An Investigation on Aesthetic Acknowledgment and Adaptation in Product Design Process among Engineering Students in Malaysian Universities

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Abstract*: An ongoing issue in product design is the argument between form and function, which corresponds to the preference between the consideration of aesthetic appraisal of product shape variations and the product's utilitarian functions. Product design is an essential element in both engineering and industrial design programs but, as demonstrated by the comparison of the practices in both programs, they have very different approach of the design process. Engineering programs often emphasize more on the functional aspects during designing of a product and the aesthetic considerations are typically neglected. The primary focus of this study is to evaluate the capability of engineering students to recognize aesthetic element as product stimuli. To achieve this goal, a survey is conducted among engineering students in Malaysian universities. From the obtained survey responses, it has been concluded that most of the surveyed engineering students are able to recognise and appreciate aestheticallydesigned product. It is also found that they have a balanced knowledge on product design process, both aesthetically and functionally. However, as admitted by most of the respondents, aesthetic element is not being implemented during their product design process. In future research, it would be worthwhile to investigate why there is a lack of and how to encourage adaptation of aesthetic element during the product design process among engineering students.

***Index Terms*: Product Design, Aesthetics Element, Design Process, Design Thinking, Industrial Design Engineering**

I. INTRODUCTION

The argument regarding form and function in product design has been ongoing since these terms are coined by Louis Sullivan in 1896 [1]. Many other researchers and designers have also published their discussions on the matter. Baxter (1995) explains that the product design process is not only about functions and aesthetics (form), but it also involves manufacturing that forms the three vertices of product design triangle [2]. This product design triangle is illustrated in Figure 1. Another similar study demonstrates that aesthetic also can improve a user's perception of product quality [3]. Today, it can be observed that the approaches in product design process can be essentially be divided into two primary school of thoughts: the ones used by designers from mechanical engineering background and those in industrial design background. A study by Jiang (2012) has highlighted the gap in the product design process between these two main groups of designers [4]. The potential effects to the final product design due to communication problems between these industrial design (ID) and engineering design (ED) students have been studied by Rasoulifar et al. (2014) [5].

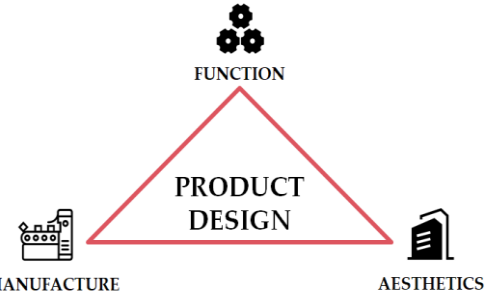

Figure 1: Three vertices of product design triangle

Several proposals have been put forth by researchers to cope with this issue. For instances, Pei et al. (2010) have suggested a card system to resolve the gap [6] while Inoue et al. (2017) have introduced visual reasoning method between groups of designers and non-designers to harmonise the process [7]. Furthermore, Beh (2012) has proposed taking the advantage of visual communication (VC) when delivering information between ID and ED students [8]. The study presented in this paper is focused on ED students and their consideration of aesthetic factors in designing a product. From previous researches, it is concluded that ID students emphasize aesthetics in design more in comparison to ED students. The aim of this research is to investigate the level of knowledge and also appreciation regarding aesthetics among the ED students, and their implementation or adaptation of aesthetics in design projects. The outcomes from this study will facilitate the planning on how to increase the understanding and adaptation of aesthetics elements among ED students in product design process.

II. METHODOLOGY

The methodology followed in this study is summarised in the flowchart in Figure 2.

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The key element in this methodology is the survey instrument that is developed based on the aim of this study. The survey is divided into two main sections.Section1is designed to assess the theory and knowledge of the survey respondents regarding design process of a component or product, also including the aesthetic theory as well as its tools usage. Meanwhile, Section 2 has been tailored to verify the respondents' ability to recognise a product's functional and aesthetic using visual stimulates. In this case, two pictures of water faucet are utilized as the stimulants. On top of this, more detailed questions are also asked to the respondents in orderto determine their ability to recognise design quality, product appeal and innovation level. For this purpose, the survey participants are asked to evaluate the product samples based on the design questionnaire and Likert-style technique [9]. The survey responses are then analysed and summarised to derive some conclusive remarks from them.

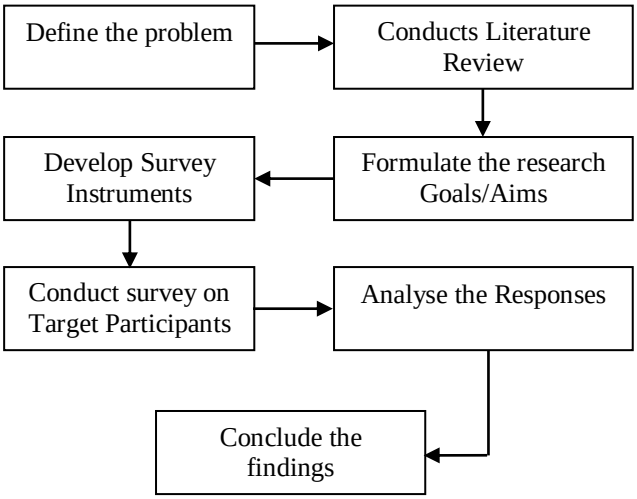

Figure 2: Research flow for this study

A. Survey Participants

The targeted participants for the survey in this study are people who have been formally taught on the process of designing a product or component in their degree program. The mode of participation in the survey is on voluntary basis and overall, a total of 166 survey respondents have been obtained among engineering students from several institutions of higher learning in Malaysia: Universiti Putra Malaysia, UniversitiTunHussien Onn and UniversitiTeknikal Malaysia. The respondents' age ranges from 21 to 25 years old, with 95 of them are males and 71 are females. They are all expected to have a similar level of design experiences with each other.

B. Procedure

First section of the survey instrument requires the participants to reveal their education background related to the topic. The questionnaire form is set in random order to ensure that all participants stay focus on the topic throughout the duration of the survey process. In this section, they are given 'Yes' or 'No' questions regarding their academic program requirements to design a product or at least a component. The questions then proceed to assess their knowledge about the aesthetic elements in product design and the application of any aesthetic methods or tools in their product design process.

In the meantime, second section of the survey questionnaire is centred on a pair of visual stimuli. Participants are asked to answer some questions based on two photos of water faucet as depicted in Figure 3. They are requested to identify the usability and aesthetics of each product. Moreover, the participants are also asked to rate their aesthetic appraisal of all stimuli on a 5-point Likert scale. The participants' ability to properly select their preferences on product appeal, design quality and innovativeness is then assessed and analysed.

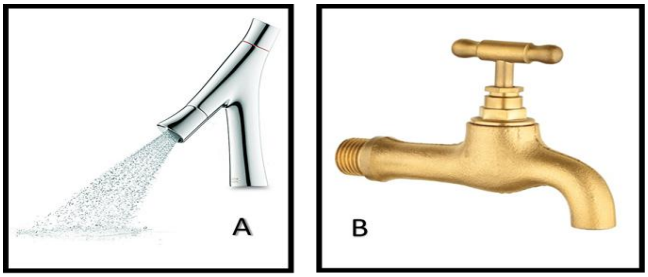

Figure 3: Faucet stimuli A and B

C. Analysis Approach

Since the rating based on a Likert scale is ordinal data, common parameters such as mean and standard deviation are invalid as they are parametric analyses based on the normal distribution [10]. Therefore, the median is adapted as a measure of central tendency. It is the number found exactly in the middle of the distribution. The median can be calculated using Equation 1, where n is the number of terms.

$$Median = \frac{\left(\frac{n}{2}\right)^{th} term + \left(\frac{n}{2}+1\right)^{th} term}{2} \qquad (1)$$

In the meantime, the inter-quartile range (IQR) is selected as a measure of the data spread, which can be calculated using Equation 2, where n is the number of terms, Q1 is the first quartile and Q3 is the third quartile. Both Q1 and Q3 can be found using Equation 3 and Equation 4, respectively. By calculating the value of IQR, it can be indicated whether the responses are scattered across the range or clustered together. Subsequently, this is taken as a reflection on how strongly the respondents agree with each other. It should be noted that the Likert scale applied in this study is a 5-point rating scale.

Please bear in mind, in order to calculate the value, Likert scale is given 5-point scale. The details of the formulation as following below. It can show whether the responses are scattered across the range or clustered together in the sample responses. So, how strongly respondents agree with each other can be obtained.

$$IQR = Q_3 - Q_1 \qquad (2)$$

$$Q_1 = \left(\frac{(n+1)}{4}\right)^{th} term \quad (3)$$

$$Q_3 = \left(\frac{3(n+1)}{4}\right)^{th} term \quad (4)$$

The median and IQR can be represented using Box-and-Whisker plot, which is a graphic representation of the data including centre, spread and skewness from the median, first quartile, third quartile data set. It helps to visualise and compare the differences for each of the factors.

III. RESULTS AND DISCUSSION

The first comparison is made from the obtained usability ratings. As shown in Figure 4, the participants are clearly able to understand the function of the stimulated photo (water faucet) with 97% correct responses. It is believed that the remaining 3% wrong responses are most likely due to negligence or mistake while answering. Based on these responses, it can be deduced that the functionality of the product is clearly understood, which is as highly expected. Furthermore, as also depicted in Figure 4, 74.1% of survey participants have preferred Product A compared to Product B as a more pleasant design. This means that slightly more than a quarter of the participants preferred Product B, which is still a considerably large group. Different preference between these two groups of respondents is believed to be influenced by their ability to judge aesthetic elements in design.

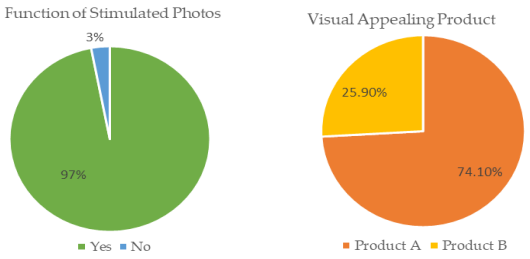

Figure 4: Pie charts for functionality and product appeal

From the results, it has been shown that there is a large effect in designing products with only functional considerations without aesthetic design appeals as represented by Product B that has been rated lower in preference compared to Product A that appears to be more sophisticated in design. This finding is consistent with the expectation that the product's design features and aesthetics relate to each other when an overall judgement is made on the product. As shown by Figure 5, most of the respondents are familiar with designing products or at least designing a component. This is reflected by the 91.6% affirmative responses when they are asked: "Do you design product/component in your current course in college?" It is thus assumed that most of the survey participants already had formal lectures in design during their study. In addition, the respondents are also asked regarding design theories that they have learned during their engineering program. As shown in Figure 5, 66.3% of them have admitted to having exposure on the theoretical knowledge of aesthetic aspect in product design process. Although it is preferred to have all respondents to have such exposure, the percentage is considered appropriate for the intent of the conducted survey.

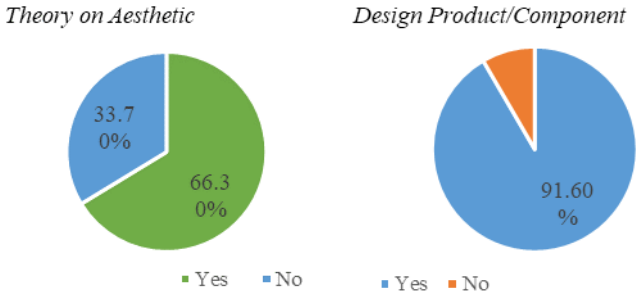

Figure 5: Pie charts of design experience and aesthetic knowledge

Nonetheless, as can be clearly implied by Figure 6, the adaptation rate of aesthetic design knowledge is very low from the obtained responses. Only 24.7% of the participants have adapted or considered aesthetic element when they are designing a product, which is less than a quarter of the total survey respondents. The remaining 75.3% or 125 people seem to ignore this essential design element in their practice. This realisation motivates further investigation as to why this situation happened.

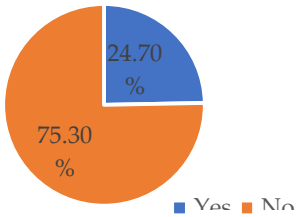

Figure 6: A pie chart of aesthetic design tool adaptation

On the other hand, for the second part of the conducted survey, it is important to ensure that the assessment of both Product A and Product B can be done in a fair and objective manner to prevent any biased analysis. Likert scale is applied in this study since it is the common rating format for surveys that can be used to measure the respondent's attitude towards particular question or statement. It is also good to note that Likert scale produces ordinal data in which an ordering or ranking of responses can be done but no measure of distance is possible to derive. Hence the best representation of the distribution of obtained responses is by using bar chart.Figure 7 shows the responses of survey participants regarding aspect of design quality. It can be observed that responses for Product B essentially follow a normal distribution where most of the respondents have given it a "neutral" rating (i.e. 96 out of 166). On the contrary, the distribution of responses for Product A is heavily skewed to the left where most respondents ranked it as a "good design" (i.e. 99 out of 166). Based on these results, it can be said that a clear preference towards Product A has been established.

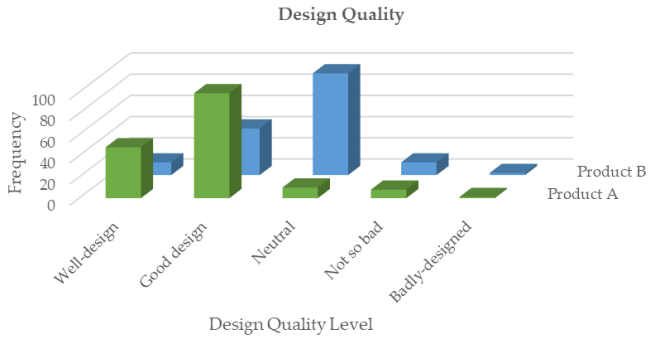

Figure 7: Bar graph for design quality comparison

The same data in Figure 7 is presented again in Table 1 for more in-depth analysis. Here, it can be observed that the preference of the respondents is very clear. The median (i.e. $\bar{x}$= 83) for Product A is in the "good design" category that is better than for Product B, which is in the 'neutral' region. IQR for Product A also lies in "good design" level whereas that for Product B spreads in 'good design' and 'neutral' regions. Therefore, it is clear that the perception of Product A as a "good design" and Product B as more towards a "neutral" design. This is taken to imply that most people perceive Product A as having more design quality than Product B.

Design Quality	Relative Frequency		Percentage		Product A	Product B
	A	B	A	B		
Well-design	0.289	0.072	28.9	7.2	$\bar{x}$ =83	$\bar{x}$ =83
Good design	0.592	0.266	59.2	26.6		
Neutral	0.063	0.578	6.3	57.8		
Not so bad	0.050	0.072	5.0	7.2		
Badly-designed	0.006	0.012	0.6	1.2		

Table 1:Data analysis on design quality

Furthermore, participants are also asked to give a rating based on their first impression for both faucet designs. As depicted in Figure 8, 82 people have rated 'somewhat positive' while 52 people have opted for 'very positive' rating for Product A. This highlights the tendency of the majority that leans towards positive feedback, with a total of 134 out of 166 people have given a positive impression on product A. In the meantime, for Product B, most of the given ratings are "neutral", with 115 out of 166 people have indicated that they are not impressed with the physical shape of Product B. The trend of responses for Product B is relatively not much different with the previous question on product quality. It appears that Product B does not have enough 'wow' factor to impress the participants in comparison to Product A.

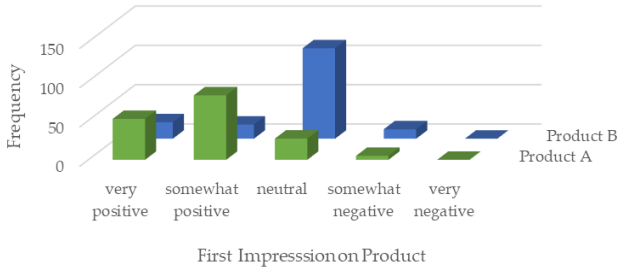

Figure 8: Bar graph for first impression comparison

Table 2 presents the data analysis for the first impression rating. The median (i.e. $\bar{x}$= 83) for Product A falls in the "somewhat positive" level in comparison to that of Product B that falls in "neutral" level. The IQR that indicates the density of preferences for Product A is within the "very positive" and "somewhat positive" levels while that for Product B is in the "neutral" level. This reflects that Product A is receiving more favourable opinion from the respondents, which indicates that its design appeals more to them than Product B. In other words, Product A is more attractive than Product B.

Product Appeal	Relative Frequency		Percentage		Product A	Product B
	A	B	A	B		
Very positive	0.313	0.127	31.3	12.7	$\bar{x}$ =83	$\bar{x}$ =83
Somewhat positive	0.494	0.108	49.4	10.8		
Neutral	0.163	0.693	16.3	69.3		
Somewhat negative	0.030	0.720	3.0	7.2		
Very negative	0.0	0.0	0.0	0.0		

Table2:Data analysis on product appeal

The third assessment on the faucet designs that is asked to the survey participants is the perceived innovation level and their responses are shown in Figure 9. It can be observed that the responses for Product B have been mostly skewed to the negative side. 75 people have rated it as "somewhat innovative", which is the highest frequency of the responses for Product B. There are even few participants who have given it a "not at all innovative" rating. All in all, it can be taken that 140 out of 166 people have indicated that Product B does not seem to have significant innovation in design.

In contrast, responses for Product A have been highly favourable, with the highest frequency response is "very innovative" (i.e. 93 out of 166). The results lean towards the positive side and 162 out of 166 people have agreed that Product A is indeed an innovative product.

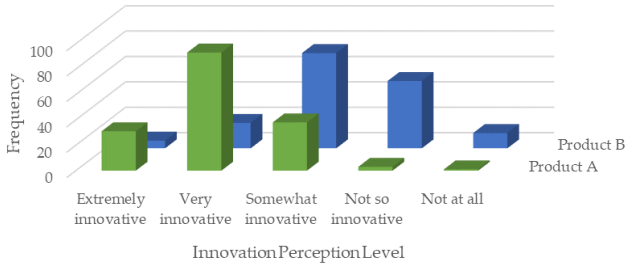

Figure 9: Bar graph for innovation perception level comparison

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As also indicated by the data analysis in Table 3, Product A still maintains its favourable responses from the survey participants against Product B, this time in terms of innovation level. The median (i.e. $\tilde{x}$= 83) for Product A falls in the "very innovative" level and its IQR also lies in the same level. Meanwhile, the median for Product B is in the "somewhat innovative" level and its IQR spreads between the "somewhat innovative" and "not so innovative" levels.

Innovative-ness	Relative Frequency		Percentage		ProductA	ProductB
	A	B	A	B		
Extremely innovative	0.187	0.037	18.7	3.7		
Very innovative	0.560	0.120	56.0	12.0	$\tilde{x}$ =83	
Somewhat innovative	0.229	0.452	22.9	45.2		$\tilde{x}$ =83
Not so innovative	0.018	0.319	1.8	31.9		
Not at all	0.006	0.072	0.6	7.2		

Table 3: Data analysis on Innovation level

Based on the results, it is an evident that Product B has been designed with the utilitarian approach in mind compared to Product A. Most of the participants in this study are able to capture the intent and they also have correctly ranked these two products. This shows that innovativeness in product design can be visually recognised and compared with by most engineering students as supported by the results of this study.

IV. CONCLUSION

This study, which is conducted through a survey, investigates aesthetics considerations in product design among the engineering students. The functionality and design of both Product A and Product B are defined for validation purposes. The respondents, who are chosen among engineering students, have been asked to evaluate Product A and Product B using a Likert scale and their responses are analysed to observe the trend. It can be seen from the collected data that aesthetic factors in product design are clearly recognised by the engineering students. This is reflected by the better opinions received by Product A in all three key aspects that are surveyed from the respondents. The findings highlight the gap that exists between recognising aesthetically designed product and adapting such approach in product design process among engineering students. They appreciate well the product design aesthetics but do not implement such consideration when designing a product themselves. As the conclusion for this survey, there is an irony among engineering students between acknowledging a good designed product and practising it. For future work, it is interesting to understand why there is a lack of and how to encourage adaptation of aesthetic element implementation during product design process among them.

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