Whole-mind teaching and learning: a case study in engineering

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ABSTRACT: Whole-mind Teaching and Learning (WmTL) activities and a case study on WmTL practices are presented in this article. The traditional logical/analytical emphasis of engineering curricula is complemented and enhanced with an intuitive/holistic approach, which implements the following practices: apply art principles; use intuition in design and in results checking; balance horizontal and vertical thinking in problem-solving; and allow time for solitary thinking in concert with supportive/stimulating group discussion. Practice in the case study was conducted by using creativity as one of the criteria in evaluating course projects. Other approaches include a *second chance* for mid-term exams and meditation practice for calming and cleansing the mind. The case study compares overall performance scores in courses with and without implementing WmTL practices. Although a definitive conclusion was not reached, an improvement seemed to be associated with the practice of WmTL.

INTRODUCTION

Twenty-first century engineers not only need to have professional knowledge and skills but also a sense of art in design and a creative mind for problem-solving and innovation. Our civilisation's continued prosperity depends on staying in the forefront of technological innovation.

Many jobs requiring a traditional logical/analytical mind (repetitive or basic logic, sequential thinking and skills associated with isolating parts from the whole), largely have been eliminated and replaced as a consequence of advances in computing and automation. Simultaneously, many new jobs are created, which specifically require human beings to use their whole mind; not only the logical/analytical-mind (popularly called left-brain) but also the intuitive/holistic-mind (popularly called right-brain) to tap into deeper sources of creation and insight.

Often, engineering is perceived as a solely logical/analytical-mind discipline. However, most practising engineers will confirm engineering is both science and art. Creativity and intuition, traditionally associated with the intuitive/holistic-mind, form an important part of any engineering project and design. Some of the best students grow up in open-minded environments that cultivate initiative, critical thinking and creativity.

Creativity is the main way to distinguish humans from computers and machines. In other words, it is creativity, which makes us irreplaceable. This is a common theme throughout human history, and the engineering profession has been, and continues to be, at the forefront of the continued evolution of human society. It is, therefore, imperative to develop teaching or learning methods and styles that foster creativity and whole-mind learning in engineering education.

Traditional engineering curricula tend to focus on training the logical/analytical-mind, ignoring or eschewing intuitive and holistic ways of thinking. Fortunately, many schools and universities have come to recognise the importance of whole-mind approaches to education. Titles such as *A Whole New Mind* by Daniel H. Pink [1], have been added to the designated reading lists of various institutions. Yet, actual curricular reformers are taking time to implement the whole-mind approach.

Part of the problem is that a majority of people, including educators, do not really know what creativity involves or how to tap into it. If the design and implementation of comprehensive, educational environments for engineering is to be achieved, then, a better understanding must be gained of how to foster both logical/analytical and intuitive/holistic aspects of our minds. The Whole-mind Teaching and Learning (WmTL) practices presented here offer some effective approaches.

CREATIVITY AND THE WHOLE-MIND

What does creative thinking involve? Some people think creativity is solely logical/analytical brain functions. They believe creativity happens only if they crank the brain hard enough in group discussion. But, experience shows that creativity is a whole-mind experience resulting from both rigorous discussion and solitary thinking, from deep thinking and relaxed distraction.

It is popular to categorise people into certain *types*, such as masculine versus feminine; introverted versus extroverted; cooperative versus uncooperative; and logical/analytical versus intuitive/holistic. However, people are complex systems and often decline to fall neatly into any one *type*. Moreover, studies have shown that creative people tend to move across the whole spectrum of *types* [2]. WmTL accepts this psychological flexibility as a prerequisite for creative functioning.

How to facilitate whole-mind learning and tap into creativity? First, creativity is not solely a brain activity. Eastern philosophy believes the human mind lives in the heart [4] and others have made connections to *intelligence* [3] from other parts of the body. A modern interpretation of this is the recognition of the importance to the creative process of intuition, gut feeling and instinct.

Second, creative solutions tend to surface in a calm and clear mind, particularly after deeply absorbing a specific problem through both solitary thinking and stimulating, collaborative discussion. Creativity involves a state of mind that provides logical guidelines but which calls upon more primitive instincts and the complex mental processes sometimes called intuition and gut feeling. Therefore, creativity is a state of mind and everyone can enter such a state [5].

Investment theory suggests that creativity is an ability that can be developed [3]. Thinking styles, personality, motivation, and environment must come together with intellectual skills and knowledge to produce truly creative results. Creativity, according to the investment theory, is in large part a decision with the learning environment playing a large role [3].

Creative ideas often are summarily rejected solely because of their newness or strangeness. Yet, some of the greatest engineering advances have come from pressing the boundaries of the ordinary, often at some risk [3]. WmTL attempts to address this with practices that teach students effective thinking styles; to focus on personality attributes that support self-efficacy; that motivate students to have an interest in the work; and to construct an environment that supports novel thinking [6].

WHOLE-MIND TEACHING AND LEARNING (WmTL) PRACTICE

In the discipline of electrical engineering at the University of North Florida, anecdotal evidence suggests the following:

- Apply art principles of simplicity, balance and beauty to engineering designs, since engineering is composed of both science and art.
- Encourage intuition. Use narrative examples to demonstrate the importance of intuition (or gut feeling) in design and in results checking. (Refer to the stories and examples in the Appendix).
- Add horizontal (or lateral) thinking to vertical thinking in problem-solving [7]. Foster holistic understanding by helping students to look beyond a specific problem to see the whole system, of which it is a part. This includes an examination of any ethical consequences of an engineering work.
- Allow time for solitary thinking balanced with group discussion. Group discussion allows for cross-fertilisation of ideas, drawing on the skills, interests and abilities of others [6]. Solitary thinking provides time for students to internalise these ideas and integrate them with their own knowledge and experience.
- Introduce simple meditation skills to calm and cleanse the mind [5]. Creative ideas often emerge in a clear and relaxed mind. Several meditation seminars at the University of North Florida (UNF) were recommended to the students, and the students were requested to conduct a short meditation before the final exam.
- Add *Second Chance* method in written exams. This helps to address the fact people have different thinking styles: some think slowly but thoroughly, some think creatively but gloss over details. *Test panic* can cause brilliant students to receive poor marks. A *Second Chance* can help diminish these effects, improving morale and, perhaps, student retention rates. Creative solutions often occur after taking time for deep and thorough thinking on exam problems. (In one implementation, a couple of days after an exam, students demonstrated to the class how a missed exam problem can be solved, earning back up to half of the missed points).
- Use creativity as one of the criteria in engineering course project evaluation. The course projects do not have to be grand innovations or inventions. The originality in project subjects and novelty in approaches, the *outside-the-box* thinking and innovative problem-solving, as well as creative expressions in reports and presentations, are examples of criteria that can be examined in engineering projects as indirect metrics of an environment to encourage creativity.
- Introduce cognitively stimulating play. Creativity requires *a lot of processing time for the conscious and the unconscious mental processes to play around* [2]. Play riddles and puzzles during breaks to stimulate and open the mind. An example of a puzzle: how to measure an hour accurately without any time measuring device (endless solutions).

This Whole-Mind Teaching and Learning (WmTL) approach may have a number of positive impacts on engineering education, including:

- Firsthand observation of examples from engineering innovation.
- Develop a comprehensive sense of what creativity involves.
- Develop skills, such as supportive teamwork that stimulate communications.
- Develop a sense of self-confidence, empowerment and willingness to take risks and accept challenges.
- Develop quiet observation and a habit of solitary reflection.
- Explore new roles and interests that connect with values and beliefs.
- Explore career paths associated with the experience.
- Improved overall student retention rates.
- Attract non-traditional engineering students, such as those who are female and those in minorities.

THE OUTCOME OF A WHOLE-MIND TEACHING/LEARNING (WmTL) CASE STUDY

The stories listed in the Appendix and the above-listed methods were practised in a senior Electrical Engineering course EEL4514 (Communication Systems) in Autumn 2009. The class discussed the logical/analytical-mind and intuitive/holistic-mind functions and how to raise creativity. Some students at the start thought they used only the logical/analytical-mind and later discovered they could benefit from the whole-mind approach. The students listed the examples in history when the great creative ideas first arose but were suppressed by the masses (e.g. the story of how the computer was born and Edison's many trials before his inventions). The discussion raised the awareness of the creativity process and whole-mind learning style at the beginning of this case study.

The case study was conducted by using creativity as one of the criteria in peer evaluation of the course projects. Compared to the creativity scores in the same course run previously, but without implementing the WmTL, the creative activities were increased. More evidence is found in the originality of the project topic selections and novelty of the project approaches, the *out-of-box* thinking and innovative problem-solving, as well as creative expressions in reports and presentations (e.g. using analogies and metaphors). Most impressive is a project by an undergraduate student, who altered the direction of the instructor's guidance and created a novel simulation method for Electrocardiogram (ECG) signals in the diagnosis of heart disease. It is unusual for that type of activity to happen within undergraduate course projects. The evidence shows that WmTL improves creativity.

Figure 1 shows the impact of the *Second Chance* method in mid-term exams. The average scores were recorded for the same course - EEL4514 Communication Systems. The *Second Chance* method was started in Spring 2005. The figure shows the increase of the scores in 2005 and Spring 2006, compared to the scores of 2004 which did not have *Second Chance*. Since Autumn 2006, the difficulty of the exam has been increased and the open-book exam has been changed to a closed-book exam. It is not surprising that the average scores dropped back to between 78 and 83. The score in Autumn 2009, when WmTL was emphasised, is a little higher than that of previous years. Although it is not known if it was the direct outcome, positive performance is associated with the practice of whole-mind teaching/learning.

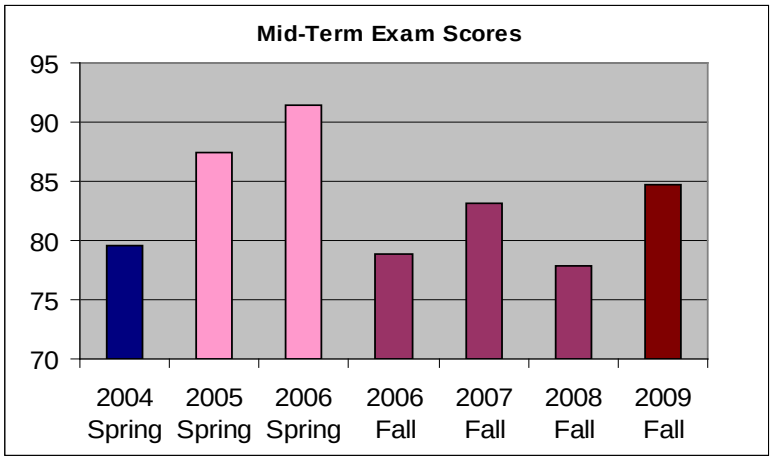

Figure 1: Impact of the Second Chance Exam.

A more obvious positive impact can be observed in the overall performance scores in Figure 2. The overall performance score is comprised of 30% from the course project, 20% from the mid-term exam, 30% from the final exam and 20% homework. Peer review, in which all students were required to evaluate other students at project presentation, was used to provide 50% of the grade of the course project. The instructor assigned the remaining 50% of the grade as an independent assessment of the projects, based on both project presentations and project reports.

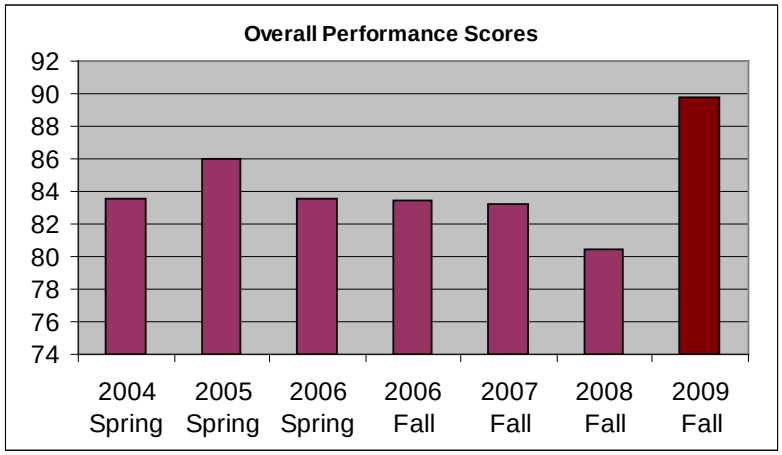

Figure 2: Impact of overall performance.

The case study has been taught for several semesters by the same instructor at the same institution. The instructor noted several key differences from previous semesters, as a result of implementing WmTL. Perhaps the most important observation was that students have more interest and passion in learning, especially in course project design and, as a direct consequence, the average course score had increased from previous semesters. Another important observation was that the students generally were more appreciative and supportive of others' ideas and new expressions. Although these observations cannot be stated scientifically, they are important notes for instructional practice and, potentially, for future research efforts.

CONCLUSIONS

The Whole-mind Teaching/Learning (WmTL) programme presented in this article was practised as a case study in a senior electrical engineering course, in the Autumn (Fall) of 2009. The environment cultivated was one that encourages the whole-mind approach, i.e. logical and analytical skills, as well as intuitive and holistic thinking. The evidence is found in the originality of the project topic selections and novelty of the project approaches, the *out-of-box* thinking and innovative problem-solving, as well as creative expressions in reports and presentations (e.g. using analogies and metaphors) using WmTL practice. One project even created a novel simulation method for Electrocardiogram (ECG) signals in heart disease diagnosis. The recorded evidence shows that the WmTL has enhanced effectively the learning experience.

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APPENDIX – THE STORIES AND EXAMPLES THAT DEMONSTRATE INTUITION AND INSTINCT INSPIRES CREATIVITY

The story: Military Boot Camp Final Test

The final test in a military boot camp was to get out from a large and slippery tube vertically inserted under ground level, without the help of tools and technology. The person under test had a whole night to work on it. If he did not find a way of getting out of the tube by sunrise, he would be put to shame by having dirt shovelled on him and be buried halfway and eventually lifted out of the tube. No-one passed this test until one general finally did. Guess how he did it? He first tried to get out using physical strength like the others and realised it was impossible. Instead of exhausting himself, he sat at the bottom of the tube and meditated for the rest of the night. The creative solutions usually surface in a clear and relaxed mind. When the dirt was shovelled on him he immediately realised the opportunity at hand, unlike others who just passively accepted this kind of punishment. He used the dirt shovelled on him to build stairs, and climbed out of the tube… Two lessons we can learn from this story: First, we often set mental blocks to ourselves such as *the test is over when the dirt is shovelled in*. Second, when someone shovels dirt on us, instead of throwing the dirt back we can simply shake it off and put it under the feet to elevate us.

The innovation: Antenna Switch in Diversity Branches for Wireless Communication

An antenna switch algorithm is developed based on a philosophy about selection and switching positions. For example, should you always monitor the job market and switch to the best job available to you*? Is the other side of the hill always greener?* Is the *best* performing position you found at the switching moment going to last long? Since switching incurs some transition difficulties and losses, as well as the cost and price for monitoring multiple positions, constantly switching to the currently measured *best* position may not be the best strategy. When should the switch be performed then? The answer is when the current position is bad enough. Now, we only monitor one position which is currently the selected position. Switch to an available position when the current position is found bad enough. The above strategy has been put into an antenna diversity algorithm in wireless communication and was simulated to be a better practical switch method, not only in diversity systems, but also in our life situations. This is the essential spirit of the antenna switch algorithm from one of the author's early patents [8].

The Example of Horizontal Thinking in Problem-Solving

A company moved to a new building in which only one elevator was installed. Most of the time it is fine except in the morning when everyone comes to work and needs the elevator to go to their offices. A company meeting was called to collect solutions to this problem. Many vertical thinking solutions, which focus on the *elevator* were proposed, such as: install another elevator; offset the office hours; elevator stops only on certain floors, etc. But, the company eventually implemented an easiest, cheapest and fairest solution: install a mirror at the entrance to the elevator. This creative solution was thought out by horizontal thinking, which tackled one of the factors contributing to the problem - the idle time while waiting for the elevator. With the mirror installed to check their appearance, people do not feel bored and no more complaints were received about the building's elevator.