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TRIZ AND HYBRIDIZATION ALGORITHMS FOR STUDENT CREATIVITY IMPROVEMENT

Abstract: The ability to generate design ideas is vital for university students to learn. Many learning approaches to inculcate the sense of design creativity have been introduced by researchers. This paper discusses the use of TRIZ and hybridization algorithms in Product Design and Development course to stimulate students in formulating new design ideas. TRIZ concepts, including the Trend of Engineering System Evolution (TESE), S-Curved Main Parameter Value (MPV) and forty inventive principles were introduced to students in addition to hybridization algorithms. Upon the completion of the course, students were then enquired to come up with ideas for new product concept and present them in the form of poster as well as oral presentation. A reflective evaluation was then carried out in order to get the brief depiction about the effectiveness of the approach. It was observed that students felt more equipped and were able to propose many ideas and initiatives.

Keywords: *TRIZ, hybridization, idea generation, product design, teaching creativity*

1. Introduction

Learning process in education usually deliberates multiple perceptions (Semple, 2000). There is no single learning method proclaimed as the best and most appropriate for all conditions. It is however, necessary to note that there is a shift paradigm from teacher centered learning (TCL) into student centered learning (SCL), where students as learners are placed as the subject of the learning activities, while teacher serves as a learning facilitator. As learning is an active and collaborative process of making meaning from experience, the students must be the central entity who actively engaged in learning things. Rogers (1983) expresses SCL as the shift in power from the expert teacher to the student learner. This paradigm of power shift from teacher to the students has emphasized focus on learning rather than on teaching (Barr & Tagg, 1995; Edwards, 2001) (Edwards, 2001).

It is well acknowledged among those who work in education-related areas, that there are three different domains of human learning, i.e. cognitive (head: knowing), affective (heart: feelings), and psychomotor (hand: doing). The learning results for each domain were arranged in order (hierarchy), from the simplest tasks to the more complex. For cognitive domain, Bloom’s taxonomy (Bloom & Krathwohl, 1956) and its revision (Anderson & Krathwohl, 2001; Wilson, 2016) are very popular (Figure 1). From product design perspective, this revised taxonomy gives clearer picture about its educational objectives in the cognitive domain.

Teaching creativity as a set of knowledge is not difficult if the learning target is just to make students remember and understand the concept. It becomes very difficult when the highest level of learning outcome (creation skill) is expected. Students should not only understand and memorize all principles and strategies, but also be able to apply the concept, to analyse and evaluate the real problems as well as to create real solutions for problems. Hence, it is important for all lecturers to find a suitable approach in delivering the knowledge and skills to students.

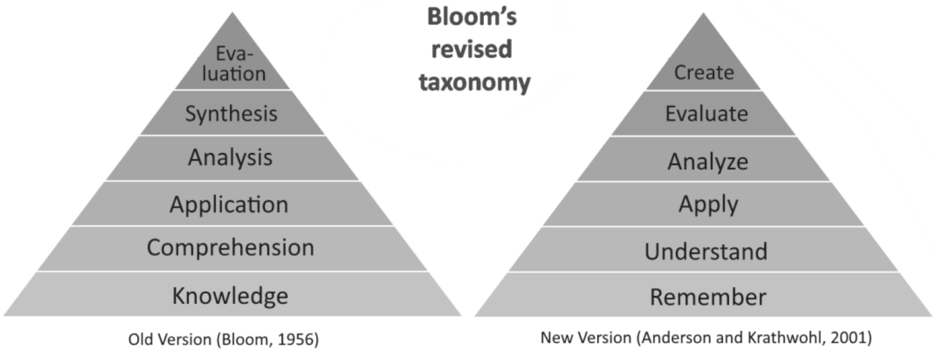

Figure 1. Original and Revised Bloom's Taxonomy

2. TRIZ and Hybridization

TRIZ, a Russian acronym for the "Theory of Inventive Problem Solving – TIPS", is a science of creativity that relies on the study of the patterns of problems and solutions, not on the spontaneous and intuitive creativity of individuals or groups. It is believed that TRIZ is able to improve individual or team's ability to solve problems since it teaches us how to make inventions, how to changes our thinking and how to construct the future (Orloff, 2006). Hence, introducing TRIZ concept in a formal education system is necessary.

The introduction of TRIZ in formal education has been conducted in many universities (Argunsah & Coates, 2007; Nakagawa, 2010). The European TRIZ Association – ETRIA (2016) reported that currently there are approximately 100 universities worldwide offer some form of TRIZ education at several levels. Based on a survey conducted in 2009, the majority of university and college education of TRIZ is based on programmes ranging from 0 to 40 hours. (Cavallucci, 2009).

TRIZ is very famous tool for problem solving, especially for inventive problems. In many cases however, identifying and formulating problems are more difficult than solving the problems. This is reasonably true as students are usually graded based on their responses to the problems given in quizzes, project or exams not based on their ability to formulate problems. This makes students to pay more attention on solving problems rather than on finding and recognizing problems. From the perspective of continuous improvement, inability to see the problems is a very big problem. It is not surprised that Taiichi Ohno, Pioneer of the Toyota Production System, emphasized in many occasions that "Having no problems is the biggest problem of all."

It can not be denied that the ability to identify the existence of problems is as important as the ability to solve the problems. Preparing students to have those two abilities is crucial in the learning process. Many learning methods have been introduced to address the later, for example problem-based learning, project-based learning and solution-based learning. It is however, still quite difficult to find the learning method for the former.

2.1. Trend of Increasing Value

Customers usually do not buy the product but the value within it. Therefore, the main problem in industry is how to improve the value of product. If the value does not increase, the product will die. The concept of increasing value is the driving force behind the development of all technology and is the basic principle of innovation. In TRIZ, the value of products can be defined by using a simple formula as follows:

$$Value = \frac{Functionality}{Cost}$$

Based on that equation, several ways to improve the product value can be done, including by (1) increasing the functionality and reducing the cost, (2) increasing the functionality and keeping the cost, (3) keeping the functionality and reducing the cost, (4) increasing the cost slightly and increasing the functionality more and (5) reducing the functionality slightly and reducing the cost more. All these strategies should be done on the right stage of S-Curve of Main Parameter Value – MPV (see Figure. 2). The good understanding of S-Curve is very important in product design process as it is statistically proven that the development of all engineering systems will follow the S-Curved Evolution. Trend of increasing value is a key for Trend of Engineering System Evolution (TESE).

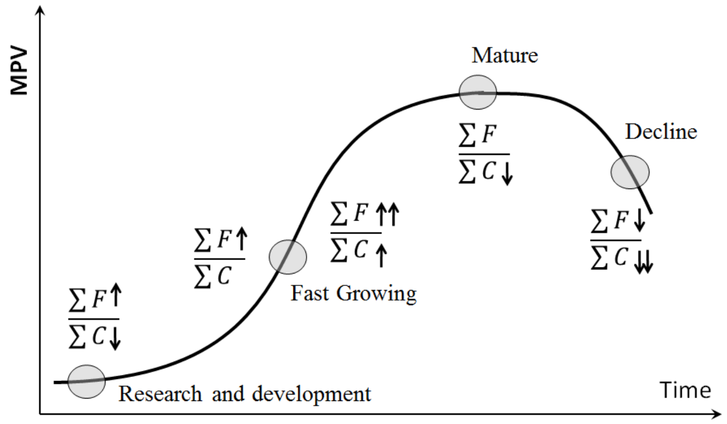

Figure 2. Strategies of increasing values on each stage of S-curve

2.2. Forty Inventive Principles

Forty inventive principles is a result of Genrich Altshuller's work in investigating more than 200.000 wordwide patents. He concluded that all innovative patents can be synthezed down and mined into just only 40 principles (Altshuller, 2002). Currently, more than 2 millions patents have been analyzed and the number of inventives principles remains the same. Altshuller argued that inventive problems can be codified, classified and solved methodically, just like other engineering problems. He considered that somebody, sometime, somewhere has already solved your problem or one similar to it and therefore, creativity means finding that solution and adapting it to the current problem.

2.3. Hybridization Algorithms

Hybridization is analytical tool for improvement for base system by transfering relevant features from alternative system (Prushinskiy, Zainiev, & Gerasimov, 2005). Hybridization algorithm uses TRIZ concept of physical and technical contradictions to introduce alternative contradiction and solve it methodically. This concepts have been widely used in fiction story in the old era. Many new creatures have been imaginated by using hybridization concept. Figure 3 shows the example of imaginative creature in Greek mythology so called "Centaur" - A creature with the head, arms, and torso of a man and the body and legs of a horse (Oxford Dictionaries).

Figure 3. Centaur – a hybrid creature in Narnia movie

3. Methodology

Idea generation is a critical topic in product design and development course. Many theories are introduced in this topic including Maslow's hierarchy of need, voice of customers, customer windows, customer needs, target specification, etc. The focus of the discussions is mainly on how to generate product concepts that meet customer needs. There is only very few concerns on how to create new customer needs, not just to fulfil them. TRIZ and Hybridization algorithms are good candidates to be included in the course material to address this issue.

A practical trial of incorporating TRIZ and Hybridization in product design and development course has been conducted. Students were introduced to the concept of idea generation, MPV, TESE TRIZ as well as hybridization, and then asked to propose idea based on what they have learnt. Two consecutive meetings of 3 credits (150 minutes) were utilized for this purpose. Thirty eight students were grouped into ten with maximum four members in every group. Each group should come up with an idea to improve the value of something and present it in front of class. Lecturer did not give students a specific problem like in a traditional Problem Based Learning, but gave them "no problem" as a problem to solve. This means the students were asked to think about any product and how to generate opportunities by using the aforementioned methods. They then should come up with a single concept selected from the concept generation results and visualize it in a 3D model by using CAD software. With the spirit that 'there are no absolutely good or bad ideas', students were freely to have any ideas. After all ideas have been presented and criticized, posters of the ideas were then displayed in the university hall for exhibition.

4. Result and Discussion

In order to share ideas to and get feedbacks from other groups, each group was requested to make project presentation in front of class. One group could present as many as ideas generated, but only one idea would be developed into final design using CAD software. The ideas could be from the concept of TESE or the concept of S-Curved MPV. Some examples of ideas generated by students based on TRIZ 40 inventive principles are shown in Figure 4a (increasing controllability) and Figure 4b (increasing completeness of system component), while ideas based on hybridization can be found in figure 5.

a. b.

Figure 4. Idea generation based on trend of (a) increasing controllability – a flexible broom, and (b) increasing completeness of system component – an automatic feeding solder

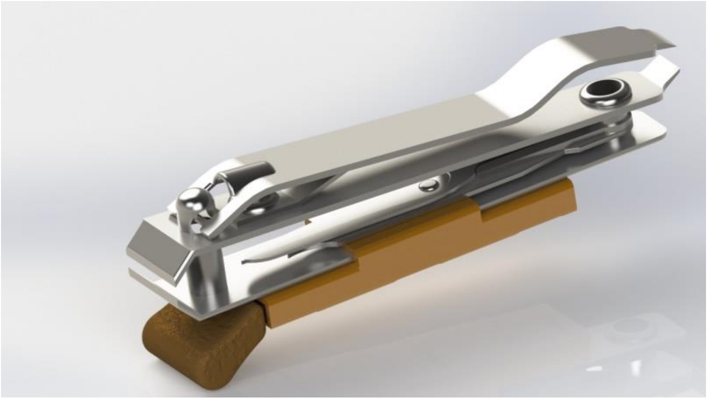

Figure 5. Example of idea generation based on hybridization – combining nail cutter, tweezers, scissors and perfume.

In order to measure the students' perceptions on learning process, in the end of semester the academic board always deploy questionnaire as feedbacks for lecturers. The feedbacks are very important reference for learning process improvements. Figure 6 shows the comparison between using new learning approach and previous semester conventional method. It is clearly shown that the new material and method can give better students' perception in almost all aspects. The top three of improvements include new paradigm introduction, project completion process and course applicability.

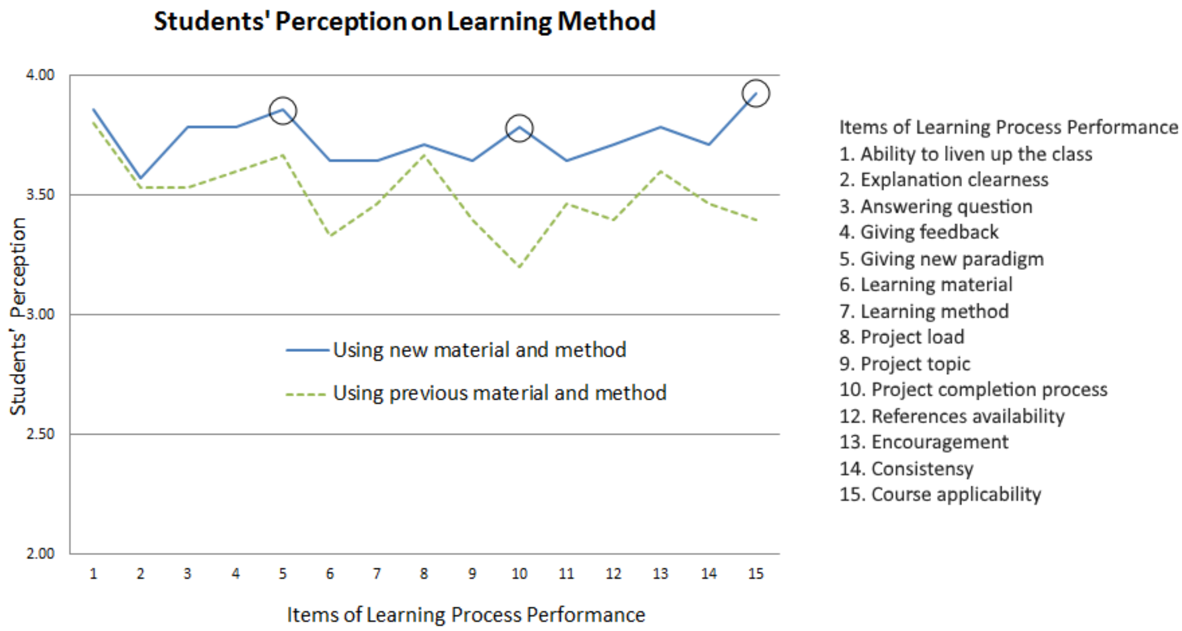

Figure 6. Students' perception on new learning material and method

In addition the academic board questionnaire, another questionnaire was conducted to deeper insights into what changed and what we learn for teaching design creativity. Students' perception of the important level of each course material is shown in figure 7 whilst some important feedbacks from focused group discussion are summarized in table1. It is observed that the combination of all the three materials (TESE, 40 Inventive Principles and Hybridization Algorithm) are perceived as very important to improve students' ability in generating idea. In case of 40 inventive principles, students feel that 40 is too many and since some of them are not related to idea generation in product design, it is better exclude some of them from the content.

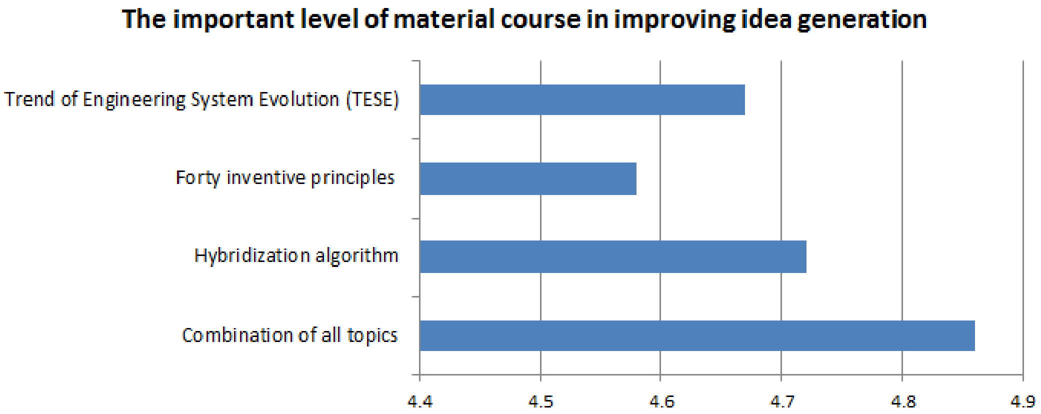

Figure 7. Students' perception on the important level of each course material

Tabel 1. Open feedbacks based on focused group discussion

Positive feedbacks	Suggestion to improve learning process
1. Having more ideas 2. Improving designing skill using CAD 3. Teamwork experience 4. Having something from project to post in social media 5. Learning new materials	1. Time allocation is not enough to cover all materials 2. It is better to offer a new course to accommodate the materials instead of incorporate them in Product Design course

5. Conclusion

The use of TRIZ concepts and hybridization algorithm to generate ideas in Product Design and Development course has been discussed in this paper. Trend of Engineering System Evolution (TESE), S-Curved Main Parameter Value (MPV), 40 principles as well as hybridization have been utilized to stimulate students' creativity in generating ideas. It was observed that students are able to come up with many ideas that need to be explored further. Based on the reflective evaluation, it was observed that students felt more equipped and were able to propose many ideas and initiatives. The perceived positive responses from students show that the approach has a potential to be explored further.

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