# Importance of Teaching the History of Technology

Sridhar Condoor
Associate Professor, Department of Aerospace & Mechanical Engineering, Saint Louis University – Parks College of Engineering & Aviation, 3450 Lindell Blvd., Saint Louis, MO-63103 condoor@slu.edu

***Abstract*** **- In most engineering courses, students learn concepts, methods and tools. The education community seldom focused its attention on teaching the historical aspects of engineering and technology. As a result, students know very little about famous engineers, case histories, evolution of engineering science and technology, and influence of engineering activity on the society.**

**The reading of engineering case histories emphasize the role of human error/failure in engineering design, the practice of engineering as an art form, and the difference between engineering and scientific activities. Due to the synergy between the product evolution and the product design, case histories can improve student learning in the capstone design courses. The paper presents a unique teaching approach, which backs away from the engineering achievements to the products and people behind the achievements, and then to the thought processes involved in the product design. This teaching approach exposes students to a few key engineering concepts and ties them with case histories. The paper illustrates the teaching paradigm using the case history of typewriters.**

*Index Terms* - Case histories, Engineering history, Evolution of technology, Role of failures.

## INTRODUCTION

We have been creating technology to aid in our amazing journey to discover the undiscovered about nature, which includes ourselves. In this journey, our daily lives are increasingly shaped by technology to an extent that it is defining who we are. We are using technology to understand the physics of human body by describing brain as a computer and heart as a pump. Whether it is good or not, we are characterizing ourselves in terms of technology by using words such as "technologically savvy," and "computer illiterate." Our reliance on products starts with the morning alarm to the nightlight. Technology continues its work of keeping us comfortable and safe while we sleep. Thus, technology became a seamless part of our life.

History helps us to not only understand, but also shape the world that we live in. It illustrates the aspirations of human endeavor and the incredible progress made due to the human imagination. It defines our place in time. By understanding our history, we can learn from the historic failures and successes, reuse the knowledge that was created before, and also, learn the intended and unintended social and economic consequences of technology.

Eugene Ferguson [1] summarizes the typical tendency of engineers as "The training of engineers tends to suppress rather than encourage a sense of history, but it is clear that many engineers transcend their academic background." At the present time, there are few courses around the country dedicated to the history of engineering/technology. Another approach is to integrate the history of engineering with existing courses.

The teaching methodology presented in this paper can be used with both approaches. The paper discusses the integration of history of technology in the capstone design course. The design course is ideally suitable for such activity as the case histories aid in:

- Understanding the evolutionary nature of technology.
- Learning the impact of engineering on the society.
- Understanding the role of failures.
- Providing mental cues for recall.

## THE TEACHING METHODOLOGY

The objective of the teaching methodology is to help students understand the thought process behind the great engineering achievements. Using the methodology, students can see through various filters that prevent a commoner in recognizing the achievements. It steps through the achievements/successes, the failures behind successes, the products behind successes and failures, the people behind products and the thought processes behind the people. This section illustrates the methodology.

*Achievements –*

The National Academy of Engineering's website www.greatestachievements.org is an excellent portal to the greatest engineering achievements of the twentieth century. The top twenty achievements are listed in Table 1. These achievements show the impact of engineering on the society. Thus, a discussion of these achievements can instill pride and purpose in the student's approach to both the engineering education and its practice.

TABLE 1
Greatest Engineering Achievements of 20th Century

| | |
|---|---|
| 1. Electrification | 11. Interstate highways |
| 2. Automobile | 12. Space exploration |
| 3. Airplane | 13. Internet |
| 4. Safe and abundant water | 14. Imaging technologies |
| 5. Electronics | 15. Household appliances |
| 6. Radio and Television | 16. Health technologies |
| 7. Agriculture mechanization | 17. Petroleum and gas technologies |
| 8. Computers | 18. Laser and fiber optics |
| 9. Telephone | 19. Nuclear technologies |
| 10. Air conditioning and refrigeration | 20. High performance materials |

*Failures behind successes –*

In the book "To engineer is human," Petroski [2] describes the human tendency to engineer as the process of continually pushing the envelope of technology. When a failure occurs, we learn from the failure by establishing limits on the applicability of the technology and also, developing new technologies to address the failure mode. Again, we continue to push the envelope till the next failure. As a result of this discussion, students become aware of the true nature of design and become more open to risk taking. It also encourages true learning based on failures in a low risk academic environment.

*Products behind the successes and failures –*

In the book "The machine that changes the world," Womack et. al. [3] describes the evolution of automobile manufacturing technology from craft shops to mass production and then, to the lean manufacturing technology. Such books can illustrate the products behind the successes and failures.

Due to these readings, students develop an appreciation for product timing. The product timing is crucial and should coincide with the opening of window of opportunity created due the societal needs and economic conditions. If the product is too early or too late to the market, it is bound to fail.

*People behind products –*

Documentaries such as PBS American Experience are a great way to look at the people behind the products. For instance, Laurie Kahn-Leavitt's PBS documentary "Tupperware!" [4] shows:

- the inventive skills of Earl Tupper in the design of the wonder bowl with "burping" seal;
- the marketing skills of Brownie Wise, the women behind the success of Tupperware; and
- the social impact of Tupperware in terms of turning women into successful entrepreneurs.

In short, it shows the development of Tupperware at the crossroads of societal needs and economic conditions.

*Thoughts behind people –*

Typical mechanical engineering curriculum views the design activity as purely functional. The goal of a design team is to create a design that meets the functional requirements. Students do not learn or appreciate the importance of aesthetics or product styling. Billington's work [5] features the development of personal style by designers and therefore, encourages the students to develop their own style from the early days.

Gordon Glegg is known for his famous quotes "A scientist can discover a new star, but he cannot make one. He would have to ask an engineer to do that." His books on design [6 - 8] show the required traits for a "real" engineer. Such books can provide students with an understanding of personal traits behind the people.

## CASE STUDY – UNDERSTANDING MARKET NEEDS: INSIGHTS FROM THE PRODUCT EVOLUTION OF TYPEWRITERS [9]

The typewriter, a great American invention, shaped our society and the mode of communication for over a century. The origin of typewriters can be traced back to 1868, when C. L. Sholes and several of his associates created the first typewriter prototype. E. Remington and Sons began selling a refined version of this machine in 1874. This typewriter was popularly known as the "blind writer" because the paper was hidden from the view of the typist. The character set consisted of upper case letters only, but an important feature was the arrangement of letters on its keyboard, known as "QWERTY" (the first six letters at the left end of the top row.) This arrangement, which helped to avoid jamming of the keys at high speeds by separating the letters that are often typed in succession into opposite sides of the keyboard, persisted over the years and is even used in present-day computer keyboards.

To improve the usefulness of typewriters, the Smith Premier Typewriter Company introduced the Smith Premier, which used a full keyboard with separate keys for upper and lower case letters. Remington, on the other hand, came up with the innovative Remington Model 2, which used the shift key to type both upper and lower case letters using a single character set on the keyboard and dual-faced type bars. This keyboard was better ergonomically designed to reduce the mechanical movement of the hand. Even though the demand for typewriters was virtually nonexistent at the time, the few typewriter manufacturers firmly believed in the great potential of the product.

Let us now step back and examine the possible needs that could be satisfied by typewriters in the later part of the 19th century. Typewriters could satisfy a need for "clear and legible documents"; however, typewritten documents were not considered socially acceptable then, so this need did not exist. On the other hand, with the increasing speed of communication at that time, a need existed for "high-speed transcription." Typewriters could potentially satisfy this need, but very few people knew how to type. There were neither

books nor instructions to teach typing. As a result, typing speeds were much lower than manual writing and it did not make sense for a customer to buy a typewriter when he or she could write faster. While the inventors believed that typewriters could help in high-speed transcription, they did not understand the big picture wherein the typewriter, and the training to use it, together formed the complete solution. The initial market failure of typewriters can be attributed to this lack of recognizing the real market need.

The breakthrough for typewriters came in 1881, when the Young Women's Christian Association (YWCA) thought of typing as a career for women and started offering typing courses. The business community immediately recognized the need for typists, which also made way for women to enter the work force in large numbers. To cope with the demand for training courses, several institutions opened across the country. The training, along with the typewriters themselves, now fulfilled the need for high-speed transcription. It sparked a great increase in the sales volume and also, the competition.

While the demand for typewriters and typists was increasing, users still had to cope with "blind writers." In 1895, recognizing the need for "seeing the document while typing," the Underwood Company introduced the revolutionary Underwood No. 5 typewriter. This was the first "writing-in-sight" or "visible-writing" typewriter. From then on, competition and sales grew steadily.

The next innovation in typewriter design addressed the need for "portability and noise-free performance." Electric technology was incorporated into typewriters in 1920, creating the electric typewriter. It had several advantages over the manual typewriter. The electrical energy was used to actuate the keys instead of finger pressure and to do the line spacing and carriage return functions. Consequently, the performance—typing speed and quality of print—was greatly improved. Recognizing these benefits, all typewriter companies moved quickly towards electric typewriters.

In 1934 Dvorak, one of the founding fathers of industrial engineering developed a new keyboard arrangement for typewriters. The arrangement, shown in Figure 1, was based on 12 years of studying languages and the physiology of the hand. In this keyboard, 70% of all English words can be typed using the middle-row keys as opposed to 30% in the QWERTY arrangement. Also, the most common consonants are placed on the right side of the keyboard whereas the most frequently used vowels are on the left. As a result, the typist continuously uses both hands in every word. This arrangement is easier to learn and use, improves typing speed by about 10%, increases accuracy, and reduces fatigue. Despite its tremendous advantages, marketing this keyboard by Smith-Corona failed. While designing the keyboard, Dvorak overlooked an important implicit constraint: the entrenchment of the existing technology by millions of people who were proficient at using QWERTY keyboards. A change would require retraining people and buying new typewriters. This constraint made the revolutionary keyboard impractical.

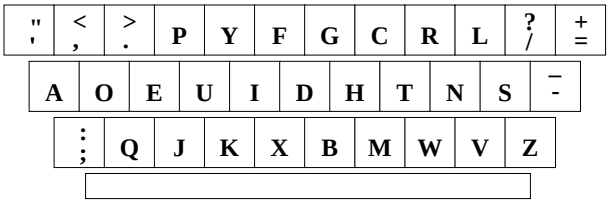


FIGURE 1
DVORAK'S KEYBOARD ARRANGEMENT

Even though the QWERTY arrangement reduced the tendency of the printing arms to collide, all typewriters, both electric and manual, were jamming at higher speeds. Recognizing this limitation of mechanical levers, IBM introduced a revolutionary concept, dubbed "Selectric," in 1961. This machine used a ball with letters embossed on it. The ball was mounted on a carriage, which continuously moved in the horizontal direction during typing as opposed to moving the paper relative to stationary keys. In addition to obviating the problem of jamming the levers, the new concept reduced the overall size by eliminating the carriage motion. It also reduced the moving mass, which in turn improved typing speed. The ball could also be changed easily to accommodate different languages and fonts, or replaced when worn.

The electronic era found the typewriter companies trying to cope with the new technology by introducing electronic typewriters. These devices allowed the typist to check and revise each line before printing to eliminate mistakes and the need for corrections. Electronic typewriters were further improved by incorporating a monitor to allow checking whole documents. However, these changes could not keep up with the consumers' need and appreciation of the greater flexibility offered by personal computers.

Recognizing the coming end of the typewriter era in the U.S., the Brother Company began increasing sales in foreign countries. By producing different language typewriters, they successfully exploited the residual value of the typewriter technology while switching to the next generation products. The company's line diversified into printers, fax machines, word processors and electronic stationery such as labeling systems and stamp creators. The Smith Corona Corporation, on the other hand, was unable to make the leap from electrics to electronics and filed for bankruptcy on July 5, 1995. Interestingly, Bill Gates, founder and CEO of Microsoft Corp., was announced the richest person in the world on the same day.

## CONCLUSIONS

The paper illustrates a teaching methodology that helps to:

- instill pride and purpose in students;
- understand the fundamental concepts using the history of engineering/ technology; and
- learn from the successes and failures of others.

Activities such as field trips to museums such as the Smithsonian and the Transportation museums, and landmark sites that are on the historical registry can supplement the teaching methodology. The history of engineering/technology creates interest in some students (about 35%) and draws a neutral response from many (50%). Most students comment that the "stories" were useful in remembering and recalling the concepts. Thus, they serve as excellent mental cues. Author plans to use this approach in teaching machine design and mechanics of solids.

## REFERENCES

[1] Ferguson, E., A Sense of the Past, Historical Publications of ASME, 1980.

[2] Petroski, H., To Engineer is Human: The Role of Failures in Successful Design, Barnes & Noble Books, 1985.

[3] Womack, J.P., Jones, D.T. & Roos, D., The Machine That Changed the World: The Story of Lean Production, HarperPerennial, 1991.

[4] Kahn-Leavitt, L., Tupperware!, PBS Documentary, 2004.

[5] Billington, W., The Tower and The Bridge, Princeton University Press, 1985.

[6] Glegg, G.L., The Design of Design, Cambridge University Press, 1969.

[7] Glegg, G.L., The Selection of Design, Cambridge University Press, 1972.

[8] Glegg, G.L., The Development of Design, Cambridge University Press, 1981.

[9] Kroll, E., Condoor, S.S. & Jansson, D.G., Innovative Conceptual Design: Theory and Application of Parameter Analysis, Cambridge University Press, 2001.