshops conducted by media services on video filming and editing and decided to create a short film tracing the ill-fated path of a term-paper at the 11th hour of its due date as it passes hands from student to student in an effort to be turned in on time, despite the repeated interference of failed technologies. The goal of the film was to educate the audience about the omnipresence of technology and our reliance on it. The team chose to highlight the following seven examples of everyday technology: alarm clocks; eating utensils; shampoo; electromagnetic keys; washing machines; mechanical pencils; and personal computers. Interspersed throughout the video were artistically placed facts regarding these technologies. The film received positive feedback from viewers, but most suggested it would be more powerful if it were shorter.

(4) Photographic Exhibit. This team chose to create a photographic exhibit consisting of three sets of fifteen-foot banners to be mounted in the Campus Center, each consisting of three photographs and an informational caption (Figure 18). The three technological themes addressed by the banners were energy, transportation, and recycling. The photos displayed on the banners were taken by the students themselves and prototypes of the banners were used to obtain user feedback (the banners themselves were too costly to implement as the students had envisioned). Twenty-six humanities students were shown the banner prototypes and surveyed. All found the format to be engaging and provocative, and viewed the themes as being relevant to their lives. Those surveyed overwhelmingly agreed that displaying the works as banners in the Campus Center would be a powerful and effective means of raising student awareness about the impact of technology on society.

(5) Lego Mindstorm Robot Interactive Session: This team invited students to the Smith College Campus Center to learn to build their own robots using basic technological concepts. To provide examples, the team displayed (1) a robot they designed and built named "Inventorbot" that tipped its hat and rotated back and forth at a ninety degree angle; (2) a gear box that had a final gear ratio of 243:1; and (3) a poster that described examples of types of gears, gear ratios, and how to use gears to perform specific functions. About 40 people attended the event, and completed designs covered a range of genres, from robot cars to engineering symbols to a model for an electric-powered wheelchair. Participants were asked to comment on the experience, and 14 of 14 comments were positive; for example, "Technology and engineering are fun" and "Engineering means creating new things". The group and some of the participants suggested that a robotics club should be created at Smith, as it would encourage more people to participate in the technological and engineering processes.

(6) Station at the Campus Center: This team's goal was to inform the community about the broad range of everyday-items that involve technology. The team developed a public display that provided examples of a variety of technologies, including: popular food items, pens, paper plates, gloves, books, iPOD®s, calculators, digital cameras. To emphasize that technology is more than electronics, the team also identified nearby doors, windows, carpet and pillars. The most popular part of the display was a skit in which the team described programming a computer by asking the audience to issue instructions to make a peanut butter sandwich. Approximately 20 people stopped at the station, and eight people responded to three questions: (1) 100% (8 of 8) said yes to "Does technology seem fun to you now?"; (2) 75% (6 of 8) said yes to "Did you learn something from this project?"; and (3) 62.5% (5 of 8) said yes to " Does technology seem less intimidating to you?

(7) "Technology as Art": This group designed and built a sculpture that symbolized the connection between art and technology and expressed that technological designs require as much creativity and ingenuity as art (Figure 19). The sculpture was displayed for one week outside of the Art Department building at Smith College and note cards were left for comments from observers. All sixteen comments that were received were positive. One humanities student wrote: "this made me realize how inter-related art and science

are … now that I think about it the science-engineering aspect of daily life coincides with the artistic aspects…". Another student wrote: "as an artist, I understand the connection between aesthetics and the importance of making it (sculpture) stable. However, I thought of it in terms of art, not technology, so I have been given a new perspective from the other arena."

Impact

Approximately 200 students on the Smith Campus (or roughly 10% of the on-campus student population) had their awareness of technology raised by the Technology Literacy project in our Engineering for Everyone course. While raising student awareness of technology is not fully equivalent to achieving technology literacy, it is a first step in piquing student interest in the topic.

As part of their final individual student portfolios, students in the course were required to write a reflection on their experiences with the Technology Literacy project. Excerpts from their reflections are provided below, demonstrating the powerful nature of the project in showing students that engineering has the potential to impact others, both locally and globally.

"Engineering is an exciting field filled with many opportunities to improve society. I find it ironic that our final project in this class was addressing the problem of technology literacy on the Smith campus. I am one of the students who really benefited from this project. Taking EGR100 has opened my eyes to technology and science. I am not a student intimidated by science and math, but I have been an ignorant student. I am so glad that I took this class."

"There were other important lessons that the final design project provided… Just on the Smith campus [alone] a student design project can have a large impact. I can only imagine what impact engineers have on the world on a daily basis. This project … stimulated a desire to want to have that impact and make changes."

"I feel [that] after the completion of the final design project addressing technology literacy, I achieved all of the course objectives… I understand now that engineering affects both the environment and society, and a [single] human being has the ability to affect the rest of society through engineering."

Conclusions

In summary, the introduction to engineering course, Engineering for Everyone, is designed to introduce all students, regardless of background, to the fields of engineering and design, with a special emphasis on the impact of technology on society. This year, we piloted a final project for the course aimed at improving technology literacy on the Smith Campus. By reading C.P. Snow's *Two Cultures* and discussing the current relevance of this work, as well as graphically cataloguing differences in student perceptions of technology and their relationship to it based on their academic affiliation (i.e. humanities/arts vs. science/engineering), students developed a sense for the problem they were being asked to address. Nine student teams worked with "user-groups" of humanities students to develop a broad range of creative ideas to increase students' awareness of technology. Approximately 10% of the on-campus student population was impacted by the final project, and participation in the project by EGR100 students increased their

own sense of the ability of engineering and technology to impact society. To obtain an even greater impact from the project, we recommend that it be implemented jointly with students from engineering and the humanities, by coupling final projects between courses in different disciplines (e.g. engineering and women's studies, photography, sociology, etc…). A key finding from our brainstorming workshop with humanities and engineering students was that for any effort to improve technology literacy among students to be successful, the approach must directly connect to students' pre-existing interests and demonstrate the relevance of technology to their daily lives and personal aspirations.

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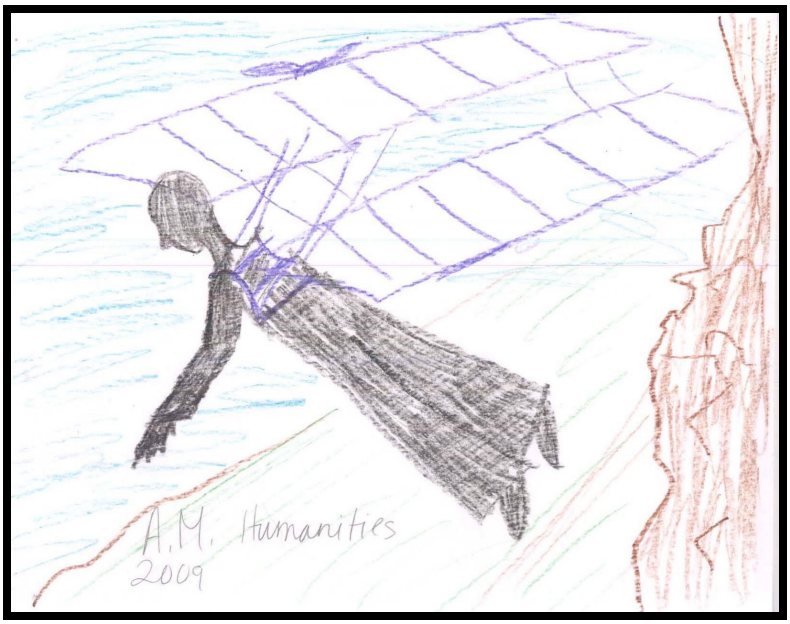

Figure 1:
"The sketch is an illustration of a person falling through the air with a pair of wings that have been invented in order to achieve flight. The person, symbolic of human civilization (which I am a part of), thinks that they are flying, that their creation has excused them from the natural laws of gravity, when really they are free-falling (which feels like flying). The ground is approaching at an accelerating rate, as our civilization seems to be headed towards its own destruction at an accelerating rate due to the irresponsible use of technology and the belief that humans are a superior species because of our technology." Perceptions of Technology Mini-Project sketch from a humanities-affiliated student.

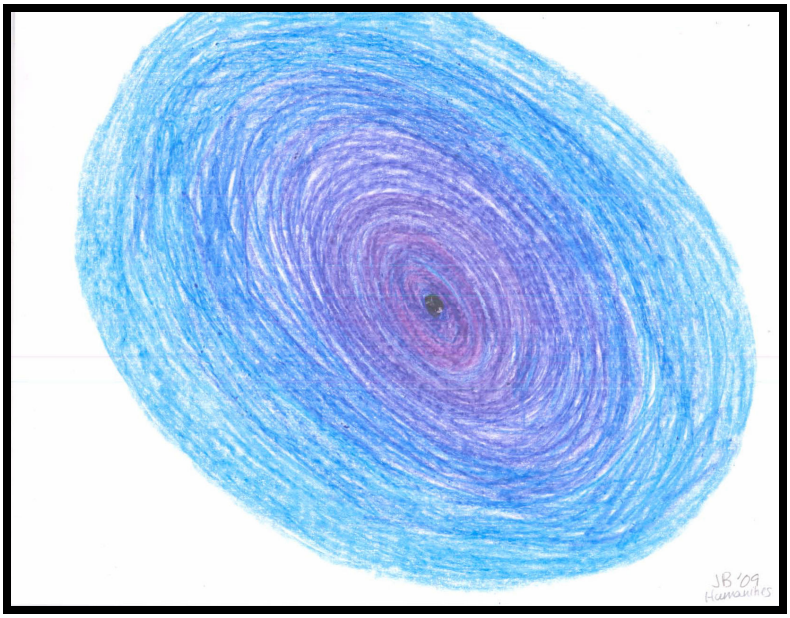

Figure 2:
"Explanation for you analytically-minded future engineers: swirling vortex of death. Period." Perceptions of Technology Mini-Project sketch from a humanities-affiliated student.

Figure 3:
"Unlike some who feel that it is extremely bad or absolutely good, I see both sides in a balance for I recognize what we have gained in our daily lives as well as what we have lost at the hands of technology. My picture thus represents this balance: one side has the negative aspects and the other has the positive. On the left is the negative which has a clock next to trees representing that we are running out of time to save natural resources … from being destroyed and disappearing forever…. Above the trees is a smoke stack polluting that side…. Below the trees is red which symbolizes blood, both the trees "bleeding" in their disappearance but also the blood that we have shed in wars by technology such as guns and other weapons. Below the blood are little squares that represent debris – it doesn't seem like much … but at the bottom it all piles up into waste. Also on that side is a heart attached to a machine by a wire. This represents the ethical issues involved in technology. On the right side, I have drawn pictures of things that we have gained. For example, there is a computer/TV, which shows the sun and clouds, which represents our ability to … gather … important information and news about our world. There are also two people on the right … The older one has a blue heart, which shows how technology has evolved to be able to prolong life, resulting in happiness for not just those whose lives are prolonged, but also those who love them. There are also houses and an airplane on that side – two things that have gotten better with technology (standard of living and travel). The clock shows how we save time with technology. At the top of this balance is the world, which should be … our main concern…. The world has curly hair, just like mine, which shows that I have a world for a head, meaning that I am thinking about it a lot and hold feelings for both sides of the balance."
Perceptions of Technology Mini-Project sketch from an engineering-affiliated student.

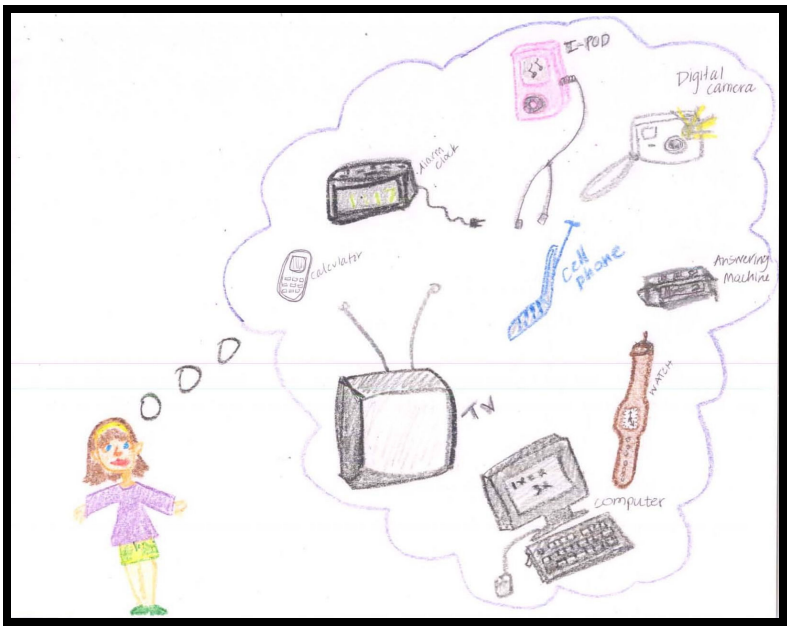

Figure 4:
"When I think of technology, I think of all of the 'gadgets and gizmos', electronic devices that I can't live my life, day to day, without. They tend to be my 'needs', like being able to wake up on time, I need my alarm clock and while I am away at school, in order to communicate with my family daily, I use the telephone…." (Humanities-affiliated student)

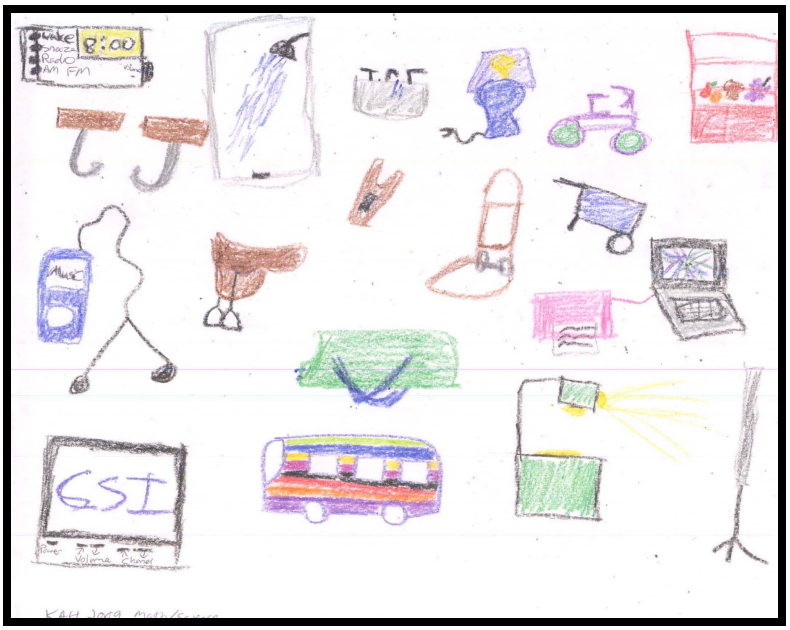

Figure 5:
"I have drawn different types of technology that are around me every day. This includes a sink, lamp, computer, printer, shower, T.V., alarm clock, iPod, and various other mechanical devices. I also included images that are not as typical in my opinion. These include a saddle, bridle, horse blanket, boot pulls and other horse-related items. These are not what first came to mind, however they are still technology. They had to be designed just like a computer or lamp."
Perceptions of Technology Mini-Project sketch from an engineering-affiliated student.

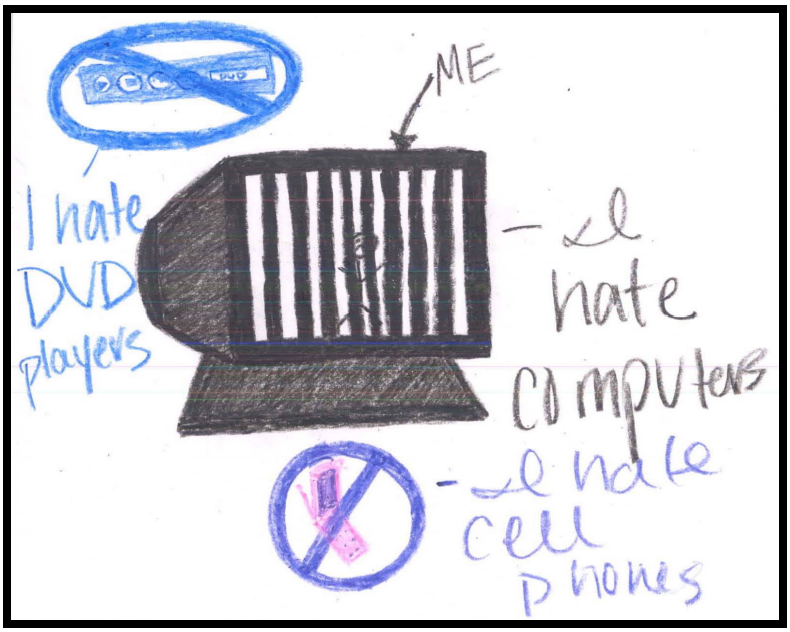

Figure 6:
"Basically, I am a technology idiot and I feel that it is out to get me. I have no idea how to use computers, DVD players, cell phones, etc… They break so easily and don't make sense to [me]" Perceptions of Technology Mini-Project sketch from a humanities-affiliated student.

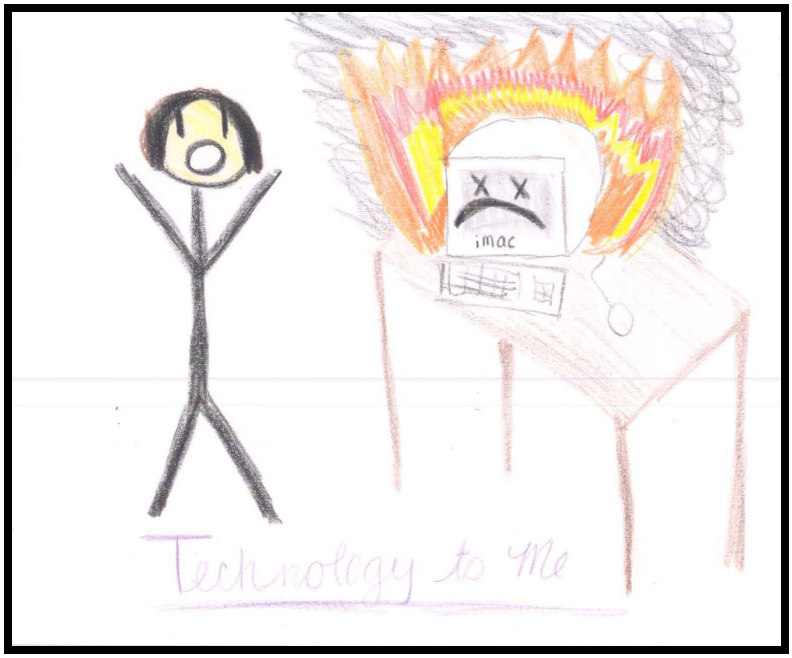

Figure 7:
"Technology to me is confusing and never works when you need it. It helps to have technology like computers to do research and write papers but sometimes the software is so advanced you don't know how to use it." Perceptions of Technology Mini-Project sketch from a humanities-affiliated student.

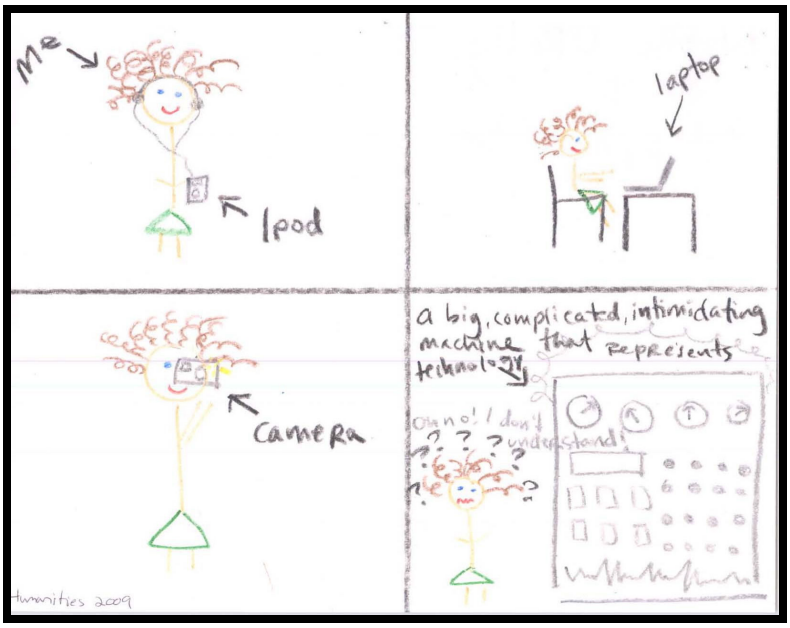

Figure 8:
"In my picture I drew myself with technology [that] I use from day to day: my iPod, my laptop, and my computer. I love these things! Technology serves me well! But I completely don't understand it. In my fourth illustration I drew myself next to a big, daunting machine that has me completely intimidated and perplexed. This basically represents how I feel about technology. It is a foreign language that I'm not sure I'll ever learn." Perceptions of Technology Mini-Project sketch from a humanities-affiliated student.

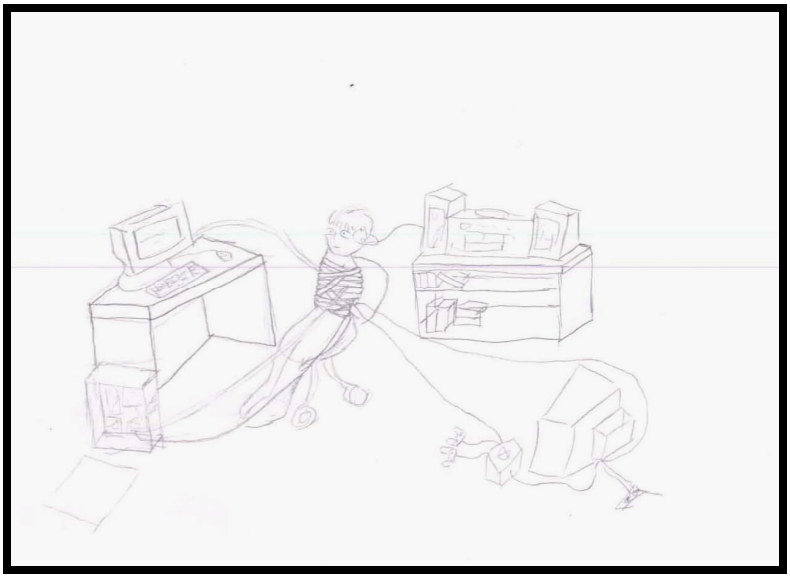

Figure 9:
"The picture shows how modern entertainment –related technology consumes us and keeps us tied to it. Blatant imagery, I know." Perceptions of Technology Mini-Project sketch from a humanities-affiliated student.

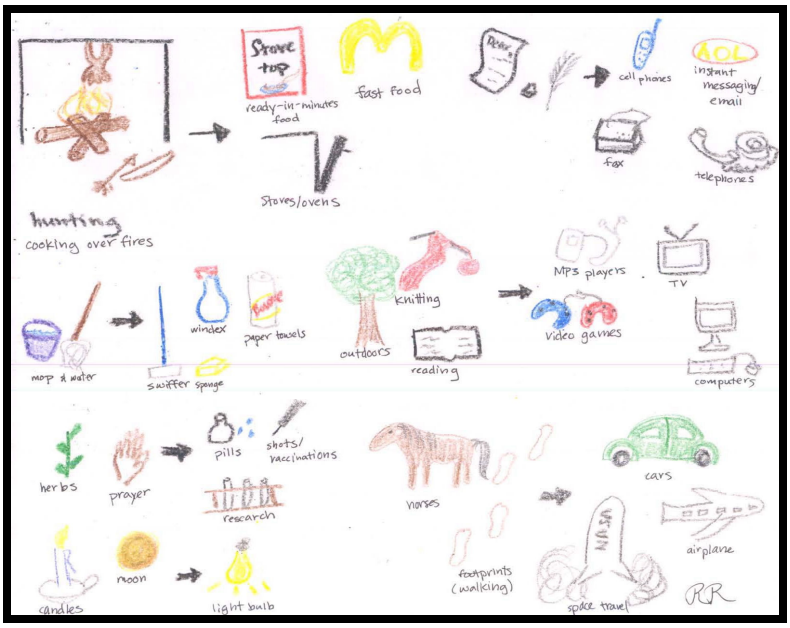

Figure 10:
"My sketches illustrate the advances humans have made through technology. To me, technology is about advancement: new methods, new products, and new ways of thinking about things. I live in a technologically advanced world. For example, instead of hunting or gathering, I buy food from a grocery store. Instead of hand-writing a letter, I will call that person email him or her, or send a message on AIM. This is not to say that I only use the most technologically advanced product or method, but I usually do. Technology isn't just about electronics, it's also a way of thinking and doing things." Perceptions of Technology Mini-Project sketch from an engineering-affiliated student.

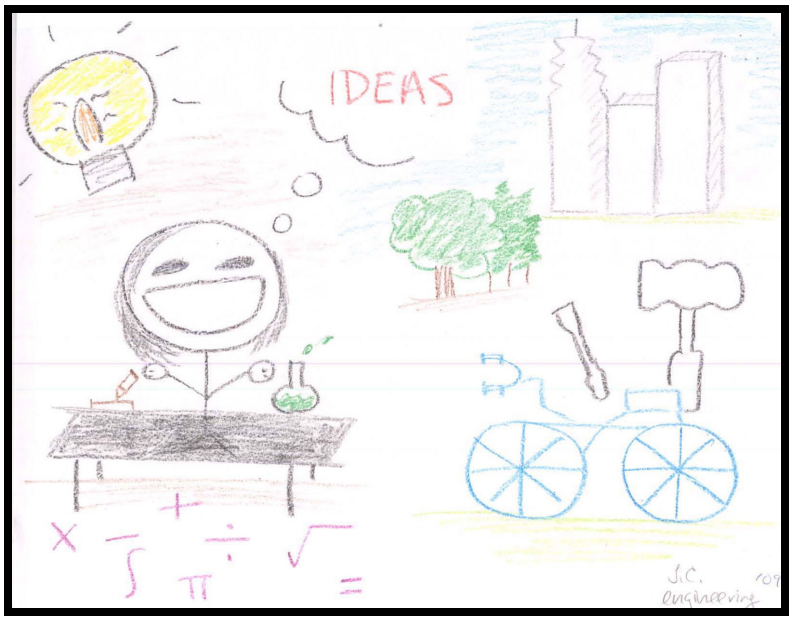

Figure 11:
"In the picture, I am using the basis of technology…to try to think of ideas that can benefit society." Perceptions of Technology Mini-Project sketch from an engineering-affiliated student.

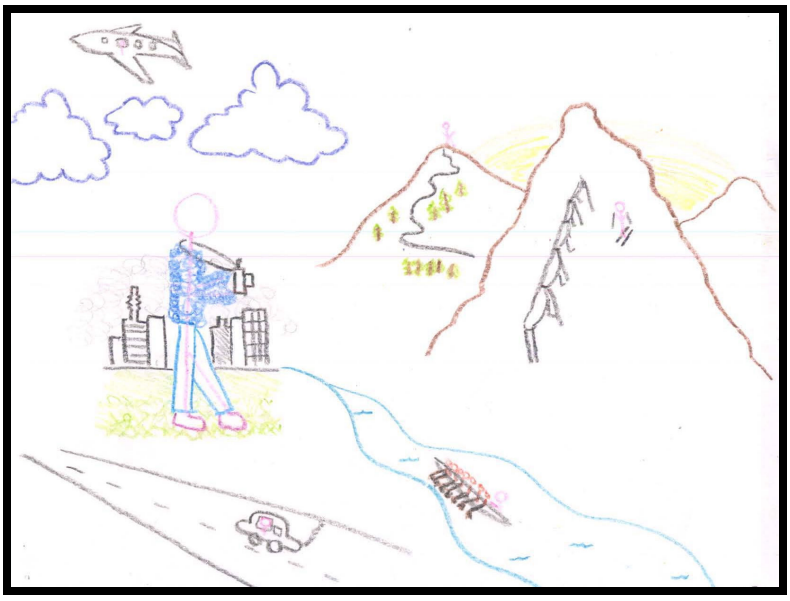

Figure 12:
"I see technology in every part of my life. I view it as an enabling force for all of my activities." Perceptions of Technology Mini-Project sketch from an engineering-affiliated student

Figure 13:
"There is so much needless waste in human society, things that we could easily be doing much more efficiently. What interests me the most in technology is remaking things we already have to be more effective and more efficient." Perceptions of Technology Mini-Project sketch from an engineering-affiliated student.

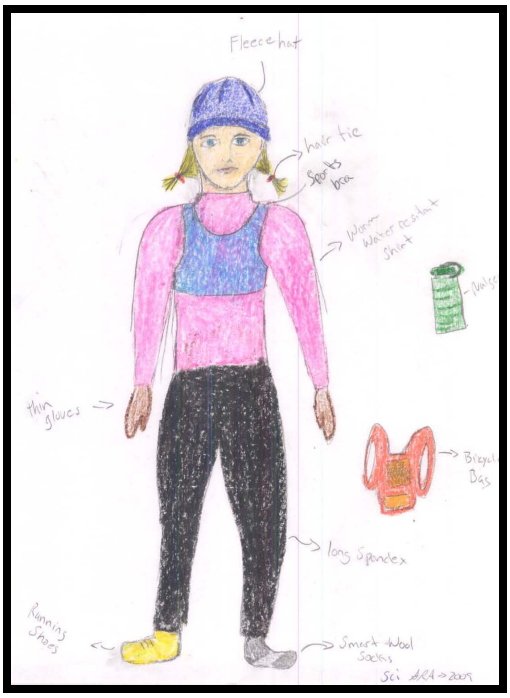

Figure 14:
"When I think of technology, I think of advancement. For me, advancements that affect me directly are those in sporting gear. For example, running shoes are always being modified….Sports bras are another example…" Perceptions of Technology Mini-Project sketch from an engineering-affiliated student.

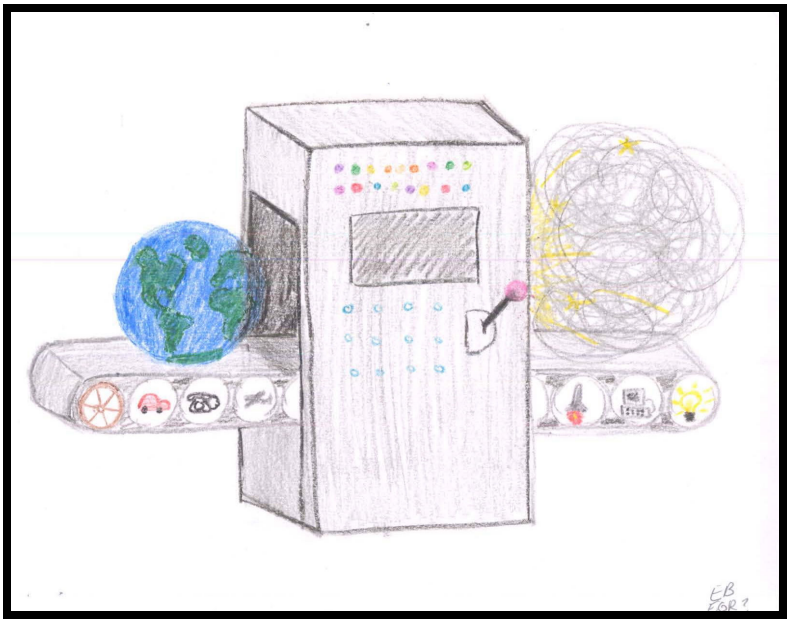

Figure 15:
"Technology swallows the world and makes it into something new, but I/we don't know what that is or whether it's good or bad." Perceptions of Technology Mini-Project sketch from an engineering-affiliated student.

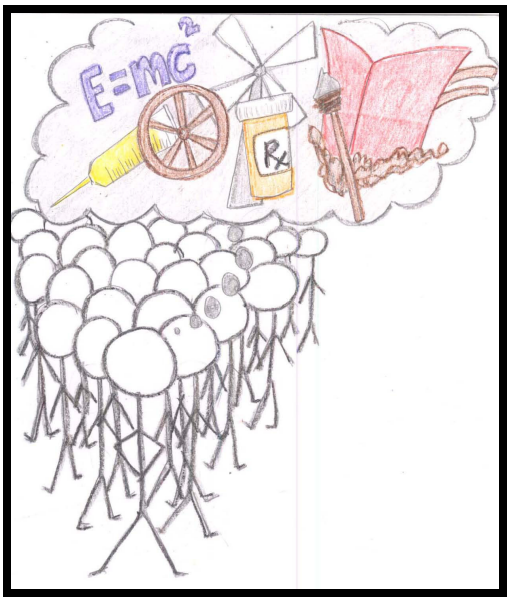

Figure 16:
"My perception of technology includes the involvement of all humankind in creating solutions to problems…. My picture depicts a thought bubble containing some examples of technological advances through the ages. A stone tool, one of the earliest inventions, moved mankind forward… The wheel led to other inventions such as the car. Metal plows improved agriculture and new drugs help cure disease. As time goes on, technology will become [more] important as we are forced to find alternative energy sources." (Engineering-affiliated student)

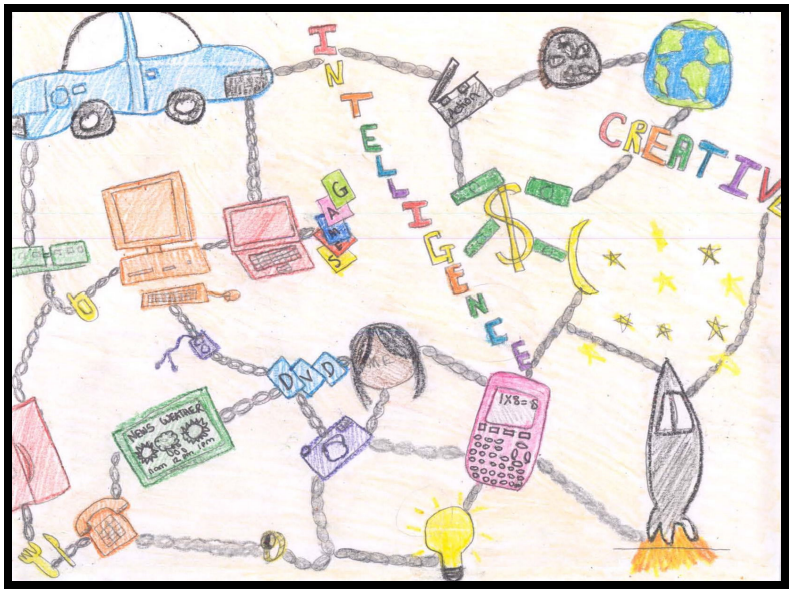

Figure 17:
"In my drawing of what technology means to me I have included numerous pictures of different types of technology. I started my drawing with the most basic technological advance, the fork and knife. From there, I drew other household products which then lead to other outside technological advances like the car. To show hoe technology is linked to every part of your life I chained each item together. Everything is linked to me, money, and the world." Perceptions of Technology Mini-Project sketch from an engineering-affiliated student.

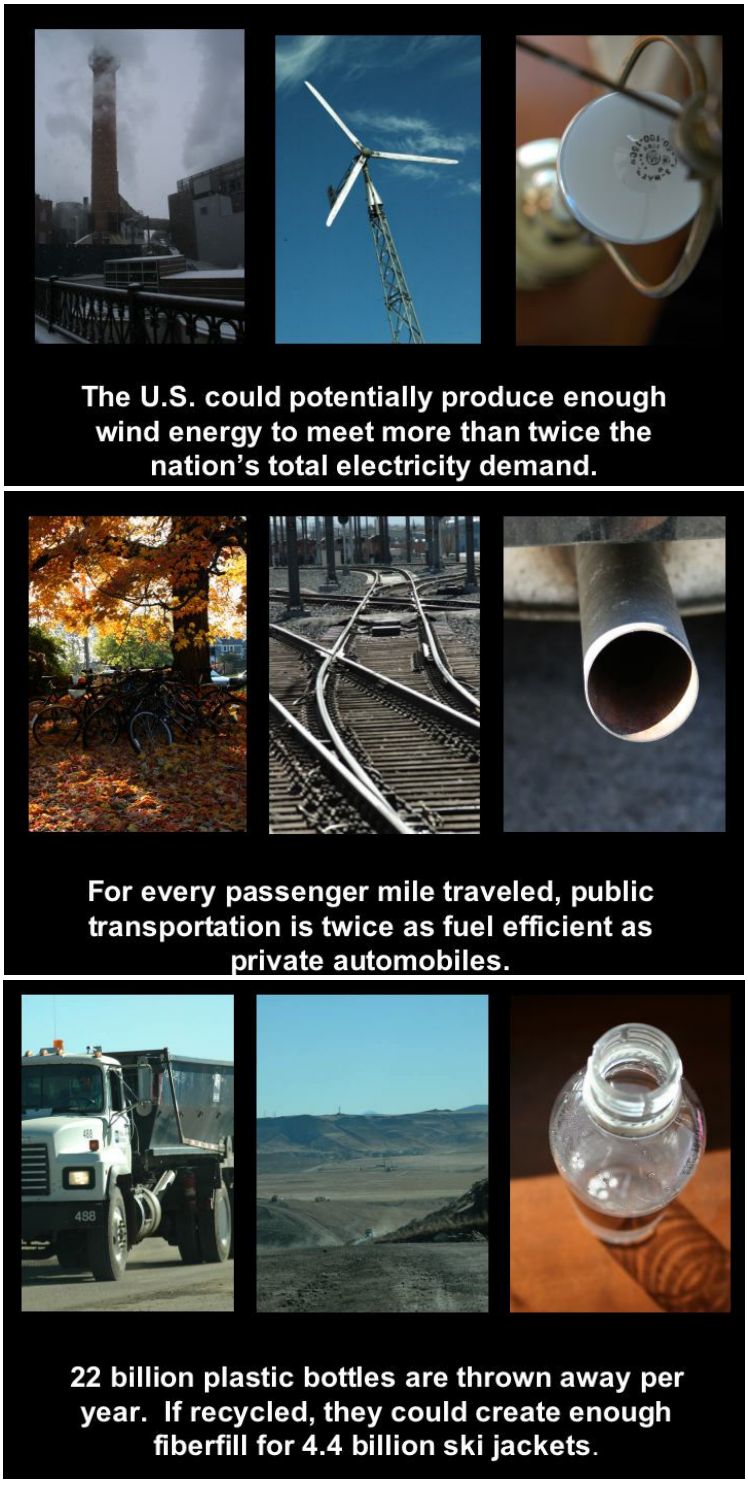

Figure 18:
Mock-ups of three, fifteen-foot banners created for final Technology Literacy project by one student team interested in using photography as a medium for engaging humanities students.

Figure 19:
The "Technology is Art" sculpture used assorted forms of technology to create a person. A lampshade was used for a head and a funnel with an air freshener for a hat. A fly swatter and spatula formed the arms, and a broom and umbrella the legs. A thermometer represented the spinal cord through the center of the body and a clock was used to represent the heart. Wound throughout the inside of the box was an orange electrical wire symbolizing a person's veins. Hanging from the wire were mirrors, which in addition to the "ribs" of spoons adhered to the sides, allowed a spectator to see themselves and be reflected in technology and art.