

Chapter 2

Ethics

This chapter introduces the reader to ethics in engineering. Whether or not you are interested in engineering, these concepts will be helpful. As you read, please make note of the things that fit into your area of interest, and see what you can learn from the rest. Michael R. Williamson is Assistant Professor in the Department of Applied Engineering and Technology Management at Indiana State University. He previously worked for the Illinois Department of Transportation. He has an interest in professional ethics

Ethics for Engineers By Michael R. Williamson

Within societies, ethical beliefs may differ from person to person. There may be various reasons for this and we will discuss some examples in the following section. The ethics of an individual can have a long and lasting impact on society because it is often related to choices that they make in everyday life.

Job Influence of Engineers

A person's career can have a definite impact on their ethical beliefs, based on the sworn duties they take an oath to follow (American Society of Civil Engineers, 2015). A good example of strong ethics are those pledged by civil engineers when they take professional oath to faithfully take on the obligation to serve the needs of the society by providing safe infrastructures that meet the demands of the local economy.

Engineers must recognize that the daily decisions they make will directly impact the safety of the common public. For example, the structures that engineers design must be strong enough to support all necessary loadings without failing. If a structure such as a building or a bridge fails, people's lives will be in danger. Engineers must have strong ethics that would prevent them from taking shortcuts that could impact the safety of the public, even if such practices were common in other industries to save costs.

In case of drinking water as well, civil engineers are entrusted with the health and welfare of the public. Some of these engineers are responsible for design and operation of water treatment plants. Great care must be taken to preserve public health, as the slightest disregard of ethics could have a catastrophic effect on public health, leading to multitudes of people getting sick or even dying.

Sustainability is also of importance and considered a prime ethical value that engineers should adopt. All projects should be designed with the intention of avoiding harm to the environment and providing sustainable solutions to problems. Unnecessary depletion of materials should not be allowed and reuse of materials on site should be encouraged. For example, when repaving a roadway, the rock needed—which is already in place—could be reused.

Additionally, engineers should only perform work within their areas of expertise and honor the integrity of the profession (American Society of Civil Engineers, 2015). Engineers as well as people in other professions must uphold the honor of their profession to keep public trust intact. There are many ways of keeping the environment safe and preventing unnecessary pollution. Keeping the trust of the general public can only be done by making judicious decisions backed by real data, taking all possible consequences into consideration.

Sustainability

Overconsumption of resources has been a common cause in the collapse of societies throughout the history of mankind (Graedel & Allenby, Industrial Ecology and Sustainable Engineering, 2010). Great civilizations across the world have been lost, as can be seen in the ruins of abandoned cities like the Angkor Wat Temple complex in Cambodia, and the many Mayan cities in Mexico. Other Native American villages located in the United States once housed a dense population. The once prosperous Native American city located at Cahokia Mounds was one of the largest cities in North America before the arrival of European immigrants. It has been proven that the city at Cahokia Mounds possessed all the characteristics of a complex society. Large plazas where ethics could have a catastrophic effect on public health, leading to multitudes of people getting sick or even dying.

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Population is an easily quantifiable measure that can be directly taken from census data in first world nations and estimated with some degree of accuracy in rural areas or third world nations. Resource use per person is quantifiable as well, which can be estimated by surveys and by knowing the overall resource consumption of a population in a particular geographic area. The part that becomes difficult is estimating the environmental impact of some resource uses. Some resource impacts are established through advanced studies through universities or other laboratory environments that offer a non-biased view on resource consumption. Many resource impacts are unknown and require more studies, making it difficult to calculate the master equation accurately.

Carrying Capacity

Eventually every society will reach its carrying capacity, and only those who take responsibility of the inevitable will survive. Let us consider a simple example of capacity with only one resource. Corn is produced widely in Midwestern United States and supports many forms of life, including humans, both for direct consumption and for feeding animals that are later to be consumed by humans. When weather patterns cause crop shortages, the impact is controlled by price increase, causing a person to consume less or rely on another product. This is a good short term control and effective in the long run as well, as it resists reaching capacity. At some point the capacity of our corn production will be reached and then, shortages will not be controlled by price increase; people will simply have to go without. Of course, in reality, the shortages would be much more expansive than just corn and the animals that rely on it. Once humans reach the carrying capacity of the earth, countless changes will have to occur or civilization as we know it will end.

Some scientists claim that the population that earth can support is somewhere around 10 billion, based on given present conditions of available resources and a current population that is estimated to be 7 billion (Wikimedia Commons, 2015). In figure 2.2, you will notice the extreme change in population growth after 1950. While there are many factors that can be linked to the sharp increase in population, one fact that is predominant is the fact that people are living longer than ever before due to the advances in the medical field. The blue curve represents the current growth rate, which has reached nearly 7 billion. Take a look at the three possible curves past our current date, each representing possible trends in population growth. The green curve represents a situation when a peak is reached just over 8 billion, causing concern. The population is projected to decrease after the peak—by low birth rates or as consequence of some catastrophic event such as lack of resources. In this case, a correction is made in time to prevent capacity from being reached. The yellow curve represents a situation when we level out our growth at capacity. In this situation, we would be using all possible resources, and as a result even the smallest reduction in crop production would have devastating effects. Finally, we have the third possibility, depicted by the red curve, to consider. It shows an unchanged population growth curve. If we continue at the current rate, the capacity will certainly be met or surpassed at some point. All possible resources will be consumed faster than they can be replaced, causing a collapse in societies around the world.

Other models on sustainability reflect a different pattern where the carrying capacity of the earth is constantly fluctuating based on environmental changes that may affect crops and other natural resources. Adjustments in population are made in order to compensate for the current carrying capacity. Another model predicts that the carrying capacity will decrease proportionately with an increase in population. As population rises, resources are consumed at a faster rate, decreasing the carrying capacity. Regardless of which model we choose to follow, these are predictions and the precise effect is unknown.

Transportation

An important topic in any society is that of transportation, which has a direct impact on a society's ability to progress. In the United States of America many transportation options are available, ranging from personal vehicles to mass transit, of several types. While in developing or underdeveloped nations transportation may be restricted to only a few ways, usually in the form of personal bikes and some mass transit.

Our choices regarding the mode of transportation that we use have a direct impact on the environment in the form of resource consumption and pollution. In the United States, most people feel the need to own their own vehicle for personal transportation and given the layout of most communities, having access to a personal vehicle may be vital in obtaining a job or even for shopping for groceries. Many urban areas, such as the city of Chicago, have acknowledged this problem and have taken steps to reduce the impact that transportation has on the environment. There are many modes of transportation available for use in the city of Chicago. While personal transportation in the form of automobiles is still a predominant choice for commuters, many residents do not own a car either because they avail of other available modes or because the cost of owning a car is too high. Other choices include walking and biking, which are made convenient for users with sidewalk designs that allow safe crossing of major roadways, dedicated bike lanes and bike sharing programs make biking to work possible, and an array of mass transit including trains, buses, and water taxis. Mass transit must keep to a tight schedule to ensure that riders get to their destinations in a timely manner. A major factor in mode choice is reliability. For example, if you have to be at work at 8:00 AM, you need transportation that will get you there on time. For everyday purposes, people will prefer to take a reliable mode of transport. One problem in having a complex transportation system such as in the city of Chicago is the consumption of many

resources. Many people have to commute each day from suburban areas to the city center for work, resulting in a high pressure on the transportation system.

According to the annual Urban Mobility Report, the Chicago roadway network costs the average commuter nearly US\$1200 per year, ranking it the 5th highest in the United States resulting in over 50 hours of delay per year per commuter (Schrang, Eisele, & Lomax, 2012). In terms of fossil fuel consumption, 127,016,000 gallons are used each year just by personal vehicles.

A problem that exists in every major urban area is that people tend to work in the urban center and live in the surrounding areas. This necessitates daily commuting, causing unnecessary traffic, and resulting in unnecessary consumption of resources and increased amount of pollution. This trend is evident in most urban areas in the United States as well as in other countries. As more and more houses are built by clearing farm or woodland, more fuel is consumed in transporting people to and from desired destination, causing pollution rates to flourish as a result.

The city of Toronto is a pioneer in reversing this trend of urban sprawl, after decades of suffering the consequent adverse effects. Toronto is building up corridors through the urban center that will attract people to live, work, and shop within walking distance. The idea is to build up key arterials through the city and provide easy access for walking, biking and mass transit along the key routes. Mass transit is available in the form of streetcars and buses with very short wait times, a key factor in deciding to take mass transit for trips. People in Toronto can live the good life without the expense of owning a car, because they can avail the various modes of transport, facilitating movement in, out and through the city. A picture showing transit options can be seen in figures 2.3 and 2.4

Other cities, including Chicago, are following this trend in an attempt to increase the quality of living in urban areas and prevent unnecessary consumption of resources.

So what causes this urban sprawl resulting in unnecessary consumption of resources? Much is dependent on the desire to live in a better environment, free of pollution and crime. Crime is heavy in areas in cities that are not properly maintained. As houses and other properties decay, so do the property values resulting in a lower quality of life. Families typically leave urban areas for suburban areas to escape crime, ending up consuming more resources and contributing to an increased amount of pollution.

Transit Stops

Even though the harmful effects of pollution are widely known, many people still decide to drive their own vehicles instead of taking mass transit. Many urbanized areas have greatly improved mass transit systems, making it a convenient choice for commuters. Shelters have been placed at many transit stops to provide a comfortable place for riders to wait. Even wi-fi is a feature in many public transit systems now, allowing riders to use their mobile devices on transit or sometimes at stops. Continual information is given to riders regarding wait times for the next arriving transit vehicles, reducing passenger's frustration regarding uncertain timings or long waits and helping them plan their trips accordingly. Many transit systems have employed advanced technology to attract more riders. Trip planning apps can now be used to quickly identify the quickest transit options from one's current location to a desired destination. The Chicago Transit Agency (CTA) provides quick access to maps showing how to get to the nearest transit stop, transit routes, schedules showing the arrival times for each transit stop, alerts providing information on crime or delay, transit trackers showing the location of each transit vehicle in real time and fare information showing the cost for a particular trip (Chicago Transit Authority, 2015). All such features are aimed at attracting more commuters to use mass transit instead of personal vehicles.

Additional transit choices in the city of Chicago are light rail, extended bus service, water taxis, and one of the largest cab networks in North America. It is possible to take transit from the outlying areas of the city to anywhere in the downtown areas. Bike lanes have been put throughout the city of Chicago, which can be easily accessed from residential areas to places of work or business. Rent-a-bike stations have been placed at key points, enabling people to rent a bike at one station and return it to another station of their choice. Yet in spite of such convenient, user-friendly options, many people still make the choice of driving their own vehicles.

So what are the reasons for so many people still not availing of public transit? Safety seems to be a key factor in the deciding on a mode of transport. Many feel unsafe waiting at transit stops or riding in a vehicle with other people whom they do not know. Trip times also have an influence. In areas with limited service, taking the bus or a train may not be the most convenient option. People feel more comfortable knowing they can make a trip anytime they choose to, without having to wait.

Life Cycle Analysis

An important concept to understand is that of “Life Cycle Analysis.” Life cycle analysis involves the complex analysis of products from raw resources to disposal. Let us analyze the life cycle of a common soda can. There are eleven stages in the life of an aluminum can beginning with mineral extraction and ending with re-melting of used cans (Belinda, 2006).

The first stage involves bauxite mining, which involves the use of heavy equipment that consumes large amounts of fossil fuels to operate. The equipment life also needs to be considered in the life cycle of the aluminum can. The depleted hours in the life of the equipment in the extraction of bauxite can very well be calculated and included in our analysis. The second stage involves the extraction of alumina from the bauxite ore. Here a chemical process is used that involves heating the material to a temperature between 140 and 240 degrees Celsius depending on the quality of the ore. Pure alumina is produced by separating all other minerals. Again, large amounts of energy are consumed in the form of fossil fuels. So we again need to consider the life of the equipment used in the second stage.

The third stage is smelting, where the alumina is again heated and transformed into aluminum. It is common for 16 kWh of electricity to be consumed to produce one kilogram of aluminum from alumina. As before, we not only need to consider the electrical energy used in the production of aluminum can but the hours of life taken from the equipment in the production. In stages 5 and 6, which involve the fabrication and filling of the aluminum, energy is consumed again and life is taken from the equipment in the production.

Stage 7 consists of the product use by the consumer, followed by the re-melting of the aluminum, which is also included in this stage, resulting in high energy use with the cans being heated to 780 degrees Celsius to remove paints that have been applied to the aluminum. The transportation of the product from place to place during the production and distribution—to the vendor, to the consumer’s home or place of use—and ending with the transportation of the used aluminum can to be recycled and the life thereby taken from all modes of transportation must also all be considered during the life cycle analysis.

The final four stages (8 to 11) involve the collection, sorting, re-melting, and transportation of the aluminum can, where it is re-used for more products. As is evident, the life cycle analysis of an aluminum can is fairly complicated, with

much energy consumed to produce a final product, broken in to several stages of the production process. Complex models have been created to analyze similar products allowing for an in-depth understanding of our resource consumption.

The Cost of Convenience

Packaging has made products more convenient to the consumer. As we as a society progress, so does the complexity of our goods, for several reasons. In ancient times packaging was limited to mainly bulk storage units. Typically, people had reusable vessels they took to the market to purchase goods and stored them within the same vessel within their homes until use. This was practical due to the fact that people could easily travel some short distance to the market place for most of their goods. Goods shipped from longer distances would have used bulk storage containers that were reusable, such as wagons or cargo bays on ships, where they were made available to the consumer. Issues with this packaging included susceptibility to diseases and undesirable display of the product. The prevalence of diseases attributed to the development of more advanced packaging that could not be easily penetrated by pests. Packaging is a form of safety in terms of public health. Even today, first world nations have less diseases as a result of more advanced packaging, whereas third world nations have more diseases from the lack thereof. As society progressed it became inconvenient to carry vessels to the market. Products began to be shipped over longer distances and it is usually safer to ship them prepackaged for health and safety reasons. In today's society people are focused more on convenience rather than seeking safety from packaging. Take into consideration the common convenience store station, where many items are on display in all types of packaging. The attractive products are ready to go; the consumer just makes a selection and takes it, to open later as convenient. Items in bulk bins would require one to do more work and take more time to make a selection or in some cases have a worker prepare something. For these reasons, packaging has really taken effect in our society. Most customers would frown on a bulk bin of candy bars or other food items that anyone could touch. Imagine finger prints from others all over your food of choice. Packaging also plays a role in a person's selection of certain products. People tend to be attracted to shiny things. Because of this effect on people's choice, manufacturers have become very competitive for attracting the consumer's eyes. Unfortunately, attracting business in this way has led to an increase in unnecessary packaging, leading to unnecessary consumption of resources. According to a recent study on the effect of packaging on consumers,

it was observed that a key to marketing for any business is in packaging (Lane, 2015). Packaging is a way to promote a product above the rest, by attracting the consumers' eye through the use of color schemes and bigger and better designed packages. Consumers think they are getting more when a product package is bigger and brighter. The security of packages was also found to have an effect on consumer choice (Lane, 2015).

Consumers were found to favor packaging that would protect the product during shipping to prevent costly returns, which in turn requires more packaging material. However, consumers were also found to favor bio-degradable packaging material or products made from recycled products.