

Usability improvement of public transit application through mental model and user journey

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ABSTRACT

Using a mobile application that is featured with local public transit information can greatly improve user action, as well as assisting travelers to have a better experience while taking public transit services. Crowd environment inside a public transit is one of the most frequent causes that lead difficulties to passengers when they engaging their mobile devices to access their apps or in some conditions. Finding crucial information such as stops points and remaining time to interchanges point when switching to another line becomes more difficult in those conditions especially for foreigners who new in a particular region. This study presents the combination of a mental model and a usability approach to construct a user journey map that led to new insights on user's experiences and challenges when utilizing their mobile local transit application. This valuable information is a part of the elicitation process to propose an alternative interaction method to enhance the usability and travel experience of the public transit app. The experimental results indicate that in contrast to the existing mobile transit app, the proposed interface with the utilization of a wearable device could considerably enhance user action when trying to reach the desired location in terms of total time and performance. It implies that the proposed solution, which works through the mental model and user journey is able to intuitively enhance the public transit app usability.

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1. INTRODUCTION

One of many frequently-used mobile applications used in daily commuting is a mobile application that relates to transportation and navigation. The high demand of local transport application and the limitation of Google Maps feature for providing comprehensive support to urban navigation in Indonesian [1] has motivated community developers to propose numbers of local public transit applications that provide specific information about route segments to help people when traveling with public transportation in a specific region. In 2016, a local mobile app for Greater Malang was developed, namely "Angkot Malang Apps." The main objective of this app was to provide information support about one of the most used public transport modes in the city called "Angkutan Kota" or simply "Angkot." This mobile application provides the Grand Malang area routing segments. This application helps users to determine the Angkot route and its itinerary points of transit

on a particular route [2]. The major issue of utilizing this app for regular daily use is the lack of usability and interaction experience between the user and smartphone. Other research shows that the usability flaw of an application in its actual usage environment may cause several negative consequences, unexpected behaviors, results, or injuries [3]. The indication of usability issues of a mobile application that is causing the difficulties of the user to operate the application is illustrated in Figure 1.

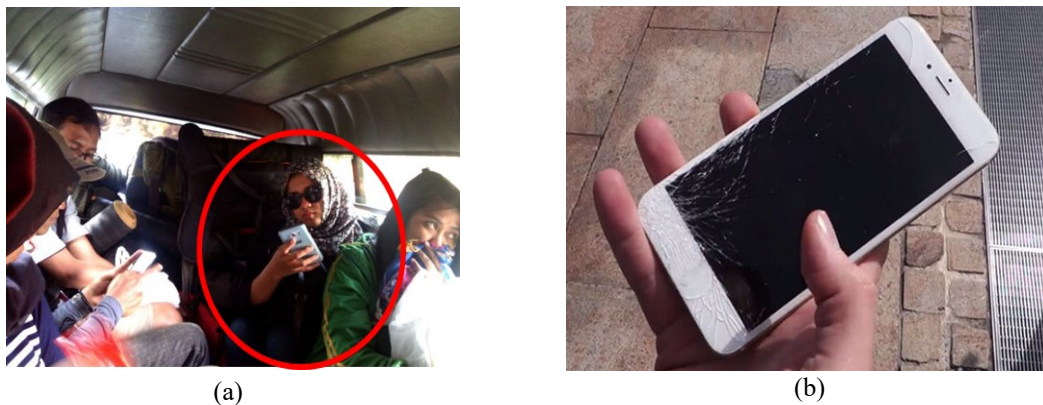


Figure 1. (a) User's gesture inside a public transportation and (b) broken smartphone that caused from inconvenient gesture

It is common to find people take their device out of their pocket or backpack and hold their smartphone continuously to use the transit app. For commuters who frequently use public transport mobile application on a smartphone, to keep monitor the application screen in order to see their location as they travel along a waypoint or a transit route segment seems to be inconvenient. In addition to that, many local public transportations in Indonesia were small in its capacity. Especially during busy hour, the use of the mobile application in a crowded situation become more inconvenient or even impossible to do. The inconvenience in using a mobile application in a such situation can cause poor gestures of users, thus lower their interaction stability that increases the probability of a device falling and break off. With this fact, finding the correct stops or interchange points to switch lines and finding the required time that they have to stay on a particular line before changing to another line becomes more difficult. Based on those issues, usability is considered as a definitive factor in developing mobile applications of the local public transit.

The usability dimension is a critical topic for mobile application development since it is necessary to develop a user-friendly application and this aspect has been identified as one of the factors that can determine the quality of an app's user experience. Usability specifically indicates the degree of user performance whiles using an application to attain a specific goal [4]. As part of usability enhancement, the process of understanding how a system works requires individuals to construct a mental model of the system in their minds. The mental model acquisition should be one of the key factors when developing a meaningful application. Having a deficient mental model may indicate a lack of awareness of the usability risks surrounding the learning activities [5]. A user journey map is a modern approach for modeling and analyzing the experience of users in the field of product design. Recent insight reveals that the user journey map is one of the effective tools to construct a mental model from a system [6-9]. This map offers the traditional user personas a three-dimensional attribute by adding a diachronic outline of the user and product interaction processes [10]. We develop a user story depending on user journey perception to record the user's mental model when using public transportation apps.

The objective of this study is to gather user story form the potential user's perspective and work with the mental model in order to present the new concept of public transit application that have better usability compared with common existing local transit app. This paper discussed how the mental model and user journey map are implemented as a tool for rapidly transforming user stories into software requirements to propose a prototype of the local public transit system that helps users intuitively achieve their destination point. In this study, we use usability variables to capture the discomfort and behaviors of the user using the following metrics: 1) effectiveness, 2) learnability, and 3) satisfaction. In addition, this report also performs a comparative overview of the existing public transit navigation applications that running on smartphones with proposed public transit navigation scenarios with a set of the new requirement that value human factors from user journey mapping results.

2. RESEARCH METHOD

Improving the usability of local public transit app for navigation has expanded our perspectives of interactive transit systems. A diary study was used to observe and investigate various user strategies to get information about local transit when traveling. This section briefly explains the methods that used to gather information from the user, identify user's challenge for constructing mental model then mapping the insight to a set of software requirement, and system design and usability strategies.

2.1. Usability oriented approach

According to the International Standards Organization (ISO 9241-11), there are three primary aspects that comprise usability of application or service: effectiveness, efficiency, and satisfaction. The effectiveness related to the application's performance to be used to perform certain tasks. Or can be said how good a product when doing the tasks that must be done. Efficiency is referred to how quickly a user can achieve a goal when using the product. While the satisfaction factor describes whether the product is free of inconvenience and whether the user shows a positive attitude towards the product [11]. In this study, The system usability scale (SUS) questionnaire was adopted to measure those primary aspects of usability [12]. Usability oriented approach in this study will focus on three aspects that relevant to use when designing a local public transportation application: field study, mental model construction, user task scenario, and user journey mapping.

2.2. Constructing mental models

The mental model is a simpler world in people's minds when they understood the objective world [13]. A mental model is a series of assumptions, ideas, images, or impressions that ingrained in the mind, affecting how people understand the world, and how they take action. It is a unique way of understanding which formed in the process of interacting with the world and it is built by people on their distinctive lives, points of view, and world understandings [14-16]. To put it simply, mental models are people's inner representation or perception of how something should work, based on their past experiences. Mental models actively influence the decisions or actions that users will take. From the literature on navigation, it is clear that the processes that needed when using a public transportation app to achieve a particular destination point could be divided into three steps scenario. The first phase starts when the commuters determine their destination (the input process of the direction). Second, they need to know the available public transit line to be used and, if necessary, they may need to specify where they need to switch to another transit line before they actually arrive at their destination (the itinerary review phase). Lastly, the navigation guiding phase in which a travel plan is arranged and actions are carried out as confirmed in the itinerary. This three steps scenario is still widely used and becomes the mental model in public transit app practice [17-19].

2.3. Recording user story

A User Journey Map (UJM) is a tabulation form of user's behavior with the horizontal axis is represented user action stages through time and there will be insight metrics or categories of theme for analysis along the vertical axis. The actions on the horizontal axis will vary depending on the problem domain, but the vertical axis will generally contain the standard metrics [20]. It visualizes how users have encountered their trip to a particular destination using local public transit applications. Detailed components of the user journey map are presented in [21].

Several consecutive field observations, diary recordings, and extensive interviews have led to gain a better understanding of user behaviors and perceptions about mobile transit apps and services throughout their trips. We are objectively analyzing the personal feedback on their possible interpretation of the subject matter of the public transit app. A number of various participants can participate in the field-study and testing. Macefield notes that the involvement of 20 potential respondents in the usability experiment would reveal as many problems of usability as more people do and it offers a reasonable value-to-cost ratio for the usability experiment [22]. In this study, 20 respondents were participated based on Macefield's insight. To record user stories, we adopted a scenario-based approach [23]. Scenarios included in this research were divided into 5 main tasks derived from user basic mental model when using the transit app. Table 1 describes the detailed tasks that should be completed by participants.

When they were carrying out the task that particular use the same 4G network capability, their activities and processes were observed. Each transaction step of their activities was recorded and mapped with a data collection form. All the list of task scenarios will be completed by each participant. Based on the data obtained from the user story and activities, we generate a user journey map which can be seen in Table 2. In the user journey construction, the user action, question, happy moment, pain point, and opportunity are used as vertical axis parameters. Actions: the thing that the individual has to complete to pass to the next action stage. Questions: the things that the user needs to answer when doing an action before they are willing to move to the further step. Happy moments: pleasant, enjoyable things that trigger a positive experience. Pain points:

negative feedback, complaints, and annoyances that ruin the user experience. Opportunities: the design enhancements that could be implemented in a new product to address any of the identified problems.

Table 1. Evaluation tasks

Tasks	Task Description
1	Start from the same source point, assuming the participant in a condition to travel around Malang city by utilizing public transport, launch the common transit app, and review the application functionality!
2	Plan to go to a Landungsari bus station (5 km in distance), input and search the destination on the application.
3	Check available transport lines provided by apps and confirm one transport line to the destination.
4	Enter the itinerary result page and review detail of travel itineraries, and present its location on a map view.
5	Determine an itinerary line to the destination, start the navigation using the app suggested results, and complete the navigation.

Table 2. User journey map for in-city public transport app

	Specify the Destination	Choose public transportation Line	Navigate to Destination
Action	<ul style="list-style-type: none"> - Open Apps. - Select source and destination location on the map view. - Press the "Go" button. 	<ul style="list-style-type: none"> - Select one line from available public transportation options. - Select one line from available public transportation routes on the map. 	<ul style="list-style-type: none"> - Get in public transportation - Check the transit point (if an interchange line is available). - Wait until arrive at the destination.
Question	<ul style="list-style-type: none"> - Do I have a GPS location? - Do I have Internet connection? - Why is the map not showing? - Do I choose the location correctly? 	<ul style="list-style-type: none"> - Is this the fastest route? - Where I am now? - How far my trip goes? 	<ul style="list-style-type: none"> - Am I choose the correct line? (If available) Where and when should I do the interchange? - Am I close to my destination?
Happy Moment	<ul style="list-style-type: none"> - App show destination location on Map. - App work properly and responsive. 	<ul style="list-style-type: none"> - Users can choose the preferred line of public transportation easily. - Users can access detailed information on the route which is shown on the maps. 	<ul style="list-style-type: none"> - Users get information about the interchange line on the trip and know when to change a line easily. - Informed when the stop point or destination is near.
Pain point	<ul style="list-style-type: none"> - Users have difficulty finding the destination on the map because they must search and select a pinpoint in the maps manually. - Type and select a wrong location. 	<ul style="list-style-type: none"> - The apps can't provide detailed information such as actual distance, travel time to support user actions. - Users don't know how far the distances in each route or inter-route (if there is an interchange). 	<ul style="list-style-type: none"> - Users often don't have control of their smartphone app. - Users don't know their actual position when inside public transportation until interchange point or their destination. - Users don't know how far the distance they should take to the interchange point or destination
Opportunities	<ul style="list-style-type: none"> - Create a new input method that a user not necessarily type a single word when choosing a destination. 	<ul style="list-style-type: none"> - Create a new feature that shows distance to the first stop intuitively. - Create a new feature to calculate the distance from each public transportation route when an interchange is available. 	<ul style="list-style-type: none"> - Provide new interaction to access information when the user inside public transport. - Give meaningful notification when user are approaching their interchange point or destination

2.4. Prototype design

Designing effective transportation applications in Indonesia for instance is not simply a matter of technical wizardry. This is due to the fact that the general public transportation data in Indonesia are unreliable and not well organized by the government compared to the general public transportation system in developed countries. Based on the insights as shown in Table 2, the current implementation of the public transit app lacks an input method interface and data integration as a portion of the user's mental model when users access and use the app inside the public transportation. Commuters also hope a travel assisting app that can take more human factors, such as the degree of comfort and safety when using the app, into consideration. To prove our concept, we build a prototype based on the insight that we have on the user journey map we had implemented for local public transportation. Detailed prototype documentation can be seen in [24]. During the first stage of the mental model, the application should obtain the user's current location as the origin point by using the device's global positioning system (GPS) sensor. However, this process doesn't require any user interface in

the wearable device app as it was performed automatically in the background. In the second phase, the application defines the target destination from one of several input methods, i.e., voice input, manually type the location name, and pinpoint a location on a map view. The voice and type location names input methods were used as an alternative approach to solving the users' difficulties in finding the destination using the pinpoint method. Activities in this phase are shown in Figure 2 (a).

The itinerary review phase begins after a user enters the origin and destination point in the application. Based on the origin and destination points, the application starts finding several appropriate public transit route recommendations. The wearable app displays the list of itineraries for the user to review. An itinerary is considered as a sequence of location checkpoints where particular public transportation will pass. Inside an itinerary, information about the distance that must be taken from the user current location to the first point of pickup to get in public transportation is also displayed. The walk distance to the nearest stops is displayed if they currently stand several meters far from the public transportation waypoint, assuming the users prefer to walk from their current location to the first waypoint. In addition to that, information related to the distance of each public transportation route can be shown on demand in the mobile application. In the third phase, the wearable device application enters the Navigation Guide phase. It periodically checks the distance of the user's current position to the currently active checkpoint and notifies the users when they are approaching the checkpoint. This process can be done by getting the user's actual location from the device's GPS sensor and calculated it toward an active checkpoint using the Haversine formula. When a user has entered a specific area for a checkpoint, by merely calculating the user's distance from the checkpoint in a circular form (geofence) as described in [25], the wearable application gives a notification to the user with a vibration when they were entering the geofence area of a checkpoint. Part of the user interface design flow of the wearable device app when seeing itineraries in the second phase and when a user is approaching the checkpoint in the navigation phase are depicted in Figures 2 (b) and 2 (c), consecutively.

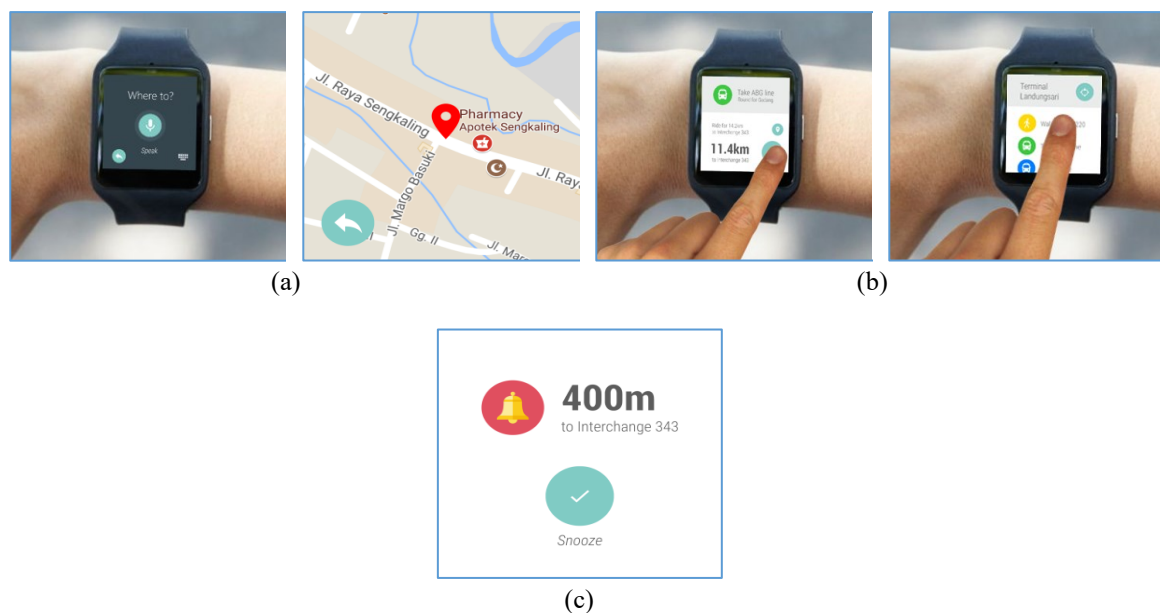


Figure 2. (a) Origin and destination input phase, (b) Reviewing itinerary, (c) During navigation phase

2.5. Usability comparison

The quality of an interactive product has become such an important criterion. In the context of the interactive application, usability evaluation is an essential task in mobile application development. Performing usability inspections during the application development process can bring several benefits such as increasing the quality in use and of the software product before its release [26]. We compare the usability level of the proposed prototype which was developed with the mental model and user journey map with existing common transit apps. The same 20 participants from the mental model recording process were involved in the experiment and they were asked to perform the same scenario as in Table 1 and use the same 4G network connection but with the proposed prototype. Each participant performed the evaluation tasks only once for each type of application, i.e., the mobile application and the proposed interaction with a wearable application.

Experimental conditions in Figure 3 (a) and Figure 3 (b) show the same task completion with two different application presentations.



Figure 3. (a) Screenshots of the common smartphone public transit app, (b) The proposed design

3. RESULTS AND ANALYSIS

Usability testing becomes one of the most common methods in verifying and validating a software quality [27]. The success rate and travel time are used as a key indicator to compare our proposed interaction with the existing public transit application based on indicators in the IEEE validation standard [28]. When the active participants were carrying out the tasks, their behaviors were observed and any issues arose or experienced by the users were noted. Upon completing all tasks on both mobile and wearable apps, participants were asked to fill the System Usability Scale (SUS) questionnaire to measure the usability quality of both apps. Participants were asked to score ten-question items, which were adapted from the SUS questionnaire, to assess several usability parameters with one of the five responses that range from strongly agree to strongly disagree as described in [29]. The usability testing session is closed with the SUS questionnaire on participant assessment of the proposed interface that involves a wearable mobile app. The SUS questionnaire includes the main usability factors, i.e., learnability, effectiveness, efficiency, and satisfaction, and a direct comparison was conducted to explicitly compare the two evaluated application usability. The original SUS items need to be modified in this study to cover the application context of use. SUS scores did not appear to be significantly affected even when the even items were rewritten with a positive tone [30, 31]. The usability results summary of each scenario, which includes the travel time, success rate, and modified SUS questionnaire for both smartphone and smartwatch version of the applications, are summed up in Table 3.

As far as efficiency is concerned, results showed both of the apps could undoubtedly assist the user to reach the destination, but taking into account the total time required to complete each task scenario, the participants performed the task relatively faster with the proposed interaction method (20.4 minutes in average) which extends the app with the smartwatch as a new user interface. The standard deviation (σ) value of the SUS questionnaire indicates that most users have similar experiences when using both applications. Even though both apps (a smartphone app with the map-based interface and the proposed app with smartwatch) have a relatively equal number in SUS ratings, it should be noted that participants have a faster learning curve to understand the entire application flows in the simple smartwatch presentation. The result of Q6 shows that in

the proposed interaction, users can perform a set of navigation tasks on their apps without requiring any direct contact with the smartphone. This kind of interaction relatively reduces the anxiety of the user during travel. Similar feedbacks of participants were also stated in favor of supporting the result of the success rate and required total time of the proposed interaction as follows: "... [Standard transit app] could lead to lots of mistakes when users do not see the smartphone screen. It was hard to follow, time-consuming, and confusing when it should keep an eye on the screen...". Although the proposed system was rated slightly better than the standard one, the majority of participants also made several comments about additional expenses that require them to have a smartwatch in order to take the full benefit of the proposed application. The number of participants stated, "... The proposed system prototype is very useful and easy to use, but a smartwatch takes an additional cost which is not everybody could afford ...".

Table 3. Usability testing results

Variables	Test Conditions	
	Smartphone (Mean / (σ)) ^a	Smartwatch (Mean / (σ)) ^a
Travel Time (minutes):	26.20 / 2.78	20.40 / 2.68
Success Rate (%):	100%	100%
Questionnaires [Usability Parameters]:		
Q1: The information flows presentation are easy to understand [Learnability]	2.65 / (0.49)	3.55 / (0.51)
Q2: The language and instructions provided are easy to understand [Learnability]	3.60 / (0.50)	3.20 / (0.41)
Q3: The colors, icons, and other interface components used are familiar and consistent [Learnability]	3.80 / (0.41)	3.60 / (0.50)
Q4: I feel I don't need someone else's guide to use the app [Learnability]	2.85 / (0.67)	1.80 / (0.62)
Q5: The information provided is very clear and effective when looking for public transportation routes [Effectiveness]	3.20 / (0.41)	2.05 / (0.89)
Q6: I don't need to keep monitoring the running of the app when it runs on the screen [Effectiveness]	0.70 / (0.47)	2.65 / (0.75)
Q7: If I make a mistake, I can quickly recover [Efficiency]	3.25 / (0.55)	2.35 / (0.67)
Q8: The button is large enough when tapped, so it efficient to select the menu [Efficiency]	3.20 / (0.77)	2.80 / (0.41)
Q9: If I need to find Angkot route, I would love to use this app [Satisfaction]	3.55 / (0.60)	3.80 / (0.41)
Q10: I think I will often use this system [Satisfaction]	2.05 / (0.69)	3.20 / (0.77)
Total SUS Score	72.13 / (6.85)	72.50 / (5.13)

4. CONCLUSION

This paper expands the usage of the mental models to reflect the user's inner thinking about public transit process. The user journey map is used to elicit the requirements of a public transit app for a daily commuting scenario with public transportation. The basic idea of user journey mapping utilization is to provide a user-centered viewpoint when inspecting the personal preferences and level of experience of the user. The prototype of our approach has been tested in a controlled real-time environment and condition. The results revealed that the proposed interaction with the smartwatch as a user interface can be categorized as usable in terms of effectiveness and efficiency. In addition, the overall functional requirement, which is gathered through the mental model and user journey, could substantially support the action of the user (in terms of reducing the travel time) when using the proposed wearable transit application, compared to the traditional public transportation app. The mental model and the user journey map are inevitably effective tools to create an overview of the user's behaviors and pain points in the elicitation phase and software requirement analysis. The user journey map also plays a great role to rapidly convert user's insight into a set of requirements that consider the human factors when developing a reliable and robust local public transit application that is expected to have a good usability level as well. Due to this preliminary study only use the sample size of data, the research insights should be interpreted with caution when applied in similar massive commercial applications considering that the smartwatch still has broad potential to explore and several limitations. More respondents also need to be involved to validate the result.

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