

Assessing the validity and reliability of creative thinking skills module in a pilot study on engineering undergraduate in Malaysia

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Abstract

This research paper presents the outcome of a research conducted to assess and determine the Validity and Reliability coefficient of Creative Thinking Skills for Conceptual Engineering Design Module administered to engineering undergraduates at a private institution of higher learning. The Creative Thinking Skills Module features few proposed creative thinking tools such as Brain Sketching, Mind Maps and Morphological Analysis. The validity consists of module content validity, and session and activity validity, evaluated by a group of five experts. The Cronbach Alpha value was determined through conducting a pilot study in a local private university where mechanical engineering undergraduate underwent the module workshop and activity. Questionnaires were given to respective experts and students respondents to measure the validity and reliability level of the module, sessions and activities.

Keywords: Validity, Reliability, Cronbach Alpha, Creativity, Torrance Test of Creative Thinking, Engineering Education

INTRODUCTION

To ensure future engineers could cope with the ever-changing world and contribute positively in 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 any engineering school. Engineers need to strike a balance between applying practical engineering knowledge and creativity in solving problems. Research urges universities 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). Creativity techniques are teachable and learnable, and these techniques are at the control of the individual Hewett (2005). Regrettably, educational institutions worldwide, including those in Malaysia, are not doing enough in supporting the cause of cultivating creativity (Brand, Hendy, & Harrison, 2015; Robinson, 2013; Terkowsky & Haertel, 2013; Haertel, Terkowsky, & Jahnke, 2012; Daud, Omar, Turiman, & Osman, 2012; Beghetto, 2010; Kazerounian & Foley, 2007). To achieve developed nation status, Malaysia is certainly in need of a well-devised higher education curriculum that focuses not only on technical skills and knowledge, but also to prepare engineering students with practical skills such as creativity to ensure Malaysia can stay afloat, relevant remain competitive in the ever-changing global arena (Grapragasem, Krishnan, & Mansor, 2014).



This paper aims to examine the effect of the Creative Thinking Skills Module (CTSM) to improve the creativity of engineering undergraduates in Malaysia. Hence, the specific objectives of the study are as follows:

1. Determination of the validity of the CTSM module based on expert perspectives on the module content, module session and activity constructed based on Russell Model (1974).
2. Determination of Cronbach Alpha values of each session and activities of CTSM based on the results obtained through a pilot study in a local private university.

LITERATURE REVIEW

Definition of Creativity

Rhodes (1961) defined form of creativity categories into four different categories representing 4Ps, which are *Process*, *Person*, *Press*, and *Product*. Only the first category *Process* is involved in this research by adopting the Torrance Test of Creative Thinking (TTCT) as a measuring tool. 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 the deficiencies; testing and retesting these hypotheses and possibly modifying and retesting them, and finally communicating the results.”



Figural creativity is of vital importance to engineer, as they are the person who designs their products mainly through sketches and drawings. The figural creativity ability can be measured using TTCT which measure the following abilities:

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

Creativity was also considered as novel thinking, which sees problems redefined, gaps in knowledge identified, new ideas emerged, generated ideas analysed, and reasonable risks in idea development are taken. The ability for one to combine and connect ideas in new ways that are novel and useful has been widely accepted as the fundamental nature of creative thinking (Daly, Mosyjowski, & Seifert, 2014). This ability is the perception of oneself as being creative and capable of creating creative solutions is an important factor that requires more attention.



METHODOLOGY

A quantitative approach has been adopted in this research. The methodology is divided into three major areas:

1. CTSM Module Development
2. Application of External Criticism Validation by expert's method to find the validity of module content and validity of session and activity content
3. Conduct of a pilot study to determine the reliability of the module.

Creative Thinking Skill Module Development

A custom-tailored CTSM named Creative Thinking Skills for Conceptual Engineering Design was developed for Mechanical Engineering (ME) undergraduates. This module focuses on introducing, stimulating and enhancing creativity levels of ME undergraduates and to well prepare them for the industry. A total of seven different creative thinking skills are available in this module to stimulate creative thinking. The seven creative thinking skills are illustrated in Figure 1.

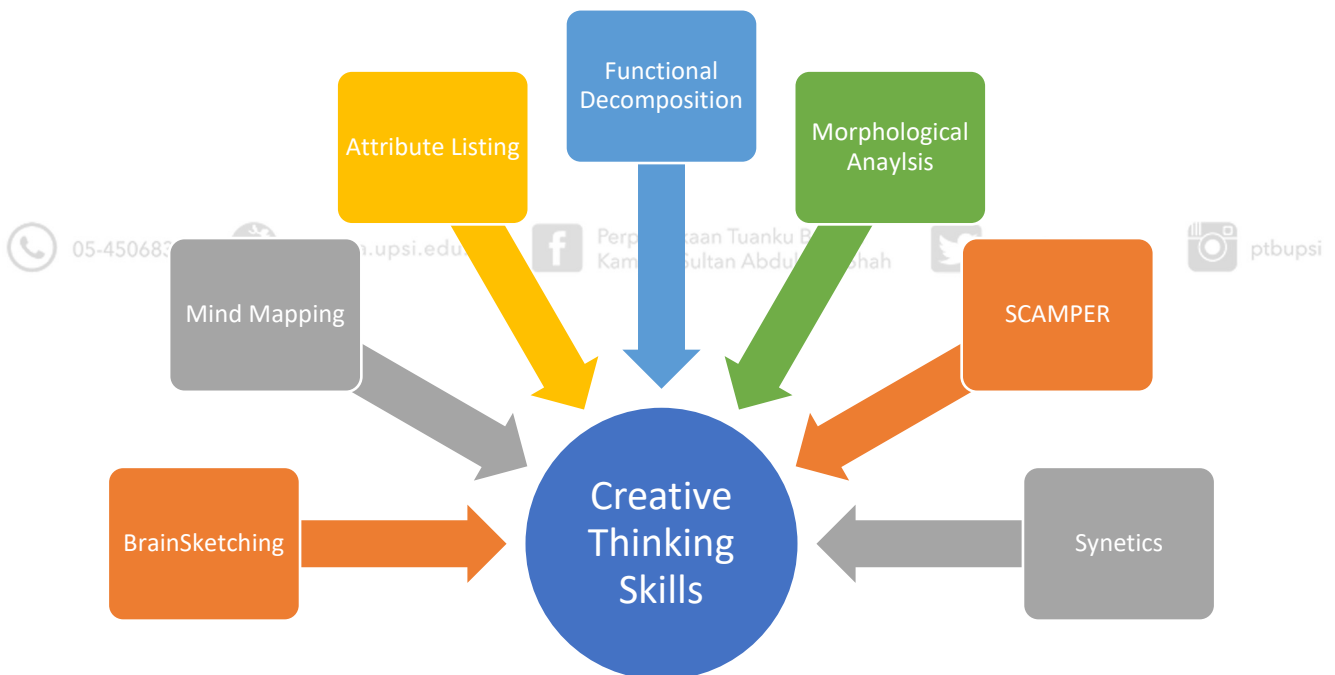


Figure 1. Seven Creative Thinking Skills in CTSM

Determination of Module Validity

Module validity refers to the accuracy of the concepts and contents of a module. The validity of external criticism method is applied and is determined in this research. This is because external criticism is one of the most effective methods of studying the validity of any research instrument (Fuad et al, 2019). For this research, the validity of the module content, and the validity of each session and activity are determined respectively. According to Russell (1974) method, the CTSM module content validity consists of five important items namely:

- a) The contents of the module meet the population target;
- b) The contents of the modules can be implemented perfectly;

- c) The contents of the module are compatible with time;
- d) The contents of this module can improve individual creative thinking skills effectively;
- e) The contents of this module can improve the students to a more brilliant direction.

The validity of each session and activity of the CTSM, on the other hand, is also determined separately according to every session and every activity in the module developed. There is a total of 9 sessions with different activities for each session. This means that the validity of the good CTSM must contain these features.

A set of validated questionnaires of module content validity, session and activity validity based on Russell's (1974) views were given to a group of appointed experts to determine the validity level of CTSM. The appointed group of experts' consist of five experts whose biodata are as illustrated in Table 1.

The scale for this validity assessment is from 1 to 10, The scale of 1 is for strongly disagree up to 10 for strongly agree. To determine the level of validity of module content, session and activity, the total number of scores were filled by the experts, (x) will be divided by the actual total score (y), and multiplied by one hundred. A module has a high level of validity when it achieves 70% and is considered to have dominated or achieved a high level of achievement (Tuckman, 1965; Sidek & Jamaludin, 2005). The formula is as follows:

$$\frac{\text{Expert Score Amount (x)}}{\text{Total Actual Score (y)}} \times 100\% = \text{Level of Validity}$$

Table 1. Biodata of the Expert Assessing the Validity of CTSM

Expert Panel	Biodata of Expert Panel
E1	More than 10 years of experience in lecturing Mechanical Engineering Degree and Diploma Programmes More than 5 years working overseas in Mechanical Engineering Programme Leader of Mechanical Engineering Department of a Private University Supervised more than 50 Bachelor Degree students
E2	Former lecturer of a Private University More than 10 years of experience in lecturing Mechanical Engineering Degree and Diploma programmes Supervised more than 50 Bachelor Degree Students Currently Technical Director of a Private Company Supervised more than 10 Mechanical Engineering intern students
E3	Senior Lecturer in a Private University More than 10 years of experience in lecturing Engineering Design related module such as Machine Design Supervised more than 50 Bachelor Degree students, Master and PhD students
E4	Director of Teaching and Learning Unit of a Private University More than 5 years of experience in lecturing Creative Thinking Module in a Private University More than 10 years of experience in providing training to tertiary educators.
E5	Former Senior Lecturer of a Private University More than 10 years of experience in lecturing Mechanical Engineering Degree programmes Currently Technology Director of a Private Company Appointed Principal Consultant of a Private Company

Determination of Module Reliability

Sidek and Jamaludin (2005) stated that the questionnaire created based on the objectives of a module or the implementation steps in the module can be used to determine the reliability of the module. This can be seen in a few successful cases reported recently. According to research conducted by Arip (2010), the module reliability is defined as the consistency and stability of a module in treating what should be treated as in the objectives of a module. The reliability determined will also be able to provide information to the

researcher how well the students can follow the contents of the module (Russell, 1974).

The study by Arip (2010) has resulted in a set of the questionnaire where the items developed based on module implementation steps and it obtained a reliability coefficient value 0.838. In another study by Ahmad et al. (2011), in the questionnaire developed using the module implementation steps, has obtained the reliability coefficient of 0.830.

A set of questionnaires are set based on the objectives and activities of the module to test the reliability of CSTM. This set of questionnaires is completed by the respondents in the pilot study in a local private university after they followed and completed every activity. The scores obtained were analyzed to obtain the reliability value using Cronbach Alpha coefficient.

Research Samples

A pilot study was conducted in a local private university where 31 3rd year Mechanical Engineering was involved. The students went through all the CTSM sessions and completed all the activities.

RESULTS

This section will provide the results of all the validity and reliability assessment from experts group and student respondents from the pilot study. The results are illustrated in Table 2, Table 3, Table 4, and Table 5 respectively.

Module Content Validity Results

Table 2 illustrates the results of the experts' validity assessment on the module content validity. The results in Table 2 show that for the module content validity with regards to statements related to perfect implementation, improving creative thinking skills, and improving the students to a more brilliant direction all scored 80% in average. Whereas, for the validity of module content with regards to the module being compatible with the allocated time scored the lowest in comparison with the others at 70%.

Table 2. Module Content Validity of CTSM

No	Item	E1	E2	E3	E4	E5	Average	Expert View
1	The content of this module meets the population target.	90	60	80	80	80	78%	Accepted
2	The content of this module can be implemented perfectly.	80	70	80	80	90	80%	Accepted
3	This module is compatible with the allocated time.	80	80	80	70	40	70%	Accepted
4	The content of this module can improve individual creative thinking skills effectively.	80	70	80	100	80	80%	Accepted
5	The content of this module can improve the students to a more brilliant direction.	80	50	80	100	90	80%	Accepted

Module Session and Activity Validity Results

Table 3 illustrates the results of experts' assessment of CSTM session and activity validity. From the results portrayed in Table 3, the highest average for the validity of each session and activities of CTSM is at 84%. Activity 2 for attribute listing and activity 1 and 2 for functional decomposition has the highest average for validity, where all 3 activities have the same average value of 84%. On the lower end of the spectrum with only an average of 70% is activity 2 of Mind Mapping and activity 2 of Synetics.

Table 3. Validity of Each session and Activities of CTSM

Session	Activity/Session Descriptions	E1	E2	E3	E4	E5	Average	Expert View
1	Introduction Activity: Torrance Test of Creative Thinking Figural Form A	80	50	70	100	80	76%	Accepted
2	Brain Sketching Activity 1: - Sketching Exercise	80	60	70	90	90	78%	Accepted
3	Brain Sketching Activity 2: - Design a new concept for a car dashboard using Brain Sketching	70	60	80	70	80	72%	Accepted
4	Mind-Mapping Activity 1 – True and False questions to test the understanding of Mind-Map	80	60	80	90	90	80%	Accepted
5	Mind-Mapping Activity 2 – Construct a Mind Map given topic on Renewable Energy: A Malaysian Context	90	60	70	60	70	70%	Accepted
6	Attribute Listing Activity 1- Do you know what attributes are?	80	50	60	100	90	76%	Accepted
7	Attribute Listing Activity 2 – Listing down attributes of a microwave oven	80	60	80	100	100	84%	Accepted
8	Functional Decomposition Activity 1 – Fill in the blanks. Do you understand functional decomposition?	80	70	80	100	90	84%	Accepted
9	Functional Decomposition Activity 2 – Functional Decomposition for UNIRIDE electric bike available on campus	90	60	80	90	100	84%	Accepted
10	Morphological Analysis Activity 1 - Describe your understanding of functions in a short paragraph	80	60	70	70	80	72%	Accepted
11	Morphological Analysis Activity 2 – Idea generation using morphological analysis: the new futuristic concept of a bicycle.	80	60	80	80	80	76%	Accepted
12	SCAMPER Activity 1 – What do you understand about SCAMPER?	80	60	70	100	90	80%	Accepted
13	SCAMPER Activity 2 – Develop a new concept for an office desk using SCAMPER	80	60	80	80	60	72%	Accepted
14	Synectics Activity 1 – Analogy as a stepping stone in Synectics	80	60	80	80	80	76%	Accepted
15	Synectics Activity 2 – Given Topic on Public Transportation, use Synectics to come out with a creative approach of new public transport concept for Malaysia	80	50	80	70	70	70%	Accepted
16	Conclusion Activity –Torrance Test of Creative Thinking Figural Form B	80	30	80	100	80	74%	Accepted

Module Reliability Results

Module reliability questionnaires were provided to students to be filled up after they followed every session and activity in the module. The questionnaire was then analyzed to obtain the value of reliability

by using Cronbach's Alpha coefficient method. The results of the value of the module overall reliability are illustrated in Table 4.

Table 4. Overall Reliability of CTSM

N	Total Items	Alpha Value	Level
31	49	0.940	High

Table 5 illustrates the results of the questionnaire of the CTSM based on all the sessions available in the module. The values at a significance level of 0.05 for Introduction is 0.811, for Brain Sketching is 0.884, for Mind Mapping is 0.823, for Attribute Listing is 0.919, for Function Decomposition is 0.875, for Morphological Analysis is 0.822, for SCAMPER is 0.758, and for Conclusion is 0.932. However, for Synetics, the Cronbach Alpha value is the lowest amongst all at only 0.677.

Table 5. The values of Cronbach Alpha of the session and activities of CTSM

Session	Description	No of Items	α	Level/Decision
Session 1	Introduction	4	0.811	High/Accepted
Session 2	Brain Sketching	6	0.884	High/Accepted
Session 3	Mind Mapping	6	0.823	High/Accepted
Session 4	Attribute Listing	6	0.919	High/Accepted
Session 5	Functional Decomposition	6	0.875	High/Accepted
Session 6	Morphological Analysis	6	0.822	High/Accepted
Session 7	SCAMPER	6	0.758	High/Accepted
Session 8	Synetics	6	0.677	Low/Rejected
Session 9	Conclusion	3	0.932	High/Accepted

One of the aims in this study is to determine the Cronbach Alpha values of each session of CTSM based on the results obtained through a pilot study in a local private university, and hence to observe the effect of CTSM to improve the creativity.

According to Kerlinger (1979), having a value of α (alpha value) exceeds 0.6 at a significant level 0.05 is a good and recognized assessment. Chua (2013), a prominent researcher in Malaysia, on the other hand, mentioned that a Cronbach Alpha Value of 0.65 to 0.95 is satisfactory. Many of the researches are following a rule-of-thumb that alpha should reach a value of 0.70 for an instrument to qualify for an acceptable level of self-consistency (Taber, 2018). It should also be noted that alpha values of less than 0.70 may not always be considered as an indication of an unsatisfactory instrument, (Plummer & Tanis Ozcelik, 2015). Adopted from Taber (2018), Figure 2 shows a graphical illustration of qualitative descriptors used for values/ranges of values of Cronbach's alpha, with an additional vertical line showing the indication of 0.70 of the "acceptable" value of the value of alpha. Despite the general 0.70 as acceptable values, it can also be seen that some authors would refer ranges of 0.60 – 0.70 as "acceptable", "satisfactory", "sufficient", "reasonable", and "adequate".

This research confirmed that the **CTSM** possessed a high level of reliability coefficient value where the overall reliability of the module is well above the 0.60 level at 0.940. For individual module session and activity reliability results, Conclusion has the highest alpha value at 0.932, while the Synetics session has the lowest value of alpha at 0.677. According to Konting (2000), when reliability value is high, the module developed has a good degree of consistency. The alpha values obtained and illustrated in Table 3 proved that all sessions conducted in **CTSM** are acceptable and reliable for use in interventions except for Synetics.

The validity of the CTSM is measured in two ways, that is module content validity, and module session and activity validity. The group of experts all gave high validity with regards to the module content, where the validity ranges fall within 70% to 80%. This indicates that the module content is valid and can achieve the specific objectives set out by the module. The session and activity validity scores by the group of experts fall within 70% - 84%, which also illustrates that the session and activity are valid. This is in line with the threshold of validity as setting up and supported by Arip (2010) and Ahmad

Jazimin, Abdul Malek, Mohammad Nasir dan Mohammad Aziz Shah (2011).

In general, this study presented the validity and reliability of the **CTSM** module to boost the creativity among the engineering undergraduates, and based on the judgements and views from the experts engaged in this research, the validity and reliability of this module are considered as high, which will be able to help undergraduates to further cope with engineering complexities.

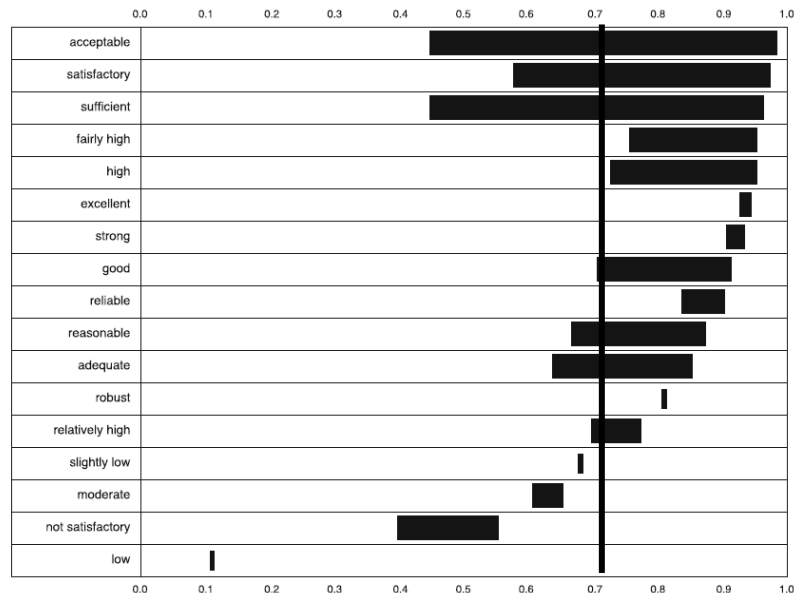


Figure 2: Figure adapted from Taber (2018), showing a graphical illustration of qualitative descriptors used for values/ranges of values of Cronbach's alpha.

CONCLUSION

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

The research findings also indicated that the Synetics session is probably unsuitable to be included as part of the skills in the module since the reliability is below the acceptable threshold of 0.7. It is recommended that Synetics be removed from the module and more time can be allocated for other skills sessions and activity.

The major findings also indirectly indicated that is a need for current engineering education providers to revamp or review the content of the Engineering programme and include creative thinking skills in their curriculum. It is important so that these future engineers will be able to identify the important information needed, to be able to identify the gap, to be able to search for creative solutions and to be able to present to his/her audience more creatively and effectively. The educators must also be aware that they need to generate engineers who can come up with abstract designs or solution that will most likely bring revolutionary changes. More attention should be given in this aspect so that the students can acquire this set of skill while still in university.

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