Abstract

Brain development is not a constant process. Parts of a human's brain develop sooner than other parts. Several medical researchers have discovered that the emotional portion of a human's brain develops rather quickly. The emotional portion becomes dominated in a person's teens and early twenties. The rational side of the brain development begins to overtake the emotional side as most people reach their mid-twenties. This is not always the case. Some younger students are very rational thinking people while some adults never develop out of the emotional dominated thinking.

As seasoned engineering educators, most of us think rationally about problem solving and how we learn. This guides us toward our "best approach" to teaching and reaching students. The problem arises when most of the students we teach are not thinking rationally, but emotionally. Most engineering educators have noticed how "non-traditional" students (older) tend to do better on the average than more traditional students (younger).

This paper deals with technics to rationally reach emotional thinking students. One popular television commercial says, "People won't remember what you said, but they will always remember how you made them feel." As engineering educators, we need to set up our lesson plans to emotionally connect with students (engage their feelings).

Introduction

Human brain development is not a uniform process. It is well established within the fields of neurological and psychological science that brain development proceeds in overlapping and asynchronous phases. For example, the capacity for emotional regulation and rational thought evolves along a trajectory and on time scales that differ with those associated with other developmental features, such as motor skills, language processing, and the fight-or-flight response. By age 7, the human brain will have grown to about 95% of its adult mass and features such as basic motor skills, perception, and working memory will have prominently emerged during this time. Between the ages of 7 and 22, many neural connections are still in the process of forming throughout the various regions of the brain and the frontal lobe – the region responsible for logic, decision making, and the regulation of emotion – is among the slowest to mature. By the mid-twenties, maturation of the frontal lobe reaches a stage to where it can counterbalance the more basal, instinctive, and often impulsive emotions that are characteristic of the "emotional" brain. The age of most university students falls in upper age range of frontal lobe maturation, so it should come as no surprise to educators when some engineering students naturally frame complex technical problems in an emotional rather than rational way.

By their very nature, engineering educators think rationally about problem solving and how students learn. This guides academic bodies toward establishing their so-called *best practices* to teaching and connecting with students. Problems can arise, however, when these best practices are applied to students who react to problems with an emotional rather than a rational approach.

Those who have taught engineering courses will have no doubt encountered students who, despite the instructor's best efforts, just can't seem to grasp the central concepts of the subject matter. No matter how many different ways the instructors attempt to explain the concept, there just doesn't seem like a way to connect with the student. It can be tempting to simply write off such students by blaming them for being unfocused, unmotivated, or even incapable. But the root cause of such disconnects could be something else altogether.

Most engineering educators will have noticed how older, "non-traditional" students tend to do better in their coursework than their younger, more traditionally-aged peers. While it may be enticing to attribute such observations to the older students merely being more mature, experienced, and focused, could there also be other drivers contributing to these trends?

Background

Many researchers have studied brain development in humans. Until recently, the physiology of brain development was not known. It was thought that beyond the prenatal stage, there were no large-scale changes and that development continued along a straight-line trajectory. (C., 2009). It turns out, however, that this is not the case. Certain brain regions are now known to develop faster than others. The emotional capacity of the brain develops and dominates when it is advantageous for humans to make emotional connections with other humans (e.g. socialization in adolescence). Later, in the mid- to late twenties, it becomes necessary to think more rationally for survival purposes (e.g. building shelter, planning hunts, self-protection, and rearing children).

This paper illustrates the adolescent-to-adult emotional development transition and how it applies to engineering education. Steinberg (L., 2004) found that adolescent boys engage in risk taking at a higher rate than adults. This behavior was found in girls, but at a lower rate. A side note, the risk-taking behavior was significantly lower when the individual was alone. The addition of peers dramatically increased risk-taking behavior. The author's reasoning was based on the emotional dominance of the adolescent brain. Chein, et.al. (Chein, 2011) reasoned individuals wanted to be liked, admired, or wanted to fit in. This is an emotional trait. With an emotion-dominated brain, how one feels about an issue tends to be more important than how one thinks about that issue. This behavior is readily observed in young adults below the age of 22.

Engineering is not the only discipline that has problems reaching students who fall in this emotional development age chasm. Kahike (Renate Kahike, 2018) chronicled the same issue in the medical field. They noted that a sizable portion of health care professionals entered into the field for largely emotional reasons, chief among those that they "wanted to help people." But like all STEM-related disciplines, to be effective in this field requires the application of highly rational thinking. Kahike wrote about the move toward "critical thinking" but pointed out there is no clear definition of what that term means as it actually means different things to different people.

As most people neurologically mature, the rational portion of their brains start to dominate the thinking process. Laidlaw (Laidlaw, 2012) described the three basic parts of the human brain. The first part can be conceptualized as the survival portion, also called the reptilian brain (brain stem). This section is present at birth and controls the essential involuntary organ functions necessary for life. The next section is the limbic brain, also referred to as the emotional brain. This section controls pain, pleasure and fear and tends to dominate thinking until the person ages into their mid-twenties. At this point, the neocortex, or rational brain overtakes the limbic brain and begins to dominate. This part of the brain governs decision making and the regulation of emotions.

Techniques

Evidence for the gap in brain maturation between 18–22-year-old students and their instructors is overwhelming. It can be difficult for rational-dominant thinkers to connect with emotion-dominant thinkers if both are unaware of the difference. Most engineering students fall in this younger age range (18-22) and as such, can be assumed to be emotion-dominated thinkers. Instructors, however, are much more likely to fall into the older bracket and are therefore more likely to be rational-dominated thinkers. How can this gap be bridged? The rational thinker has to be aware of this difference and accommodate for it. For an emotion-dominant thinker, it is not what is said, but how they are made to feel (Konijn, 2018). Inspiring the student to care about the subject at hand is the key.

It is important to determine what motivates students, what do they care about. By taking a poll in class on the first day, this can be ascertained. A few questions are as follows:

- Why do you want to be an engineer?
- What industries do you want to work in?

Most of the mechanical engineering students here in Arkansas say they are interested in the automotive industry. From then on, the questions are all geared toward automobiles. If the subject at hand is teaching about torque, a drive shaft torsion is used. In thermodynamics, piston-cylinder assemblies and combustion are the automotive related topics. Heat transfer can be related to an automobile radiator or the HVAC system. Getting the students to care about the material, and most importantly, showing the students that you care about them, makes a very big difference. It is still hard to relate to some students. By working on projects within an area that they care about, they begin to see the purpose of the equations and analyses.

When I talk to my advisees, I always ask them about how they are doing, how is their family, do they have any personal issues that are getting out of hand, etc. Then I write it down. The next semester, I review these notes and I am better able to communicate with the students about what they care about. "How's your mother doing since her illness?" You remembered and you care.

Conclusions

Young people are still developing in many ways, including mentally. As the emotional portion of their brains dominates in their late teens and early twenties, they have a hard time relating to a purely rational lecture. As rational people, we instructors have to make emotional connections to the students. We have to make them "feel" like this information is beneficial to them. We have to make them "feel" like we care about them and not just doing our job.

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