Creative Thinking for Conceptual Engineering Design – A Conceptual Model

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***Abstract*—Engineers are the group of professionals that deals with complex technical problems where they are to come up with new solutions, systems and products that are crucial for the wellbeing of humankind. In order to handle these design works effectively, engineers definitely requires creativity. Creativity was once considered as gift to selected few. Recent research however has indicated otherwise. Numerous research has concluded that creativity is a skill that can be taught as well as acquired through training. Recent research conducted also indicated that creativity, which is also one of the vital skills for the engineers in the 21st century, have reduced significantly. There is a need to for engineering educators in Malaysia to address this issue. This paper presents a proposal for research that is able to assess the current creativity level of engineering undergraduates in Malaysia specifically related Mechanical Design. A Creative Thinking Techniques Module specifically catered for conceptual engineering design is presented. The research objectives and abridged methodology is also presented**

Keywords—Creative Thinking, TTCT, Engineering Design

I. INTRODUCTION

According to the latest Engineering Accreditation Council (EAC) 2017 Manual, Engineering is defined as "the creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation or safety to life and property" [1].

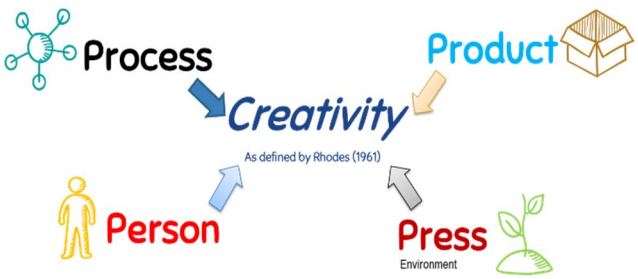

Figure 1. The 4 Ps of Creativity

In other words, engineers are the group of well-trained individuals whom possess the capability to solve problems by developing new solutions or new technology. With the progression of time, changes in the society and environment as well as many other factors are bound to appear. These changes such as global warming, health care issue, demand for energy, water resources, food security, increase in ageing population to name a few are all affecting humankind daily. All these changes are complicated in nature and strongly demand creative solutions from our engineers of the day to generate new solutions as explained by Cropley [2]

Malaysia in her journey to achieved developed nation status is definitely in need of a well-designed higher education curriculum that should not only focus on technical skills and knowledge. The engineering education providers in Malaysia must develop curriculum that equips our undergraduates with the applied skills such as creativity to enable Malaysia to stay upfront, relevant and competitive in the global marketplace [3][4].

II. DEFINITION OF CREATIVITY

Creativity was once considered as a divine gift to a selected few; and it was also considered as the ability to develop creative works. Creativity in the past has also been considered as a type of novel thinking, where problems are redefined, gaps in knowledge are identified, emerging new ideas, analyse the generated ideas, and taking reasonable risks in idea development. Creative thinking has also been taken widely as the ability to combine and connect ideas in new ways that is both novel and useful [5].

Creativity is also defined as the development of ideas that are original and appropriate. An idea that is novel but it is of little or has no use to anyone cannot be considered as creative at all. Creativity comes in various forms. Little "c" creativity is the type that is exercised by everyone every day. Little "c" creativity allows ordinary people like us to create unique language pattern, interpret music or even write papers in our daily lives. Big "C" on the other hand is the creative genius from the likes of Isaac Newton, Pablo Picasso and Albert Einstein. This level of creativity usually involves huge changes in human understanding regardless of domain [6].

Creativity as one can see had been defined in many ways and there is no one theory that is able to encompass all varieties of creativity theories [7]. Rhodes summarised the different categories of creativities into four major types: **Process**; **Product**; **Person** and **Press** [7].

For this study, **Process** and **Product** will be the dimensions to be applied in the research as these two dimensions are directly related to engineering where Process such as Creative

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Thinking is a skill that can be taught and learned. Product is another dimension that is also directly relevant to engineering as engineering student undertaking engineering design module will have to design a certain product, thus the product can be another way to determine the creativity of the undergraduates.

The first category **Process** applies to motivation, perception, learning, thinking and communication. This category of theory look into the causes that made creator strives to original solutions to problems. According to Rhodes, this creative process can be taught and learned. Graham Wallas ,through his book ***The Art of Thought***, is the pioneer in this field and was the first person to be recognised for his introduction of a model to explain the process of creative thinking [7][8][9][10].

The second category is the **Product**. Creativity is not just about creative thinking but creativity also involves development of tangible solutions to problems, thus the products designed. Engineers applied their knowledge and skills to solve problems that are driven from the needs and changes that are happening around us. These solutions often take the form of tangible artefact. Engineers create what was never existed i.e. products, that are actually the link that unite engineering and creativity. Understanding the role of creativity in engineering indirectly means understanding the characteristics of a creative product, and also how these can be identified and measured in a practical setting.

III. DECLINE IN CREATIVITY

Creativity has been on a decline in the past for quite some time. Research and studies have shown that there is a sharp decrease in creative scores using standardized creativity test [11]. There are numerous reports that stood out and called for the support of engineering students to be equipped with the ability to think creatively [5].

It is not until recently that research began to prove and suggest that it can be a tool for all who wish to use it, and that it was not the sole ability of a privileged few, but also the potential ability of anyone with the capacity to learn [6]. Studies had also shown that there are rooms for improvement across the fields, and that engineering has the most room for improvement in supporting creative skills development [5].

Understanding the current state of creativity for both individual as well as group is a necessity for creativity training research. In order to have better and more effective creativity training, better understanding of underlying process is needed.

The question now is to be focus on "How creativity can be learned, exercised and expressed?" since creativity is something not necessarily gifted to the selected few. The answer to this question provides vital information and skills for future development of engineers of the 21st century.

IV. ASSESSMENT OF CREATIVITY

J. P. Torrance developed the world famous Torrance Test of Creative Thinking (**TTCT**) that is able to measure or evaluate several attributes in creativity that includes originality, fluency, flexibility and elaboration. The TTCT is widely accepted and used in various creativity researches around the world for years, not only for children but also for adults.

Over the decades, Torrance had refined in 1974, 1984, 1990 and 1998 the administration and scoring of the TTCT that leads to its enduring popularity. The TTCT consist of 2 main categories, Verbal and Figural tests, that again each category comprises Form A and Form B which can be used alternately. For the purpose of this research, Figural test is the chosen assessment rubric to assess the creative thinking level of the engineering undergraduates who will be designing products.

V. ENGINEERING EDUCATION IN MALAYSIA

The engineering education in Malaysia began in 1956 with the setting up of Engineering Department at the University of Malaya in Singapore. When Malaya gained her independence in 1957, the University Malaya campus was moved to its current campus in Kuala Lumpur in 1958. The engineering education in Malaysia achieved another major milestone with the upgrading of Universiti Teknologi Malaysia (UTM) in 1975 from a Technical College, which ever since then became a major institution that educate and train all fields of engineers in Malaysia.

Over the years, engineering education in Malaysia has undergone tremendous changes to meet the professional, technological, and industrial needs. Currently the engineering curriculum is tailored to meet the Bloom's Taxonomy as well as the Outcome-Based Education (**OBE**) without neglecting or overlooking the emphasis on core engineering subjects. These core engineering subjects are the foundation for all engineering programmes that help to nurture and enhance the ability of the graduate engineers to identify and solve problems.

Malaysian engineering graduates are often reported to be equally competent in terms of education and knowledge when compared to graduates from overseas universities. However, research conducted shown that Malaysian graduates are lacking in terms of many other skills in communication and presentation and also when it comes to creative thinking and being innovative [12].

VI. PROPOSED CREATIVE THINKING MODULE

A Creative Thinking Module specifically tailored for Conceptual Engineering Design undergraduate in this case is seen as a promising option to enhance the creativity level of the students when they are still studying. The Creative Thinking skills proposed to be covered in this module are as illustrated in the following figure.

Figure 2. Creative Thinking Skills in Creative Thinking Module

Attribute listing is a divergent thinking method that is used to generate creative ideas or solution for products or situations. This technique requires users to divide the problem or situation into key attributes, then all attributes are managed separately and room for improvements are determined for the attributes

Brain Sketching is one of the many creative thinking techniques that is used to generate ideas and it was developed from the traditional brainstorming technique which was developed by Alex Osborn in the 1930s. In Brain Sketching, ideas are sketched out by team members in the design team instead of written down in word form or discussed verbally. It is a silent process and by using Brain Sketching, users are able to satisfy the needs of having visual expressions while generating ideas. This is very useful as the saying goes, a picture is worth a thousand words, and all ideas can be conveyed with a single picture more effectively than any verbal or written description.

Functional decomposition is an important idea generation technique as it is a systematic design approach that will yield neutral and unbiased solutions to existing ideas. Users are not tied down to thinking only about the physical components or parts of a product such as while performing physical decomposition but are free to come out with any idea that is able to achieve the required

A **Mind Map** on the other hand uses graphics and pictures to represent information such as ideas and notes in diagrams that branch out like trees. Utilization of mind maps during idea generation stage can stimulate the generation of better, and sometimes new ideas and concepts. An alternative name for mind map is 'Spider Diagram'.

A **Morphological analysis** is generally presented in table form which is called a morphological diagram. A morphological diagram is simple to use as it allows users to list out their creative ideas systematically in an easy to view table form.

SCAMPER is used to develop new ideas from existing products, meaning users should have an existing product that required improvement, innovation or solve problems to apply this technique. SCAMPER is actually an acronym that consist of seven different thinking processes. It can be listed out in checklist format to ease the recording of ideas.

Synectics is defined as '*Bringing together different, unrelated elements to create a unified connection*'. Synectics could also be described as '*Making the strange familiar and the familiar strange*' in some publications.

VII. Conclusion

Higher employability rates is heavily related to employing graduates who are capable of coping with the current as well as future trends, needs and challenges. Engineering Education providers in Malaysia need to continuously evolve and adapt in order to produce young graduates who are able to exhibit a greater degree of survival skills such as creativity in order to easily secure employment. Improving creativity in engineering undergraduates is a concern that needs to be tackled with right now so that future engineers are able to remain competitive with the market needs

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References

[1] Engineering Accreditation Council, Board of Engineering Malaysia, in EAC 2017 Manual, Engineering, 2017, pp 3.
[2] Cropley, D. H. The importance of Creativity in Engineering. In D. H. Cropley, Creativity in Engineering. Sydney : Academic Press, 2015, pp. 13 – 54.
[3] Selvaraj, Anbalagan, & Azlin. Current trends in Malaysia Higher Education and the Effect on Education Policy and Practice: An Overview. Int. J. of Higher Education, 2014, 85-93
[4] Mohd T., Mandeep S., Ali A. & Muhammad I., Engineers of the Future, in Jurutera. IEM : 2018, pp 15-19.
[5] Shanna, R., Erika, A. M., & Colleen, M. S. Teaching Creativity in Engineering Courses. *Journal of Engineering Education*, 2014, 417-449
[6] Starko, A. J. *Creativity in the classroom: Schools of Curious Delight.* 2014, New York: Routledge.
[7]Rhodes. An Analysis of Creativity. *The Phi Delta Kappan*, 1961. 302-310.
[8] A. K. Palaniappan. *Creativity Research in Malaysia.* Puchong: 2008. Scholar Press
[9] Plucker, J. A., & Makel, M. C.. Assessment of Creativity. In J. C. Kaufman, & R. J. Sternberg, *Cambridge Handbook of Creativity* (pp. 48-73). 2010. New York: Cambridge University Press.

[10] Fields, Z., & Bisschoff, C. A.. A model to Measure Creativity in Young Adults. *Journal of Social Sciences*, 55-67, 2013.
[11] Kim, K. The Creativity Crisis: The Decrease in Creative Thinking Scores on the. *Creativity Research journal*, 285-295, 2011
[12] Soon, T.-K., & Quek, A.-H. Engineering Education in Malaysia-Meeting the Needs of A Rapidly Emerging Economy and Globalisation. *International Conference on Interactive Collaborative learning* (pp. 583-587). Kazan : IEEE. 2013