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Is Engineering Education Inevitable for Design Creativity? Mediating Role of Creative Components and Behaviors

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Article Info
Volume 82
Page Number: 3488 - 3498
Publication Issue:
January-February 2020

Article History
Article Received*: 18 May 2019*
Revised*: 14 July 2019*
Accepted*: 22 December 2019*
Publication*: 20 January 2020*

Abstract:
The aim of this paper was to assess the linkage between engineering education (EE) and design creativity (DC) in order to know is the engineering education inevitable for DC. Furthermore, the current study examined the mediating roles of creative components (CC) and creative behaviors (CB) between EE and DC. For this purpose, the data was collected through structured questionnaires from 380 students of technological universities and colleges of Malaysia. The data collected from sample students was analyzed through SPSS and AMOS in which the confirmatory factor analysis and structural equation modelling were applied on the data. The quantitative analysis of this study revealed that there is significant positive impact of engineering education on design creativity. It has been further found through results that the use of creative components plays the significant mediating role between engineering education and design creativity. Furthermore, creative behavior has also been found as a significant mediator between engineering education and design creativity. These findings will contribute to the literature and practice by clarifying the role of engineering education, creative components and creative behaviors in design creativity.

Keywords: *Engineering Education, Design Creativity, Creative Components, creative Behaviors*

I. INTRODUCTION

Design creativity refers to the skills and abilities that are needed in order to create new and unique designs of products. The process of design creativity starts from asking about the needs, demands and ideas related to the creation of a design. Then this idea is given an image form through which whole process is supposed to be executed. A detailed planning take place in order to discuss different practices used in the creation of that particular design and finally the design is created based on the whole planning of it. Sometimes, flaws may be observed in the creative design of a product, which needs further improvement (Zbainos & Lubart, 2016). There are two important aspects in design creativity i.e. design solutions and design productivity. Design solutions involve the production of new and unique ideas about creation of a design referred to be idea creativity while design productivity involves the use of certain technology or process in order to create a design referred to be product creativity. The process of design creativity obviously starts with idea creativity and then moves towards product creativity and this whole process involves the concept of innovation as an important factor. Engineering education plays a vital role in innovation. We know that engineering education provides necessary skills, knowledge and information either technical or managerial in order to bring innovation in various processes used in organizations (Zedelius & Schooler, 2016). It not only provides ideas related to innovation in processes but also provides skills and information to bring those ideas into practical form. Innovation is a key to growth and development of any type of organization now-a-days, so we can say that engineering education plays significant role in the growth and development of an organization, where individuals with engineering education are hired.

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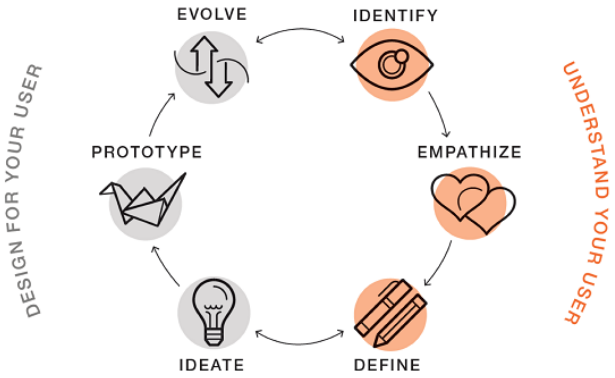

Figure 1. Design Creativity (Source: ef.com)

Figure 1 shows different steps that are involved in design creativity process. Creative components play important role in design creativity and determine the level of performance in design creativity. Many creative components have been recognized that are very important in the creation of new and unique design. An individual who is willing to produce a creative design must be having some creative traits and in built abilities i.e. the personality traits of that individual must conform with design creativity and he must be having a mind with exceptional quality of creative thinking (Van der Schyff, Schiavio, Walton, Velardo, & Chemero, 2018; Weinberger, Cortes, Green, & Giordano, 2018; Wu et al., 2019). These individuals must be having proper knowledge and information regarding design creativity. They must be encouraged and influenced by certain incentives and a proper environment where they have to work for design creativity. Proper working environment includes the cooperation of other workers, best leadership qualities of the person supervising the whole process and complete support from the organization in the design creativity process (Thomson & Jaque, 2018). Individuals involved in design creativity must be having high levels of self-efficacy and positive intentions to produce an innovative design. All these creative components result in improved design creativity process. Creative behavior refers to the certain behaviors of an individual that lead towards the process of design creativity. There are various dimensions of creative behavior. The first dimension is behavioral intention which refers to the intention, willingness and tendency of an individual to show a particular behavior towards the design creativity process (Sonn, Kasat, & Quayle, 2017). Another dimension in this regard is attitude, which shows any negative or positive image or concept of creative designing of an individual. It shows whether an individual feels positive or negative about the design creativity process. Next dimension, subjective norms represent the influence of something towards a particular behavior which means that whether something is enforcing the process of design creativity or not (Smeekens & Kane, 2016). The last dimension in this regard is perceived behavioral control which represents some difficulty or some kind of control in a particular behavior or negative influence on an individual to engage in the process of design creativity.

Engineering education enhances the creative components and creative behaviors of individuals that are engaged in design creativity process, which ultimately results in the improvement of design creativity of that individual. But unfortunately in Malaysia, engineering education is not being much valued and promoted due to which creative components and creative behavior are affected adversely (Santos, Jimenez, Sampaio, & Leite, 2017). This has negative impact on the ability of design creation of students in Malaysia. Other developing and under developed countries are facing the same dilemma resulting in decrease of design creativity abilities. If this problem prevails for a longer span of time, it will have serious outcomes in the form of lack of creative components and creative behavior leading towards decreased design creativity (Santos et al., 2018). So it is the need of the hour to pay attention to this factor so that it must be solved as early as possible in order to avoid its serious outcomes.

There are several researches that have studied creative components, creative behavior and design creativity in detail. Few studies also have shown the impact of creative components and creative behavior on design creativity. But there are no studies in which the impact of engineering education on design creativity is shown. In the same way, no research has been conducted in order to study the mediating role of design components and design behavior between engineering education and design creativity. So a research paper has recommended studying the mediating role of creative components and creative behavior in this regard (Chang, Lin, Chien, & Yen, 2018). The most important objectives of this research are as follows:

- To analyze the significant impact of Engineering Education on Design Creativity in Universities and Colleges in Malaysia
- To analyze the mediating role of use of Creative Components between Engineering Education and Design Creativity in Universities and Colleges in Malaysia
- To analyze the mediating role of use of Creative Behaviors between Engineering Education and Design Creativity in Universities and Colleges in Malaysia

As we know that the image of Malaysia has been significantly changed from agricultural country to industrial country resulting in increase of economic growth and development of the country, design creativity has become very important in most of the organizations of Malaysia in order to increase organizational performance and customer satisfaction levels (Sanders, 2019). The scope of this study revolves around the

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concept of design creativity and the impact of engineering education in this regard. It also shows the mediating impact of creative components and creative behavior between the above mentioned variables. This research provides complete literature about design creativity and its relation with creative components and creative behavior (Ronen, Goldschmidt, & Erez, 2018). It will assist the organizations of Malaysia to make improvements in creative components and behavior to increase the level of design creativity in students of colleges and universities that will ultimately increase organizational performance and growth and development of a particular organization. It will also help the government of Malaysia to introduce policies and provide funds if necessary in order to promote the culture of design creativity.

II. Literature Review

Creative Cognition Approach

Creativity depends upon the mental processes involved in thinking and learning of individuals, environment in which the individuals are living, their culture and the skills and abilities those individuals possess. However, mental process is considered as the most important factor related to creativity (Rogaten & Moneta, 2015). Many theories are in practice to study the creativity process but the most important theory is Creative Cognition Approach. This theory revolves around different processes and procedures that are involved in creative thinking by individuals. One of the most important purposes of creative cognition approach is to properly understand and explore the creative processes through cognitive approach. There are so many creative processes and none of them can be identified as the only creative process. Another important concept of creative cognition approach is to learn about the creative processes in regard of cognition. In addition, new and more exploring questions are addressed in this regard (Mulet, Royo, Chulvi, & Galán, 2017). Creative cognition approach is actually based on different concepts including associationism, Gestalt psychology and computational modeling. All these concepts have different aspects and properties related to the cognitive process and mental processes. Creative cognition approach results in the better understanding of cognition and how to optimize and increase creativity of the people. As our study is based on design creativity and various creative components and behaviors, this approach can be used to discuss various impacts, these variables have on each other and also to evaluate them effectively.

Impact of Engineering Education on Design Creativity

Design creativity means all the necessary and required skills and abilities that can be used in order to produce a unique and a whole new level product. Design creativity is not a single step process, instead it comprises of a whole series of events that take place in order to produce a new and unique product. First of all, a unique idea is required which depends upon the level of creativity an individual has. Studies have shown that more creative mind will give more creative idea (Matsui, Ono, & Watanabe, 2017; Mekern, Hommel, & Sjoerds, 2019; Mohammad, Razak, Kamis, & Haron, 2017). After getting a creative idea, an individual needs to design an image or plan flowchart through which that idea is going to be converted into a real product. This planning may consists of a series of steps through which an individual can convert a creative idea into an actual product. This planning process also requires a lot of creativity and managerial skills so that the plan is made in such a way that its execution becomes easy. This planning then leads to the actual execution process which consists of many technical and innovative processes and procedures that can convert a creative idea into reality in the form of an actual product (Li, 2017). This whole plan execution process again involves creativity because mere following the plan steps is not enough in order to produce a creative product until a technical expert who knows all the technicalities related to that particular process. Studies have shown when a creative product is made, it is not necessary that it is perfect in all senses; there may be certain flaws and loopholes left in it. These flaws and loopholes can be filled again by an expert who knows all the technicalities related to the process of production. There are two most important concepts related to design creativity (Leyden, Campbell-Law, Nguyen, & Piazza, 2018). These include design solutions and design productivity. Design solution is actually the concept through which new and unique ideas are produced related to the creative design of a particular product. This is an important concept because it is the actual base of the whole process of design creativity. This is due to the reason that a particular unique idea is necessarily required in order to produce a creative design of a product. Without a creative and unique idea, the whole concept of design creativity gets flop because there no base attached to it (Komlos, 2016). Studies have shown the idea formation process can also be linked to planning process as the idea leads to creative planning of production of a creative design of a particular product. An innovative mind can design the whole planning for design creativity that is more efficient and cost effective, which is necessary for the success of a creative product design. The concept of design solutions can also be referred to be idea creativity because it consists of idea formation and plan formation (Joo & Bennett III, 2018). The other important concept related to design creativity is design productivity which revolves around the use of innovative

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processes and technologies that can be used in order to execute the plan of production of a creative design of a product. Studies have shown the person who is involved in the production process must be equipped with all the necessary technical and managerial skills that are required for that particular process. Creativity is the essence of the person involved in this process. The actual process of design creativity basically starts with idea creativity which leads towards product creativity and in this way an innovative, unique and creative product is produced (Gero, 2015; Grace, Maher, Fisher, & Brady, 2015; Hui & Yang, 2017). As observed in the above discussion, the whole process of design creativity revolves around innovation, technical and managerial skills, sense of technology and necessary knowledge and information about creativity. Engineering education provides all of them. Studies have shown engineering education provides all the required technical and managerial skills to individuals who can use them in the field of design creativity. Innovation is the essence of engineering education and also an important part of design creativity. In other words, engineering education results in better production of creative designs of a product (Fu, Fuge, & Brown, 2018). All the aspects related to design creativity can be discussed and evaluated under the creative cognition approach. From the above discussion we can conclude that engineering education has significant impact on design creativity in universities and colleges in Malaysia. We can generate the following hypothesis:

H 1: Engineering Education has significant impact on Design Creativity in the universities and colleges in Malaysia.

Mediating Role of use of Creative Components between Engineering Education and Design Creativity

Creative components are very crucial in the process of design creativity as they can be used to measure the performance of the process of design creativity. Creative components are actually some attributes of a person who is involved in the production of creative designs of a product. In other words, in order to make unique and creative products, a person must be having all the important creative components (Ditta & Storm, 2018). Researchers have discussed that there are different dimensions of creative components such as design creativity related skills, personal skills and attributes related to creativity, levels of motivation in that person and the effects of the environment in which that particular person is living. Design creativity related skills involve all the technical, innovative and managerial skills that are very important in the process of design creativity. These skills are important not only for the creation of an innovative idea, but also for the planning and execution of those plans in regard of design creativity. Engineering education provides these required skills to individuals who are into design creativity (Cropley, 2016). Studies have shown these skills enhance the design creativity of those individuals and result in increase in creative designs production. The next dimension of creative components is creativity relevant processes which refer to the thinking skills of an individual as well as different personal attributes that are required for design creativity. These skills are very important in idea generating process as it requires creative thinking of an individual. Other than that, some other skills such as commitment, positivity, determination etc. are also required in the process of design creativity for better outcomes. These skills and attributes can be obtained from engineering education. Next dimension related to creative components is the level of motivation of an individual for design creativity process (Christensen-Salem, Kinicki, Zhang, & Walumbwa, 2018; Crilly & Cardoso, 2017).There must be a factor of motivation for an individual who is willing to create creative designs of a product. Studies have shown the motivation may be of any kind; it may be materialistic, it may be internal motivation, but in any way it plays important role in the design creativity process. The last dimension of creative components is the environmental factor in which the individual is living. There are various internal and external environmental factors that influence the abilities and skills required for design creativity. All these dimensions of creative components are very important in the process of design creativity and engineering education plays an important role in this regard (Brown, 2019). The above mentioned impacts can be discussed and evaluated on the basis of creative cognition approach. From the above all discussion, we can conclude that the use of creative components has a significant mediating role between engineering education and design creativity. We can generate the following hypothesis in this regard:

H 2: Use of Creative Components has significant mediating role between Engineering Education and Design Creativity in colleges and universities in Malaysia.

Mediating Role of use of Creative Behavior between Engineering Education and Design Creativity

Just like creative components, creative behavior is another factor that affects or influences the process of design creativity (Benedek et al., 2017). Creative behavior has various dimensions that are important in this regard. These dimensions include behavioral intention of an individual, attitude of an individual, subjective norms and perceived behavioral control related to the process of design creativity. Behavioral intention of an individual refers to his/her intensions regarding the concept of design creativity (Beaty et

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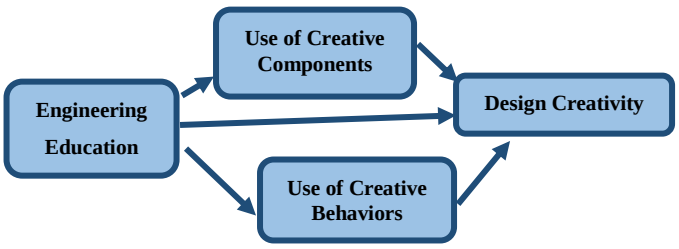
al., 2018). In other words, willingness of an individual to produce creative design products represents the behavioral intensions of that particular individual. Attitudes of an individual regarding design creativity may be either positive or negative. Studies have shown the ways in which an individual thinks of design creativity process and evaluates his behaviors represent the attitudes of that particular individual. Subjective norms related to design creativity, as the name implies, refer to the beliefs and opinions of people related to design creativity (Baer, Kulik, Oldham, & Wrzesniewski, 2018). The ways in which people think about design creativity and have beliefs about this concept represent the subjective norms of these people related to design creativity. Researches have shown that these subjective norms are important in this regard because they affect the behavior of individuals related to design creativity. The last dimension of creative behavior is perceived behavioral control, which refers to any incentive or disincentive that influences and enforces people to engage in design creativity process. Any kind or pressure or some monetary or non-monetary incentive may change the behavior of individuals in context of design creativity. Therefore, this impact is really important in design creativity process (Bachar, 2018). All these dimensions of creative behavior affect design creativity process in one way or the other. Studies have shown engineering education plays an important role in the use of these dimensions of creative behaviors. Engineering education provides enough training in regard of behaviors and attitudes of individuals which affect the creative behaviors in design creativity. This ultimately enhances design creativity process and result in increase in production of creative designs of products (Atkinson, 2018). All these impacts can be discussed and evaluated under the light of creative cognition approach. From the above discussion, we can conclude that use of creative behaviors has significant mediating role between engineering education and design creativity process in universities and colleges in Malaysia. We can generate the following hypothesis:

H 3: Use of Creative Behaviors has significant mediating role between Engineering Education and Design Creativity in colleges and universities in Malaysia.

Research Model



III. Research Methodology

Population and Sample

This proposed study is about observing the importance of engineering education for design creativity, in mediating role of creative component and creative behavior. Population of study in this proposed study is Malaysia and the sampling frame consists of the Limkokwing university of creative technology, IATC College and UCSI university. Data has been collected from students of these college and university those who have taught about the creative designing. This sample has been selected by simple random sampling technique because data has been selected from those colleges and universities, which taught creative designing that's why almost every student have knowledge about creative components and creative behavior. So, these students can respond well that how the engineering education became inevitable for creative designing. Coming towards sample size, it has been calculated on the basis of idea presented by Klein (2015), which states that accurate sample size can be calculated with the use of formula such as number of questions*10. The sample size 380 has been calculated and it has been considered that it is more suitable for the SEM analysis technique. 380 questionnaires have been distributed between respective respondents but only 320 filled questionnaires have been received. Out of which 299 were considered valid because rest of the questionnaires have been discarded due to the invalid and incomplete responses.

Data Collection Procedure

In this research study, researcher used questionnaire for collecting quantitative responses from respondents. Survey questionnaire has to be composed of two type closed ended questions, first type is demographic questions and second type is variable scaled questions in which researcher asked about the relationship of the variables of study. Researcher conduct pilot study on few numbers of respondents in order to checked that whether survey items understandable by the respondents or not understandable. If respondents felt any difficulty in understanding the items then researcher modified the questionnaire according to the perspective of the involved participants. Moreover, researcher verified the language and content validity of the scales before finalizing the questionnaire. Researcher has been mailed the final questionnaire to the respondents with the help of online software. Moreover, researcher also administered the questionnaire by self-administered technique because it might happen that respondents were unable to understand the specific terms of questionnaire.

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RELIABILITY AND VALIDITY OF MEASURES

Reliability has been evaluated by SPSS and criteria to examine the evaluation are Cronbach's α and composite reliability. According to these criteria, internal consistency and desirable level of items reliability can only be ensured when its values greater than 0.70. Coming towards validity of measures, it has been evaluated by AMOS and three criteria have been examined for the assessment of convergent validity. (1) items loading λ, its threshold range is greater than 0.70, (2) composite constructs reliability, its values have to be higher than 0.80 and (3) average variance extracted, its threshold range is greater than 0.50 because its values were stronger above this specified limit. As far as discriminant validity is concerned, it can only assess by one criterion which states that constructs can only be considered distinct when the square root of AVE for this construct has been greater than all other related constructs.

It is mandatory to evaluate the respective variables of study with different measures if single measure will use for the evaluation then common bias method has been spotted in the study. Researcher faced difficulty in identifying the CBM because corrupt measures contaminate the outcomes of the study. Harman's single factor test is the best suitable option for testing the existence of the common bias method in the proposed study. To run the diagnosis of test, researcher considered all the variables of the study such as engineering education, creative components, creative behaviors and design creativity. According to the test results, not all the variables accounted by single factor, almost 79% of variance accounted for by different factors and 23% of variance accounted for by single factor. Hence, concluded that common bias method has not been existed in the proposed study because 50% of variance not interpreted by single factor.

MEASURES

Different measures have been used for the measurement of the independent, dependent and mediating variable; these measures have already been used by different authors in previous literature. Researcher used following measures in the evaluation of respective variables.

A. Engineering Education

In the proposed study, engineering education act as independent variable, this variable has been measured or evaluated on the bases of 12 questions. These survey questions have been adapted from the earlier research work of (Jarrar & Anis, 2016) on much similar study. In which respondents were asked about the impact of engineering education on design creativity. Out of all these survey questions, one survey question is "Engineering education contributes in enhancing the designing skills of students". Respondents were responded these items in the 5-pointr Likert scale, in which respondents' responses are in range of strongly disagree to strongly agree.

B. Design Creativity

Dependent variable such as design creativity has been evaluated in the proposed study in the bases of 7 survey items. Research studies of (Chang, Lin, Chien, & Yen, 2018) has been take into consideration while developing these survey items. One of the adapted survey items is "Ability to design creative products get enhanced by latest engineering education". Responses of these survey items are in range of 1-5 of 5-point Likert scale. Respondents responses can be 1 strongly disagree or 5 strongly agree, and it might be in between 1-5 range.

C. Creative Component

In the proposed study, four dimensions of creative component such as dominant relevant skills, creativity relevant skills, task motivation and social environment have been measured with 4-items scale, which has been developed from the work of (Amabile, 2012) in previous literature. One of these survey items is "I can handle the materials and assemble parts using the basic tools". These survey items responses have been measured in scale such as 5-point Likert scale, in which 1 refers as strongly disagree and 5 refers as strongly agree.

D. Creative Behavior

For the measurement of the four dimensions of creative behavior, researcher of this study has been used 4 survey items. Out of these four survey items, one is "I feel happy designing and crafting creative products". The items measures have been adapted from the research work (Ajzen, 1991), because his research study is much related to the proposed study. 5-point Likert scale has been taken into account for the measurement of responses, as it record the responses in range of 1-5, in which 1 considers as strongly disagree and 5 considers as strongly agree.

HYPOTHESES TESTING

For the reporting of acceptance or rejection status of hypotheses, researcher has to checked the relationship among them because if hypothesis is positively related the hypothesis get accepted but if hypothesis is negative related then hypothesis get rejected. For this reason, hypothesis testing has been performed by using structure equation modeling under AMOS. Path analysis of structure path model has been performed in two basic steps, firstly standardization of path has been checked and secondly, significance of influenced path has been verified. Afterward, it has been reported that which hypothesis get accepted or which hypothesis get rejected.

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IV. Empirical Findings

The current study examined the impact of engineering education (EE) on design creativity (DC) and the mediating roles of creative components (CC) and creative behaviors (CB) in this relationship by collecting and analyzing valid data of 299 responses. These 299 responses were selected for analysis after screening out the blank, missing and invalid responses. 175 out of 299 responses were reported by female respondents while 124 out of 299 responses were filled by males. 48.2 percent respondents were post-graduated, 40.8 percent respondents were having qualification of Masters, 7.7 percent respondents were graduated and 3.3 percent respondents were having other qualifications. The age of 82 percent of respondents was ranging from 21 to 30 years, 14 percent of respondents was ranging from 31 to 40 years, and 3 percent of respondents was ranging from 41 to 50 years. However, there were only 0.7 percent respondents who were older than 50 years.

1) *Descriptive Statistics*

The descriptive analysis was performed to check the adequacy and normality of the data of all four studied variables of this study. The "means, minimum statistics, maximum statistics, standard deviation and skewness" of DC, CC, CB, and EE have been provided in table 1.

Table 1
Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
EE	299	1.00	5.00	3.4451	1.10199	-.617	.141
DC	299	1.00	5.00	3.5991	1.06612	-.895	.141
CC	299	1.00	5.00	3.5594	1.12850	-.760	.141
CB	299	1.00	5.00	3.5828	1.11034	-.820	.141

Results of descriptive statistics are clearly indicating that this data is in position to be used for further analysis because its normality and adequacy have been proved. There exists no outlier in the data because means for all four variables are falling around 3 and 4 that are between their minimum (1) and maximum (5) values. The minimum values and maximum values are also confirming that there is no extreme value in the data because 1-5 is the rating scale at which each variable has been measured. The skewness of EE, DC, CC and CB are -0.617, -0.895, -0.760, and -0.820 respectively that are all ranging from -1 to +1. Not a single value of skewness is beyond the acceptable range so, the normality and adequacy of the data is proved.

2) *Convergent validity and Discriminant validity*

After checking the descriptive statistics, the convergent and discriminant validity of the data were checked by using key indicators of CR, AVE, MSV and correlations. Table 3 is showing the convergent validity of the current data.

Table 3
Convergent Validity

	CR	AVE	MSV	Max R (H)
CC	0.939	0.793	0.372	0.940
EE	0.917	0.780	0.250	0.984
CB	0.937	0.788	0.360	0.987
DC	0.923	0.743	0.372	0.990

The CR for CC, EE, CB, and DC are 0.94, 0.92, 0.94 and 0.92 respectively that are all >0.7 which is the threshold value. The AVE for all these variables is >0.5 and the MSV is less than its respective AVE. The values of Max R(H) are also meeting the threshold value because they are all >0.9 so, the convergent validity and internal consistency of the data has been proved. Table 4 provides the results about discriminant validity.

Table 4
Discriminant Validity

	CC	EE	CB	DC
CC	**0.890**			
EE	0.391	**0.883**		
CB	0.600	0.445	**0.888**	
DC	0.610	0.500	0.528	**0.862**

It can be seen in table 4 that CC, EE, CB and DC all have highest correlations with themselves as compared to their correlations with any other variables of the study. Hence, the discriminant validity of the data has also been proved.

3) *Confirmatory Factor Analysis*

The model fitness was assessed through CFA indicators that have been provided in table 5 along with their threshold ranges.

Table 5
CFA

Indicators	Threshold range	Current values
CMIN/DF	Less than or equal to 3	2.116

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GFI	Equal or greater than .80	.870
CFI	Equal or greater than .90	.964
IFI	Equal or greater than .90	.964
RMSEA	Less than or equal to .08	.061

It is obvious from table 5 that observed values of all key indicators for the current model containing DC, CB, CC and EE are satisfying the standard values so, the current model is said to be fit. Figure 1 represents the screenshot of CFA taken from the AMOS during analysis.

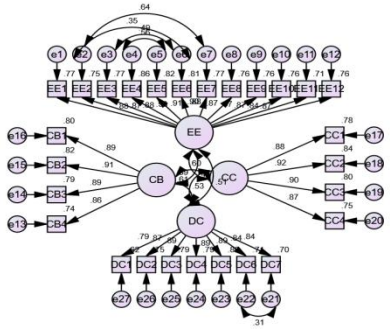


Figure 1
CFA

4) *Hypotheses Testing*

The current study checked the hypotheses by running "structural equation modeling" (SEM) on the collected data. SEM helped the researcher to estimate total and direct as well as indirect effects of EE on design creativity as provided in table 6.

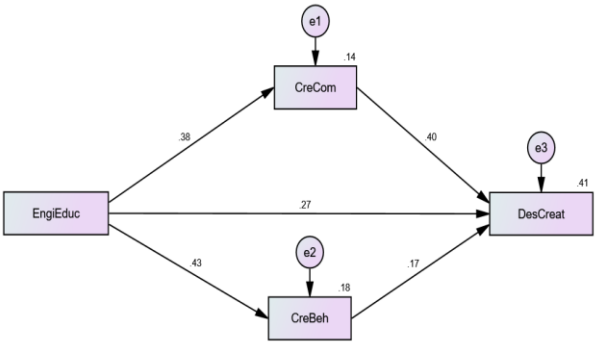
Table 6
SEM Results

Total effect	EE	CB	CC
CB	.429***	.000	.000
CC	.376***	.000	.000
DC	.498***	.174**	.402***
Direct effect	EE	CB	CC
CB	.429***	.000	.000
CC	.376***	.000	.000
DC	.273***	.174**	.402***
Indirect effect	EE	CB	CC
CB	.000	.000	.000
CC	.000	.000	.000
DC	.226***	.000	.000

Note: *** indicates p-value <0.001, ** indicates p-value<0.01, * indicates p-value <0.05.

It is quite clear from table 6 that all hypotheses of this study have been significantly supported by the results because the positive and significant impact of EE on DC has been found along with significant mediation of CB and CC between EE and DC. The total impact of EE on DC is 49.8% (p-value<0.001) however, this effect has been divided in direct and indirect effect of EE on DC. The inequality of direct and total impact of EE on DC is showing some sort of mediation which is played by creative behavior and creative components because they are significantly and positively influenced by EE and then, they significantly and positively influence the DC. Hence, the EE has been proved as a significant predictor of DC and CB and CC have been proved as significant mediators between EE and DC. Figure 2 provides the screenshot of SEM run on AMOS.

Figure 2
SEM



V. Discussion

The aim of the current study was to know about the impact of engineering education, which provides a company with a ability of professional practices of engineering and provides the company with the ability to perform activities to stay ahead in this ever changing era of innovation and competition that how it can significantly contribute to enhance the design creativity (Abele et al., 2015). The study also aimed to know about the mediating impact that use of creative components play between engineering education and design creativity (Martin, 2015). The study emphasized the mediating role of creative behavior between engineering education and design creativity. The study was conducted by collecting data from 240 eighth-grade students including 130 boys and110 girls

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from a public junior high school in Taipei, Taiwan. The collected data was analyzed and then it was exposed to different testing techniques (Bucciarelli & Kuhn, 2018). The results of the analysis will be discussed along with the evidences from the past in this section one by one. The first hypothesis proposed by the present study was that, "Engineering education has a very significant and positive impact on design creativity." This hypothesis is accepted according to the study of (Chao, Chen, & Chuang, 2015), it was concluded that engineering education involves the education of the incorporation of innovative and creative abilities which can bring in competitive advantages even if the employees are trained and given engineering education it becomes possible to instill creativity in them (Newstetter & Svinicki, 2015). Moreover, such employees enforce the implementation of creative ways performing tasks so it can clearly be concluded that engineering education is the factor which promotes design creativity (Martínez-Núñez, Fidalgo-Blanco, & Borrás-Gené, 2015). The second relationship that was discussed in this study was that, "Use of creative components has a very significant and positive mediating role between engineering education and design creativity." This hypothesis is accepted as well keeping in view the conclusion of the research work of (Devadiga, 2017), as it is stated that thinking out of the box and the use of creative ideas in order to achieve success in a certain task is the thing which promotes, instills and increases the creativity in a person. It can be concluded from this perspective that if unique and creative components and ideas are utilized, a person can develop creative way of accomplishing short- and long-term goals and this enhances the impact of engineering education on design creativity (Lima, Andersson, & Saalman, 2017). The fourth hypothesis proposed was that, "The mediating role of creative behavior is significant and positive between engineering education and design creativity." This hypothesis is accepted as well because when a person adopts and continues to use creative ideas for the accomplishment of different tasks, according to the research work of (Horváth, 2016), this person will better be able to design creatively and will be able to pursue his goals with a creative approach. This study and past studies as well, support the school of thought that in order to instill or enhance someone's creativity, a creative behavior and a creative approach to even the minute tasks is important, so creative behavior significantly and positively mediates between engineering education and design creativity (Karabulut- Ilgu, Jaramillo Cherrez, & Jahren, 2018).

VI. Conclusion

The aim of the current study was to know about the impact of engineering education, which provides a company with a ability of professional practices of engineering and provides the company with the ability to perform activities to stay ahead in this ever changing era of innovation and competition that how it can significantly contribute to enhance the design creativity. The study also aimed to know about the mediating impact that use of creative components play between engineering education and design creativity. The study emphasized the mediating role of creative behavior between engineering education and design creativity. The study was conducted by collecting data from 240 eighth-grade students including 130 boys and110 girls from a public junior high school in Taipei, Taiwan. The collection of data was through a creative assignment and use of relevant scales. The collected data was analyzed and then it was exposed to different testing techniques. A confirmatory factor analysis was done and structural equation model was used to analyze the data. The results clearly explained that there exists a very positive and significant relationship between engineering education and design creativity. Use of creative components mediate significantly and positively between the engineering education and design creativity. Moreover, there is a significant and positive mediating role of creative behavior between engineering education and design creativity.

VII. Implications of the Current Study

This study has made various contributions to the world of research. Most importantly this study has contributed very significantly to the theoretical importance of design creativity, use of creative components, creative behavior and engineering education. The study has highlighted that how all of these are important for the national competitiveness, industrial competitiveness, and personal development. The study has also encouraged the implementation of these variables practically as it will only make a person able to think out of the box and take out an idea when all the dull minds will stop their processing. This study has highlighted the importance of the fact that how government should implement the compulsion of engineering education of at least a very basic level so creativity and innovation can be instilled in every individual for the purposes of national growth and competitiveness.

VIII. Limitations and Future Research Indications of the Study

This research lacks the theoretical model regarding creative components, so the future researchers are encouraged to incorporate such model in their research work and the aspects of creativity should be elaborated individually then. Moreover, in future, rather than only collecting data, training sessions with the teachers and students can also be included as a part of the research conduction as well because teachers require awareness of the fact that they need to implement such

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systems in their teaching methods which involve creative approaches and which will instill creativity in the growing minds. Future researchers are recommended to fill these gaps by conducting a study on the suggested patterns.

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