

Reliability of Creative Thinking Module on the Creativity Level of Engineering Undergraduates in Malaysia

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Creativity is an important factor when it comes down to engineering designs. Creativity and engineering complement each other to provide useful yet eye-opening solutions to everyday problems. Recent research has indicated that creativity, which happens to be one of the vital skills for engineers in the 21st century that can be taught and learnt, has reduced significantly over the years. Thus, there is a need for engineering educators to address this issue by introducing creative thinking as a skill to be acquired by the current generation of engineering undergraduates. This research paper presents the outcome of a research conducted to improve and enhance the creativity level of local engineering undergraduates at a private institution of higher learning through a Creative Thinking Module that features a number of creative thinking tools such as Brain sketching, Concept Maps and Morphological Analysis. The Torrance Test of Creative Thinking Figural Forms was applied to measure the creativity level of respondents in a local Private University. Results indicate that the Reliability of Creative Thinking Skills Module is acceptable.

Keywords: *Reliability of critical thinking, Creativity Level, Malaysia*

Introduction

Engineers are required to solve problems related to humankind within the ever changing world, that is ridden with new issues which need to be overcome such as the Covid-19 pandemic. The current scenario requires engineers to engineer innovative ventilators, patient transporters and innovative mobile test units to cope with the shortage of such vital equipment in combating the pandemic. We could not deny that more and more ‘out of the box quick reactions’ are required to ensure that problems can be mitigated with new solutions. To ensure that future engineers can cope with the ever-changing world and contribute positively to improving the world through innovative engineering solutions, the current generation of engineering students should be equipped with creativity on top of the technical knowledge that is taught in engineering schools. This is due to the fact that creativity is an essential quality of engineering that must not be ignored or neglected. It is vital for engineers to strike a balance between applying practical engineering knowledge and creativity in solving problems, thus, creativity should be nurtured in engineering students. In fact, even back in 2002, Universities were urged to provide avenues for engineering students to nurture creativity (Baillie, 2002).

The engineering profession requires practitioners to acknowledge, validate and resolve problems individually or in a team (Liu & Schönwetter, 2004). Most importantly, engineers should demonstrate novelty and creativity in providing ‘out of the box quick reactions’ towards solving problems. According to Hewett (2005), creative techniques are teachable and learnable, and these techniques are at the control of the individual. Regrettably, educational institutions worldwide, including those in Malaysia, are not doing enough in supporting the cause of cultivating creativity (Brand et. al, 2015; Robinson, 2013; Terkowsky & Haertel, 2013; Haertel et. al, 2012; Daud et. al, 2012; Beghetto, 2010; Kazerounian & Foley, 2007). In addition, so called ‘modern technologies’ applied by educators in the industry are merely emphasising old methods of teaching and learning (Resnick, 2007). To achieve developed nation status, Malaysia is in need of a well-devised higher education curriculum that focuses not only on technical skills and knowledge, but also on preparing engineering students with practical skills such as creativity to ensure Malaysia is able to stay afloat and remain relevant and competitive in the ever-changing global arena (Grapragasem et. al, 2014).

Literature Review

Definition of Creativity

According to Torrance (1974), creativity is defined as:

“A process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficult; searching for solutions, making

guesses or formulating hypotheses about deficiencies; testing and retesting these hypotheses and possibly modifying and retesting them, and finally communicating the results.”

Another prominent researcher, Rhodes (1961), has classified the various forms of definitions of creativity categories into four different categories representing **4Ps**, which are **Process, Person, Press, and Product**. This research project will focus on the first category of Process.

According to Torrance’s definition of creativity (1974), one of the most prominent tools for measuring creativity is known as the Torrance Test of Creative Thinking (TTCT), and in this research it has been adopted to be an instrument for gaining a measure of creativity as a **Process**. The Figural creativity ability of TTCT measures the following abilities:

- 1) **Fluency**, which is the ability of respondents to produce a large number of figural images;
- 2) **Originality**, which is the ability of respondents to produce uncommon or unique responses;
- 3) **Elaboration**, which is the ability of respondents to develop, embroider, embellish, carry out, or otherwise elaborate on ideas;
- 4) **Abstractness of Title**, which is the ability of respondents to synthesise and organise processes of thinking, capture the essence of information involved, know what is important and produce good titles;
- 5) **Premature Closure**, which is the ability of respondents to “remain open” and delay closure long enough to make a mental leap that makes original ideas possible.

Creative individuals differ from non-creative individuals in numerous ways, particularly in personality traits. Amabile (1989) states that creative people are risk takers, while Cropley (2001) suggests that creative individuals are non-conformist. They also derive great satisfaction from discovering and innovating (Claxton et. al, 2006).

The skill to develop creative ideas was once deemed as a divine gift for a select few. Creativity was also considered as novel thinking, which redefines problems, identifies gaps in knowledge, facilitates emerging new ideas, generates analysed ideas, and take reasonable risks in idea development (Felicia et. al, 2017). The ability to combine and connect ideas in ways that are novel and useful has been widely accepted as the fundamental nature of creative thinking (Daly et. al, 2014). This ability is the perception of oneself as creative and capable of producing creative solutions which requires further attention.

Creative Thinking Module

A custom- tailored Creative Thinking Module named Creative Thinking Skills for Conceptual Engineering Design (**CTSM**) was developed for Mechanical Engineering (ME)

undergraduates. This module focuses on introducing, stimulating and enhancing the creativity levels of ME undergraduates and prepare them for the industry. A total of six different creative thinking skills are available in this module to stimulate creative thinking (Saien et. al., 2019).

Attribute Listing

Attribute listing is useful in improving a product or system; thus, it is able to aid users in generating new, creative solutions (Hassan, 2004). It is classified as a divergent thinking method. To perform attribute listing, users are required to break down the problem or situation to be solved into key attributes, which are smaller bits while utilising this technique. All attributes are then managed individually to determine improvements or viable substitutes to be made for each attribute.

Brain Sketching

Brain sketching was developed based on Alex Osborn's traditional brainstorming technique and involves individuals in teams silently sketching ideas on sheets of paper instead of verbally discussing or writing out words representing their ideas. Team members exchange sketches and proceed to sketching on the same sheet of paper used by their team members until each team member has completed sketching on each other's sketches (Linsey et. al., 2011). It must be emphasised that a sketch is practically just a messy drawing of ideas done quickly (Lugt, 2002). This technique fulfils the desires of users to express themselves visually while being used for product development, as the saying goes 'a picture is worth a thousand words,' therefore it is more effective to express an idea using a single picture than to communicate verbally or through writing. A study involving product design students working in teams has shown that brain sketching generates more ideas compared to brainstorming in (Lugt, 2002).

Functional Decomposition

In functional decomposition, users are not restricted to only considering physical components or parts of performing physical decomposition but are encouraged to provide any ideas that could be a solution to achieving the required function. According to Ullman (2010), there are four phases in performing functional decomposition including recognising the general function of a product required, generating sub-function descriptions, arranging sub-functions into logical order and lastly enhancing sub-functions. Research has suggested that functional decomposition could aid in improving creativity amongst users (Litchfield et. al., 2011).

Mind Mapping

Mind mapping is an idea generation technique introduced by Buzan & Buzan (1996) which is proven to be effective amongst users and has been introduced to mechanical engineering undergraduates to enhance creativity (Johari et. al., 2011). Mind Map utilises graphics to represent useful information, allowing users to form connections between information and real time scenarios and stimulating users to generate improved and fresh ideas (Selvi & Chandramohan, 2018). All information such as ideas and notes are organised into tree branch like structures in a mind map.

Morphological Analysis

Morphological analysis uses a table called a morphological chart or morphological diagram that is presented in table form containing functions and possible solutions for each function (Smith et. al., 2012). Prior to constructing a morphological chart, problems are decomposed, and all vital functions required to tackle the problem are listed in a column. Rows of the morphological chart are then filled up with possible functions that could tackle the stated problem (Riyati & Suparman, 2019). After all functions have been addressed, possible combinations are formed to generate various theoretical solutions. This method enables users to systematically list all ideas in table form for easy viewing and generating combined ideas.

Scamper

SCAMPER is an acronym developed by De Bono consisting of seven thinking processes including **Substitute, Combine, Adapt, Modify, Put to other uses, Eliminate** and **Reverse** roles (Barak, 2004) (Ozyaprak, 2015). SCAMPER is used to develop new ideas from existing products, so that users should have an existing product that is required for improvement, innovation or solving problems. Research has shown that SCAMPER is able to stimulate creative thinking for users (Ozyaprak, 2015).

Assessment of Creativity: Torrance Test of Creative Thinking (TTCT)

The well-known TTCT was developed by Torrance, a pioneer in creative education. This test is widely accepted and applied in creativity research for all ages and is used to evaluate attributes in creativity. TTCT can provide consistent measurements on creativity of subjected participants. There are 2 different types of TTCT, including Verbal and Figural tests. For both Verbal and Figural tests, 2 forms consisting of Form A and Form B are used while their sequence for pre-test and post-test are irrelevant. The administration and scoring system of TTCT has been refined during 1974, 1984, 1990 and 1998, making it relevant and leading to its popularity amongst creative researchers (Torrance et. al, 2017). Only the Figural test

will be utilised for this research to access the creativity level of mechanical engineering undergraduates while performing product design.

Research Methodology

Research Aims

This research was carried out to identify the reliability coefficient of the **CTSM** developed by the researcher. More specifically, this research aims to examine and identify the reliability coefficient of the 7 sessions in the **CSTM**.

Research Design

According to Campbell & Stanley (1971), a study is quasi-experimental when some of the quasi-experimental features are conducted during the selection and placement of subjects into experimental groups and control groups, which are supposed to be performed randomly.

In another article by Cook & Campbell (1979), quasi-experiments have both intervention and control groups, and are both measurable and experimental, but do not use random groups in an effort to summarise changes due to behavioural changes.

Cresswell & Miller (2000), and Marican (2006) state that quasi-experiments are experimental studies that do not fully fulfil conditions in pure experiments, including : a) only one dependent variable is manipulated at any given time, b) there should be a control group and c) the subject of treatment and control groups should be randomly selected. While these three conditions are easily achievable, environmental impact is another factor that can hardly be controlled as in experiments performed in labs.

The purpose of this study is to examine the effectiveness of the Creative Thinking Skills For Conceptual Engineering Design Module (**CTSM**) which was developed by the researcher regarding the Figural Creativity of Mechanical Engineering Undergraduates in a private institution of Higher learning in Malaysia.

Research Samples

A purposive sampling method was applied in replacement of random sampling method in the selection and placement of subjects in the control and intervention groups. The respondents were 3rd year Mechanical Engineering students undertaking a design module in the studied university. From a total of 62 students, 30 students formed the Control group, while another 32 students formed the Intervention Group. Experimental studies were conducted using Pre-

Test and Post-Test designs as illustrated by Chua (2016) to treatment and control groups as described in Table 1 below.

Table 1: Pre-Test and Post-Test Design

Type of Group	Pre-Test Measurement	Intervention	Post-Test Measurement
Control Group	M1		M3
Intervention Group	M2	X	M4

Keys:

X – Intervention using **CTSM**

M – Measurements

Module Reliability Study Tool

According to Arip (2010), module reliability refers to the consistency and stability of a module in treating the required information such as the objectives of a module. Testing the reliability of a module can be observed through how far a student can follow the contents of the module (Russell, 1974).

To test the value of reliability of the module, Sidek & Jamaludin (2005) stated that questionnaires can be created based on the objectives of a module or the implementation steps in the module and administered to respondents. A study by Arip (2010) regarding the construction of self-improvement concept modules has built reliability items based on module implementation steps and obtained the reliability coefficient value .838, while study by Ahmad et. al, (2011) concerning the construction of the CTRT group counselling module also built reliability items based on the prescribed steps and obtained a reliability coefficient of 0.830.

The researcher has developed a set of questionnaires based on the objectives and activities to test the reliability of Creative Thinking Skills for Conceptual Engineering Design. This set of questionnaires is completed by respondents after they followed and completed each activity (Kiong et. al, 2020). The questionnaire was analysed to obtain the reliability value using Cronbach alpha coefficient. According to Konting (2000), if the reliability value is high, or at least .60 means that the module has an effective level of consistency. On the other hand, the value of reliability that does not reach the value of .60, means that the module's level of consistency is poor and need to be improved. On the other hand, Chua (2013) maintains that a reliability value of .65 to .95 is satisfactory.

Module Reliability Results

In this study, 32 Mechanical Engineering undergraduate students who formed the intervention group and followed and completed the module, were involved in the determination of reliability. In order to test the reliability of the module, a set of questionnaires was designed based on a study by Arip (2018). The questionnaire consisted of items to test the steps in each activity listed in the module in order to find the reliability coefficient value. Module reliability questionnaires were given to students after they followed each activity in the module. The questionnaire was later analysed to obtain the value of reliability by using Cronbach alpha coefficient method. The results of the value of module overall reliability is illustrated in Table 2:

Table 2: Overall Reliability of CTSM

N	Total Items	Alpha Value	Level
32	37	0.898	High

Table 3 illustrates the results of questionnaires of the CTSM based on all sessions available in the module. The α values at significance level of .05 for Introduction is 0.701, for Brain Sketching 0.717, for Mind Mapping 0.708, for Attribute Listing 0.738, for Function Decomposition 0.882, for Morphological Analysis 0.831, for SCAMPER 0.840, and for Conclusion 0.828.

Table 3: The value of reliability of the session and activities of CTSM

Session	Description	No of Items	α	Level/Decision
Session 1	Introduction	4	0.701	High Accepted
Session 2	Brain Sketching	6	0.717	High Accepted
Session 3	Mind Mapping	6	0.708	High Accepted
Session 4	Attribute Listing	6	0.738	High Accepted
Session 5	Functional Decomposition	6	0.882	High Accepted
Session 6	Morphological Analysis	6	0.831	High Accepted
Session 7	SCAMPER	6	0.840	High Accepted
Session 8	Conclusion	3	0.828	High Accepted

Discussion

According to Kerlinger (1979), having a value of α (alpha value) exceeding 0.6 at the significant level .05 is an effective and recognised assessment. On the other hand, Chua (2013) mentions that a Cronbach Alpha Value of .65 to .95 is satisfactory.

The major findings of this research confirm that the **CTSM** possessed a high level of reliability coefficient value. The overall reliability of the module is well above the 0.60 level at 0.898. Functional Decomposition has the highest alpha value at 0.882 while the Introduction session has the lowest value of alpha at 0.701. According to Konting (2000), if the reliability value is high, the module developed has a good degree of consistency. Therefore, this module is acceptable and reliable and can be used in intervention. Hence, the alpha values obtained and illustrated in Table 3 proved that **CTSM** is acceptable and reliable for use in interventions.

Conclusion

In this research, the researcher developed a Creative Thinking Skills for Conceptual Engineering Design to address the issue of decline in creativity that had been reported by many other researchers. The content of the module was tested in terms of reliability by determining the Cronbach Alpha value. The major findings of the study consist of the success of **CTSM** in obtaining acceptable reliability from respondents. Based on the above findings, it can be concluded that Engineering undergraduate students can be trained to be more creative when it comes to deriving various relevant designs of products or solutions.

However, the research findings also indicate that there is a need for current engineering education providers to revamp or review the content of the Engineering program so that these future engineers will be able to identify the important information needed, to be able to present to his/her audience more creatively and effectively. Educators must also be aware that they need to generate engineers who can generate abstract designs or solutions that will most likely bring about revolutionary changes. More attention should be given to this aspect so that students can acquire this set of skills while still in University.



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