Online at www.e-iph.co.uk

Indexed in Clarivate Analytics WoS, and ScienceOPEN

E-B Environment - Behaviour Proceedings Journal

KICSS2024

Kedah International Conference on Social Sciences:

https://kicss2024.wixsite.com/kicss2024

e-IPH e-International Publishing House Ltd., United Kingdom

IC2reDIT: International Conference On Creative Design, Innovation & Technology

Virtual Conference, 23 & 24 October 2024

Organised by: Universiti Teknologi MARA, Kedah, Malaysia

Analysing Aesthetic Values in Product Design: Role of design components in enhancing CAD education

Indera Irawan[1*], Leong Kooi Hoong[1], Astri Yulia, Nazlin Hanie Abdullah[3]

**Corresponding Author*

[1] Faculty of Design and Built Environment, First City University College (FCUC), Bandar Utama, Selangor, Malaysia, [2] Faculty of Education and Social Sciences, Selangor University (UNISEL),Bestari Jaya Campus, Selangor, Malaysia, [3] Faculty of Engineering & Life Sciences, Selangor University (UNISEL), Bestari Jaya Campus, Selangor, Malaysia

indera.chandran@firstcity.edu.my, kh.leong@firstcity.edu.my, dr.astri@unisel.edu.my, nazlin@unisel.edu.my
Tel: +60132041503

Abstract

Understanding consumers' aesthetic preferences is critical to improving product design performance. This study dives into the aesthetic elements, with a particular emphasis on product design requirements (PDR), product design ideas (PDC), product design detailing (PDD), and product design assessments. The study reveals the critical impact of shape and color as mediating elements that increase the importance of PDC in influencing aesthetics, followed by PDD, PDE, and PDR. By explaining these correlations, the study provides valuable insights for educators in the field of CAD instruction in Technical and Vocational Education and Training (TVET) programs.

Keywords: Aesthetic; Product Design; TVET; CAD.

DOI: https://doi.org/10.21834/e-bpj.v10iSI29.6905

1.0 Introduction

1.1 Research background

The pace of product design development is accelerating. Nevertheless, product design is confined to the national market. Consequently, contemporary product design requires a systematic and painstakingly organized approach to guarantee that each product meets the specified criteria and standards (Baxter, 2017). Ergonomics, color, form, function, and safety should all be considered during the design process and the user's needs (Isa et al., 2014). At the same time, it provides an opportunity for manufacturers to benefit by performing sociological and demographic research on users and offering new technologies. As a result, the design process can create more inventive goods. Product design is a component of the development process of a system that is interconnected with many other fields of research. The setup process is critical to operational styling because it shapes the shape and feel of the product as it interacts with the user. Communication and coordination are used throughout the development process to create, test, modify, and mature the design until it is ready for launch.

Creating the correct product takes time, effort, and money. If the public watches the entire process, they will be astounded by the time and money spent on a new product in the industry. The majority of large corporations that invest in new goods make significant

DOI: https://doi.org/10.21834/e-bpj.v10iSI29.6905

investments in R&D. The right product is not generated at the design stage; rather, it evolves through continuous study, analysis, design studies, engineering, prototyping, experimentation, modification, and additional experimentation until the final design is flawless. Completing this cycle can take anything from a year to a dozen years. Even though the design process is time-consuming and requires several steps, computer-aided design (CAD) can shorten it. CAD can generate engineering drawings and product information. The manufacturer can then design a prototype of the product. Simultaneously, the rapid method allows the manufacturer to produce the new product for the market without sacrificing other design techniques. This study focuses on the Manufacturing Technology (Machining) curriculum offered by Malaysia Vocational College (KVM), which teaches product design procedures to promote local product innovation.

The Ministry of Education (MOE) provides vocational programs in higher education with an emphasis on manufacturing. One of the product design programs is the diploma in industrial machining technology. The program incorporates Computer-Aided Design (CAD) as a key outcome, requiring students to develop a novel product design. Computer-Aided Design (CAD) is essential for effective product development as it allows stakeholders to evaluate designs, detect flaws, and optimise the production process. Consequently, CAD can significantly contribute to ensuring that the newly designed product operates effectively and faces only minor obstacles throughout development.

Meanwhile, Aesthetics is part of the design process, which is usually developed and documented through sketches (Kwon et al., 2018). This helps develop the final idea before proceeding to CAD and prototyping process (Ranscombe & Bissett-Johnson, 2016). That documentation will reflect the designer's or student's critical thinking in problem-solving. Aesthetics also are integral to the design process, usually formulated and recorded through sketches (Kwon et al., 2018). This aids in refining the final concept before to progressing to CAD and prototyping (Ranscombe & Bissett-Johnson, 2016). This documentation will exhibit the designer's or student's capacity for critical thinking and problem-solving. Consequently, cultivating aesthetic sensitivity inside the product design and analysis module is essential for augmenting the Industrial Machinery program. Therefore, learning to develop aesthetic sensitivity in the product design and analysis module is needed to improve the Industrial Machinery programme.

1.2 Problem Statement

The Diploma in Industrial Machinery curriculum at the TVET college is regarded as a technical program. Students ought to create innovative goods for their final assignments. Nonetheless, the majority of technical students exhibit low performance levels and insufficient comprehension of product design aesthetics (Doran & Ryan, 2017). Product design should adopt a human-centered approach in its strategies, processes, and methodologies, leading to new product development, company growth, and alignment with human needs (Dyer, 2019). Consequently, the product's manufacture must prioritise excellent quality, including aesthetics, ergonomics, materials, functionality, and safety (Yehua et al., 2018).

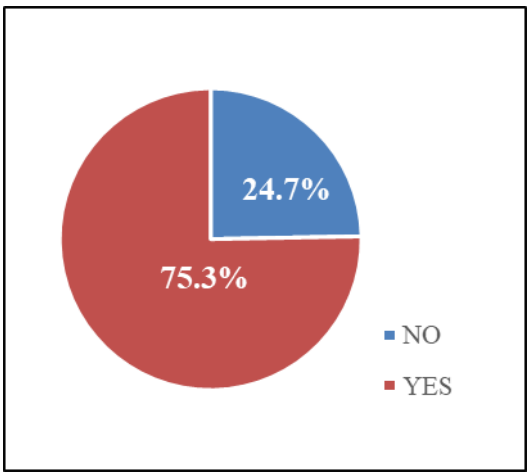

Fig. 1: A pie chart aesthetic design tools adaption

In addition to vocational colleges, comparable difficulties have been observed in other higher education institutions. Saleh (2020) asserts that numerous product designs produced by design technology students at the Institute of Teacher Education (IPG) have a deficiency in sophistication about their aesthetics and packaging. Syukri et al. (2017) contend that engineering students lack solid design concepts that adhere to aesthetic, ergonomic, and creative standards. Becker and Mentzer (2015) characterize creative and critical thinking as the process of honing and condensing imagination into viable concepts while understanding diverse technical limitations. A rigorous inquiry must be undertaken to merge the artistic and the practical. To maintain consumer interest, the designer must also account for aesthetic value. Simultaneously, initiatives fostering critical thinking and creativity have emerged in response to the recognition that certain designs may encounter technological limitations either from manufacturing difficulties or economic repercussions (Galati et al., 2018). A comprehensive examination of the convergence between aesthetics and technology is necessary. While the technical component may be resolved, artistic sensibility must also be taken into account. Ibrahim et al. (2019) indicate that, as illustrated in Figure 1, merely 24.7% of Malaysian students incorporate and modify aesthetics in their designs. Consequently, the students' systematic design methodology appears to be flawed. Company et al. (2015) acknowledged the difficulty students face in adhering to a systematic design technique. Company et al. (2015) asserts that technical students in European countries face a prevalent issue: they

fail to produce first concepts or sketches before initiating the design process in CAD programs. Figure 1 illustrates that just 40% of students utilized accurate dimensioning in engineering drawings, whereas 60% did not adhere to established standards and systematic design protocols. Consequently, there is a must to enhance their teaching and learning framework.

1.3 Research Objective

This study assesses the aesthetic skill components of the CAD course module and proposes enhancements for Technical and Vocational Education Training (TVET) colleges offering Diploma in Industrial Machining Technology programs. The aesthetic aspect of product design skills is anticipated to guide and enhance the instructional resources utilized by educators to address aesthetic deficiencies in the teaching and learning process. To fulfil the study's aim, the subsequent objectives were established:

1)To ascertain the prerequisites for aesthetic components within the domain of product design competencies.
2)To elucidate the perspective of product users concerning the aesthetic attributes integrated within the product design skills framework.
3)To assess the aesthetic attributes of the product design skill framework when incorporated into Computer Aided Design.

2.0 Literature Review

2.1 French Product Design Process and the Pahl and Beitz Design Models

This study used the French Product Design Process and the Pahl and Beitz Design Models. Both models are used to identify product design requirements, formulate problem statements, and conduct problem analysis. The Design Process Model by French (2013) is the backbone of the study in the CAD-based product design skills model. The French Design Process Model consists of eight steps, namely, (1) requirements, (2) problem statement, (3) problem analysis, (4) concept design, (5) embodiment, (6) scheme selection, (7) details and (8) working drawings. The Pahl and Beitz Design Model follows the market positioning methodology, which means that the first step is to study the socio-economic factors of the market and compare them with the design and development potential of industrial or company products. According to both models, there are four elements: Product Design Requirement (PDR), Product Design Concept (PDC), Product Design Detailing (PDD), and Product Design Evaluation (PDE).The Product Design Requirements (PDR) are meant to create and define logical and identified demands in order to investigate and produce a comprehensive view of the problem. Product design requirements studies are carried out to discover difficulties by gathering data, analysing it, and organising demands based on the hierarchy of product importance. It refers to the functional and social value expected by consumers or product users.

The Product Design Concept (PDC) is an idea that influences the final design. Design concepts can be used in a variety of methods, including brief descriptions, flow charts, sketches, modelling, and cost calculations to communicate design ideas. However, color and form are two critical components of PDC.The Product Detailing Design (PDD) consists of computer-generated drawings and three-dimensional solid models that depict the product's detailed design components. Three-dimensional (3D) modeling and product detail design drawings are examples of product design detailing components that illustrate product assembly and highlight textures and materials.The Product Design Evaluation (PDE) is a continual evaluation that determines whether to accept, improve, continue, or end the product design process. The decision will be based on aesthetic, ergonomic, finishing, and safety considerations. The hypothesis, based on a literature review, is stated below.

H1: The product design requirement significantly contributes to the aesthetics on product design skills in Computer Aided Design.
H2: The product design concept significantly contributes to the aesthetics on product design skills in Computer Aided Design.
H3: The product design detailing significantly contributes to the aesthetics on product design skills in Computer Aided Design.
H4: The product design evaluation significantly contributes to the aesthetics on product design skills in Computer Aided Design.

3.0 Methodology

3.1 Analysis component

The project collects data using surveys and questionnaires. There are two portions. The first component includes demographic information about the respondent, such as age, academic credentials, gender, and current job. The following section, which includes 22 items, comprises Likert scale questions. The scale ranges from 1 to 5, with five being extremely important, four being important, three being somewhat important, 2 being slightly significant, and one being not important. These questions sought product users' thoughts on the factors included in the study.

3.2 Population and sample

The research involved both cluster sampling and simple random sampling approaches. Simple random sampling is a method for selecting individuals of a population randomly, without regard to stratification. In 2020, the Klang Valley recorded 1.6 million product users (KPDNHEP,2020). An appropriate and contemporary sample size ranges from 30 to 500 respondents (Roscae, 1975). Sekaran and Bougie (2016) endorsed the suggested sample size, asserting that a sample above 500 respondents may result in a Type 1 error. Previous studies indicate that a sample size of 100-200 is generally a suitable first benchmark for path modelling (Wong, 2019). The Krecie-Morgan formula was employed to calculate the sample size. Table 1 comprises a constant sample size of 384 respondents. This study selected a sample size of 461 respondents, reflecting a 20% increase, to mitigate the risk of an inadequate questionnaire or insufficient responses.

Table 1 Formula and Sample Study Calculation of the sample (Krecie & Morgan,1970)

Formula	Sample Study Calculation
$S = \frac{\chi^2 NP(1-P)}{d^2(N-1) + \chi^2 P(1-P)}$ S = Sample size required N = Population size P = The population ratio 0.5 d = degree of accuracy χ^2 = Chi square value at the level 0.05 confidence, which is 3.841	$= \frac{3.841 \times 1600000 \times 0.5 (1-0.5)}{0.05 \times 0.05 (1600000-1) + 3.841 \times 0.5 (0.5)}$ $= \frac{6145,600 \times 0.25}{3,999 + 0.960}$ $= \frac{1536400}{3999.96025}$ $= \underline{384}$

3.3 Questionnaire Design

There are 2 sections in the questionnaire—section A is for demographic data and descriptive statistics. Section A includes the user's job positions, salary, age, and educational background. Meanwhile, section B focuses on the inference statistics. In section B. Item numbers 1, 2 and 3 consists of the functional value of the product design (FV). Item numbers 4 to 5 consist of the social value of the product design (SC). Item numbers 6 to 8 consist of the form design (FO). Items 9 to 11 consist of the product's colour (CO). Item numbers 12 to 14 consist of the product texture (TE). Items 15 to 17 consist of material selection on the product design (MA). Items 18 and 19 consist of the product design safety (SA). Then item numbers 20 to 22 consist of the ergonomics (ER).

3.4 Data analyzing

The study employs SmartPLS 4.0 software for inferential statistical analysis. The preliminary phase entailed the analysis of data from 440 samples to assess the measurement model, referred to as the outer model. Figure 2 illustrates the initial study model employed for the Partial Least Squares Structural Equation Modelling (PLS-SEM) analysis. The research utilised a model of eight factors, each assessed by 22 reflective indicators. Assessment of products encompasses various factors, including functional values (PDR), social values (PDR), shape (PDC), colour (PDC), texture (PDD), material (PDD), safety (PDE), and ergonomics. This study analyses various metrics, including composite reliability (CR), coefficient of determination (R^2), and direct correlations between exogenous and endogenous variables.

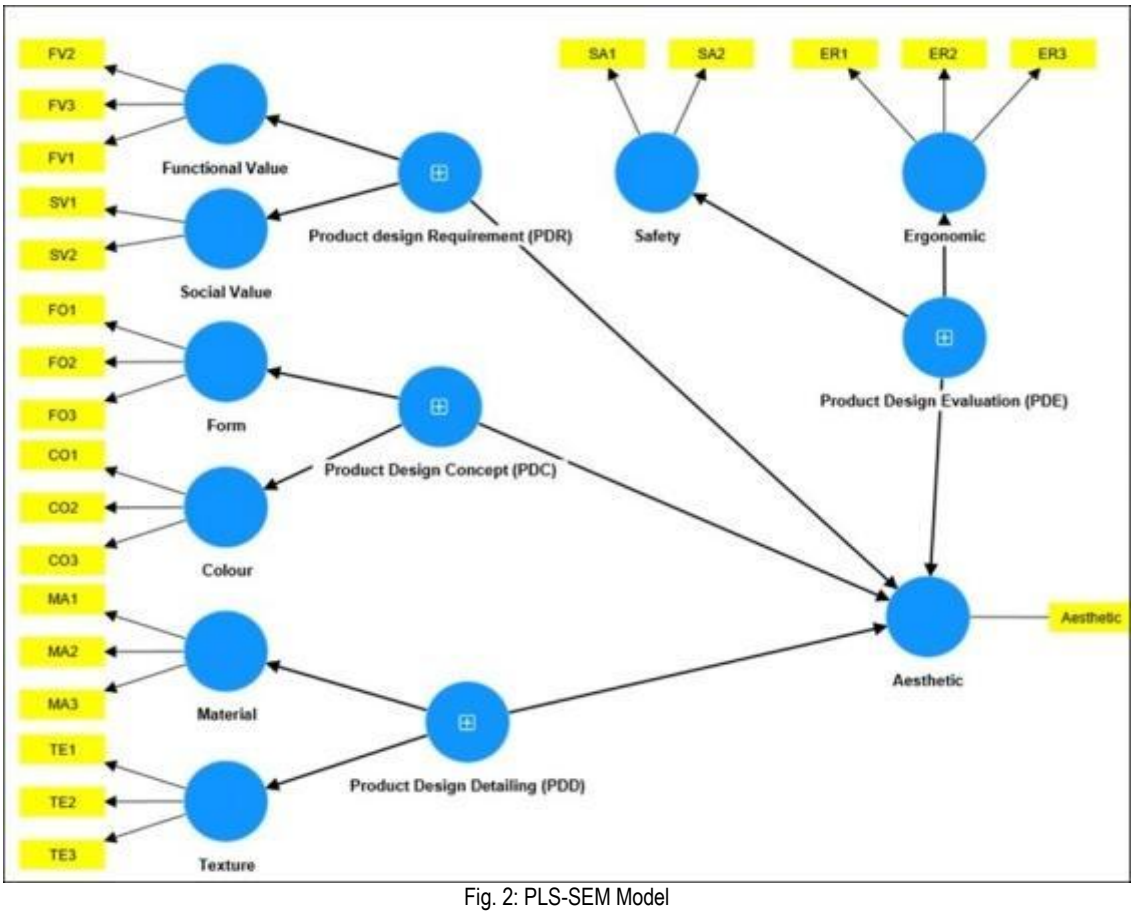

Fig. 2: PLS-SEM Model

4.0 Findings

4.1 Composite reliability (CR)

The composite reliability is measured on a scale of 0 to 1. According to Hair et al. (2019), a range of 0.60 to 0.70 is generally acceptable, whereas values between 0.70 and 0.90 are desirable. It is worth mentioning that higher composite values indicate more reliability. As a result, within the scope of the study, a composite dependability value of 0.70 was considered acceptable. All constructions had values above 0.70, ranging from 0.844 to 0.938. As a result, all structures demonstrate satisfactory and strong internal consistency. Fulfilling all three parameters related with this notion helps to prove convergent validity. Table 2 contains details on the convergent validity analysis on loadings, AVE and composite reliability, and the Cronbach alpha. All three circumstances have loadings greater than 0.70. To analyze the presence of collinearity, this study must examine the variance inflation factor (VIF) value (Hair et al., 2019). All VIF values, both for individual indicators and sets of indicators, are less than 5. Thus, multicollinearity is acceptable in the study.

Table 2 The convergent validity investigation focused on examining the loadings, Average Variance Extracted (AVE), Composite Reliability (CR), and Cronbach's Alpha.

		Loadings	**Alpha**	**Composite Reliability**	**AVE**
	Aesthetic	SIC	SIC	SIC	SIC
Colour	CO1	0.930	0.893	0.934	0.824
	CO2	0.922			
	CO3	0.870			
Ergonomic	ER1	0.812	0.766	0.865	0.681
	ER2	0.837			
	ER3	0.827			
Form	FO1	0.929	0.901	0.938	0.836
	FO2	0.936			
	FO3	0.876			
Functional Value	FV1	0.680	0.670	0.819	0.603
	FV2	0.831			
	FV3	0.809			
Material	MA1	0.806	0.755	0.860	0.671
	MA2	0.818			
	MA3	0.833			
Safety	SA1	0.843	0.630	0.844	0.730
	SA2	0.865			
Social Value	SV1	0.878	0.639	0.846	0.734
	SV2	0.835			
Texture	TE1	0.912	0.898	0.936	0.830
	TE2	0.901			
	TE3	0.920			

*SIC = Single Indicator Construct

4.2 Coefficient of Determination (R^2 Value)

Next, the coefficient of determination, usually known as R2, was calculated. R2 values of 0.75, 0.50, and 0.25 are frequently interpreted as indicating significant, moderate, and mild degrees of connection, respectively. Excessive R^2 scores in academic fields may indicate overfitting. However, it is vital to note that the assessment may differ based on the topic of study. When analysing a physical process and taking precise measurements, it is acceptable to expect R2 values of more than 90%. Aesthetics has an R2 score of 0.973, indicating that product design idea, product design details, product design evaluation, and product design demand can explain 97.3% of the variance. See Figure 3.

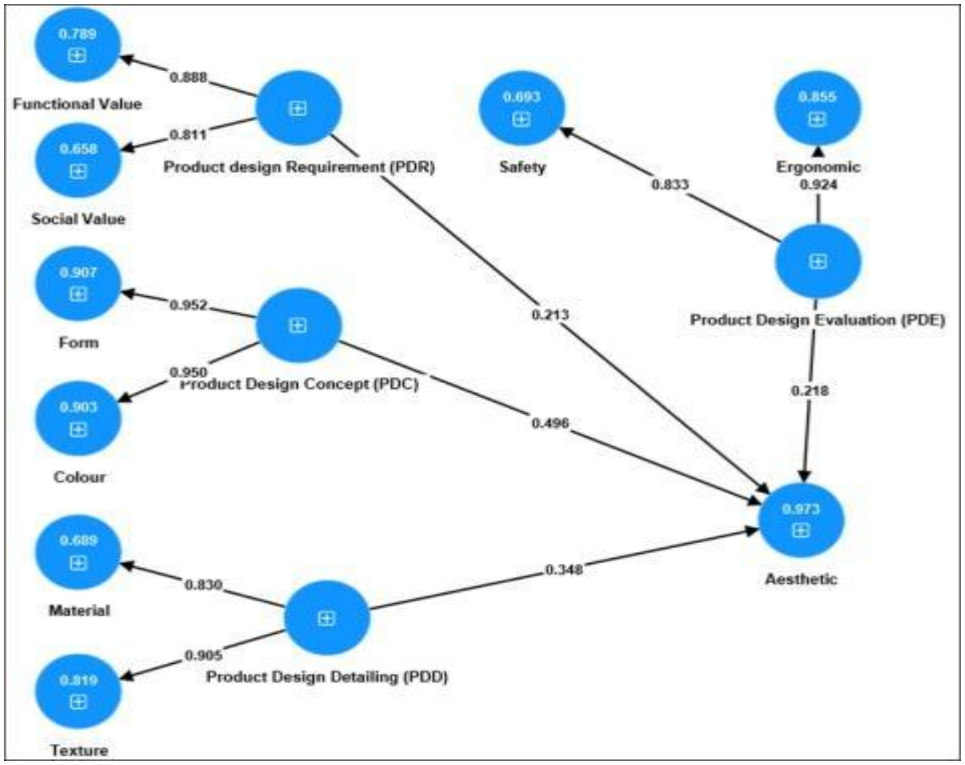

Fig. 3: Coefficient of Determination (R^2)

5.0 Conclusion

5.1 Levels of Product Design Concept (PDC)

Shape and colour are the two subfactors that determine PDC. The colour and form variances in the product design concept are 0.903 and 0.907, respectively. The consumer liked the product's shape and colour. Human eyes can recognise forms that correspond to pleasing colours (Wynn & Clarkson, 2018). According to design theory, visually pleasing designs have no colour concerns (Johansson et al., 2015). PDC had the strongest relationship with aesthetics in the study, as evidenced by a path coefficient (ß) of 0.496 and t-value of 30.154. PDC should be highlighted in the curriculum because designers frequently plan and sketch before developing a product (K. Ulrich & Eppinger, 2016).

5.2 Levels of Product Design Detailing (PDD)

Material and texture are two sub-factors that influence PDD. Product design details include variation values of 0.689 for material (68.9%) and 0.819 for texture (81.9%). This implies that the user investigates the texture and feel of a product. Users can identify materials that are relevant to the product. A design notion says that appealing textures influence the product's appearance. The study discovered a relationship between PDD and aesthetics, as shown by a path coefficient (ß) of 0.348 and a t-value of 27.736. PDD should be featured in the module because designers can create the product using CAD or manual marker rendering techniques.

5.3. Levels of Product Design Evaluation (PDE)

Two sub-factors influence PDE: ergonomics and safety. The product design evaluation has a variance value of 0.855 (85.5%) for ergonomics and 0.693 (69.3%) for safety. The user also considers the ergonomics and safety of a product. The study discovered a correlation between the PDE value and aesthetics, with a path coefficient (ß) of 0.218 and a t-value of 16.223. Merter and Hasırcı (2018) define ergonomics as prioritising human comfort during product use, which includes physical posture, material selection, and environmental safety. Product safety encompasses safeguarding the product during the manufacturing process, which includes materials, components, and production quality (Mike Baxter, 2017).

5.4 Product Design Requirement Level (PDR)

There are two subfactors: functional value (0.789, or 78.9%) and social value (0.658, or 65.8%). The variance values for the PDR are provided below. The user also evaluates the product's usability and social relevance. The study discovered a correlation between PDR value and aesthetics, with a path coefficient (ß) of 0.213 and a t-statistic of 13.915. Customers like items that are durable, user-friendly, and functional. The study contributed significant contributions to the existing body of knowledge. These contributions fall into two categories: theoretical and practical. This study evaluated the advantages of PDC and determined that it has the highest aesthetic value. This is due to the need for detailed hand sketching and coloring of product design concepts (PDCs) prior to production. Product design

requirements, or PDRs, are the initial stage of research in the design process. Although not the major goal of this research, users want a product that works in vivo and for the greater community. This is referring to the discipline of marketing research. Creating a novel product that cannot be marketed is pointless.

6.0 Discussion

Product design detailing (PDD) can occur during or after the product development cycle (PDC). After receiving user data, the designer can make changes. According to the findings, people place a higher value on product appearance than on interior features. Truman et al. (2016) define PDD as a complete visual and data depiction of a product's outward and interior characteristics. It will include information about each component's configuration, morphology, dimensions, tolerances, surface qualities, materials, and manufacturing procedures. PDE involves design tasks that assess ergonomics and product safety. Products without safety will not generate market demand. Designers must balance user safety and comfort. The study uses four criteria to determine the aesthetic value of product design: product design requirement (PDR), product design concept (PDC), product design detailing (PDD), and product design evaluation (PDE). Understanding PDR, PDC, PDD, and PDE is crucial and should be built into the product design educational framework since it improves CAD software usage. Creating digital graphics requires the use of computer-aided design (CAD) tools. This would also speed up the preparation of technical drawings and renderings by TVET students who use computer-aided design (CAD) software. TVET students will gain experience in the research process prior to designing new products. This technique can provide visually appealing and high-quality product designs.

The study focuses on the aesthetic basis and makes inquiries by looking at the answers from product users in Klang Valley city friends. It should be continued by looking at the education experts' perspectives on TVET and Product Design. One of the methods that can be done and can be continued is applying modified Delphi, where this future study will conduct three rounds to get accurate answers and results from the experts. Next, the study can be continued by experimenting on 2 groups, namely the control group and the experiment group. Here can see whether there is a proposal to renew the CAD module in TVET. Researchers can go to TVET college and select the groups for experimental research,

It is also suggested that future studies be addressed to examine any significant differences among categories under the demographic characteristics. For example, examining the perspective of rural users. This study only used one instrument, which is the questionnaires, to collect data. Future studies could use qualitative or mixed methods to support the results of this study. The advantage of qualitative research is that researchers may explore more details on issues or factors involving online loyalty due to the nature of qualitative methods. The result from either qualitative or mixed-method might significantly impact user and expertise's perspective on aesthetics.

Paper Contribution to Related Field of Study

Through the survey research on the aesthetic product design, the Pahl and Beitz Design Model and French Model is combined, which provides a new perspective and case support for the product design process in TVET CAD course. The research results not only enrich the theoretical system of aesthetic product design, but also provide practical guidance which involving with human behaviors and design theories. The framework will also serve as a resource for TVET instructors in their teaching and learning.

References

Baxter, M. (2018). Product Design (1st ed.). CRC Press. https://doi.org/10.1201/9781315275246

Becker, Kurt & Mentzer, Nathan. (2015). Engineering design thinking: High school students' performance and knowledge. 5-12. 10.1109/ICL.2015.7318218.

Company, P., Contero, M., Otey, J., & Plumed, R. (2015). Approach for Developing Coordinated Rubrics to Convey Quality Criteria in MCAD Training. CAD Computer Aided Design, 63, 101-117.https://doi.org/10.1016/j.cad.2014.10.001

Dyer, M. (2019). STEAM without hot air: strategy for educating creative engineers. Australasian Journal of Engineering Education, 24(2), 74–85. https://doi.org/10.1080/22054952.2019.1693122

French, M. J. (2013). Conceptual design for engineers. In Conceptual Design for Engineers (3rd ed.). Springer. https://doi.org/10.1007/978-3-662-11364-6

Galati, Manuela & Minetola, Paolo & Marchiandi, Giovanni & Atzeni, Eleonora & Calignano, Flaviana & Salmi, Alessandro & Iuliano, Luca. (2019). A methodology for evaluating the aesthetic quality of 3D printed parts. Procedia CIRP. 79. 95-100. 10.1016/j.procir.2019.02.018.

Glen Truman, J. M. & A. M. (2016). Computer aided drafting and design program review January 2016 (Issue January). http://www.pcc.edu/resources/academic/core-outcomes/mapping-index.html

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. European Business Review, 31(1), 2–24. https://doi.org/10.1108/EBR-11-2018-0203

Ibrahim, M. Q., Romli, F. I., & Alli, H. (2019). An investigation on aesthetic acknowledgment and adaptation in product design process among engineering students in Malaysian universities. International Journal of Innovative Technology and Exploring Engineering, 8(7), 1561–1565.

Johansson, U., Sköldberg, K., & Svengren, L. (2015). Industrial design as a balancing artistry: Some reflections upon industrial designer ' s competence Abstract : Phronesis A Journal For Ancient Philosophy, May 2015, 1–11.
Karl T. Ulrich & Steven D. Eppinger. (2016). Product design and development. In Biosensors and Bioelectronics (6th ed., Vol. 7, Issue 2). McGraw-Hill. https://doi.org/10.1016/0956-5663(92)90013-D

Ken Kwong-Kay Wong. (2019). Mastering Partial Least Squares Structual Equation Modeling (PLS_SEM) woth SmartPLS in 38 Hours. iUniverse.

KPDNHEP. (2020). Statistik utama KPDNHEP Januari 2019.

Lee, M. F., & Syaid, S. (2017). Factors contributing towards Malaysian Technical University (MTU) students' mental health. Pertanika Journal of Social Sciences and Humanities, 25(May), 93–100.

Leyva López, J. C., Solano Noriega, J. J., Ahumada Valenzuela, O., & Romero Serrano, A. M. (2022). A preference choice model for the new product design problem. Operational Research, 22(4), 1–32. https://doi.org/10.1007/s12351-021-00666-x

Love, J. (2018). Sensory spaces: Sensory learning - An experimental approach to educating future designers to design autism schools. Archnet-IJAR, 12(3), 152–169. https://doi.org/10.26687/archnet-ijar.v12i3.1704

Md Isa, W. M., Mohamed Khalid, N. A., & Zainuddin, M. F. (2014). Peranan ergonomik dalam rekabentuk kerusi sekolah: Kajian kes di sekitar Perlis, Kedah dan Pulau Pinang. 1st International Conference On Creative Media, Design & Technology, November, 1–7.

Merter, S., & Hasırcı, D. (2018). A participatory product design process with children with autism spectrum disorder. CoDesign, 14(3), 170–187. https://doi.org/10.1080/15710882.2016.1263669

Pahl, G. & Beitz, W. (2013). Engineering design: A systematic approach. In Ken Wallace (Ed.), Engineering Design: A Systematic Approach (2nd ed.). Springer Science & Business Media. https://doi.org/10.1007/978-1-84628-319-2

Ranscombe, C., & Bissett-Johnson, K. (2016). Digital sketch modelling: Integrating digital sketching as a transition between sketching and CAD in industrial design education. DRS2016: Future-Focused Thinking, 2(June 2016), 1–15. https://doi.org/10.21606/drs.2016.69

Roscae. (1975). Fundamental research statistics for the behavioral sciences. Prentice Hall.

Saleh, B. (2020). Pembangunan model rekabentuk produk berkualiti berasaskan computer aided design (CAD). The National University of Malaysia.

Seddon, P. B., Constantinidis, D., Tamm, T., & Dod, H. (2016). How does business analytics contribute to business value ? Information Systems Journal. https://doi.org/10.1111/isj.12101

Syukri, M., Halim, L., & Mohtar, L. E. (2017). Engineering design process: Cultivating creativity skills through development of science technical product. Jurnal Fizik Malaysia, 38(1), 010055–010065.

Tsegaw, F. G., Balasundaram, K., & Kumar, M. S. S. (2017). A case study on improvement of conceptual product design process by using quality function deployment. International Journal of Advances in Scientific Research and Engineering (Ijasre), 03(4), 1–10. http://www.ijasre.net/uploads/1/2807_pdf.

Uma Sekaran & Roger Bougie. (2016). Research methods for business. In Wiley (7th ed., Vol. 53, Issue 9). John Wiley & Sons , Inc.

Wang, J., & Hsu, Y. (2019). Does sustainable perceived value play a key role in the purchase intention driven by product aesthetics? taking smartwatch as an example. Sustainability (Switzerland), 11(23). https://doi.org/10.3390/su11236806

Wynn, D. C., & Clarkson, P. J. (2018). Process models in design and development. Research in Engineering Design, 29(2), 161–202. https://doi.org/10.1007/s00163-017-0262-7

Yehua, Q., Xuanbo, M., & Dian, L. (2018). Research on the role of design aesthetics in modern design. MATEC Web of Conferences, 02012, 1–5