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An Evaluation of Quality Model Making Between Guided and Non-Guided Group

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Abstract

The majority of design school programmes fine-tune their approach and implementation of design courses. Students will be taught to do research and understand problem-solving techniques. Additionally, students learn to sketch to convey ideas and to build models of products and thoughts. The more skilled students get at rapidly creating models, the more quickly their concept will be grasped. Model making (MM) is a vital element in the industrial design process where the designer visualizes the design from two-dimensional to three-dimensional stage. However, numerous researchers have highlighted problems in understanding MM comprehensively among undergraduate students based on the previous study conducted. Through the valuing and reviewing process of the previous experimental evidence in the operational model of the MM process, the lack of mastery, especially in the context of foam sculpting, material selection and processes, and handling tools were found. Therefore, there is a need to develop MM techniques and processes related to the Malaysia context to produce a quality model. This research proposes to study the understanding of model making techniques among industrial design students at the public universities (IPTA) and private universities (IPTS) in Malaysia. Open-Structure Interview will be conducted with 30 undergraduate industrial design students followed by an observation procedure using Protocol Analysis to analyze the effectiveness and significance differences of model making techniques between the guided and non-guided approaches. Video Recorder will be used to capture both interviews and observations, and Adobe Premiere Pro will be used to process the videos. Finally, the model making expert will evaluate and compare the quality of model making results between the guided and non-guided approach of model making throughout the research activity. Syntactic analysis will be used to investigate the relationship between form and entity, indicating a consistent approach to visual composition, functionality, and design format. The implications of this research aspire to benefit the education system, assist future designers and future design educators in their understanding of MM. Moreover, the significant outcomes of this research will aid in improving the quality of education as a socioeconomic drivers in Malaysia which in the line with one of the Framework 10-10 Science, Technology, Innovation and Economic Malaysia (MySTIE) detailed by The Ministry of Science, Technology, and Innovation Malaysia (MOSTI).

Keywords: Industrial Design, Model Making, Education

Introduction

Industrial design is a field of study that merges visual arts, science, technology, problem-solving and communication. Industrial design is a process of solving problems, identifying barriers, and identifying opportunities to save time and money and connect emotionally with the consumer. Industrial design creates better value in the economy, social, health, safety, and the environment by transforming challenges into opportunities is the role of the industrial design sector. It combines innovation, technology, research, business, and human-centered design process to enhance the economy, social, health, safety, and environment. In Malaysia, industrial design students often learn drawing skills, presentation skills, computer-aided design skills, sculpting and forming skills, MM skills, and a basic understanding of materials and manufacturing techniques. A prototype produced through the MM and prototyping process helps the student to visualize their design. MM and prototyping are vital tools in design education, especially for design students. Furthermore, there are several considerations in MM. According to Hallgrimsson (2015), MM and prototyping are very different, even though they are closely related. Prototyping examines how a new product will be used and its appearance in its complete form. In other words, prototyping is the process of resolving issues. According to Hallgrimsson (2015), MM is a step-by-step process for producing the prototype. Designing from an initial concept to a comprehensive design may be examined using MM and prototypes (Kelley, 2010). MM and prototyping processes create models used as communication tools between students and the project that is being developed. It improves design students' visualization of three-dimensional objects and enhances the quality of models throughout the design process (Delikanl, 2020). In the real world, having a model is essential for designers working on their designs. It helps avoid mistakes being carried over into the final product and increases the designer's costs (Evans, 1992). Both tangible (physical) and intangible (digital) models have been used in current design education to help students prepare for future practice and assist them in developing disciplinary knowledge. Despite this, tangible models serve mainly as communication models, prototypes, and tools to explore the shape and space of the intended item. Several researchers have found that university students have difficulties in fully understanding MM predicated on previous research. Based on the recent experimental data in the operational model of the MM process, that expertise is lacking, especially in the areas of foam sculpting, material selection and processing, and tool handling (Afify et al., 2021; Das & Das, 2019). Therefore, this study investigates industrial design students' understanding of MM techniques.

Literature Review

Industrial Design

Industrial design is a profession that entails the process of creating a product with an emphasize on its function and aesthetic value for the consumer. According to the Industrial Designers Society of America (2021b), industrial design is concerned with creating ideas and specifications, as well as designing goods, objects, and services that will be used and benefit the user, industry, and society as a whole. According to Moody (1980), industrial design is a creative activity aimed at developing the formal characteristics of industrially manufactured items, in line with the concept of product design. External characteristics are included in these for real qualities, but they are mostly structural and functional links that make a system work together from both the producer and the user's point of view.

Industrial Design Education

Due to the fact that industrial design is a multidisciplinary area of study, new concepts emerging from various scientific disciplines have an impact on the education of industrial designers. The program, according to Cartier (2011), covers engineering (technology, methods, materials, and processes), ergonomics (operation, safety, usability, sensation), business (marketing, management, planning, corporate identity), aesthetics (form, visualization, style), and social, environmental, and cultural concerns. On the other hand, different areas and countries may choose a different approach to implementing the program. The product design education program should include at least three areas of competence, according to Cartier (2011), as part of a complete product design education program. These areas of competency are as follows: 1) fundamental characteristics such as problem-solving abilities, organizational skills, and the ability to adapt to rapid changes, among other things; (2) knowledge and skills in industrial design – design thinking and procedure, design methodologies, visualization skills and knowledge, product development techniques, production, materials and processes, design management, environmental awareness, model making, and so on; and (3) knowledge integration – strategies of system integrators, among other things (Kamil & Sani, 2021).

In 1967, Institut Teknologi MARA (ITM) created the Department of Art and Design as part of the School of Applied Arts and Architecture. The Department of Art and Design was separated from the School of Architecture in 1972 to become the School of Art and Design, which also featured the establishment of the Department of Industrial Design. ITM, which later known as Universiti Teknologi MARA (UiTM), is no longer Malaysia's only institution of higher learning to offer degrees in industrial design, due to the Malaysian government's emphasize on industrialization and the profession's growing prominence. Universiti Teknologi Malaysia (UTM), Universiti Putra Malaysia (UPM), Universiti Sains Malaysia (USM), Universiti Malaysia Kelantan (UMK), Universiti Sultan Zainal Abidin (UniSZA), and University Malaysia Sarawak (UNIMAS), as well as other commercial art institutions such as University Kuala Lumpur (UniKL), Malaysian Institute of Art (MIA), and Lim Kok Wing Institute for Creative Technology (LICT) all offer industrial design courses (Ibrahim, 1999).

The Role of Model Making and Prototyping in Industrial Design Education

Model making (MM) is a graduate-level process for developing a prototype. It educates design students how to envision while developing a prototype. A model serves as a medium of communication between design students and the product under development. It assists design students in visualizing three-dimensional things and enhances model quality throughout the early phases of the design process (Delikanl, 2020). Previous studies shown that MM is required for the following step of the thinking process. Once they begin experimenting with materials and production techniques, design students are prepared to enhance their concepts in order to make them work (Hadia, 2010). According to Ying et al (2018), manual MM is a hands-on training that is utilized to strengthen students' visual imagination skills and their ability to solve design problems in real-world circumstances. Earlier study has emphasized the significance of MM making as a vital step-by-step method for prototyping (Hallgrimsson, 2015). Three-dimensional model design provides a method for students/designers to clarify and develop their ideas, as well as convey these ideas to their colleagues on the design development team, at every step of the design process, from concept to final.

Meanwhile, prototyping is a method for evaluating a product's performance, function, form, and usability. Physical prototypes are used in prototyping to investigate and test how a new product will be used, as well as how it will appear and be produced (Hallgrimsson, 2015). According to Broek et al (2000); Gill et al (2011), prototypes assist design students in more effectively and beneficially controlling the design process. A prototype is described as "an approximation of the final product along one or more specified dimensions." This phrase is distinct from the more typical definition in that it encompasses concept sketches, simulations, test components, mathematical models, and fully working preproduction prototypes of the product. Prototyping is the process of developing such an approximation of the product. Prototypes may be classified into two relevant dimensions:

1. Physical prototypes: The first dimension is the extent of physical in a prototype as opposed to analytical. Physical prototypes are physical items designed to mimic the final product. Aspects of the product that the development team is interested in are actually made into artifacts for testing and experimentation. Physical prototypes include models that look and feel like the product, proof-of-concept prototypes used to quickly test an idea, and experimental hardware used to verify a product's functioning.

2. Analytical prototypes: Analytical prototypes are nontangible representations of the product, generally mathematical or visual. Rather than producing, interesting elements of the product are evaluated. Computer simulations, systems of equations recorded inside a spreadsheet, and computer models of three-dimensional geometry are all examples of analytical prototypes (Ulrich, 2012).

Table. 1
Classification of physical prototypes by several researchers (adapted from Cubramanya & Chakravarthy (2019)

Author(s)	Classification of mock-up / model / prototypes	Observation
Kojima, 1991	• Image models • Rough mock-up models • Presentation models • Prototype models	Sketching included along with physical models
Mascitelli, 2000	• Initial rough models • Refined models • Formative prototypes • Refined prototypes	4 level classification with models and prototypes as basic divisions
Ullman, 2003	• Proof of concept • Proof of product • Proof of process • Proof of production	Classifies models based on functionality
Ulrich and Eppinger, 2012	• Soft model • Hard model • Control model • Prototype	Simplified version based on material and purpose
Siti Salwa Isa, 2014	• Soft model • Hard Model • Presentation model • Prototype	A combination based on previous researcher's classification

Criteria to Clarify a Good Model Making and Prototyping

As an outcome of model making, soft models (physical) enable designers to experiment with different materials and shapes before moving on to the next step (Kojima et al., 1991). According to Ulrich (2012), soft model is an initial and rough version of the design purpose in which the designer intends to present something quickly rather than accurately. Soft models are often used to evaluate the proportion, overall size, and shape of many concept ideas. According to Huffstetler (2016), a small change in the soft model's proportions may have a huge impact on how someone views the intent product's look, function, and value. A product's color, material, and finish are as equally important as its shape, size, and proportions. The appearance of the models (also known as "looks like" models) are used to experience and sense certain material qualities physically. Thus, it can be concluded that the main criteria to clarify a good model making and prototyping in industrial design are proportion, color, material, finishing, shape, size and the appearance of the model.

Without categories, it will be difficult for the designer to determine how physical models might be applied to other fields. Designers and researchers have classified models in a variety of ways, attempting to categorize them according to their cost and use in the design process. Others attempted to categorize models according to their intended use: to investigate or test functionality (Michaelraj, 2009; Kojima et al., 1991; Ulrich, 2012).

Table 2
Classifications of Model (adapted from Isa & Liem, 2014)

Soft Model	Hard Model	Presentation Model	Prototype
• Rough modeling • Use to assess the overall size, proportion and shape of many proposed concept. • Constructed from dense sculpting foam • Fast evaluation of basic sizes and proportion • Reshaped and refined by hand to explore and improve its tactile quality	• Technically non-functional yet are close replicas of the final design. • Very realistic look and feel. • Made from wood, dense foam, plastic, or metal are painted and textured. • Have some "working" feature such as button that push or slides that move	• Model that constructed and matched from CAD data or control drawing. • Complete model and fully detailed composition of the product. • Component of this model will be simplified or neglected due to cost or time shortages.	• High-quality model or functioning product that produce to realize a design solution. • Would be tested and evaluated before the product is considered for production.

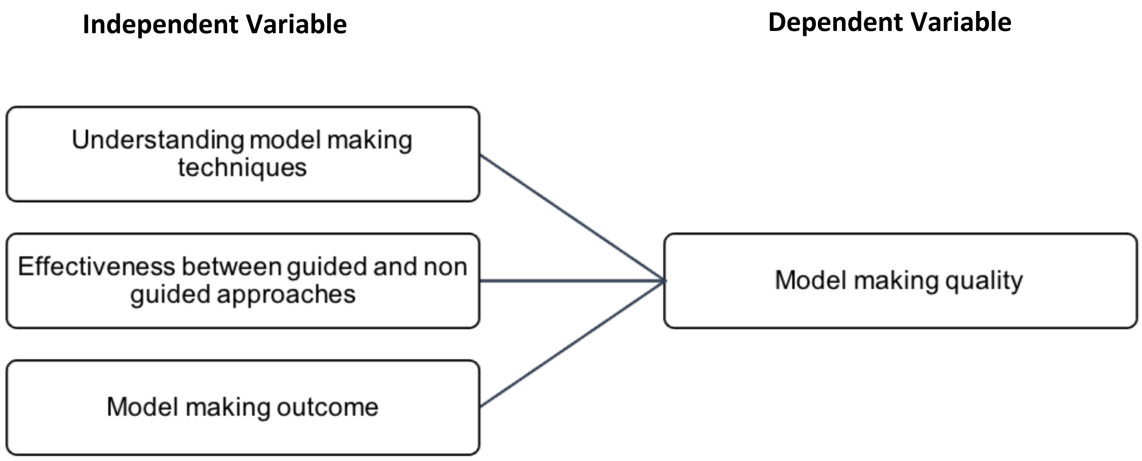
Criteria to Define Students Understanding of Model Making Techniques

According to Hallgrimsson (2015), prototyping and model making are important for designer, since it helps the designer to discover and solve difficulties. Models also serve the dual purpose of assisting the student designer in the development of concepts as well as promoting effective communication with others. They play an important role in education since they help educators evaluate students' progress and learning needs.

Moreover, the material, volume, proportions, shape, and color are the most vital factors of modelling (Dunn, 2010; Eriksson & Florin, 2011). Apart from that, block models should always accurately represent the final product. It includes the finishing of the surface, parting lines, fittings, and fixings (Setlhatlhanyo et al., 2017).
Meanwhile, industrial designers and model makers have often been tasked with the responsibility in designing prototypes. Prototypes are models that may be constructed in a variety of ways and must accurately represent the shape, fit, and function of the final product (Eriksson & Florin, 2011).

Due to the fact that model making is a tool for the designer to communicate, visualize the whole idea, and solve problems, it is also a tool for the designer to communicate. The material, proportion, shape, color, surface finishing, parting line, fitting, fixing, and function are all criteria in model making.

Methodology



According to Cross (2007), proposal is of forms of design research. The purpose of this research is to study design, create an artefact, and study design methods and form of modeling. This study will examine the spectrum of design methods by examining how guided and non-guided approaches affect the quality and effectiveness among undergraduate Industrial Design students in Malaysia. Therefore, the independent variable of this study could be defined as follows: 1) Understanding model making techniques, 2) Effectiveness between two groups (guided and non-guided) approaches, 3) Model making outcomes. These independent variables are derived from the context of the study: the context that manages to illustrate the basic theme, boundaries and perimeters of knowledge to be explored, which is hoped to establish the effectiveness of guideline for the quality of model making. This conceptual framework will be put into action via the research inquiry. The inquiry helps in the clarification of the framework for the research activity, which will be undertaken in line with the problem statement and central proposition, the formulation of research questions and objectives, and the selection of the appropriate technique. Therefore, three research questions with specific objectives and methods to accomplish and answer them are formulated.

Research Question	Research Objective	Methodology
1. What are students' understandings of model making techniques?	1. To identify students' understanding of model making techniques	*Open-Structured Interview
2. What are the effectiveness and significance differences of model making techniques between the guided and non-guided approaches?	2. To analyze the effectiveness and significance differences of model making techniques between the guided and non-guided approaches	*Observations -2 groups of respondents (guided and non-guided approaches) execute model making process in controlled situation
3. How does the quality of model making outcomes between the guided and non-guided approaches can be established?	3. To evaluate the quality of model making outcomes between the guided and non-guided approaches	* Evaluation by model making expert - Syntax (synthesis) analysis

Research Design

The purpose of this study is to determine the effectiveness of guidelines on model quality by comparing between guided and non-guided approaches. The principal investigator will undertake the majority of the study. The qualitative method will be used to collect data, which will include information obtained from primary and secondary data.

An Open-Structured Interview with 30 Diploma in Industrial Design students from Universiti Teknologi MARA (UiTM) Kedah Branch, Universiti Sultan Zainal Abidin (UniSZA), Universiti Teknologi MARA (UiTM) Melaka Branch, and the Malaysian Institute of Art (MIA), Widad Collage, and Southern University College will be conducted to achieve the first objective of this research. Video Recorder will be used to record the interviews, and Adobe Premiere Pro will be used to edit the video. Respondents will be given a series of questions and will be asked to express their thoughts, perceptions, and reflections on model making techniques. To describe the perspective of design students, a coding analysis adapted from the grounded theory approach will be executed. The video will be systematically coded into information categories as presented by Glaser and Strauss in 1967 to extract the adequate explanation and construct the abstract thought of the industrial design undergraduate student.

Purposive sampling is a technique in which a researcher assesses what information is needed and then seeks out individual who are capable and willing to provide it based on the expertise or experience (Bernard, 2006). Participants in interviews and observation will be chosen via purposive sampling. In this research, homogeneous sampling will be used to collect a specific group of participants, such as undergraduate students enrolled in a Diploma in Industrial Design program in Malaysia who are between the ages of 18 and 21. For the interview and observation, respondents aged 18 to 21 are chosen from a group of recent graduates with a Diploma in Industrial Design. To eliminate outside influence, the interview will last 60 minutes and will take place in a closed room.

During the first year of the research activity, an observation process will be conducted at IPTA and IPTS to meet the second objective of the research. The conclusion of the process will help in establishing a strong grasp of the effectiveness of model making using the proper guidelines.

Figure 1: A three-dimensional illustration of design students and the researcher in actual protocol analysis session between guided group and non-guided group

The effectiveness and significance differences of model making strategies between guided and non-guided approaches will be evaluated using protocol analysis. During the protocol analysis research, five cameras will be installed to obtain a complete view of the design student at the model-making workspace. The researcher will stand in front of the design students during the experiment to assist with verbalization. Meanwhile, in the non-guided group, the design student is free to move using any tools, techniques, or machines while creating the model. During the observation, design students must create three types of models: soft model, hard model, and presentation model.
Lastly, the final goal of this study is to have a model making expert assess the quality of model making results between guided and non-guided throughout the second or third year of research activity. Syntactic analysis will be used in this study to examine the connection between form and entity, indicating a consistent approach to visual composition, functionality, and design format (Abidin et al., 2016; Kamil & Abidin, 2015; Warell, 2001; Abidin et al., 2014).

Design Syntactics		
Form Syntactics	**Form Functionality**	**Design Format**
Visual composition and structure of form design	Purpose and function of form aesthetic	Content and use of form ingredients

Figure 2 : The theoretical framework of Design Syntactic, adapted from (Warell, 2001)

A structural framework for visual product forms is called design syntactics. There are three levels to the framework. The following are the three levels which this approach identifies: At the highest level, there are form entities and form elements of the product form (outer shape); at the intermediate level (form features), there are characterized shapes and form elements (features) of the product form (inner shape); and at the lower level (product component), there is a signifying curve (form ingredient) distributed across the product form (Abidin et al., 2016; Kamil & Abidin, 2015; Warell, 2001; Abidin et al., 2014).

Figure 3: Example of design syntactic analysis of computer mouse

(1) The superior gestalt level (outer shape): A: The shape of the outer shape of the computer mouse
(2) The intermediate level (form features): B: Create significant characterized shape and form element (features) of product form (inner shape).
(3) The lower level (product component): C: The scroll wheel and back/ forward button of the computer mouse.

Conclusion
This paper can conclude that to discover quality model making between the guided and non-guided groups. Design students should better understand model making, especially in material selection, proportion, shape, color, surface finishing, parting line, fitting, fixing, and function of a product. This study will identify the design student's understanding of model making through the interview and observation. A series of questions will be asked to design students to express their opinion, perspectives, and reflection on model making. Observation will be conducted between the guided and non-guided groups to establish a solid grasp on the effectiveness of model making with the proper guideline. The final goal of this study is to have a model making expert assess the quality of the model making results between guided and non-guided throughout the research activity. Developing better guidelines such as a course module, a book or apps on the MM process and method can be beneficial to industrial design students in improving their skills in MM and enhancing the design curriculum. The guideline is to help students create a three-dimensional design that is easily assessable, which will benefit them in their future professional careers, especially in the MM industry. Furthermore, the guideline will assist future educators in model making teaching and learning. The novelty of this study aid in improving the quality of education as a socio-economic driver in Malaysia, which in the line in line with one of the Framework 10-10 Science, Technology, Innovation and Economic Malaysia (MySTIE) defined by the Malaysian Ministry of Science, Technology and Innovation Malaysia (MOSTI).

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