Creative Problem Solving in Engineering Mathematics through Computer-Based Tools

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Abstract

Creative problem solving (CPS) is a multi-steps method for solving problems in various disciplines that can support students' learning in engineering mathematics and their generic skills. Computer-based tools have potential to help engineering students' learning in mathematics and support their generics skills during the process of CPS. The main goal of this study is to explore the theoretical reasons of using CPS in teaching and learning of engineering mathematics through computer-based tools. Using CPS through computer-based tools is expected to help engineering students in the learning of mathematics and support their generic skills such as communication, teamwork, and problem solving skills.

Keywords: Creative problem solving; computer-based tools; engineering mathematics; generic skills

INTRODUCTION

The main goal of mathematics learning for engineering students is the ability of applying a wide range of mathematical techniques and skills in their engineering classes and later in their professional work.[1] Mathematics subjects are important courses for engineering students, provide them to work with several mathematical ideas and also use this knowledge in their engineering fields.[2]The lack of understanding of concepts in engineering mathematics may hinder the understanding of other concepts or even subjects.However, for most undergraduate students, specifically engineering students, mathematics is one of the most difficult courses in their fields of study.[3-8]

Current trends in technology and our increasingly complex society and the workplace require engineers to have a greater variety of capabilities, skills, and a wider understanding of engineering as a discipline, if they want to succeed.[9]It means that graduate engineering students need the skills and abilities other than those relating to the discipline they studied.[10-11] Generic skills are becoming major and important requirements set by industrial competitiveness and graduates engineers who can think critically, solve problems and communicate are highly sought by employers.[11-12] Rapid change of technology in society did not produce a corresponding change in engineering education and the same material basically is taught with the same tools and methods that have been used since many years ago.[13-15] The limitations of traditional teaching and learning styles may not only be the reasons of engineering students' weakness in generic skills such as communication, teamwork, and problem solving[13,16] but may also had caused engineering students encounter many obstacles in the learning of mathematics.

CPS as a problem solving framework can be used to support students' thinking and generic skills in engineering, science, and even mathematics courses.[13, 16-21] CPS employs different thinking skills and tools, therefore, it can fundamentally improve the way students learn and support their generic skills.[22-23]

The CPS model has changed and expended in many ways since its origins around six decade ago. The framework that exists today requires problem solver to make a thoughtful and carefully planned choices and to also decide on the best tools needed in order to solve their problems.[24] In universities, various models and approaches to CPS were developed by researchers and developers.[24-26] The most important goal in using CPS for education setting is to enable the students to increase their ability in solving actual problems successfully as well as creatively.[25]Some researchers used CPS framework in engineering, science and even mathematics courses.[13, 17-21, 27-28]Lumsdaineand Lumsdaine[16] explained a CPS framework in teaching and learning of mathematics for engineering students in which by invoking generic skills such as communication and teamwork can support engineering students' problem solving.

However, there is very little literature reporting on the foster of CPS to help engineering students in the learning of mathematics and in using computer tools.[17-21] Furthermore, there is not much study done in supporting effective communication, teamwork, and problem solving in mathematics courses by CPS and computer tools. Thus, in this study, we shall explore what are the theoretical reasons of using CPS through computer-based tools in teaching and learning engineering mathematics to support students' learning and generic skills.

CPS IN MATHEMATICS TROUGH COMPUTER- BASED TOOLS

Lumsdaine and Lumsdaine[16] suggested a CPS framework in the teaching and learning of mathematics for engineering students. Their framework is based on Herrmann model of thinking preferences. To better understand their approach, the Hermann model needs to be explained first. Herrmann[29] studied the development of preferences and their relationship to the physical brain and neural connections. In his model, brain is as a circle that is divided into four quadrants. The upper left (cerebral) quadrant is designated A, followed by B, C, and D in a counterclockwise direction (Fig. 1). Each quadrant has its' own very distinct clusters of thinking abilities or ways of learning and knowing. The following are Lumsdain and Lumsdains' mode of thinking preferences and some activities to practice them:

(i) Quadrant A- quadrant A thinking is logical, critical, factual, technical, analytical, and quantitative. In CPS, the activities to practice quadrant A thinking are collecting data and information about particular subject or problem, organizing the collected information logically into categories, developing graphs, flowcharts, outlining from data and information, and learning how to use an analytical software package or program.

(ii) Quadrant B- quadrant B thinking is conservative, structured, sequential, organized, detailed, and planned. Meticulously following directions, implementing repetition skill, providing detailed homework problems, writing a sequential report on the results of experiments, following the steps when doing lab work, using programmed learning and tutoring, taking detailed notes, planning projects, and making schedules are some activities to support quadrant B thinkers.

(iii) Quadrant C- quadrant C thinking is interpersonal, people-oriented, kinesthetic, emotional, spiritual, sensory, and feeling-based. The activities that can help C-quadrant thinker are, listening and sharing ideas, using group discussion, learning by teaching others, and learning by using tools.

(iv) Quadrant D- quadrant D thinking is visual, holistic, intuitive, innovative, imaginative, future-oriented, and conceptual. By doing simulations, making use of the visual aids in lectures, solving problems with many possible answers, and exploring hidden possibilities are some of the preferred learning activities.

In a two-component gel, it is easy to modify the molecular structure of either of the two components.

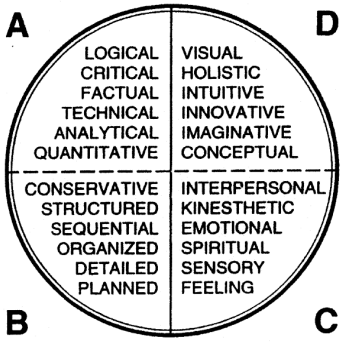

Figure 1 The (four-quadrant brain model of thinking preferences developed by Herrmann

According to Lumsdain and Lumsdain,[16] CPS is a framework thatencourages iterative thinkingin the most effective order. CPS iscooperative in nature and is most productivewhen it is done as a team. They stated the CPS in five steps in which the potential of whole brain is employed. The five steps are:

(i) Problem Definition- to understand and to define an actual problem is considered as one of the most difficult aspects of problem solving. However, to obtain the information needed in order to solve a problem, one is required to collect and analyze information and data, talk to individuals who are familiar with that particular problem, confirm all finding and finally continue to collect information.

(ii) Idea Generation- generating innovative ideas is the heart of the CPS process. Verbal brainstorming as a team activity, methods to improve creative ability, recognizing and breaking mental blocks, and taking risks for those who usually work alone are the important methods that help people to obtain creative ideas.

(iii) Creative Idea Evaluation- creative idea evaluation is second round of brainstorming. It is more focused than the divergent thinking process that was used during the idea generation phase since it is a time to use convergent thinking to clarify concepts and arrive at practical ideas that can be implemented to solve the problem. The methods in these steps are to decide which problem to address, to select the best idea from possible alternative, and to decide how to avoid additional problems in the implementation of the chosen.

(iv) Idea Judgment- the next step in CPS is to select the idea or solution among the best ideas that will solve the original problem effectively. During the judgment phase, establishing judgment criteria and then sifting and ranking the ideas and solution according to criteria are some important methods.

(v) Solution Implementation- The final step is making decisions on which solution to implement in order to solve the original problem efficiently. Examining all consequences of the solution and finding a logical solution are the important methods of this step.

These five distinct steps correspond with different thinking modes. In fact, CPS is a framework which employs many different thinking skills and thinking tools. In CPS, the analytical aspects of quadrantAthinking are needed in order to analyze clues and data about real problem and also involved at the highest level in evaluation and critical judgment of ideas. The organizational aspects of quadrant B thinking are needed during the implementation of idea for planning, execution, follow-up, and final process of evaluation. The interpersonal aspects of quadrant C thinking are needed for teamwork during problem definition (to take the customer's needs into account), during idea generation (when we use feeling-based ideas and intuition), and during implementation (when we are working for the acceptance of new solutions and any time when good communication with others is required). The imaginative, wishful aspects of quadrant D thinking are needed during problem definition (to explore trends and context), during idea generation (in brainstorming), and during implementation and judgment (when ideas and solutions are being improved).[16]

CPS let to use computers to enhance thinking, learning, and communication.[16, 23, 30-33] In fact, computer is the best analogy of the functioning of the human brain, however the brain is able to synthesize information and to think creatively. Computer can be used to focus on the fundamentals, to investigate and define the problem and its broader context, to model the problem, to visualize the problem and results graphically- all of which enhance learning and make it fun.[16] According to Lumsdaine and Lumsdaine,[16] in the context of teaching, learning, and thinking at least four distinctly different ways of using computers and their relations with four quadrants of brain are as:

(i) Database and data processor (calculator)- computers can be used for analytical problem solving, data processing, and also inquiry. Strong A-quadrant thinkers thrive when they can work with computers as an analytical tool. They like the command-line interface and disdain icons as a means of communicating with computers. They are fascinated by the microprocessor technology itself.

(ii) Teaching machine- computers by using good quality interactive software can make excellent teachers. They can transmit information and concepts, and they can be used for practice and testing mastery (comprehension). In drill and practice, they offer instant feedback, but they are not very suitable for the teaching of higher-level thinking skills. When teaching routine procedures and problem-solving techniques, they serve as best one-on-one tutors for B-quadrant, sequential learners, but are not as effective with students with right-brain learning styles. Writing computer programs is an excellent training for quadrant B thinking. Software tools for evaluation can also appeal to quadrant B people.

(iii) Communication tool- computer can be used in many ways to enhance communications. It can be used to communicate powerful messages by combining text and visual information. Computer networks are an efficient and amazing way to move information and feedback between students and teachers. The software that are now available allows peoples to brainstorm their ideas individually and in groups. People with C-quadrant thinking preferences become "friends" with computers since it is a helpful tool that let them interact with other people.

(iv) Simulator and visualizer (graphics)- computer is able to perform a vital teaching function when they are used as simulators. Computer can integrate many different sources and techniques as multimedia presentations in high-tech classrooms. Good software packages with interesting problems let students play an active role in problem analysis and problem solving activities. Computers capabilities for presenting data graphically by helping to visualize problems and results offer valuable ways to enhance quadrant D thinking. D quadrant thinkers like to play with sketching and painting utilities, 3-D models, and animation.

By using the potential of whole brain, CPS does not only help students in the learning of engineering, science and mathematics[13,16-18,27-28] but it can also encourage the students' generic skills such as communication, teamwork and problem solving. Computer and the way of using them in CPS process can play an important role to support students' leaning and skills.

CONCLUSION

This study explored the importance and theoretical reasons of using CPS through computer-based tools for supporting students' learning in engineering mathematics and their generic skills. This research suggested a method for teaching and learning of mathematics that provides engineering students with learning experiences based on CPS through computer-based tools. The method is expected to help engineering students in the learning of calculus. Moreover, this method may support students' communication, teamwork, and problem solving skills.

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