

## ERGONOMIC DISPLAY DESIGN FOR BUS ROUTE

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### ABSTRACT

Public transportation is one of the most important services in supporting the smooth running of community activities in cities where people most commonly use a bus to reach a destination. Consequently, it requires a clear travel route so passengers find it easy to go on a trip. Display is a device for providing information. However, the existing display receives some complaints where more than 60% of passenger experience difficulty in reading what is shown, taking more time for them to understand the information. It is evidence that the device is not effective and efficient to use. Thus, development of a new display is crucial. The purpose of this study was to design an innovative display that is more ergonomic in displaying bus route information. Survey was conducted to identify user requirement. Axiomatic design method was applied to determine the design parameters of the display by mapping process from customer attribute and functional requirement on the basis of the ergonomic principles. Statistical analysis was conducted to test hypothesis. The result of this study showed that the display developed is valid to meet customer criteria at 5% of significant level, covering the criteria of being informative (0.144), comfortable (0.063), digitalized (0.070), and easy to access (0.378). Thus, it is more effective and efficient for passengers to gain any information needed.

**Keywords:** Display, information, ergonomics, axiomatic design, bus route

### INTRODUCTION

Currently, industrial development has come to industry 4.0 eras, whose one of the most important elements is digitalization of system<sup>4</sup>. Furthermore, <sup>4</sup> explain that synthesis of digital technology and physical cyber enable to connect users with such technology. Using the same token in the transportation industry, digital system especially for display, has become significant. It is related to some information that people search for such as travel route and traffic condition.

According to <sup>1</sup>, display is a device to provide information to users so the device should be clear and easy to understand. <sup>14</sup> Expresses that the guidelines to design the display can be grouped into four principles namely perceptual principles, mental model principles, principles based on attention, and working memory principles. Perceptual principles include (a) easy to deliver information and clear, including the colour and font size. (b) Easy to interpret based on past experience. (c) Redundancy and distinction that is the combination of letter and image, image and sound. Mental model principles are related with (a) pictorial realism of information description, (b) movement of object or elements. Meanwhile, the principles based on attention are about (a) minimizing the time to access information, (b) conformity of information, c) delivering various information. Finally, working memory principles encompass (a) reducing the load of memory visually, (b) providing a guide to future conditions and (c) consistency<sup>14</sup>.

However, the existing display in transportation terminal is still complex yet plain, thus causing difficulty for passengers to read and understand information, and requiring longer time. Based on the preliminary study it is found that 60% of passengers experienced difficulties in interpreting the information displayed. As said by <sup>3</sup>, the current display system on public transportation was still inadequate for user. Thus, it is necessary to improve the system by referring to ergonomic principles.

Some previous studies on ergonomic display design have been done by <sup>8,5,13,2,11</sup>. <sup>8</sup> studied the use of various backgrounds and text for readability. <sup>5</sup> Investigated the colour for images where full colour is more significant for working memory than partial colours. In addition, the study of favourite colour for virtual static object and motion object in display design was conducted by <sup>13</sup>. Meanwhile <sup>2</sup> found in his study that there are four categories that must be considered for the development of public displays in public transport i.e. visibility, positioning, content and functionality. <sup>11</sup> designed an effective and ergonomic display for tourist parks.

The objective of this study was to develop an innovative and ergonomic display design for public transportation that satisfies passenger's requirements.

### METHODS AND MATERIALS

Paper-based survey was conducted in this study to identify customer criteria for designing the ergonomic display of bus route. Questionnaires

were distributed to more than 50 passengers. The respondent were people who commonly used bus to travel. Their ages ranged from 15 to 50 years old.

Some devices used in this study to gather and process the data are below:

1. Questionnaires were used to gain some user criteria of the design being developed and to validate the proposed design.
2. IBM SPSS software version 22.0 was used to process statistical data.
3. CorelDraw application software version 2018 was used to design a virtual prototype of the developed display design.

<sup>12</sup> explained that axiomatic design method is applied to develop a product that satisfies customer needs. This method can be used to design various types of systems, including simple and complex ones. <sup>6</sup> identified that axiomatic design method is often used in <sup>1</sup> product design, <sup>2</sup> decision making, <sup>3</sup> software design, <sup>4</sup> system design, <sup>5</sup> manufacturing system design, and others. The method consists of four domains namely customer attributes (CA), functional requirements (FR), design parameters (DP), and process variable (PV) <sup>7,12</sup>. The mapping process among domains can be seen in Figure 1.

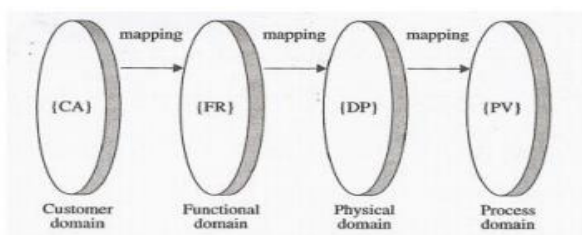


Fig. 1. The Concept of Axiomatic Design [7]

This process starts by determining the attributes of design that customers require. Then functional requirement is developed to satisfying the customer attribute. Design parameters are determined to meet the functional requirement. Finally, the last step is the process variable, i.e. how to create a product based on the design parameter determined.

Conceptual design was developed based on the result of the mapping process that is design parameter of display. The CorelDraw application software was used to create a virtual design.

Non parametric statistical analysis was used in this study. Spearman Rank Correlation test was conducted to test the validity of the attributes<sup>10</sup>. Then Cronbach Alpha was used to determine the reliability of the attributes<sup>15</sup>. Meanwhile Stuart-Maxwell Test of Marginal Homogeneity was used to test the hypothesis. The hypothesis is there is no significant difference between the proposed design and the criteria.

## RESULTS

Table 1 shows the result of customer survey where four groups of attribute of the design were found. They are informative, comfortable, digitizing system, and easy to access.

Table. 1 Customer attribute

Customer Requirements	Code	Validity Score	Reliability Score	Customer Attribute
Informative	P1	0.524	0.788	Informative
Use of symbols	P2	0.602	0.773	
Color contrast	P3	0.684	0.761	Comfortable
Easy to read	P4	0.692	0.760	
Attractive design	P5	0.741	0.751	
Not Complicated	P6	0.811	0.736	Digital system
Use of letters on design	P7	0.647	0.770	
Digital system	P8	0.467	0.809	Easy to Access
Easily accessible	P9	0.353	0.799	

Informative design is one feature of a good display<sup>1</sup>. This attribute is required to allow passengers get complete information easily and accurately without experiencing confusion. Thus, it can help passengers make a decision. Comfortable is an attribute that passengers need in design. This attribute requires the use of any symbol and letters for objects and sentences with colours that are contrast with the background, making them easy to read and attractive.

The attributes of digital system are needed by passengers in order to be able to access information easily, anywhere, anytime. This is because the system involves cyberspace which allows passengers to search for information more effectively and efficiently by using internet.

Table 2 to Table 5 present the result of the mapping process of the display design. Table 2 describes the design parameters that satisfy the informative attribute. Table 3 shows the design parameters that refer to the comfortable attribute. Table 4 shows the design parameters of digital system. While Table 5 explains the use of the display in term of passengers' ease of access.

Table. 2 Informative ergonomic display design of bus route

Code	Customer Attribute	Code	Functional Requirements	Code	Design Parameters
CA1	Informative	FR 1	Providing complete and accurate information	DP 1	Ergonomic display design
		FR 1.1	Providing the information needed by passengers	DP 1.1	Travel information design to and from
		FR 1.1.1	Showing information for passengers to go accurately	DP 1.1.1	Information about routes, fleets, departures, destinations, estimated time, transit, delay
		FR 1.2	Reducing errors in reading information	DP 1.2	Design of typography for display
		FR 1.2.1	Providing ease of read about the information needed	DP 1.2.1	Times New Roman font size 30.

Table. 3 Comfortable ergonomic display design of bus route

Code	Customer Attribute	Code	Functional Requirements	Code	Design Parameters
CA2	Comfortable	FR 2	Improving passengers ability to read information	DP 2	Ergonomic display design
		FR 2.1	Providing appealing interface for passengers	DP 2.1	Attractive interface design
		FR 2.1.1	Increasing the calm and cool feeling for passengers to read	DP 2.1.1	Blue color (R:53 G:157 B:215) for background
		FR 2.1.2	Improving clarity for passengers to read	DP 2.1.2	White color (R: 247 G:251 B:254) and/or black color (R: 54 G:52 B:53) for letters and numbers

Code	Customer Attribute	Code	Functional Requirements	Code	Design Parameters
		FR 2.1.3	Making it easy for passengers to understand the information needed	DP 2.1.3	Proximity, similarity, symmetry and continuity of display element
		FR 2.1.4	Minimizing the complexity of information	DP 2.1.4	Independent simple route

Table. 4 Digital system of ergonomic display design of bus route

Code	Customer Attribute	Code	Functional Requirements	Code	Design Parameters
CA3	Digital system	FR 3	Making it easy for passengers to access informations about bus routes in anywhere and anytime	DP 3	Ergonomic digitized system of display design
		FR 3.1	Providing information about bus routes quickly and accurately	DP 3.1	Ergonomic web design
		FR 3.2	Providing information of about bus routes in detail	DP 3.2	Table of information

Table. 5 Easy to access ergonomic display design of bus route

Code	Customer Attribute	Code	Functional Requirements	Code	Design Parameters
CA4	Easy to Access	FR 4	Reducing passengers search activity to find the information needed	DP 4	Ergonomic design of search menu
		FR 4.1	Easy searching	DP 4.1	Command button
		FR 4.1.1	Providing the continuity of information search	DP 4.1.1	Layer displays

The conceptual design or prototype of the display can be seen in Figure 3, Figure 4, Figure 5 and Figure 6 below.

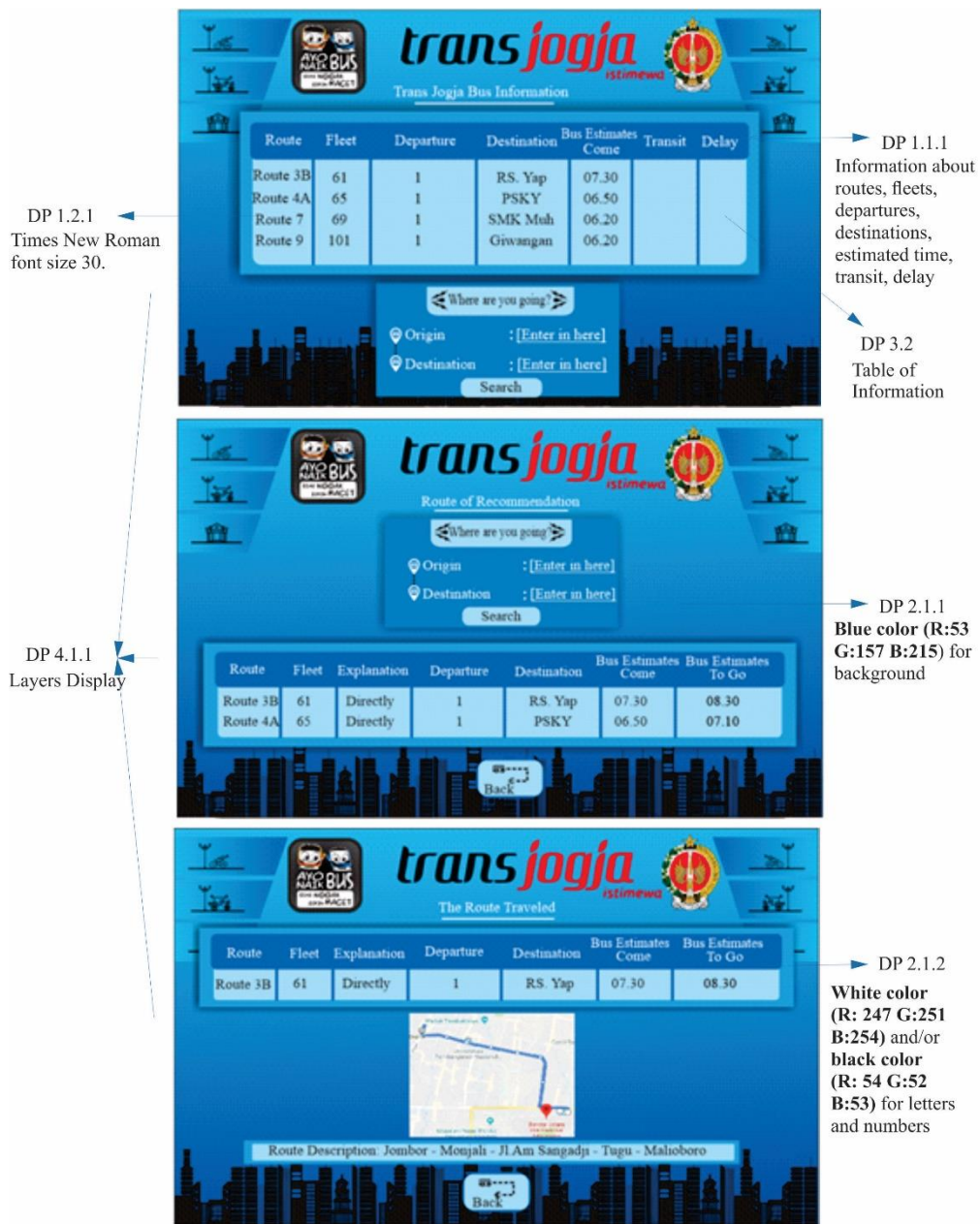


Fig. 2. Parameter Design Representation



Fig. 3. Layer 1 of Bus Display Information



Fig. 4. Layer 2 of Bus Display Information



Fig. 5. Layer 3 of Bus Display Information

The result of the marginal homogeneity test using Stuart Maxwell method is presented in Table 6 where the Z values for each customer attribute are 0.144 for informative, 0.063 for comfortable, 0.070 for digitalized system, and 0.378 for easy to access.

Table. 6 Result of Stuart Maxwell of Marginal Homogeneity test

Customer Attributes	Z values
Informative	0.144
Comfortable	0.063
Digitalized System	0.070
Easy to Access	0.378

The test showed that the null hypothesis is accepted at 5% of significance level for all the attributes.

## DISCUSSION

This study hypothesizes that the displays are not yet effective and efficient in providing information to the prospective passengers, because it still makes them having the difficulties in reading the information. Previous studies<sup>1</sup> explained that a display is a device used to provide information to passengers' so as it must be clear and easy to understand. Another study explained that the confusion and the discomfort in getting information was not expected by passengers when reading<sup>2</sup>.

Result of this study founded there are 4 attributes in developing the displays in order that satisfying passengers need. They are informative, comfortable, digitizing the system, and easy to access.

Ergonomic design parameter of display (DP 1) should provide complete and accurate information (FR 1) to passengers which

encompasses routes, fleets, departures, destinations, estimated time, transit, delay (DP 1.1.1). This aim to allow passengers to gain any information they need to go. In addition to avoiding mistakes in reading the information, its description should be clear and easy to read by applying the font size of 30 Times New Roman (DP 1.2.1). Thus, these parameters are expected to satisfy customer need for being informative.

Besides, the ergonomic display design should also be able to improve the ability (FR 2) and easiness (FR 2.1.3) of passengers to read and understand the information displayed. Hence the design must be clear and easy to read (FR 2.1.2), provide appealing interface (FR 2.1) and increase the calm and cool feeling (FR 2.1.1) for passengers as well as not complex (FR 2.1.4). Thus the design parameter should be attractive (DP 2.1) and simple (DP 2.1.4) by using blue colour for the background (DP 2.1.1), and white and/or black colour for letters and numbers (DP 2.1.2) based on the proximity, similarity, symmetry and continuity of the display element (DP 2.1.4).

Digital system (Table 4) of display is a system that passengers require. Thus, the design parameter should be ergonomic (DP 3) and able to ease passengers to access information about bus routes anywhere and anytime (FR 3). This parameter must use web system (DP 3.1) and the information should be displayed in tables (DP 3.2) providing bus routes information quickly, accurately, and in detail (FR 3.2). Hence the system has ease the passengers in searching the menu (DP 4). It is to reduce search activity (FR 4) and ease (FR 4.1) passengers to get information continuously (FR 4.1.1). The command button (DP 4.1) is designed and layer system has to be applied (DP 4.1.1).

The statistical analysis showed that the proposed display design is a significant valid to meet the passengers' requirements which it was more informative, more comfortable, easier to access and more effective and more efficient.

## CONCLUSION

It can be concluded as follows:

- 1) The attributes of the display design for bus route are informative, comfortable, digital systems and easy to access.
- 2) The design parameters of the display should be ergonomic, encompassing:
  - a. The design contains route, fleet, departure, destination, estimated time, transit and delay elements and also uses the font size of 30 Times New Roman for letters.
  - b. The design should use blue colour (R:53 G:157 B:215) for the background, white (R: 247 G:251 B:254) and/or black (R: 54 G:52 B:53) for letters and numbers, and the proximity, similarity, symmetry, and

continuity of the display elements as well as independent simple route.

- c. The design should use an ergonomic web design and also present description using tables.
  - d. The design consists of several layers to provide continuity of information retrieval from the command button.
- 3) The proposed display design for bus route is valid to meet passenger's criteria at 5% significance level.

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