

WHAT IS ENGINEERING??*

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Abstract

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1 Introduction

What is engineering? What is an engineer?? Although it is a very old activity or trade, engineering is a relatively young academic discipline or profession. Only in recent years has it reached a stage of maturity where some of its defining details and differentiating characteristics can be articulated. Engineering is the endeavor that creates, maintains, develops, and applies technology for societies' needs and desires. Its origins go back to the very beginning of human civilization where tools were first created and developed. Indeed, a good case can be made for the defining of humans as those animals that create, develop, and understand the significance of technology.

Over time, the part of technology that acts as an extension of human capabilities became the purview of engineering. One can view bicycles, cars, and trains as extensions of walking and running. Airplanes are an extension and application of a bird's ability to fly transferred to humans. The telegraph, telephone, radio, television, and the internet are extensions of talking, hearing, and seeing. The microscope, telescope, and medical x-ray are also extensions of human sight and vision. Writing, books, libraries and computer databases are extensions of human memory and the computer itself is an extension of the human's brain in doing arithmetic and carrying out logical arguments and procedures. Indeed, looking around your environment in almost any setting, will illustrate just how pervasive technology is. In almost any home or office, there is very little that is truly "natural"; i.e., little that is not created or manipulated by technology. The food that you eat, the utensils that you eat with, the table that you eat off of, the house that you are in, the clothes that you wear, the book that you read, the television that you watch, the telephone that you communicate with, the car that you travel in – these are all technologies created by human cleverness to satisfy human needs. This process of creation is engineering and those who do the creating are practicing engineering, whether they call themselves engineers or not.

Not only is much of the inanimate world created by engineering, part of the living world is also. Almost all crops and agriculturally produced food stuff are "engineered" through selective breeding. The same is true of domestic animals such as pets and animals raised for food or sport. Certainly the dogs, cats, and cattle have not "naturally" evolved to their current state. They have been "created" or "designed" to satisfy human desires or needs. The slow and less exact methods of controlled breeding are being replaced by genetic engineering, tissue engineering, and applications of nanotechnology. We humans have the cleverness to do

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that. It is the development of the tools, theories, and methods and the understanding of the appropriate sciences and mathematics for that process that is engineering. It is a central part of the history of humanity.

Not only has engineering made our lives easier and longer, it has sometimes made them more terrible and shorter through improving our ability to kill and harm when we wage war. Indeed, military and defense needs have been a historic driver of technological advancement. One of the earliest categorizations of engineering was into military and civilian (or civil) engineering.

Because technology enables and causes change, it and its creators, the engineers, are viewed with mixed feelings. This is especially true in modern (perhaps post-modern) times when the negative side effects (“unintended consequences”) of technology must be addressed.

This note is an attempt to address the question of what engineering is and then that of what an engineer is. It is intended for the general public to better understand just what this thing that has such a profound effect on our individual and collective lives is. The note is intended for the student who is considering becoming an engineer and, therefore, it is for parents and high school and college counselors as well. It is for the university engineering student and professor and for the university administrator. It is for the state and federal governments who fund engineering education and research and the investor who invests in technology. It is for the husband, wife, parent, or child who wants to better understand their spouse, child, or parent. It is for everyone who accepts the argument that a human is a technological animal and that technology has a pervasive effect on our lives.

An important part of this note is the list of references. This collection of short essays is intended to open many topics and ideas, not develop them. A rather long list of references is given to allow the reader to pursue any of the many ideas further.

2 Science and Engineering

One of the first distinctions that must be made is between science and engineering. It is not a simple distinction because the two are so interdependent and intertwined, but whatever difference there is needs to be considered.

Science is the study of “natural” phenomena. It is the collection of theories, models, laws, and facts about the physical world and the methods used to create this collection. Physics, chemistry, biology, geology, etc. try to understand, describe, and explain the physical world that would exist even if there were no humans. It is creative in building theories, models, and explanations, but not in creating the phenomena that it studies. Science has its own philosophy with an epistemology, esthetics, and logic. It has its own technology in order to carry out its investigations, build its tools, and pursue its goals. Science has its organizations, culture, and methods of inquiry. It has its “scientific method” which has served as a model (for better or for worse) in many other disciplines.

Science is old. It was part of the original makeup of a university or college in the form of natural philosophy. It came out of antiquity, developed in the middle ages, blossomed in the renaissance, was the tool of the enlightenment, and came into its present maturity in modernity. Indeed, the history of science is, in some ways, a history of intellectual development. This is certainly only true in conjunction with many other strains of philosophical, economical, theological, and technological development, but science is a central player in that story. Science is often paired with the arts (and Humanities and Social Sciences) in the “College of Arts and Science” of a traditional university.

Engineering is the creation, maintenance, and development of things that have not existed in the natural world and that satisfy some human desire or need. A television set does not grow on a tree. It is the creation of human ingenuity that first fulfilled a fantasy of a human need and then went on to change the very society that created it. I use the term “things” because one should include computer programs, organizational paradigms, and mathematical algorithms in addition to cars, radios, plastics, and bridges.

Science is the study of what is and engineering is the creation of can be. Only recently has engineering developed the set of characteristics that make it a legitimate academic discipline. Earlier, engineering often was viewed only as the application of natural science. Now, engineering has developed its own engineering science for the study of human made things to supplement natural science which was developed to study

natural phenomena. Parts of computer science are wonderful examples of that. Engineering has its own philosophy and methodology and its own economics. It even has its own National Academy.

We differentiate science and engineering, not because their difference is great, but because, in many ways, it is small. Science could not progress without technology, and engineering certainly could not flourish without science and mathematics.

A more illuminating comparison might be between the humanities and engineering. One might find more similarity in style (not content) between English literature and engineering than between science and engineering. Both literature and engineering are the study of human created artifacts. Both teach creation in the form of creative writing and engineering design. Both teach analysis in the form of literary criticism and engineering analysis. Both are intimately connected with the needs and desires of individuals and society. A similar analogy could be made between art and engineering looking at studio art, art criticism, and art history.

Most scientists (but not all) feel there is some unique objective truth behind the physical phenomena they are studying. Their goal is to find it and describe and explain it, and this truth is unique although the approaches and approximations to it are certainly not. In literature and engineering, the designed entity is not unique to the situation, but it is a creation of the particular writer or designer and perhaps unique to the creator.

The distinctions of this section are not as clean or clear as have been presented here. The boundary between science and engineering can be and often is murky. Many items of study in science are influenced if not literally created by people. This is obviously true in biology and the life sciences but also true in physics where certain elements in the periodic table do not exist in nature. Perhaps, therefore, the areas of pure science are very limited. On the other hand, since people are members of our natural system, an argument can be made that their products are as natural as anything else and, therefore, the areas of pure scientific study are very broad. Clearly engineering is constrained in what it can create by the laws of science as everything is. Nevertheless, there is a difference in spirit in the two disciplines worth trying to delineate.

3 Engineering Yesterday, Today, and Tomorrow

In early times, the practice of engineering was that of a trade or craft with training occurring through some form of apprenticeship. As it developed into a profession and more recently as an academic discipline, it took on the shape of other academic disciplines, with preparation being an education rather than a training. An important turning point in the United States was the land grant college act (Morrill act) of 1862 which established an institution for the teaching of agriculture and the mechanical arts (engineering) in each state. This officially legitimated engineering in higher education although it still had the form of training. Interestingly, this act came into being during the American Civil War and was signed by Abraham Lincoln.

World-War II was the second turning point when it was discovered that many of the technical innovations necessary for that effort came from scientists, mathematicians, and theoretically educated engineers rather than traditionally trained engineers. Most engineers prior to that time had been trained to develop and apply ideas already in existence, not to create new solutions to new problems. After WWII, the university curricula in engineering became much more scientific and mathematical. It took on more elements of an education rather than a training. It slowly became a real academic discipline in its own right rather than only an application of other disciplines. However, it retains the integrating role of applying the physical and life sciences using some of the tools of the social sciences, law, and policy and the values derived from the humanities, letters, arts, and business.

We are now going through a third transition in engineering in response to many factors in society and in technology itself. In the larger picture, society went through the agricultural phase, the industrial phase, and now the information phase. These three phases of civilization created and were created by the most powerful and applicable technologies of the time. Engineering is and will be the creative element in the information age as it has been in preceding ages.

4 References

A list of references can be found the Reference module.