Designing Universitas Indonesia Molina EV Bus Dashboard Using ECQFD and TRIZ

Muhammad Faiq Pradhila\textsuperscript{1,1}, Amalia Suzianti\textsuperscript{1,2} and Prilly Putri Adinda\textsuperscript{1,3}

\textsuperscript{1}Industrial Engineering Department, Faculty of Engineering, Universitas Indonesia, Depok, Indonesia

\textsuperscript{1}mhd.faiq@ui.ac.id, \textsuperscript{2}suzianti@eng.ui.ac.id and \textsuperscript{3}prilly.putri@ui.ac.id

Abstract. Universitas Indonesia is involved in the national electric car development program. One of the focus by the research team is to develop the Molina EV Bus which is planned to replace the current operational bus at UI so that it can be more environmental friendly. With UI developing facilities for the disabled, the Molina research team planned to make a new prototype of the Molina EV Bus to contribute to the facilities developed for the disabled. The new prototype is expected to increase the quality of the previous features of the EV Bus, including the dashboard that had been ignored. To support the development of the new prototype, this research was conducted to design a suitable dashboard for the new prototype. Design of the prototype are made using Autodesk Inventor. This research used the integration of ECQFD (Environmentally Conscious Quality Function Deployment) and TRIZ (Theory of Inventive Problem Solving) method. ECQFD was used to translate user needs into quality characteristics based on environmental aspects. TRIZ was used to translate the quality characteristics into technical specifications. This research has generated 3 sustainable, innovative, and user-preferred dashboard design recommendation for the new prototype.

1. Introduction

It is inevitable that today, most of the people in Indonesia love to buy a motor vehicle, whether it is a motorcycle, car, or other. This is one of the contributing factors of the increasing number of motor vehicles in Indonesia each year [1]. According to data, about 32.7% of energy consumption patterns in Indonesia in 2011 came from fuel oil. The increase pattern of fuel consumption in Indonesia every year is one of the consequences of the habits of people who love to buy motor vehicles. In the event of a scarcity of fuel, this large dependence on fuel will cause an energy crisis.

With the aim to reduce emission, the automotive industry has started to divert the source of power generated for car engines by conducting research and development [2]. This new source of power is called electric motor, which do not generate emissions at all. Cars with the electric-based engines are cares that are expected to play an important role to help keep the environment in the future. Indonesia is also active to develop electric cars. Research and development has also been done both by ministries and also by universities. A total of five State Universities (PTN) are appointed to develop a research roadmap, with Universitas Indonesia (UI) being one of them. The mandate of the development of electric cars was marked by the signing of a cooperation mandate between the five state universities, with the Institute of Education Fund Management (LPDP).

Research at Universitas Indonesia on electric cars is still running. Universitas Indonesia (UI) has launched 4 units of electric vehicles. Compared with the other four universities that focus on the technical development of small urban vehicles (city car), UI also examines the technology of electric
buses and social studies related to the acceptance of society and industry in the homeland of electric vehicles in Indonesia.

When viewed directly on the prototype of this bus, the dashboard has not received attention and is still using the standard design of the car body maker. Meanwhile, this bus is a convertible electric bus which means that the device from this bus dashboard could be different from the required functionality required on an electric car.

Currently, planning is underway for the development of the 2nd Molina EV Bus prototype. The prototype was developed with the aim of updating the technology to be used on this bus. In addition, the prototype was developed to improve facilities and infrastructure at Universitas Indonesia, specifically in the field of infrastructure for disabled users. Therefore, a new bus design to support those needs is required. The different prototypes of the new UI electric bus are planned to have low-floor features. In addition, it is also expected for the dashboard part of the bus to be updated.

2. Theoretical Overview

2.1. Electric Car
An electric car is a car that is driven by an electric motor by utilizing electrical energy stored on rechargeable batteries or other energy storage media as a source of energy. The use of electric motors provides instant torque to electric cars resulting in a smooth and strong acceleration.

Along with its development, electric car technology is also applied to more large-capacity cars such as buses. Just like an electric car, electric buses are generally divided into hybrid and pure electric. The difference is that electric-powered hybrid buses are still combined with the use of internal combustion engines, while on pure electric buses only use electric motors without conventional combustion engines.

2.2. Dashboard
The car dashboard is the front area of its interior that gets most attention at all times from the driver and the place where the car operational control activities are centered. Dashboard also serves to place the radio/tape/CD, bottle holders, drawers, button control air conditioners, lights and indicators of the vehicle. In addition to function as a panel of various switches and indicators, the dashboard is also a physical boundary between passengers with views beyond the windshield.

The dashboard on the bus has the same function as cars in general, but the dashboard on the bus has more features that do not exist in private cars. This is because the bus has more operational functions compared to private cars.

2.3. QFD (Quality Function Deployment)
QFD is a method for turning qualitative user demand into a quantitative parameter for implementing quality-building functions, and methods for implementing design quality into subsystems, components, as well as specific elements of the manufacturing process [3-8].

2.4. TRIZ
TRIZ (Teoriya Resheniya Izobretatelskikh Zadatach) is an inventive problem-solving method based on logic and data that can help us solve problems creatively. TRIZ is very closely related to contradiction. In product design, contradiction appears when we apply improvement towards a parameter of a system, but at the same time, the other parameter undergoes diminishment. In TRIZ, the contradiction itself is divided into 2 namely contracts of physical and technical contradictions. In general, TRIZ solves technical contradictions, in which occurs between two or more subsystems in a system [8-10].

3. Research Methodology
This section explains about the data and methodology used in this study. This study used two types of data, namely primary data, which was gained through questionnaires, and secondary data, such as data gained from reports, journal, etc. The method used in this study are ECQFD and TRIZ.
In the beginning of data collection, identification of user needs and design attribute is needed [1]. These types of data were obtained using literature study and benchmarking from other buses dashboard, and used to conduct a questionnaire and data processing using ECQFD. Afterwards, questionnaire was obtained based on the user needs and design attributes. This questionnaire aimed to determine the weight of each design attribute based on user preferences [9]. The result of this questionnaire is used as an input data for data processing using ECQFD. In ECQFD, the identification of the relationship between user needs and quality characteristics and between quality characteristics and each component of the product was completed. Table 1. shows the design options obtained to be evaluated.

| Table 1. Design Options Comparison |
|-----------------------------------|
| **Option 1** | **Option 2** |
| Component Type | Dimension |
| Indicator | Structure & Geometry |
| Component Amount | Weight |

Afterwards, QC Improvement Rate, UR Improvement Rate and UR Improvement Effect of each option was calculated. The effect of improvement from each quality characteristic was accumulated to compare between the two options. It was aimed to find which option gives better impact [8].

The result from the comparison showed which option is better than the other. However, that option is not necessarily the best combination to apply improvements to the design. Therefore, in TRIZ data processing, it was needed to find the combination from two design options from ECQFD with the aim to find the best design combination [9].

4. Results and Discussions

This section explains about interpreting the results explained in this study. From the solution of the problem of contradiction with analysis using TRIZ method, solutions for innovation and improvement of bus dashboard design were obtained, namely adjustable body, natural/synthetic fiber composite materials, modular functions, touch screen function, compact shape and separate support devices.

As the result, three design options were obtained to be made for recommendation. In the first design as shown in Figure 1., the main differentiator with other designs is its adjustable function. The dashboard height and proximity can be adjusted with the driver. In addition, the shape and size of this dashboard is compact, thereby it can save space. In this dashboard design, supporting devices such as multimedia and others are located separately from the dashboard.

![Figure 1. Design Option 1](image)

In the second design shown in Figure 1., the dashboard can function modularly. The desired functions can be easily replaced and installed according to user preferences. There are also supporting devices such as cup holder and multimedia devices in this design.
In the third design, a function that distinguishes this design from other design is that all functions is operated by touch screen. All functions and support devices are also available in touch screen on both side of the dashboard.

5. Conclusion
This study aims to generate design factors of consideration for electric bus dashboard design based on user needs, and to recommend dashboard design for the development of the next Molina EV Bus prototype.

The early stage of this study was determining user needs for electric bus dashboard using literature study and interview. Questionnaire was conducted, and the result was used as an input data for ECQFD method. Afterwards, interview and brainstorm with experts were also conducted to process data using ECQFD and TRIZ method.

This study resulted in 6 quality characteristics that can be improved to get an innovative and environmentally friendly dashboard design, namely component type, indicator, component number, dimension, structure and geometry, and weight. Based on troubleshooting contradictions using TRIZ, there are several innovative design specifications, namely adjustable body, natural / synthetic fiber composite materials, modular functions, touch screen function, compact shape, separate support devices and the use of the key as a functioning operating device. This study also resulted in 3 designs of dashboard.

For further research, there are several things to be considered. First, further research can be conducted as deeper design evaluation using ECQFD with involving more environmental factors. Second, the range of this research object can be expanded to public bus, not only UI Molina EV Bus. Third, for a similar study, the methods performed can be integrated with other methods, namely AHP for analyzing the best design option to be chosen, or other ergonomic analytics method to evaluate human factors of the design. Fourth, for further research, survey can be conducted by using another
method such as conjoint analysis to find the combination of user-preferred features. In addition, financial and economic factors can be included as concerns for the design to provide an optimal design overview for manufacturing process and consumer purchasing power.

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