

USE OF THE MODIFIED DELPHI TECHNIQUE TO DEVELOP ELEMENTS OF QUALITY PRODUCT DESIGN CONCEPT BASED ON COMPUTER AIDED DESIGN (CAD)

**BAHARUDIN SALEH, MOHAMAD SATTAR RASUL*,
HARYANTI MOHD AFFANDI**

Faculty of Education, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia

*Corresponding author: drsattar@ukm.edu.my

Abstract

Product Design is a transformation process of an idea about a product into an actual product. The process needs an explicit specification to sustain the quality of the product design. One of the design processes will apply computer-aided design (CAD) software to produce technical documentation. Therefore, identity establishes elements of the quality product design concept is needed to improve Malaysian design and technology trainees teacher. The modified Delphi technique has been conducted on 16 panels of experts, which invited from Malaysian Teacher Training Institute, local university, and industries. The expert committees answered the questionnaires given. The questionnaires applied Likert scale with five options (ranking from very important to very unimportant) for each statement. There were three rounds of modified Delphi surveys. The experts' committees rate 21 predetermined elements of quality product design based on CAD. However, the expert committee discusses and to add more elements of quality of the product design. Through the survey and discussion, the final finding show 22 elements of quality product design concept based on CAD has reached consensus. These elements will help to standardize the product design concept and assist Malaysian design and technology trainees' teacher in producing quality product design.

Keywords: CAD, Design concept, Modified Delphi technique, Product design, Quality product design.

1. Introduction

The conceptualization on the product design was given a high impact positively in the market nowadays. The product design is now entering the industrial revolution 4.0 (IR4.0). The product designs were expanding the entire world and become the important production of the human needs. Hence, the systematic planning is required for the creation of a quality design [1]. The product should be designed with the standard elements [2]. It can reduce costs and improve the product quality if follow the standard design procedures [3]. Thus, the manufacturing industry also needs to adopt procedures standard to increase the production and minimize the costs but can produce variation of product design [4].

Product design process is important to attract consumers to purchase the products [5]. This is also will create loyal consumer when the quality of product been applied [6]. The high-quality designs depend on product features e.g., aesthetics, ergonomics [7], colours, design shape, functionality [8], safety, and others affecting to the user's choice of products [9]. The manufacturing industry is continuously striving to produce products that deliver in high quality. Hence, every personnel in the manufacturing organization need to ensure that the quality of a product must be on excellent level to avoid defects product in the manufacturing process [10].

The feedback of customers on attractive design and convenient to use with a reasonable cost also become the factors on a quality design product [11, 12]. Backhaus et al. [13] argue that it is quite challenging to convert consumers' perceptions into effective designs. To address the problem of product, the design concepts should be refers to the consumer tastes, and listen to the consumer voice [14]. The innovation elements also play an essential role in stimulating creative ideas in product designs [15].

The purpose of this study is to develop elements of quality product design based on CAD to prepare the students, which lacked of soft skills, such as critical thinking, communication, and innovation [16]. During the product development stage, it requires a sustainable ecosystem of innovation, which is a somewhat tricky element to implement. Supported data from the analysis report on student coursework of Design and Technology in the subject of Computer Aided Design (CAD) shows that 65% of students weak on the aesthetics such as product features, product finishes, and product functions. Another 55% of students did not mastering on the ergonomic element encompassing the characteristics of product comfort to consumers and functionality of the product. While 60% of students were unclear in the initial idea development such as finding information on products to be designed and translated in the form of idea sketches on product characteristics [17]. Synthesis activities with problem-solving elements are also essential to highlight creative ideas in the process of designing a product that meets the needs of consumers [18].

2. Product Design Concepts

Incremental thinking can trigger the idea of producing a product design and innovation with a systematic process [2]. The design process will involve creative ideas and problem-solving where is the most critical process because the product to be produced must meet consumer demands [18]. In this study, several

constructs to provide quality products have identified. The first aspect to identify for design requirements is analysis the consumer problems experience through in-depth studies conducted by the designers [19]. The second aspect is concerning on product design specification study through the preliminary survey [20]. According to Jalil [21] stated that designer should understand the details of the problem especially to do innovation on the existing product. The product design process also involves discussions on various product designs with brainstorming activities, the addition of the creative ideas with the problem-solving methods [22-24].

These ideas development were triggered in abstract visualized in the student mind thinking. The continuation of the importance of idea-setting of product design concepts can become the result of a conceptual idea [25]. After identifying the ideas, the next step is to design a concept by combining visual thinking and creativity that is an essential element in the design process [26]. Conceptual and concept-based sketches will evaluate through the Methods of Assessment based on the Metric Assessment Table (MST) [19, 21]. According to the Weighted Assessment Table (WAT), the selection of a final concept design will translate into sketches and can make improvements in the same time [19, 27]. Therefore, it shows that sketches is one of the important procedure in design process.

Meanwhile, the first aspect in CAD three dimensional modelling (3D), which emphasizes on the features, sizes, colours, finishes and dimensions of the products [19, 28]. The second aspect is the detail drawing of the product design, which can illustrate the details of each component. The details of each element may indicate essential product features such as draw on a scale [29, 30], and essential dimensions of the product [31]. The CAD software application will apply the detailing of product design especially display in 3D images [32].

3. Research Methodology

This research use a Modified Delphi technique to explore the elements that contribute of Quality Product Design Model based on Computer Aided Design (CAD). In this research, a structured questionnaire based on the systematic review with the practical screening of articles was utilized in the first round of survey [33]. After that, several rounds of additional surveys were conducted to determine the quality product design based on CAD, which focusing on the Technical Teacher Training Institutes. The samples involved 16 experts including Teacher Training Institutes Lecturer, university lecturer and engineer from industries, who identified them according to their five years of experience in teaching and designing product.

The identified processes by the panel of experts' were approached through via email and face-to-face meetings. In initial collaboration, the researcher explained the purpose and the design concept, which included the several rounds of surveys. The first round survey consisted of 6 parts: questions that required experts to rate their knowledge's on the predetermined important of quality product design concept gathered from systematic review and open-ended question. The researcher also asked the panel of expert to add any proposal or new suggestion to increase the quality of the product design.

In the second survey, the panel of experts were required to revise the conflict important elements (important that received mean ≤ 4.00 , mode ≤ 4.00 , Standard Division (SD) ≥ 1.00 and Inter Quartile Range (IQR) ≥ 2) and rate new important elements from the first round survey. Meanwhile, in the third survey, the experts revised the conflict significantly, and rate again the important elements of identify quality of design from the second survey. Likert scale with five options (ranking from very important to very unimportant) was applied in closed-ended questions in both rounds of the survey. The descriptive statistics were applied to analyse the research data. Consensus was determined when the important received mean ≥ 4.00 , mode ≥ 4.00 , Standard Division (SD) ≤ 1.00 [34-36] and Inter-Quartile Range (IQR) ≤ 2 [36, 37] scores. The survey will be conducted for several rounds until the entire important consensus been predetermined and additional important elements by the experts has been determined.

4. Results

The result from first round survey shows that 18 predetermined elements of quality product design concept received with high consensus ratings and three predetermined of quality product design concept received no consensus level. The following three quality product design elements received with no consensus (the tasks not meeting pre-determined consensus criteria mean ≥ 4.00 , mode ≥ 4.00 , SD ≤ 1.00 and IQR ≤ 2) from all 16 experts were: i. setting product design features, ii. generate new product design concept different from other idea and iii. create 3D sketches using a computer. These three elements were eliminated from the item survey.

In the comments and open-ended section of the first round survey, the expert panels were asked to comment, "Proposed product design requirements in terms of producing product concept design against product quality improvement." Based on the analysis, the expert panels suggested four new elements were carried forward to the second and third round survey. The following four elements were: i. ergonomic aspects of product design, ii. aesthetic aspects of product design, iii. colour aspects of product design and iv. safety aspects of product design.

The researcher omitted the quality product design concept elements achieve the pre-determined consensus criteria mean ≥ 4.00 , mode ≥ 4.00 , SD ≤ 1.00 and IQR ≤ 2 in the first round and second round survey. Therefore, only four new elements of quality product design concept were included in the second round and third round survey. The result of the second and third round survey shows that four new elements of quality product design concept meeting pre-determined consensus criteria mean ≥ 4.00 , mode ≥ 4.00 , SD ≤ 1.00 and IQR ≤ 2 . Based on the final analysis, the panel of expert identified 22 elements of quality product design concept based on CAD. The elements were listed in Table 1.

Table 1. Quality product design concepts elements.

No. of Survey	Elements	Criteria of Consensus				Level of Consensus
		Mean	Mode	SD	IQR	
First Round	Ideas of product design	4.63	5	0.619	1	High
	Product design ideas using checklist.	4.63	5	0.500	1	High
	Setting product design features.	4.56	5	1.031	0.75	No Consensus
	Generating creative ideas	4.31	5	0.873	1	High
	Produce design concepts	4.38	5	0.719	1	High
	Combine existing ideas for new design	4.5	5	0.632	1	High
	Generate new product design concept different from others idea.	4.13	5	1.147	2	No Consensus
	Lists idea of conceptual product design	4.5	5	0.894	1	High
	Communicating in groups	4.38	5	0.855	1	High
	Combining visual thinking and sketches.	4.56	5	0.512	1	High
	Free-hand sketches	4.44	5	0.727	1	High
	Create 3D sketches using computer	4.56	5	1.094	0	No Consensus
	Produce external appearance sketches	4.5	5	0.632	1	High
	Produce design sketch of parts	4.5	5	0.632	1	High
	Generate detailed sketches	4.5	5	0.730	1	High
	Applying a matrix assessment table in the selection of product design.	4.5	5	0.632	1	High
	Apply the problem solving methods in the Selection of product design.	4.50	5	0.632	1	High
	Determining factors of weighted importance of product design criteria.	4.63	5	0.619	1	High
	Select the end design concept based on weighted importance criteria number.	4.69	5	0.479	1	High
	Choose best design ideas using the selection chart and decision matrix.	4.31	5	0.793	1	High
Improvement of the end design concept	4.63	5	0.5	1	High	
Second Round	Ergonomic aspects of product design.	4.69	5	0.479	1	High
	Aesthetic aspects of product design.	4.5	4	0.516	1	High
	Colour aspects of product design.	4.63	5	0.5	1	High
	Safety aspects of product design.	4.69	5	0.602	0.75	High
Third Round	Ergonomic aspects of product design.	4.81	5	0.403	0	High
	Aesthetic aspects of product design.	4.69	5	0.479	1	High
	Colour aspects of product design.	4.25	5	0.775	1	High
	Safety aspects of product design.	4.87	5	0.352	1	High

Notes: SD=Standard Division, IQR=Inter Quartile Range

5. Discussion

Product design is the idea concept of a product that transforms the ideas into the real products. Therefore, to convert the concept into reality, a specification of the product must be prepared. This specification is developed by considering the customer expectation. After that, analyse final product design concept process for the final decision. This decision can be associates in any aspect related to the product including the dimensions, colours, and safety. After identify the final concept, the detailing design process will be apply to ensure that the primary features such as sizes, colours, packaging's, and dimensions will be applied in the design process [19, 28].

This consensus by panel of expert, which similar with Tayal [2] mentioned the design process also involve with exploration of critical thinking, make comparison and analyze the various designs due to create quality of the product design. According to Taib and Hanafiah [20] and Jalil [21], mentioned that after identify the design problems including the aesthetics, ergonomics, colours, and safety, the

detailing methods of settlement should implement during the design process. This design problem is in line with the findings of the consensus of a panel of experts in the elements study for identify the design problems and apply the problem-solving method in the process of product design information study. The panel of experts also agreed with the survey by Ilevbare et al. [22] and Jin and Li [24] that the product design process also involves with the discussions on various product designs with the brainstorming activities, adding creative ideas with problem-solving methods.

This finding also supported by Choo et al. [25] statement that the design concepts can trigger by the addition of ideas and critical thinking to the systematic processes [1]. The importance of design elements in the perspective of trainee teachers such as making free-hand sketches and make improvement based on final concept selection can trigger the idea of the development of the design process stage [26]. It also can be evaluated it into the final concept, which will meet the specification of the product design process [19, 21].

The panels of experts agree that the design and technology trainee teachers should be focused into the design features such as ergonomic, aesthetic, colour and safety during the product designing stage. Hence, the design features will be the benchmark of the quality product design concept that's teacher trainees should be able to select and make an improvement on the end product.

6. Conclusions

This study identified 22 elements will applied to produce the quality of the product design process and usually will involves the ideas exploration. This could be a range of many different styles and methods of design process. Occasionally, the idea may have been planned out with the form selection. The guideline also meant to accomplish by following: 1) focused on design features such as ergonomic, aesthetic, colour and safety, 2) analyze any possible design concept early on product design ideas thrive with the best design and 3) all product design concepts the exact requirement and output will be tailored to the on-going design.

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