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EVALUATING CONSTRUCTION DEFECT MOBILE APPLICATION USING THINK ALOUD

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ABSTRACT

Construction Defect mobile application (app) is used by Ministry of Defense's Construction Defect Inspection Team to help the team in recording construction defect. However, the mobile app has never been evaluated formally to identify any usability problems. The objectives of this study are to identify usability problems of Construction Defect mobile app using think aloud and to recommend design improvement of Construction Defect mobile app based on the identified usability problems. The think aloud study involved 15 participants. During the evaluation, every participant carried out the given tasks and gave his impressions as he went along the tasks. Three usability problems were identified. Some recommendations have been proposed to improve the design of Construction Defect mobile app. As for the future work, the study may be conducted using different usability evaluation technique.

Keywords*: Usability, Human Computer Interaction, Think Aloud, Mobile App, Construction Defect*

1. Introduction

Construction defects are among the major concerns in the construction industry. Defect inspection process is performed to assess the physical condition of building components such as structural works, architectural works, mechanical and electrical works and external work. The process includes building site inspections, identifying defects, recording defective information using paper, entering information into the database online, and hand over such information to designers and builders to repair such defects (Dong, Maher, et. al, 2009).

The implementation of defect inspection using mobile device is considered as a part of early stages in the construction industry development. It is a typical information gathered from an actual construction site by the worker in charge. The use of mobile device is an ideal choice for construction industry personals as they are presented to natural variables, for example, terrible climate and lack of information technology infrastructure.

A mandatory step in developing mobile applications is to conduct usability evaluation (Zhang & Adipat, 2005). The evaluation elements are the design and the characteristics of the product based on the selected user feedback (Rebelo & Soares, 2012). The evaluation is also an important requirement but often neglected in evaluating the design and efficiency of software applications (Nielsen, 1993; Hamborg, 2004). The evaluation results will save resources while reducing the overall system error (Hamborg, 2004; Dumas & Redish, 1999).

Currently, Ministry of Defense's Construction Defect Inspection Team are having problems due to many mistakes that have been made, therefore the head of Defect Inspection Team require the team to find a solution on how to reduce the mistakes and increase the productivity by giving feedback to the developer to improve the mobile app design.

This study is to evaluate the usability of the mobile app. The evaluation is important for a mobile app to highlight the usability problems from user sides. An interview session was conducted with Lt Kol Ahmad Sallahuddin Ibrahim, the head of Defect Inspection Team, and based on the interview, he said that the mobile app has never been evaluated formally to identify any usability problems for instance, on the navigation and orientation error. Currently, only verbal complaint had been made such as having lag time when recording construction defects into the mobile app. The team might have other difficulties but they do not give any formal feedback about the usability performance of the mobile app such as the effectiveness, efficiency and error.

The scope of this study focuses on the Defect Inspection Team and the participants are from engineering discipline which include Architectural, Structural, Mechanical and Electrical at Ministry of Defense's construction projects. This study uses mobile app as data entry tools for the defect reporting. This study is about investigating the usability problem of the Construction Defect Inspection mobile app's main modules, which are user login and logout, projects reporting, defect reporting and photographs (evidence) attachment and also provides suggestion for improvements.

This study helps to identify the mobile app usability problems and later to rectify the current design problems based on user's perspectives. As a result, it gives better user experience among the Defect Inspection Team to accomplish the task in a more structured manner.

1.2 Problem Statement

Manual defect data collection process can lead to negligence where the defect data might disappear and lead to misunderstanding among stakeholders in the construction site. To make the best decision, top management needs to obtain information from the construction site before any action is taken. The distance between the construction site and the main office delayed the decision making process as well as lowered the level of efficiency and productivity.

This method of communication is ineffective because of remoteness of construction site and conventional defect record based on paper is defined as the key problem. To improve the efficiency of construction and improve the productivity of construction management is to use mobile computing technology (Pascoe, Ryan, & Morse, 1998). The use of mobile computing technology for data collection at construction sites was investigated as early as 1992 (McCullouch & Gunn, 1993). This study addresses the manual process of defect data collection issues through the mobile app. The study seeks the answers to the question: Does the data entry user interface of mobile app increase efficiency and productivity of Defect Inspection Team?

2. Literature Review

2.1 Think Aloud

This study uses the think aloud method. Think Aloud method is an instrument that involves some particular specific participants who will interact with the system separately. The fundamental part of the think aloud method strongly urge the participants to give verbal depictions on what are they proposing to do and what is going on their screen (Rubin & Jeffrey, 2004).

This method is often used in human computer interface evaluation, though traditionally it is used as a psychological research method. Think aloud usability evaluation method is one of the most basic evaluation methods where testing is performed with real participants (Nielsen, 1993). This evaluation process requires the participants to verbalize their thoughts and comments while using a system or prototype to complete a set of pre-defined tasks. All observations and comments will be recorded, and then analyzed. The purpose of the analysis is to determine the problem in the system.

Think aloud is a direct observation method of user testing that involve asking users to think out loud as they are performing a task. Users are asked to say whatever they are looking

at, thinking, doing, and feeling at each moment. This method is specifically helpful for determining users' expectations and identifying the aspects of a system.

2.2 Benefits of Think Aloud

Think aloud is the most important method in the toolkit of usability evaluators because it uncovers more problems than any other measure (Ramey, Boren, Cuddihy, et. al, 2006). Perhaps due to this, think aloud is one of the most popular and frequently applied techniques in testing (Nielsen, Clemmensen, & Yssing, 2002).

Also think aloud method best applied to website evaluation to gain further insight into user experience. It plays an important role in educational research, as a tool for studying both teacher and student thought processes (Rikard & Langley, 1995).

In the usability lab worldwide, think aloud is the main method. Moreover, this method is also popular in the scientific community of psychology and computer science. According to some researchers, this method is often expected as the most widely used evaluation method in the computer industry. (Jacob & Schmolze, 1998)

The most vital benefit of think aloud is that it provides input to designs from actual users, who are representative of the user population. By verbalizing their thoughts, participants give practitioners an understanding of how they view the computer system, enabling evaluators to identify users' major misconceptions (Nielsen, 1993; Razak et. al. 2018). The process of think aloud allows practitioners to gain thorough examination of users' behavior, which can be analyzed to reveal the causes of usability problems.

Additionally, observational data provides insight into users' affective reactions including; sighs, frowns and scowls which speak of users' dissatisfaction and frustrations (Preece, Roger & Sharp, 2002; Zain et. al., 2008). Flexibility of the think aloud approach is also beneficial for usability practitioners. Some facilitators of the method realize that changing conduct during think aloud can affect the kind and amount of data collected. They may therefore manipulate the session to ensure user exploration of certain areas to match the objectives of the test (Ramey, Boren, Cuddihy, et. al, 2006). This is a great benefit of the approach when concentrating on certain aspects of an interface which may be suspected to be problematic and to uncover reasoning for the problems.

2.3 Research Framework

This study adapted mobile application usability model proposed by Zhang and Adipat (2005) to measure the usability of the data entry user interface of mobile application. They have proposed nine attributes of usability evaluation namely learnability, efficiency, memorability, user error, user satisfaction, effectiveness, simplicity, comprehensibility and learning performance. Productivity is dictated by observing production produced (effectiveness) as opposed to efforts being made to achieve results (efficiency). At the end of the day, if users can achieve more success by using little effort, productivity increases (Keh, Chu, & Xu, 2006). Therefore, this study will highlight the effectiveness and efficiency attributes in data entry user interface usability evaluation.

3. Methodology

3.1 Research Design

This section describes the procedure that has been performed to select the participants, data collection methods and data analysis.

- Participants

15 participants as listed in Table 1 have been selected to evaluate the data entry user interface. The chosen participants were selected based on their experience in defect inspection and with at least one year of experience in using Smartphone. The participants have participated in the usability evaluation based on users' core components experience. For this study, the selection of users' core components experience is important because the information about the target participants of the data entry would be helpful to identify typical participants for user testing (Tzanidou, 2006). In addition to that, the participants additionally should be accessible, can explain contemplations and past experiences (Palinkas et al., 2015).

Table 1. Lists of Participants

Participant	**Work Experience (years)**	**Inspection Experience (years)**	**Core Components**
P01	22	22	Structural, Architectural, External
P02	16	16	Architectural, Mechanical & Electrical, External
P03	15	15	Structural, Architectural, External
P04	15	15	Architectural, Mechanical & Electrical, External
P05	19	5	Mechanical & Electrical, External
P06	17	1	Mechanical & Electrical, External
P07	7	7	Architectural, Mechanical & Electrical, External
P08	2	1	Mechanical & Electrical
P09	1	1	Mechanical & Electrical
P10	9	5	Architectural, Mechanical & Electrical, External
P11	20	9	Structural, Architectural, External
P12	18	6	Structural, Architectural
P13	15	6	Structural, Architectural, External
P14	11	6	Structural, Architectural, External
P15	15	15	Architectural, Mechanical & Electrical, External

3.2 Data Collection Methods

The researcher has developed the task scenario for the target mobile application. This included the actual tasks for the selected data entry user interface which represented the actual use of the defect inspection data entry. In setting up the task scenario, the proposal from Nielsen (1993) and Preece and Rombach (1994) were mulled over concerning the start and completion of the tasks. Simple tasks were chosen for the principal tasks with the expectation to allow the

participants to feel great at the initial stage. The participants would have the chance to feel great when they achieved something towards the end of the tasks.

Amid the usability evaluation, every participant played out the tasks given to them on the objective mobile application. The participants were advised to be verbalized, toss out their idea and help each other while playing out the usability testing. Almost every piece of information and steps are logged by the researcher on a piece of paper, recorded by ADV Screen software and built-in Smartphone camera. Data were gathered through these steps. The participants are permitted to speak uninhibitedly about any blunder they confront or the positive point about the mobile application while playing out the given tasks. The usability test of data entry user interface concentrates more on the accumulation of qualitative data, for example, participants' considerations, feelings and responses.

4. Analysis and Findings

Smartphone screen activities were recorded for detailed analysis. Then, transcripts were coded using both predetermined codes based on research framework that has been adapted from Zhang and Adipat (2005) and codes that emerged from the data. Microsoft Excel was used to analyze the codes found in the think aloud method and debriefing interview data. Lastly, the themes that have been fabricated based on the codes (Groenewald, 2004).

4.1 Task Scenario

The task scenario usability evaluation sessions and debriefing session was written in English and Malay to ensure all participants understand the questions. The participants were given the task scenario prior to the evaluation session.

Tasks. All participants were able to complete all the tasks. The screens of the Construction Defect Inspection mobile application appear as shown in Fig.1 and Fig.2. Table 2 lists the findings from the think aloud.

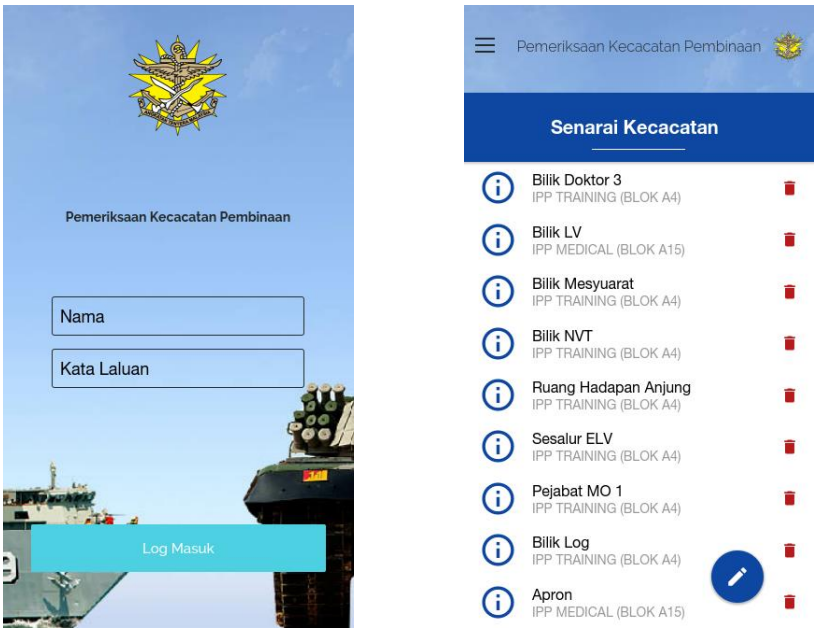

Figure 1. (a) Login; (b) Defects List ("Senarai kecacatan")

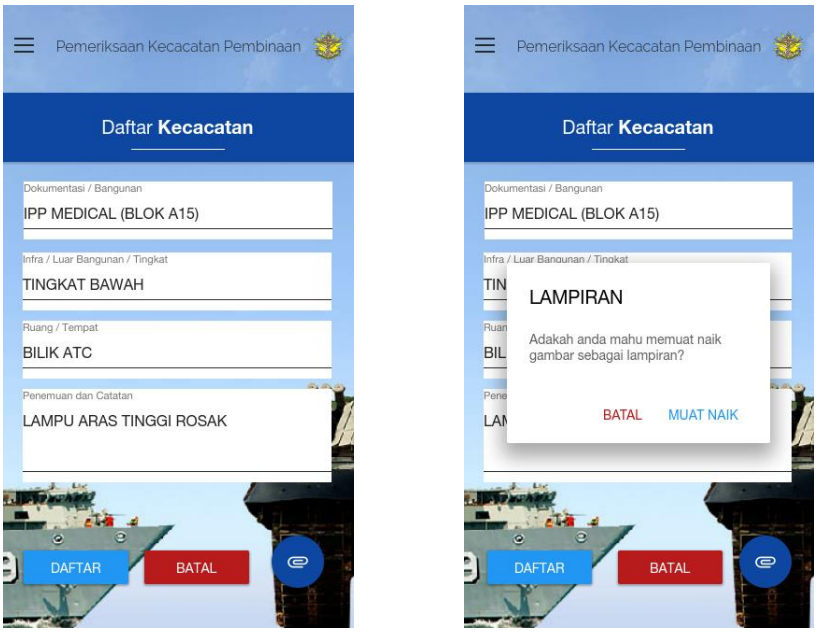

Figure 2. (a) Register Defect ("Daftar kecacatan"); (b) Attach Photograph

4.2 Research Result

i) Table 2 summarized the feedback from the participants.

Table 2. Summary of Think Aloud.

Tasks	Think Aloud
1. Please open the Construction Defect Inspection mobile application and enter the username and password that have been given to you.	Login is easily understandable.
2. You are now in the Commanding Officer's Toilet located at Level One, IPP Training (Block A14) building and found that the stopcock is not working. Please register the defect.	• Some icons are small and options for adjusting the font size is needed. • All the text fields are well organized and text boxes size are suitable.
3. Update the defect report as in Task 2 by uploading and attaching the photograph to the report.	Participants find this step was the easiest but could not edit the photograph that they have already inserted.
4. You are now in the ATC Room located at Ground Floor, IPP Medical (Block A15) building and found that the high bay light fitting malfunction. Please register the defect.	See #2
5. Update the defect report as in Task 4 by uploading and attaching the photograph to the report.	See #3
6. End of Tasks and logout.	Logout is easily understandable.

ii) The usability problems will be the key aspects to be improved in the design of Construction Defect mobile application. Table 3 summarized the three usability problems identified and their level of importance given by the participants.

Table 3. Usability Problems.

Usability Problem	Severity	Theme
1. Participants had difficulty dealing with slide in menu.	Moderate	Navigation
2. Participants do not familiar with icons used.	Minor	Screen Layout/Design
3. Participants could not edit the photograph that they has already inserted.	Critical	Content

iii) The research question: Does the data entry user interface of mobile application increase efficiency and productivity of Defect Inspection Team?

To answer question in (iii) the study adopts usability attributes chosen namely learnability, efficiency, user error, user satisfaction and effectiveness.

- Learnability

Learnability alludes to the capacity of the application to be effectively learned by all levels of participants. The interface in the mobile app is intended to have the capacity to streamline and quicken the way toward figuring out how to use the application.

- Efficiency

Efficiency is also achieved by reducing the amount of input needed via typed or entered by the participants using autocomplete prefilling to provide accurate suggestions and enables participants to enter the input field with fewer keystrokes than regular input fields.

- User Error

From the evaluation, inexperience participants have contributed to the identified usability problem because they lack of knowledge in construction defect inspection.

- User Satisfaction

Most of the participants satisfied with the mobile app.

- Effectiveness

Effectiveness is achieved when the mobile app is successfully help the user in doing the task.

4.3 Design Improvement Recommendations

Several specific design improvement of the Construction Defect Inspection mobile app based on the identified usability problem were provided during the evaluation.

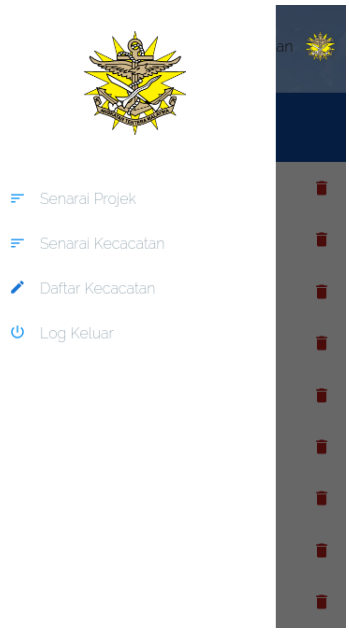

Fig. 3. (a) Slide In Menu

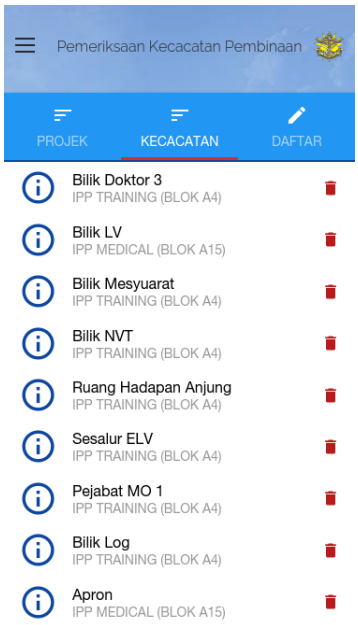

Fig. 3. (b) Tabs Menu

The first identified usability problem is participants had difficulty when dealing with slide in menu as shown in Fig. 3. (a), therefore, the recommendation design improvement is by using tabs as shown in Fig. 3. (b).

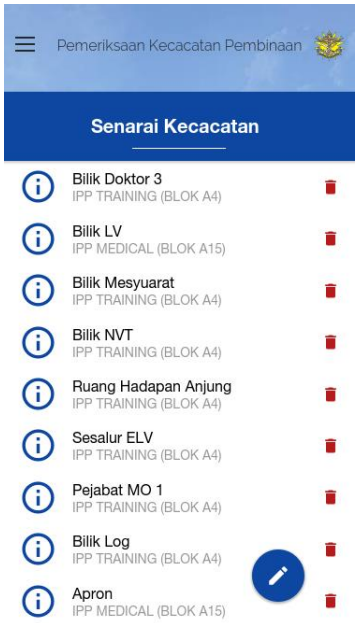

Fig. 4. (a) Icons Used

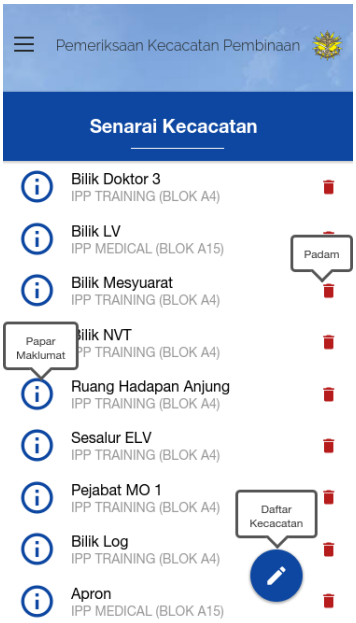

Fig. 4. (b) Tooltip

The next identified usability problem is participants do not familiar with icons used as shown in Fig. 4. (a) and the recommendation design improvement is to add tooltip next to icon as shown in Fig. 4. (b).

Fig. 5. (a) Inserted Photograph ("Masukkan gambar")

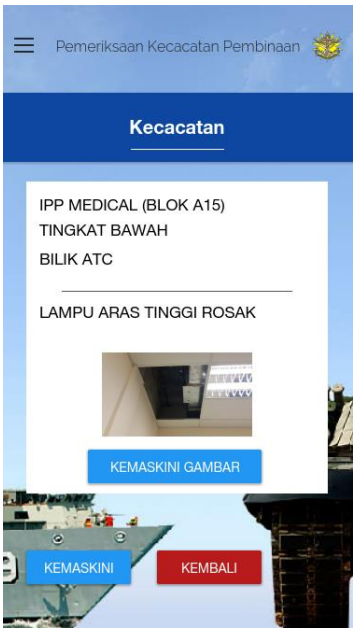

Fig. 5. (b) Update Photograph ("Kemaskini gambar")

The next identified usability problem is participants could not edit the photograph that he / she has already inserted as shown in Fig. 5. (a), therefore, the recommendation design improvement, participants is able to edit the photograph under Update Photograph ("Kemaskini gambar") button as shown in Fig. 5. (b).

5. Conclusion, limitation and Future Work

This study verifies the acceptance of usability of data entry user interface and highlights significant issues pertaining the outcome of the study.

The findings obtained from this study will benefit in increasing efficiency and productivity of Ministry of Defense's Construction Defect Inspection Team. Moreover, it improves decision making process for Top Management in many aspects such as data entry and report preparation time; reduces misplaced photograph and inspection time for Defect Inspection Team; and fast commencement of defect repair for Contractors.

However, there are three limitations associated with the sample. First, this study only involved 15 participants. The contribution of a bigger participants may prompt diverse outcomes or an expansion in the quantity of themes. Second, because of the various knowledge and experience of the participants in construction defect towards the use of mobile app could cause inaccurate feedback. Third, the study only focuses exclusively on Construction Defect mobile app in an android version.

For the future work, an iPhone/Apple version of Construction Defect mobile app will be developed and using different usability evaluation technique to identify the usability performance of the mobile app.

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