ENGINEERING SKETCHING AS A VISUALIZATION TOOL – PART DEUX: VISUALIZING ENGINEERING CONCEPTS

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Figure 1. Auditory-Sequential and Visual-Spatial thinking. [1]

Abstract

Engineering sketching is a method of externalizing the thinking about, and solving of, design problems. Sketching, from the Greek σκεδίος (meaning “sudden”), can be defined as:

1. A simple, rough drawing or design
2. A brief plan or description of major elements.

Sketching exists somewhere between writing and formal drawing as a means of formulating ideas. In the third year of teaching engineering sketching in our first year design course, assignments were given an additional component: the visualization of engineering concepts. This had three motivations:

1. Students should be given the opportunity to integrate knowledge from other first year engineering courses
2. Students should be challenged to think spatially
3. Students who were not necessarily strong renderers should be able to do well in the “concept” category.

This paper will discuss how these new components encouraged the students into a more Visual-Spatial (vs) thinking mode. There will be some discussion regarding how vs type students “understand” with respect to more prevalent Auditory-Sequential (ASQ) type students. The goal of visualizing engineering concepts is to bridge the ASQ style of deliveries (from other knowledge-bases) with a more vs style of problem solving.

1. Introduction

“Well, I’ve made some mistakes. But at least I snagged one of those Michael Graves toilet brushes back in 2004!” [2]

This is the third year the drawing component of the first year design course was offered. We see sketching and drawing practice still as one of the building blocks for idea generation, problem solving and right hemisphere stimulation (visual-spatial). If we are to believe the assertion in Daniel Pink’s book *A Whole New Mind*, North America is on the brink of a new age. Pink refers to this new age as the Conceptual age, following the Information age [Fig. 2].

Figure 2. From the Agriculture Age to the Conceptual Age.

In *A Whole New Mind*, he describes how North American professionals, engineers among them, will have to get ready for this new age. He sees three causes for this much needed shift in thinking: Asia, abundance, and automation. How prepared is North America after answering the following three questions:

1. Can someone overseas do it cheaper?
2. Can a computer do it better?
3. Is what I’m offering in demand in an age of abundance?

Apparently a designer toilet brush is. If the first two answers to the above questions are yes and the third answer is a resounding no, Pink suggests that we have been neglecting our right hemisphere for too long. This part of the brain enables us to “forge relationships rather than execute transactions, it can tackle novel ideas rather

than solve routine problems and synthesize the big picture rather than analyze a single component”[3]. In order for us to educate well-rounded thinkers, who use the right in conjunction with the left hemisphere (auditory-sequential), Pink points to six areas which he feels stimulate our right hemisphere: Design, Story, Symphony, Empathy, Play, and Meaning. “For businesses”, he argues, “it’s no longer enough to create a product that is reasonably priced and adequately functional – it must also be unique, beautiful and meaningful” [4]. You need your right hemisphere for the latter: “try explaining a designer garbage can to the left hemisphere”.

While the second half of Pink’s book becomes a bit of a self-help debacle, he has some very valid and probably – by now – well-known points.

The design class is the perfect environment to test some of these concepts. This past year some additional components were added to the (up to this point) relatively straight-forward drawing assignments. Three of these components will be briefly discussed to illustrate how we tried to get students to take these visualization exercises one step further.

2. More on ASQ and vs

“The right brain harbours the truth in sensory experiences and by choosing the words to articulate the moment, the left brain becomes the publisher and the curator of meaning.”[5]

The Western focus on left-hemisphere and auditory-sequential education stems from Western culture and philosophy. Western thought is “sequential, temporal and analytic compared with Eastern culture and philosophy, which is spatial and holistic.”[6] The Euro-American thinks in terms of cause and effect, whereas from an Asian point of view a synchronicity of unrelated events is more appreciated. Language in both cases confirms these differences; Asian language is based on pictures, Western languages “are constructed out of non-meaningful elements – letters of the alphabet.”[7]

When left brain thinkers are asked to answer a question, they will look for the right answer based on the facts at their disposal. When right brain thinkers are asked a question, they usually respond with some form of “tell me more/it depends”. As all their knowledge is connected, they can see many paths to differing answers and they want more information to help them decide which path to take to the required answer. This divergent thinking is the hallmark of creativity, but may not be un-

Figure 3. Stress and loci assignment/student work.

derstood in school where achievement is often seen as having the right answer. As Jeffery Freed says, “because one of the attributes of right-brained thinking is a non-sequential divergent form of thinking, these minds often veer into unusual and different territory. This can result in illogical or often unsubstantiated conclusions. On the other hand, they may view a problem from an entirely different angle, leading to new breakthroughs and discoveries.” [8]

3. Component 1: Stress and Loci

Students were asked to draw a sectioned skateboard wheel in isometric and in three view orthographic. The second half of the assignment was added to see if students could show visually the stresses in a wheel when someone stands on top of a stationary skateboard. The use of colour, arrows, and shading was encouraged [Fig. 3].

They were also asked to show the path (locus/loci) a point on the outside rim of the wheel makes while the skateboard is rolling at a constant speed. They were asked to consult their Statics & Dynamics professors in an effort to show that all engineering questions do not cease to exist at the door of the lab, and can flow from one classroom into the next [Fig. 5 & 6].

4. Component 2: Movement Analysis

In this assignment students were asked to choose a scene of a movie, a ‘play’ in a sports game, or sequence of events they had experienced themselves. They were then asked to show this movement in a three-dimensional oblique space and a two-dimensional orthographic side or top view [Fig. 7 & 8].

5. Component 3: Design Style Analysis

Students were introduced to the history of design from about 1850 (around about the time that engineers started to have an influence on design) to the present. They were introduced to artistic, craft and high-tech influenced styles [Fig. 4]. Students were asked in their assignments to pick an object from one of the design styles introduced, draw some details, and explain the object using their first year engineering knowledge from all courses. They were asked to look at the two aspects of design as so called by John Heskett: *utility* and *significance* [Fig. 9 & 10]. Kathryn Henderson, in *On Line and On Paper*, describes this as follows: “Aesthetics and standards are equally important in engineering and both can be read in functional and symbolic terms. The line between aesthetics and standards is drawn mainly by the distinction

that standards embody the specific rules of design work while aesthetics encompass the unwritten rules that distinguish mediocre work from quality design.”[9]

6. Conclusion

If, as Daniel Pink asserts, we are heading towards a conceptual age, students should be introduced to the possibility of a shift. The class assignments were designed to encourage students to solve problems in a more intuitive manner. By introducing visualizations of stresses, movement, and other engineering design concepts, students were given the opportunity to stimulate the ‘big picture’ right hemisphere. The purpose of these exercises is not to separate the brain into some Cartesian mind/body duality, but to prepare future engineers for a rapidly changing society where computers are faster, abroad is cheaper, and your ‘whole’ brain is the only real commodity.

7. References

- [1] Silverman, Linda K. *The visual-spatial learner: An Introduction*, 2003, p. 6.
- [2] Pink, Daniel H., *A Whole New Mind - Moving from the Information Age to the Conceptual Age*, Riverhead Books, New York, 2005, p. 35.
- [3] *ibid*, p.39.
- [4] *ibid*, p. 33.
- [5] Blackburn, Emma. “Free Your Mind: A Right Brain Future”, p. 19.
- [6] Silverman, Linda K. “Effective Techniques for Teaching Highly Gifted Visual-Spatial Learners”, p. 1.
- [7] *ibid*, p. 1.
- [8] Freed, J. “Teaching Right: Techniques for Visual Spatial Gifted Children”. *Understanding Our Gifted*. January/February, 1996.
- [9] Henderson, Kathryn. *On Line and On Paper Visual Representations, Visual Culture, and Computer Graphics in Design Engineering*, The MIT Press, Cambridge, 1999, p. 149.

Figure 4. Design history as presented to the first year design class.

Figure 5. Stress and loci assignment/student work.

Figure 6. Stress and loci assignment/student work.

Figure 7. Two and three-dimensional movement analysis/student work.

Figure 8. Two and three-dimensional movement analysis/student work.

plexity of modern aircraft requires engineering from all disciplines. Beginning with the interior of fit, the property of air which is a fluid must be d as well as the properties of gases present in the re. The pressure difference between the interior and must be known in order to ensure the aircraft's and windows can withstand the applied forces. The d characteristics of air must also be known in order e an efficient low drag airfoil and enough pressure ; in order to create lift (Bernoulli's Principle). The ; material used in construction may require the study structures to create or determine the best-suited

The basic electrical components within the aircraft er major area of study. The navigation instruments teraction of electric and magnetic fields relates to arned in Physics 259. Coaxial cables are likely used in order to prevent inaccurate instrument readings. amming of software relates to the possible n of knowledge of Engg233. In terms of the overall of the aircraft, Engg 205 is the most relevant course. es applied to the aircraft, which can be determined or through testing can be applied to the frame of the ing computer modeling. The various forces of ' compression acting on members can be determined ared to the limit of force for the particular material. cepts of statics which can be applied to the aircraft he analysis of machines. Machines are prevalent in

and control surfaces (elevators, rudder and ailerons). A specific force output may be needed, and a machine can be designed to meet that requirement. The dynamics portion of mechanics allows one to determine the acceleration, velocity, drag, and thrust of the aircraft. For instance, it is known that each engine produces 3400 h.p. Appropriate calculations can be taken into consideration from this fact. In chemistry 209 some basic chemistry knowledge has relevance to an airplane. For instance, knowledge of corrosion resistant materials aids the design considerations for materials. The knowledge of how to maximize the energy generated by the exothermic reaction caused by the combustion of fuel is vital to the design of the engines. Lastly, Engg 251 and 253 have great relevance to an aircraft. The summation of the design process required elements of the design trinity in order to create the functional yet aesthetically pleasing final product.

Examples of Equations and Concepts Used Aircraft Design

Formula	Use
$V_m = \left[b + \frac{R}{P} \right] V_m^2 + \frac{q}{P} V_m - \frac{qk}{P} = 0$	van der Waals eq. for real gases liquid
$C_D = \frac{D/A}{\frac{1}{2} \rho V^2}$	Dimensionless Drag coefficient
$E = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$	Used to determine electric field
$\vec{S} = \vec{E} \times \vec{B} = \mu_0 \vec{r}^2$	Find tangential and

DRAWING	Assignment #2
TITLE	Design Analysis (2 parts)
DATE	Feb. 11, 2005

Figure 9. Design style analysis/student work.

Figure 10. Design style analysis/student work.