Presenting Historic Individuals in Engineering Education

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Abstract

This paper explores the pedagogy of engineering education with reference to individuals in a historical perspective. Having students exposed to the individuals involved in what they are learning, gives them a perspective that enhances insight, appreciation and a better understanding of the subject matter. Exploring the naming of units, components and systems, for individuals that have done the research in a given area, or who are honored for work they have done, provides context, a deeper understanding and an appreciation for the hard work and effort that goes along with science and engineering. It is the objective of this paper to present examples of historic individuals in engineering and explore ways to engage students with a historical perspective of engineering.

Keywords

History, Engineering, Education

Introduction

Having students look at technology with a historical perspective provides a multitude of pedagogical advantages. The historical context of a subject can stimulate a natural curiosity providing a catalyst for a deeper understanding of the material. It can also reinforce the ideals of lifelong learning. Having an understanding of the individuals and the stories behind the subject matter can spark interest in the lives of scientists and engineers, and promote a natural curiosity. A multicultural component is an inevitable outcome as well, when one looks at the diversity of individuals involved in the development of technology.

Enhancing Understanding of the Engineering Process

Having students exposed to the individuals that are connected to a technology can provide an appreciation, that would otherwise, be unknown. Understanding the work and perseverance that is behind many technological advances provides an example for students to emulate. Relating the well known story of Thomas Edison's perseverance regarding the invention of the light bulb, provides a good example for not giving up. Edison's famous statement "genius is one percent inspiration and 99 percent perspiration" [1] is but one example that can be shared with students.

A historical perspective also provides insight to the fact that many advances are the unintended consequences of research or development with different objectives. Knowing that many technological advances were discoveries made by observing and analyzing the results of an experiment which was not the intention of the original experiment, is another aspect of history from which to learn. The discovery of PTFE, Teflon®, was unintentional. Dr. Roy Plunkett of the DuPont Company was doing research and development work on refrigerants. He reacted tetrafloroethylene (TFE) with hydrocloric acid (HCl) to synthesize a refrigerant in a pressurized cylinder. Leaving it overnight, he returned in the morning to find the pressure in the cylinder had dropped to near zero, although the cylinder still weighed the same, indicating that it had not leaked. Subsequent removal of the valve produced only a few flakes of slippery white powder, so the cylinder was sawed in half to revel a thick coating of polytetrafloroethylene (PTFE), now trademarked as Teflon® (Figure 1). It was only through due diligence and a true curiosity that Plunkett gave us this widely used material. [2]

Figure 1
Depiction of the discovery of PTFE by Dr. Roy Plunkett and his assistant, Jack Rebok.[3]
(Coutesy: the DuPont Company)

Life Long Learning

People learn by example. Making a student aware of the history related to inventions, the people behind them, and the hours of work that have gone into many products and concepts, promotes an understanding of the importance of perpetual learning. One example of perseverance and a life time of innovation is the story of Leonhard Euler (Pronounced *"Oiler"*) (1707-1783), (Figure 2). A genius of the first order and a prolific producer of mathematical theory, his existing collective works fill 60-80 volumes. It is believed that much of his work had been lost in a fire. In the 1730's he lost sight in his right eye and was completely blind for the last 17 years of his life, but this did not slow him down, as this was one of his most prolific periods of production in his life. [4] Euler is responsible for the symbol "*e*" as the base for natural logarithms, " *i* " to represent the square root of minus one and "*f* ( )" to represent a function. "Euler was the most prolific mathematician of all time, writing on every branch of the subject and always being careful to describe his reasoning and to list the false paths that he had followed." [5] This represents quite a productive and full life of learning.

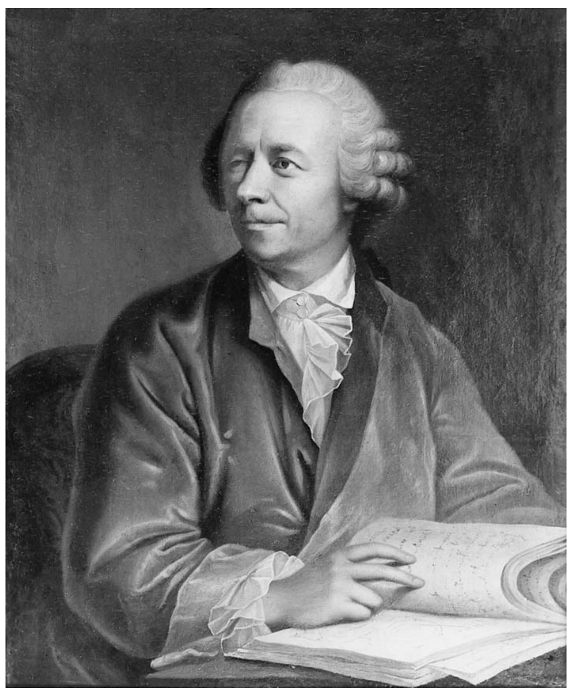

Figure 2
Leonard Euler

Multicultural Awareness

Technological advances know no boarders. Exposing students to the individuals and their heritage provides multicultural awareness. As an example, within electrical engineering, the most fundamental principles are conveyed in Ohm's Law. Ohm's Law typically stated as: $E = I \times R$ has a total of three variables, each named for a different scientist. The letter "R" representing resistance, with units of Ohms, was investigated by Georg Simon Ohm (1789-1854), (Figure 3) , a German physicist [6], who was responsible for bringing together the work of Alessandra Volta (1745-1827), (Figure 4), an Italian physicist [7], and André Ampère (1775-1836), (Figure 5), a French mathematician and physicist. [8] This represents a truly international and multicultural group. In Ohm's equation, "E" represents electro-motive force, measured in Volts and "I" represents current flow, measured in Amperes. Units are not always named by the researchers, themselves, who have done the fundamental work in the area. An example of such a unit is the Watt. The unit of Watts is used by the metric system to represent power, the rate of doing work. James Watt (1736-1819), (Figure 6), a Scottish engineer, was not responsible for the unit of Watts, but rather was given the honor because of his work in establishing the unit of Horsepower. James Watt established the unit by testing a strong horse in 1783. The horse could raise 150 pounds four feet in one second, giving the "horsepower" a definition of 550 foot-pounds per second. [9]

Figure 3
Georg Ohm

Figure 4
Allessando Volta

Figure 5
André Ampère

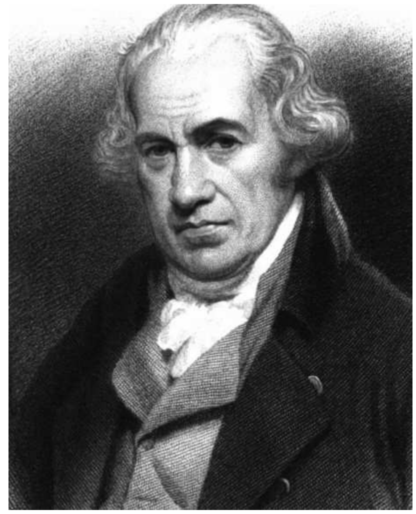

Figure 6
James Watt

Stories and Humor

One pedagogical technique, that I believe to be under rated, is humor. Keeping the learning environment light and relaxed promotes learning and retention. Although not related to engineering education, but in a study related to language education, shows that the interjection of humor, when relating a story, results in greater retention [10]. Humorous stories of the individuals, or their exploits, serve to provide a forum for engagement with students. Having the students' attention is essential to learning and keeping them alert and involved, is always a challenge. One of my favorite stories to relate, is the famous "The Barometer Story," [11] attributed to Niels Bohr,(1895-1962) [12], (Figure 7), but most certainly not true. It does, however, convey some humor and illustrates the over used "thinking outside the box" catch phrase, which has become all too popular. If you are not familiar with the story, it goes like this... As a young college student, Niels Bohr was not challenged by some of his prescribed courses. Upon taking a physics exam, a question posed stated, "Given a new barometer, how would you determine the height of a high-rise building?" Bohr answered by stating that he would take the barometer to the top of the building, throw it off and time how long it would take to hit the ground. Knowing the acceleration of gravity, a simple calculation would determine the height of the building. The professor marked it wrong. Bohr protested, stating that there was nothing technically incorrect with his answer. The matter was brought to the attention of the Dean and a compromise was established by having Bohr meet with the Professor for an oral exam. The Dean figuring if he could get them to talk, they could work it out. So at the prescribed time, Bohr arrived at the professor's office. The professor stated that he had a half an hour to answer his questions, and he only had one question… "Given a new barometer, how would you determine the height of a high-rise building?" After some time of silence, the professor told Bohr, that this would be his last chance to pass the course and didn't understand why he had not answered, as "I know you are bright." Bohr answered by saying that he was trying to decide which answer to give. The professor replied, then give me all your answers. He began by repeating his first answer of dropping the barometer from the top of the building, added that he could, on a sunny day, measure the length of the shadow of the building as well as the shadow length of the vertical barometer and calculate a ratio to determine the height of the building. Thirdly, he could use some scaffolding and knowing the height of the barometer, scale it up the side of the building and multiply the height of the barometer by the number of steps, to determine the height of the building. As a fourth answer Bohr stated that he could tie a string to the barometer and using it as a weight, let it drop over the edge of the building roof and once the barometer touches the ground, mark the string and then measure the length of the string to determine the height of the building. My personal favorite, he stated that, he could find the superintendent of the building and say to him that if he tells him the height of his building, he'd give him a nice new barometer. Finally, Bohr stated, that if he were not at all creative, he could use the barometer at the ground floor to measure the atmospheric pressure and then measure the pressure at the top of the building, then using the difference in pressure, determine the height of the building. Using stories, and especially humorous stories, an instructor can make their point, and with a greater likelihood that the students will retain the information. There is also a lesson in this story for the teacher, do not ask a question that is ambiguous or that could have multiple, unforeseen, but correct answers.

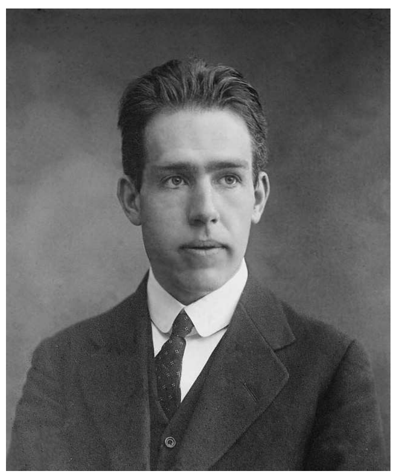

Figure 7
A Young Niels Bohr

Implementation with Student Paper Presentations

A technique that I have used to engage students is to have them choose from a list of individuals and topics, or they are also free to propose their own individual or topic, which provides a working title for a paper that is then presented to the class. Students are required to complete a fairly short, several page, report on an individual, such as William Shockley (1910-1989) credited with the development of the bipolar transistor,[13] or Ernst Alexanderson (1878-1975), developer of high frequency mechanical generators.[14] As stated, the students may also choose to do their paper and presentation on a topic. A topic could be the history of a company or technology related to the course material. In the past this has ranged from the development of the 555 timer integrated circuit to the history of Silicon Valley. When students do the research for their papers, it exposes them to a much more detailed history, then what could be conveyed in the limited time of the classroom lecture setting. And because they have a choice in the subject of their paper, it is hoped that they would have a greater interest and therefore be more motivated and complete a more rigorous investigation of the material.

Conclusion

History, especially when it is related to a student's engineering major, helps enrich their educational experience. Understanding and appreciating the individuals and the stories of history, give the student insight into the traits, talents and circumstances that lead to success in their field.

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