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Teaching Right-Brain Thinking in a Construction Curriculum

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Students in Construction Management programs take mathematics and science courses to aid them with the engineering aspects of their discipline. These are subjects that rely on the left hemisphere of the brain, which processes verbal, mathematical and scientific information. Imagination, holistic awareness, and spatial recognition are right- brain processes, and, unquestionably, desirable traits to possess as a constructor. However, construction education most often emphasizes left-brain activities, to the virtual exclusion of the right brain. As construction educators, we believe we are educating students to become good problem solvers through the knowledge of mathematics and physical science. Yet, are we effectively teaching students the skills of critical thinking and problem solving using intuition and application of knowledge? The answer is probably no. To accomplish these skills, students must develop both hemispheres of the brain. Critical thinking skills are very important in the construction industry for visualizing the components of a construction project and the finished project, reading working drawings, and communicating with construction industry personnel. This paper discusses how construction educators can teach their students simple, right-brain exercises to aid in the development of these skills.

Key Words: Right Brain, Critical Thinking, Creative Thinking

Introduction

Is construction an art, or a science? Those from an engineering background would likely reply a "science." They relate to the mathematic and convergent thinking aspects, and probably interpret the word "art" as representing paintings and sculptures created by artists. Those with an architecture background relate to the design aspects, and would probably respond with an "art." However, the response of a construction management faculty member would most likely be "both" or "neither." Please do not think the authors are trying to categorize people by their backgrounds. Not in the least. We are merely relating a non-scientific observation from our conversations with numerous faculty and people in the industry over the years.

Construction involves producing various buildings, structures, roads, highways and bridges. Industry personnel are faced with solving complex problems on a daily basis utilizing people, machinery, raw materials and sometimes-complex mechanisms. Construction requires the ability to visualize and plan, to think creatively and intuitively, and deals with accuracy, time constraints and lineal sequence. Therefore, is construction an art, or a science? The answer is definitely: both.

Now, if we ask whether the learning process uses the left hemisphere or right hemisphere of the brain, one would likely say both. However, in postsecondary education, particularly in construction education, we primarily (and unknowingly) educate to the left side of the brain. At the same time, we ask students to think creatively without adequately developing the right side.

For example, in construction courses we ask students to solve problems based on directed analytical facts by using relational, holistic and imaginative reasoning. They proceed to do so relying on intuition and their previous knowledge. Many times the results are fantastic, but many times they fall far short of our expectations. Why? Unfortunately, it is often due to our teaching methods.

Imagination, holistic awareness, and spatial recognition are right brain processes. These processes can be developed in students by exercising the right brain. In this paper we will discuss these processes and describe some simple exercises that have proven to work in right brain development. We will also describe one university's seven-year experiment in adopting the right-brain concept into the curriculum.

Left-Brain vs. Right-Brain Thinking

The human cerebral hemisphere is divided into two distinct hemispheres. Thinking strategies and learning styles vary in individuals based on the development of the left and right hemispheres. We are not experts in neurological studies, but would like to point out some facts concerning the development of the brain and the cognitive development of each of its hemispheres. The rationale of the two-sided brain structure/function forms the basis of our discussion on the right-brain relationship to construction education.

For example, left-brain characteristics include the ability to be objective, abstract and analytical (see Table 1). The left side is also rational, time conscious and goal-oriented, and is where verbal language processing takes place.

Right hemisphere characteristics include the ability to be creative, divergent, intuitive, subjective and nonlinear. The right side also provides the cognitive skills needed to solve problems (see Table 1). In general, the right brain is more proficient in visualizing and remembering events and faces, and in other spatial and emotional functions, such as visual construction tasks, artistic awareness, musical appreciation and intuitive insight (Beakley, et al., 1987). Also, the right hemisphere is not completely void of language. Scullion Moscovitch, in his *Communication and effect: Language and thought*, claims that the right side can attain the vocabulary of a 5-year-old.

The role of the left hemisphere in education is well documented. Reading is considered to be a principal left hemisphere function as is mathematics, particularly calculus and algebra. Using a computer for spreadsheet applications "... relies on an orderly, sequential, lineal, analytical style of thinking, particularly the programming aspect is predominantly left brain orientation" (Rubenzer, 1985).

Table 1

Comparison Of Left Brain And Right Brain Processing Modes

Left brain	**Right brain**
Verbal Temporal, convergent, using words to name, describe and define	Non-verbal Awareness of things, minimum word image and speech
Abstract Disassociated from any specific instance, theoretical, detached, no pictorial representation	Analogical Inferences, resemblance correspondence, seeing likenesses between objects
Sequential Succeeding before or after, continuation of events, step by step process	Diffuse Spread freely, distribute
Temporal Time conscious	Non-Temporal Not conscious of time
Mathematics/Digital Calculations, numerical methods by discrete units	Geometry Properties/relationships of points, lines, angles, etc.
Analytical Separate into components, figure out in a step by step process	Synthetic Blending together into one composition
Symbolic Relationships characterized by symbols representing items	Visual Producing mental images relating to what is seen
Explicit Externally visible, fully developed or formulated ideas	Spontaneous No external constraints, no contrived/manipulated stimulus
Logical Linked ideas, one thought leading to another often to a convergent conclusion	Holistic Relationships between parts and wholes, see whole things all at once
Logical Formulating conclusions on a logically based hypothesis	Intuitive No external constraints, no contrived/manipulated stimulus
Convergent Move toward a point in a step by step	Spatial Visualizing parts to form a whole, and nature of space

Writing is basically a function of both hemispheres, as is geometry. When reading (a left-brain function) and language (a right-brain function) are combined, we have speech. However, the verbal communication of the right hemisphere is relatively limited, and dependent on upon the left hemisphere (Rubenzer, 1985).

In post-secondary education, especially construction education, students are taught in subjects that exhibit left-brain thinking processes. Students who have limited ability on the right side, or under-exercise their right side due to the left-brain demands of their studies, can be at a great disadvantage when it comes to using critical thought processes.

Construction curriculums complicate the matter further when they eliminate the only right-brain thinking courses -- basic mechanical drawing and construction detail courses -- and replace them with computerized drafting. Today, many of these courses have gone the way of the slide rule. The pencil has been replaced with a mouse. Communicating our ideas through handmade drawings and sketches inspired creative thinking. Now, we merely have to push the right buttons to produce a drawing. We have relinquished control of our cognitive thought processes to what is in essence only a tool -- an electronic slide rule. We are not advocating the return of the slide rule, but we are suggesting that with the advent of the calculator and computers, some basic problem solving processes have weakened.

Many students can now simply go through the motion of solving mathematical problems without truly understanding what they are solving. The tradeoff is speed versus the slower process of solving problems by "hand." Both methods may seem to use left- brain reasoning; however, when solving mathematical problems by hand, we are actually using intuitive, divergent, and relational reasoning steps to solve the problem -- all right-brain processes.

Have Students' Critical Thinking Processes Been Changing?

Critical thinking is a popular buzzword, and various definitions have been offered depending on its application. For our purposes, critical thinking as it pertains to construction education can be viewed as stated by Robert Yinger, "... the cognitive activity associated with the evaluation of products of thought. This cognitive activity, more accurately called critical or evaluative thought, is an essential element of problem solving, decision making, and creative production" (Young, 1980).

Have you noticed that students today seem less creative in their answers, and are not as intuitive in the pursuit of researching information as they were five to ten years ago? At the same time, are you finding that students are more dependent on having answers given to them? In addition, are you finding that students are deducing solutions to problems based on linear thought or abstract reasoning without consideration of other pertinent facts? If your answer to these questions is yes, then you have noticed what many other educators are finding in postsecondary education. That is, students these days seem less inclined to develop reasoning skills and less creative in their thought processes than they were a few years ago. At this time, we do not have scientific proof to substantiate this statement. However, it is a consistent observation based on discussions with colleagues across the disciplines, and has been a topic at several teaching seminars over the past few years.

In fact, the U.S. Department of Education Office of Educational Research and Improvement have taken the issue of developing students to think critically seriously. In their June 1992 publication, *National Assessment of College Student Learning: Issues and Concerns*, one of the five objectives listed under the National Education Goal 5 (Goals 2000) is, "The proportion of college graduates who demonstrate an advanced ability to think critically, communicate effectively, and solve problems will increase substantially." However, they have not found concrete data to substantiate their informal findings as to the decrease in students' ability to think critically. In the March 1991 Interim Report of the National Goals Resource Group it was noted that, "... neither national nor state information is currently available on the ability of college graduates to 'think critically, communicate effectively, and solve problems'." The report suggested that "a new kind of assessment will have to be created" to measure this ability.

This is not to say that students today are less intelligent than their counterparts of five to ten years ago -- in fact, just the opposite. Students today are retrieving more information and utilizing that information more resourcefully than we could even imagine ten years ago. The problem as we see it is that students of the computer age are less inclined to develop the right brain since the computer or calculator can perform the creative function for them. New technology is aiding the retrieval and usage of information, but is smothering the development of creativity and right brain development.

Teaching strategies that do not address both left and right brains will contribute to lopsided development of individuals. It is common knowledge that we are tapping only the tip of the brain's "potential iceberg." Furthermore, in order to equip the future citizens of the 21st century with the skills to creatively use the vast information storage, retrieval, and manipulation capacities (all left brain processes) of the computer, it is imperative that educators today understand and cultivate right brain creative processing skills so that these students will be able to maximally exploit the computer's left brain potential (Rubenzer, 1985).

Let us use a realistic example of what is happening in the construction industry today to illustrate the point made above. The estimating process has always been considered to be both an art and a science. The science function involves the quantity survey and mathematical extensions, much of which is done with the use of computer software. This is a very analytical endeavor and hence, is extremely left-brain oriented. The "art" function is employed when the estimator begins making decisions on choosing the appropriate labor crew mix, the proper equipment and applies the correct overhead and markups to the basic estimate. Each of these decisions requires a large amount of intuition based on many years of experience and a thorough understanding of the project being estimated.

In addition, with the introduction of new procurement methods in construction during the past 10 to 20 years, e.g. design-build, the estimator is expected to take on additional responsibilities. The most prominent of these are the conceptual estimates and value engineering -- both of which are based on innovation, intuition, creativity, and cognitive problem solving. With estimating being one of the more critical skills taught in our construction curricula, it seems obvious that we must prepare our students for their expanding role as "para-designers/estimators," equipped with the capacity to use the right-brain endowments in either creating a design or improving one.

Table 2 indicates the brain's cognitive development in using both hemispheres for the construction applications of estimating and scheduling.

Developing Right Brain Processes Through Drawing

In creating this paper, we primarily processed information in our left-brain, since we used a keyboard to input our ideas into a computer, in lieu of a pencil or pen to write out the manuscript. Previously we stated that communication (reading, writing and computer programming) is a left-brain activity. However writing with a pen or pencil in hand is a right brain activity (Edwards, 1979; Hanks and Belliston, 1992; Rubenzer 1985).

Table 2

Brain Function Matrix Pertaining To Construction Functions And Activities Of Estimating

Left Mode Processing Activities	Construction Function	Right Mode Processing Activities
	ESTIMATING	
Symbolic Convergent Orderly Linear Mathematics Reading	**Quantity Survey** Reading working drawings, visualization of the parts and removing the quantities in a methodical fashion	Visual Spatial Random Holistic Geometry
Logical Verbal Abstract Analytical	**Pricing & Bidding** Creating prices which reflect the project's predicted construction cost	Insight Non-verbal Analogical Synthetic
Explicit Facts Positive	Perception of the validity Profit margin	Spontaneous Feelings Negative moods
Temporal	Time constraints	Non-temporal

Advocating that students should write their term papers in longhand would be completely counter-productive. In fact, if we had to read some students' handwriting, it would probably drive us mad! But there is another way to incorporate the process of using the hand to transform ideas from an abstract to a real form: through exercises in basic free-hand drawing.

Now the mere mention of the word "drawing" turns off many adults, particularly academics. Early on in a child's development, when drawing is as natural as breathing, we tell them to stop. We become art critics of eight-year olds, criticizing and ridiculing drawings, which creates insecurity and stifles most people's desire and willingness to draw (Hanks and Belliston, 1992). In our society, beginning around the fourth grade, teachers tell Jill and Johnny to quit drawing and doodling, and return to their assignments. This rebuke continues throughout most of their education. Drawing becomes art, and art becomes something we do as a hobby or when we have time. Sadly, a person's measured creativity actually decreases as the student proceeds through the educational system. This reduction in creative thinking abilities counters the development of the right hemisphere of the brain (Rubenzer, 1985).

If your doctor informed you that you must do certain exercises to become healthier, wouldn't you heed the advice and exercise? Thus, one should view drawing as an exercise to develop right brain functions. Just as there is a proper way to exercise your body, there is a proper way of teaching drawing to enhance the development of the right brain. You do not need to be an artist or an art teacher to instruct the proper methods. However, the method of teaching this style of drawing is very important. If not properly taught, most students will only draw from the left side of the brain with little, if any, improvement on the right side.

Experiment Using Right-Brain Concepts In A Freshman-Level Drawing Course

In 1986, the College of Engineering & Applied Sciences at Arizona State University introduced two 3-semester hour courses that were mandatory for all students entering the College. The first of these courses was ECE 105, Introduction to Languages of Engineering, which is the focus of our experience in right-brain teaching.

Table 3

Brain Function Matrix Pertaining To Construction Functions And Activities Of Scheduling

Left Mode Processing Activities	Construction Function	Right Mode Processing Activities
	PROJECT PLANNING AND SCHEDULING	
Analytical Symbolic Explicit Temporal Linear	Separating out activities and determining sequence of activities; determining duration and critical activities and adjusting	Synthetic Spatial Spontaneous Non-temporal Holistic
Sequential Abstract	Re-examining durations and scheduling activities	Defuse Analogical
Reality Positive	Insight as to validity of schedule activities	Awareness Negative
Reading Writing Mathematics	Diagramming	Logos (Art) Geometry
Convergent	Critical path and adjusting duration	Spatial

Basically, ECE 105 was a 3-credit hour course that was divided into two distinctive parts that were completely unrelated. One dealt with introducing the students to computer programming and used the lecture format. Class size was usually about 300 students in a large lecture hall, and there were two such sections per semester. The other part of ECE 105 involved the dozen or so drawing laboratories, which generally contained about 40 students each and conducted in a room with individual drafting-type tables available for each student. It was in this second part that the right-brain concepts were practiced.

We tried to convince the students that if they could perform a simple function such as signing their name, they could learn to draw using primarily their right brain mode. The environment/ atmosphere created by the instructor was crucial to the learning process, as all of these students were enrolled in one form of engineering, technology or construction discipline. Hence, they were more or less "programmed" to function with their left-brains. One instructor used to turn off all of the lights and have the students close their eyes for the first five minutes. Sound like shades of kindergarten days? Possibly, but the effect was dramatic. Students would relax and begin to experience the left/right-brain "shift" much faster than if instruction began immediately after coming in from the "real world."

The following is a direct quote from the ECE 105 syllabus for the lab portion:

> "Drawing from direct observation of nature is the basis of visualization and visual communication. Drawing is a skill that can be learned by anyone, and is the outcome of acute perception coupled with effective practice. As a learner, you must take an active role in the process of learning to draw from observation, for you cannot learn to draw by reading a book, or by listening to someone talk about it. In this course, you will not be required to memorize a list of terms, or learn a step-by-step procedure, for drawing skills cannot be acquired in that way. Instead, you must observe and draw, intently and frequently. If you do so, your progress will amaze you. At the end of the course, you will be able to think and communicate graphically. This will undoubtedly help you to formulate and solve design problems."

The first week was spent on "pure contour" drawings, which are accomplished using the opposite dominant hand and never looking at the paper during the actual drawing process. For example, a right-handed person would hold the pencil in their left hand. They would then focus their eyes on the object being drawn and let their eyes follow the contours of the object as the pencil created the drawing on the paper. During the course of one drawing, they could pause about every ten minutes to re-orient the pencil, but they were never allowed to look at the paper while drawing. To facilitate this, we would generally have them set the object 90 degrees to paper to discourage any peeking. In other words, the pencil/hand/arm simply became an extension of their eye movement and at the same, slow pace. They were given over an hour to do a pure contour of a pinecone (the most complex of our "objects") -- and many never completed it. The ones that finished in a matter of minutes had not shifted to the right brain and were asked to try again! Put yourself through this exercise and we guarantee that if you don't learn anything else, you will have achieved a great degree of discipline. Most of the students absolutely hated these exercises at first, and many never were able to adapt. Those who did adapt came to enjoy the experience and felt that it helped them think with less inhibition.

Subsequent weeks covered other types of contour drawings, gesture (or "movement") drawings, portrait drawing, color, shading, texture, shadows, reflections, and basic geometric "primitives" (shapes such as cubes, cylinders, etc.). The final exercises involved the student assembling some type of "model" using Styrofoam geometric primitives and toothpicks. The model was whatever they could come up with from their imagination, usually a mechanical device such as a robot, vehicle, aircraft, etc. They were asked to draw the model at varied stages of design, starting with a rough outline and progressing to a finished description of their creation, using all of the tools learned during the semester (see Figure 3). The ultimate objective, which we emphasized to the student, was that this would be used in some future presentation as a solution to an engineering concept or problem.

In order that we might have some quantitative measure of improvement (not that we graded on this, but just an indicator of "course effectiveness"), during the first week we asked each student to accomplish a self-portrait drawing, or, if possible, a portrait of another person. At the end of the semester, they would repeat the exercise using the same model and again incorporating all of the drawing tools, with emphasis on shading techniques. They would do the same for two other drawings, usually a tree and a chair, but the portrait of a human face is definitely the greatest challenge.

The self-portrait, done on a pre and post basis, is chosen for three reasons. One, we can measure improvement in the pre and post drawings; two, portrait drawings are possibly the hardest drawings to perform -- thus, the biggest confidence-builders when accomplished; and three, the right brain specializes in recognition of faces. So, it only makes sense that if we are trying to develop the right brain, we should choose a subject the right brain is familiar with (Edwards, 1979).

In course sections where the instructors properly applied the concepts of right brain thinking, the results were astonishing. By observation, approximately 70% of the class showed great improvement, 20% some improvement, and, of course, there were those that showed no improvement. Keep in mind, the goal here was not to make students better artists, but to use these drawing exercises to enhance right-brain activity.

In our estimation, there were two factors that diminished the effectiveness of this course. One was the use of instructors who had no experience in this type of teaching and/or a total lack of understanding of the concept behind the use of the right brain as a creative part of learning. A department chair that needed a "body" to fill a requirement usually assigned these instructors. Consequently, many of them looked upon the assignment to teach the lab portion of ECE 105 as a type of "penance".

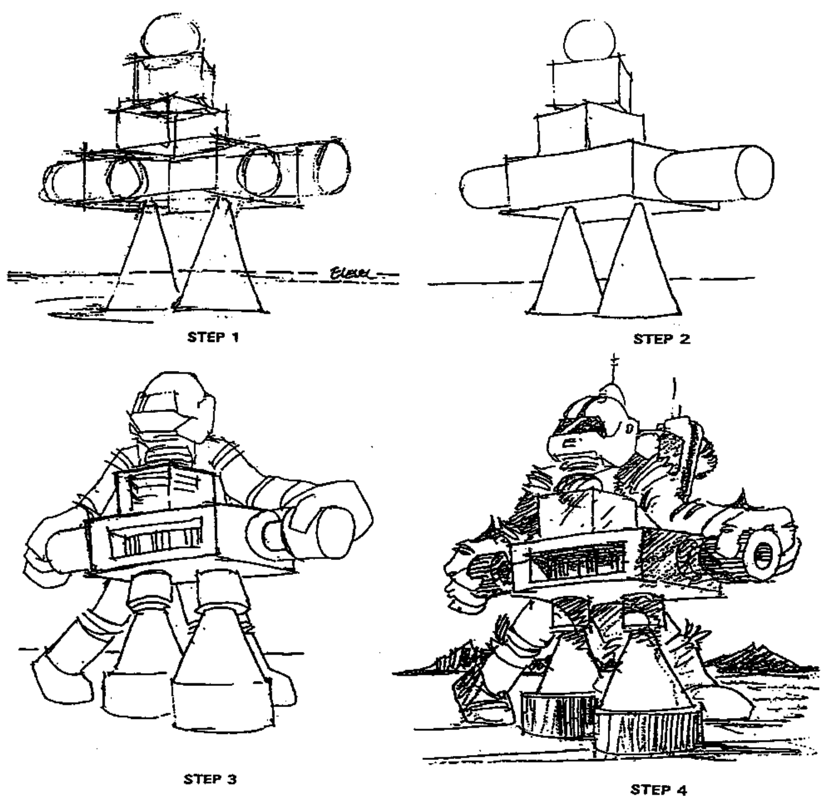

Figure 1. Model at varied stages of design.

Some thought that teaching "art" to students was frivolous and could not see the value of drawing in engineering disciplines. It is not fair to say everyone held these attitudes, as some accepted it as a challenge and really did quite well. The second factor involved was the fact that the lab was one-third of a 3-semester hour course in which two-thirds dealt with learning about computer programming. The computer part of the course had nothing whatsoever to do with the lab portion. In fact, due its left-brain emphasis, it became impairment to achieving our goals in the drawing lab.

The follow-up course for ECE 105 was ECE 106, Introduction to Computer-Aided Engineering. This 3-semester hour course was divided into three segments -- a lecture, recitation and lab -- each taught by a different instructor, and emphasized design and problem solving. The first 2 to 3 weeks of the lab portion was spent doing hand (pencil) drawings as a refresher of ECE 105 concepts and a precursor to the CAD-generated drawings. At this point the right-brain exercises were essentially completed.

Students were then assigned a major semester project that compelled them to think creatively. One of these project assignments (which changed every semester) was to design a storage building for storing organic fertilizer. The building could have no sides except for an office area, and was constrained by certain width, length and height measurements. The building was also to be located in a rainy, windy area and the product being stored would need weather protection without the aid of tarps. In addition, these freshman students had virtually no previous education in design, structural engineering or construction. Lack of prior knowledge about construction and engineering factors was actually an advantage, because the students had less inhibition to restrict their creative thought. Throughout the semester the instructors would guide them as to the feasibility of their designs and ideas, and they were graded on their creative thought process as well as their data. Some faculty stated that freshmen couldn't think in those terms. Our observation was the opposite. A majority of the students excelled in this assignment. The computer data and drawings were compelling examples of their creative thought processes.

Unfortunately, most of the instructors did not understand or appreciate the concept of right-brain thinking, thus failed to teach these activities properly. This led to an increasing dissatisfaction with the ECE 105/106 courses, and in 1994, ECE 100, Introduction to Engineering Design, a 4-semester hour course, replaced the ECE 105/106 series. All right-brain thinking exercises were eliminated.

Conclusion

The authors recommend that to properly teach right-brain thinking exercises, certain strategies should be considered. First, they must be introduced in the students' freshman year. The drawing exercises do not need to be a complete 3-credit course, but can be incorporated in an existing course dealing with design and/or critical thinking. Second, the drawing portion of a course must be given the credence and time needed to accomplish the goals of the specific exercises. Approximately 90 minutes of continuous lab time twice weekly is recommended. Third, the exercises must integrate with the application of critical thinking concepts in the curriculum. Fourth, reinforcement of right brain and critical thinking concepts throughout the students' education is vital. And finally, faculty must accept the benefits of teaching these exercises, and be properly trained in their delivery.

Enhancing critical thinking by exercising the right brain shows great promise for students in construction programs. Just as a good football team needs both a strong offense and a strong defense, our students need to develop both the left and right sides of brain to fully develop their thinking processes, and increase their chances of success in the construction industry.

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