

Teaching Engineering for Students with Right Brain Dominance

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Abstract

Traditionally engineering education is heavily left brain dominant; as a result, right brain dominant students are discouraged from entering this field. However, this approach also causes some problems for the left brain dominant students, as the power of the right brain is not fully utilized. In this paper we propose a more balanced approach, which can make full use of the functionality of both hemispheres of the human brain. Therefore, engineering education can be more effective for all students, especially for those with right brain dominance.

Introduction

Most humans are left brain dominant, and brain lateralization is also widely present in many animals¹. This arrangement is proved as an advantage if both sides are fully engaged. For example, it is often very challenging to recite prose, but it is much easier to recite a poem with rhyme, and it is effortless to remember the lyric of a song. The difference lies in how the information is processed in the brain, where the left hemisphere processes the content, while the right hemisphere processes the rhyme and music. In addition, when we learn something, the left hemisphere takes care of the details (wood), while the right hemisphere deals with the large picture (forest)²⁻³. Therefore, people can learn more effectively if both hemispheres are engaged at the same time.

The functionality of the two hemispheres of the brain has been well studied, and the main features of the two hemispheres can be listed below. Left hemisphere: logical, sequential, rational, analytical, objective and detailed; right hemisphere: random, intuitive, holistic, synthetic, subjective and global. From this list we can see that left brain characteristics are more emphasized in engineering, so the students with right brain dominance will have considerable challenges in this field. However, if the functionality of the right hemisphere is totally ignored, even the left brain dominant students will suffer from a number of problems. There has been a considerable amount of research on this topic in elementary education⁴⁻⁶, and it also attracted attention in the field of engineering education⁷⁻⁸.

On the other hand, engineers in many fields need the visualization capability to design products, which is a feature of the right hemisphere. Many students feel that there is a barrier between the reality and the mathematical formula describing it, in other words, the two hemispheres are not well interconnected. Fortunately this challenge can be overcome by the assistance of computer

simulation, where the connection between messy mathematical derivation and reality can be bridged. Therefore, the advancement of technology has provided the tool to teach both hemispheres at the same time.

Bottom-Up Approach

As mathematical derivation plays an important role in traditional engineering courses, the conventional teaching and learning methods are optimized for the left hemisphere. If we make an analogy of engineering education as the construction process of a building, the dominant approach is similar to laying down the bricks layer by layer from the bottom up. In the past, this approach achieved considerable success, and most faculty members were educated in this way. However, in the information age students are surrounded by so many distractions, and this traditional approach becomes problematic. For example, cell phone and human networks have penetrated deeply into the life of college students, and many of them also work part time, so their study is carried out in a “defensive mode”. From students’ point of view, the academic activity is embedded into a matrix of enjoyable events, and the assignments from professors are unpleasant barriers in their daily life. On the other hand, most faculty members are frustrated and puzzled by a phenomenon: many students are not well prepared with the needed background knowledge, although they have taken the prerequisite courses. In other words, most of the knowledge they acquired during a semester will evaporate quickly after the final exam.

The knowledge retention problem can be understood with the analogy of photolithography in the semiconductor industry. As we know, the patterns of integrated circuits need to be formed on the photoresist first, and then they can be further transferred to the silicon wafer. The commonly used photoresists are polymers with large molecular weight, where the long molecular chains prevent it from dissolving in solvents quickly. If it is exposed to intensive UV light in the photolithography process, the long chains are cut into smaller segments, which can be dissolved easily. This is exactly what happens to the learning process of college students, and the knowledge they acquired becomes fragmented, which can be easily washed away. Therefore, in order for the students to keep the knowledge for a longer time, we need to have a more integrated approach.

Top-Down Approach

In the process of building modern skyscrapers, first a solid foundation is laid, then a steel skeleton framework is constructed, and finally the floors and walls can be filled in. In engineering education, we can also adopt this top-down approach. The foundation for college education is laid at high school, where students can receive a broad education, but the many subjects are often not well interrelated. After entering college, most students still keep such a mindset, and they tend to view the integrated curriculum as a collection of independent courses. One way to overcome this problem is to introduce an introductory course in the first year, which will give an overview of the whole curriculum and show the relationship between the courses.

Nationwide, engineering programs suffer from relatively low retention rates, and part of the problem is that students fail to see the connection between the math/physics courses in the first two years and the engineering courses in the last two years.

If we plan a journey to somewhere by car, usually we need to get some assistance from an on-line map. There are two different kinds of information available: the first is a map with the travel route highlighted, and the second is the detailed turn-by-turn instructions. The conventional instruction method in class is similar to the second approach; it is very efficient at the level of details, but often misses the larger picture. If the homework problems encountered are simple, students can solve them very quickly. On the other hand, if the problems are complicated, most students will be at a loss and give up. In addition, many students are very context sensitive; they feel comfortable in working on homework problems, but screw up at the final exam. Therefore, the large picture approach is very useful if it is combined with the detailed knowledge⁹.

Two-Way Approach

As we see that both the top-down and bottom-up approaches have their advantages and drawbacks, the best option is the combination of both of them to create a two-way approach. Between the two hemispheres of the human brain, there are about 200 million nerve fibers in the corpus callosum, which enables constant information exchange between the two hemispheres. Therefore, we can take advantage of this capability and engage the whole brain in our teaching.

Just like investigating a travel route with an on-line map, one can conveniently zoom in and zoom out. This approach can be applied in our teaching process, and we can first zoom out to the large picture, and then zoom in to the details. One way to achieve this is to set up a knowledge map of the whole course with the key units included, and show this map to the students at the beginning of every lecture. In this way, all the details can be fit into a large framework of knowledge.

Left brain dominant students are more sensitive to audio instruction, while the right brain dominant students can learn more effectively with visual images. Many engineering courses involve lengthy mathematic derivations, which is very challenging for the right brain dominant students. Therefore, showing a few simulation results will be of great help to those students. Fortunately many software packages are available in most engineering fields, which can be applied to bridge the gap between the abstract mathematics and the applications in the real world.

In addition, the two brain hemispheres can also compensate for each other¹⁰. For example, right brain dominant students can take advantage of their graphic capability to imagine the solution of differential equations. On the other hand, the left brain dominant students can use their strong logic functionality to reduce a nonlinear problem to multiple linear approximations. Furthermore, in this approach students can also have the opportunity to develop the capability of their disadvantaged hemisphere, while keeping their dominant one fully engaged. We will apply this approach to our instruction in some our classes, and report on its effectiveness in the future.

Conclusion

Advances in neural science have yielded important insights into mental functioning, and they can be of great help in engineering education, as well as in other areas. A salient feature of the human brain is the lateralization, where the two hemispheres have different functionality. Traditional education methods overemphasize the left brain skills. Now is the time to have a more balanced approach. This can be done in two different levels: curriculum design and course instruction.

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