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UFREN WORKER: A USER-FRIENDLY MOBILE APPLICATION SOFTWARE TO IMPROVE CONSTRUCTION SITE COMMUNICATION

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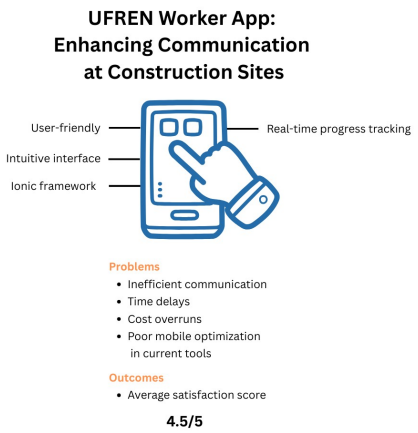
Graphical abstract



Abstract

Effective communication among project participants in construction site is a real dilemma for construction projects productivity. To improve the efficiency of participants in construction projects and ensure a speedy delivery of these projects, this research presents the development of a mobile-based project monitoring system to support construction site communication. In line with the Industrial Revolution (IR) 4.0 as mobile phone as Internet of Thing (IoT), the mobile apps (Ufren Workers Mobile Apps) is designed to enhance or improve communication between project manager, site supervisors and site workers at the construction sites. Development of Ufren Worker was conducted based on the main objectives; current requirement existing mobile-based apps, real-time progress tracker features and validate the practicality of user friendly mobile-based project monitoring system to construction site team. The analysis was conducted on developed program according to its practicality and suitability. There were 11 respondents involved as beta-users to evaluate their satisfaction level and validation rating on the Ufren Workers Mobile Apps from the questionnaire given. Overall, Ufren Workers Mobile Apps scored 4.5 (good) mean in total based on perception toward satisfaction evaluation that has been rated. Ufren Workers Mobile Apps provide simplicity of system, good optimization, attractive user interface design, useful updating progress and top notch performance. Nonetheless, features on Ufren Workers Mobile Apps should be upgraded due to the demand of technological growth. There are many competitors developing mobile worker apps in the market that provide the latest features with good optimization. This app is imperative to facilitate communication in construction sites, which is much needed in this information intensive sector.

Keywords: Communication, Ufren, mobile, apps, construction, IR 4.0

1.0 INTRODUCTION

Lately, Industrial Revolution 4.0 (IR 4.0) has been widely mentioned through its significant using mobile application system as Information and Communication Technology (ICT) tools for communication efficiency. Both academics and practitioners have paid close attention to the role of information technology in mobile project monitoring management because it plays a crucial role in communication management issues in the construction workplace [1].

Traditional way of doing things is not able to fulfil industry needs. Currently, it is difficult and slow to deliver necessary information to a construction site or to return collected data to

the office [2]. One of the main reasons for using mobile project monitoring systems is to improve communication between project participants over and above traditional paper-based poor communication, which is thought to have a significant negative impact on projects by adding delays and inefficiencies [3].

Based on a preliminary study, 40 respondents have given their responses toward questionnaire on mobile apps for the project monitoring system to improve communication among workers at construction sites. Top 2 from the analysis shows poor mobile optimization contributes to (50%) and long subscription progress contribute (45%) of a score which is the major weakness of mobile apps features that exist in the current market.

Thus, user-friendly mobile apps for project monitoring at construction sites need to be magnified of its importance requirement to solve communication problem between workers that contribute to less efficient or failure of mobile apps implementing on Malaysia based on study current requirement of existing mobile-based project monitoring system on construction sites; develop a user-friendly prototype of the mobile application project monitoring system using real-time progress tracker; and validate the practicality of user-friendly mobile-based project management system to the construction site team.

2.0 LITERATURE REVIEW

This section reviews the industrial revolution 4.0 and the application of mobile device as Internet of Things (IoT) in term of Industrial Revolution 4.0. Besides, the importance and the problem of site communication at construction site area are reviewed. Also, the requirement and implementation of mobile apps development will be explained based on studies that researchers had done.

2.1 Industrial Revolution 4.0 in Construction Industry

IR 4.0 refers to innovative new technologies pushing a huge shift toward high efficiency and productivity in the construction industry. In addition, it describes the current trend of digitalisation, automation, and widespread ICT application in the construction industry by referring to the nine pillars of IR 4.0, which include advanced robotics, additive manufacturing, augmented reality, system integration, simulation, internet of things (IoT), cyber-security, cloud computing, and big data analytics [4]. Digitalisation in construction industry ensures the information to be store and share information through technology advancements of Building Information Modelling (BIM), Augmented Reality (AR), Cloud Computing, Internet of Things (IoT) and Big Data. It offers an ecosystem where industrial automation can connect with one another to function and exchange information without a human operator to increase the effectiveness of the building process [5]. Additionally, the IoT is always integrated with ICT (wireless communication, smartphone, sensor network technology), allowing for real-time monitoring without the need for project stakeholders to physically be present [6].

2.2 Mobile Apps as Cloud-based Software

Construction companies are already using cloud-based software for some project management, analytics and tracking applications, but with Industry 4.0, more production-related undertakings will require increased data sharing across sites and company boundaries. At the same time, the performance of cloud technologies will improve, and they will eventually be able to achieve reaction times of just a few milliseconds [7]. Figure 1 shows the top perceived IoT benefits after implementation of a certain period. Perceived IoT benefits are improving productivity, reducing costs and internal processes automation.

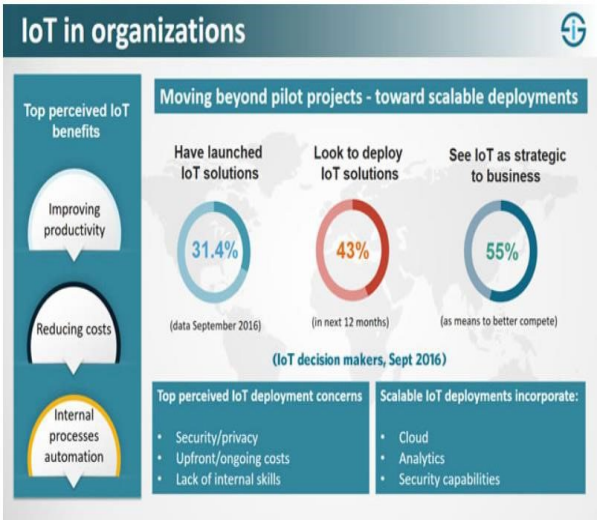


Figure 1 IoT implementation in various industrial (Source: IDC report organization, 2016)

2.3 Importance of Effective Communication in Construction Industry

Several researchers indicate that ineffective communication practices are one of the serious factors that contribute to the poor performance of the construction industry in terms of low productivity that leads to higher project cost and time overruns. Gamil & Rahman (2018) reported that the most recurring consequence of lack of effective communication was time overrun, followed by cost overrun [8]. Lew et al., (2019) emphasised that cost overruns and delays in construction projects can be attributed to poor coordination caused by inadequate information handling and exchange, inadequate, insufficient, inaccurate, inappropriate, inconsistent, or a combination of all of them [9]. Sun et al., (2018) and Meland et al., (2014) identified inadequate information and communication exchange as one of the main causes of project failure. Figure 2 shows the relative importance of good communication exchange [10, 11].

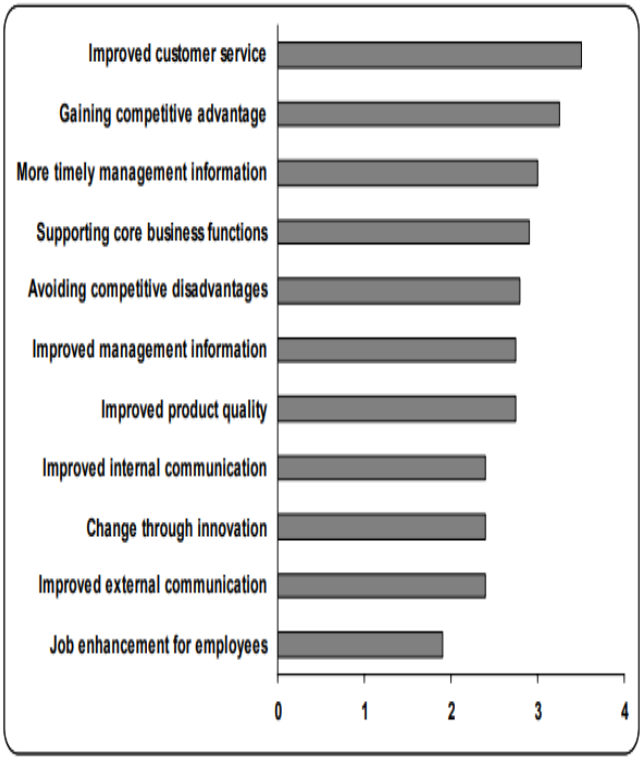


Figure 2 Relative importance good communication exchange (Source: Meland et al., 2014)

2.4 Mobile and Wireless Application System at Construction Site

The use of wireless technology and mobile devices to enable business transactions, information access, and communication from any device, from anyone, from anywhere, at any time [12].

Table 1 Mobile-commerce benefits (Source: Carlsson et al., 2006)

Benefit	*Mean*	*Agree (%)*	*Disagree (%)*
Enhanced communication features	3.74	68.9	18.9
Flexibility (anywhere, anytime)	3.73	64.9	14.9
Convenience and handiness	3.40	55.4	25.7
New dimensions of communication	3.07	43.1	33.0
Reminder and information services in real time	3.01	41.4	36.4
Uniqueness: exclusively mobile services	2.98	41.9	36.1
More effective use of time	2.78	37.8	44.0
Lower prices/special offers	2.72	29.7	41.2
Personalized information and services	2.24	22.7	64.1
Entertaining features	2.15	17.7	65.5
Being trendy/ahead of my time	2.04	15.4	68.8
Lack of proficiency with computers	1.89	16.5	75.1
Only connection to the internet	1.84	13.7	75.2
Accentuation of social status	1.65	8.4	81.3

Based on Table 1, a 5-point Likert scale was used (5 = strongly agree, 1 = strongly disagree) for the response. In the table, the first column represents the mean value. The next two columns represent the percentage of people who responded, 'strongly agree' or 'agree' respective 'strongly disagree' or 'disagree'. From the interviews with people working in the construction industry, it can be concluded that computers and, to some extent, mobile technology have become a part of everyday life in this industry as well. Usually, people who are in charge of the construction site, or have other managerial responsibilities, rely on laptops and or mobile phones. Additionally, Rebolj and his friends emphasised how the information system can improve information integration and information flow efficiency in the construction industry [14].

2.5 Implementing Mobile Apps in Construction Industry

Appropriate implementation of information technologies is a key focus area that must be addressed by the construction industry. The uniqueness of the construction industry poses challenges to the implementation of automation and ICT technologies such as mobile apps. But despite these difficulties, a number of signs point to a changing nature of the construction industry [13]. These factors include:

- Real-time monitoring and documenting of construction operations;
- Reduced paperwork;
- Improved project management capabilities in terms of tracking people, equipment, and assets;
- More accurate performance data which can be used for planning of future projects.

3.0 METHODOLOGY

The flow of this methodology starts from the study to tackle on development of Ufren Workers Mobile Apps to as project monitoring system improve communication level among workers on construction sites. There are two parts of the methodology, quantitative method and develop a prototype in collaboration with industry. For the quantitative method, the data collection came from the sampling of selected beta user respondents. Questionnaires were used as a medium to obtain the required data. As the prototype is in collaboration with industry, system implementation for software architecture and layer customization was studied by both sides and create a system of mobile apps by data collection. Figure 3 illustrated the methodology flow chart.

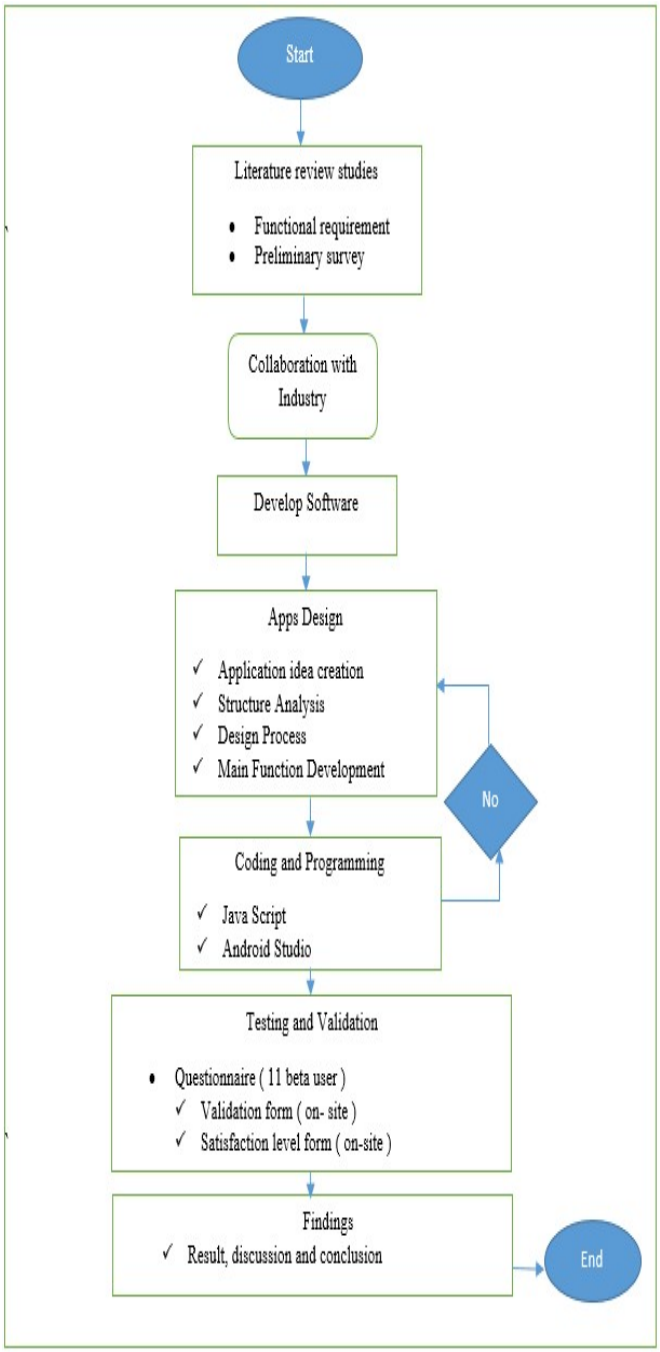


Figure 3 Methodology Flow Chart

3.1 Respondent

For this study, 11 of respondents were grouped into three categories which are the project manager, supervisor, and site workers randomly via construction sites in Johor as beta users of the app's development.

This study focused on the position of construction sites workers who are from the big cities in Malaysia such as Johor. Construction sites workers play an important role as respondents and testimonial users for the mobile app that was developed as a result. These cities have more construction companies such as Chang Sheng Global Development Sdn. Bhd., Pelangi Wira Sdn. Bhd. and ST Lim Value Sdn. Bhd. which have a bigger implementation using mobile apps.

3.2 Questionnaire

In this study, questionnaires were distributed to 11 selected beta users to demonstrate usage of Ufren Workers Mobile Apps. The questions in the questionnaire were designed based on previous literature review studies. Combination of different literature review studies and articles were made to generate a set of suitable questions.

3.3 Ufren Software Modelling Process

The Ufren Worker mobile app system development was discussed in this section. The system development process was divided into five stages which are application idea creation, structure analysis, design process, main function development and testing and validation. Table 2 illustrates the Project Ufren Workers Apps development process.

Table 2 Project Ufren Workers Apps Development Process

Stage	Activities	Deliverable	Tool
1) Application Idea Creation	Identify: •Problem statement •Objective •Scope •Software & Hardware requirement Application content	•Proposal Application idea creation checklist	Microsoft Word
2) Structure Analysis	Analyze: •Navigation •Object	•Application structure checklist	•Microsoft word & Excel
3) Design Process	Create: •Navigation structure Design: •User Interface •Project Navigation •Add-on/delete project button	•Navigation structure •Flowchart •Application Interface	•Microsoft Word •Ionic framework
4) Main function development	•Coding and programming of application.	•Prototype	•Android Studio
5) Testing and Validation	Perform: •Alpha Testing •Beta Testing (respondent)	•Output •Questionnaire and validation form form	•Android Studio •Google Forms •Microsoft Excel/Word

3.3.1 Application Idea Creation

This application was developed to be a mobile-based application that can help communication at construction sites as a project monitoring tool. Although there are many construction mobile apps already in existence in the market, most of them are too complex, lack of apps optimization and have a poor user interface. Thus there is a need to develop a new mobile app to tackle the issues faced. Figure 4 shows the idea discussion with industry.

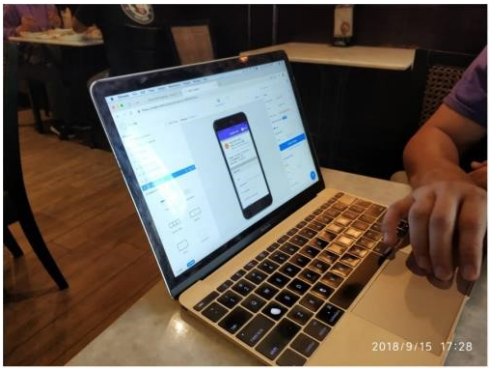


Figure 4 Idea discussion with industry

3.3.2 Structure Analysis

The structure analysis involved navigation analysis and object analysis. The purpose of conducting navigation analysis was to measure the functionality of the application while object analysis was carried out to analyse the usability that is contained in the application. Navigation analysis was conducted to inspect the complete navigation path in the application. Navigation menu consists of 6 directories to each sub-task which are 'my profile', 'project list', 'change password', 'setting', 'about' and 'logout'. There are 3 subtasks under the main task, which are 'project scope', 'project task' and 'update task'. These sub-tasks assist the application to accomplish its main task which is to create a new project in the main navigation. Figure 5 (a) and (b) show navigation menu and one of the sub-tasks in the app.

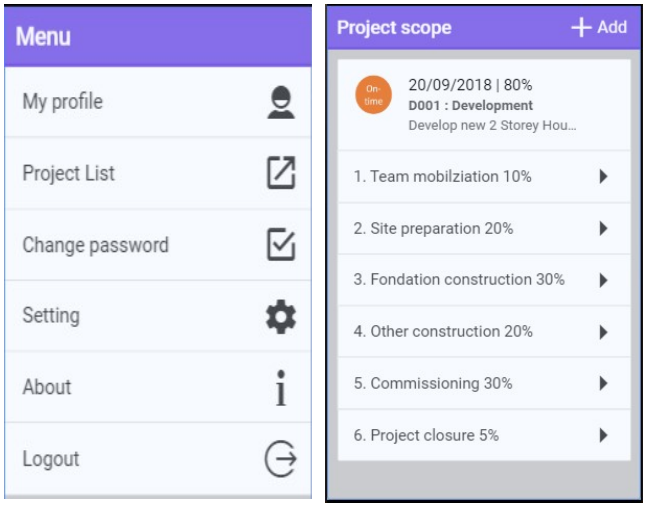


Figure 5 (a) Navigation menu; (b) Sub-task

3.3.3 Design Process

Ufren has been developed using an ionic framework from the design stage. Ufren has been designed in ionic.io for free. As ionic is a hybrid platform, it comes with compiled JavaScript and CSS for easier coding solution. Due to free subscription, only basics features can be an add-on. All key-function and user interface were recognized and selected. In the design process, all navigation buttons are added to each main user interface depending on its functionality. All types of button design were chosen based on previous studies and surveys to ensure its suitability for the targeted user and user-friendly. Figure 6 shows the navigation drawer and component that need to develop while Figure 7 shows features and function that is required of developing the software.

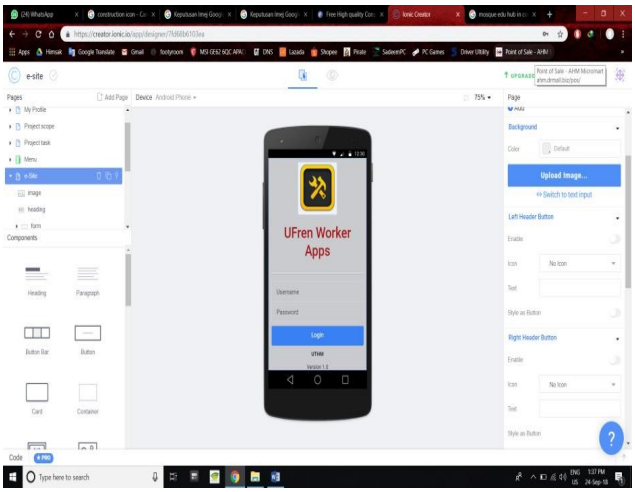


Figure 6 – Navigation drawer and component design process

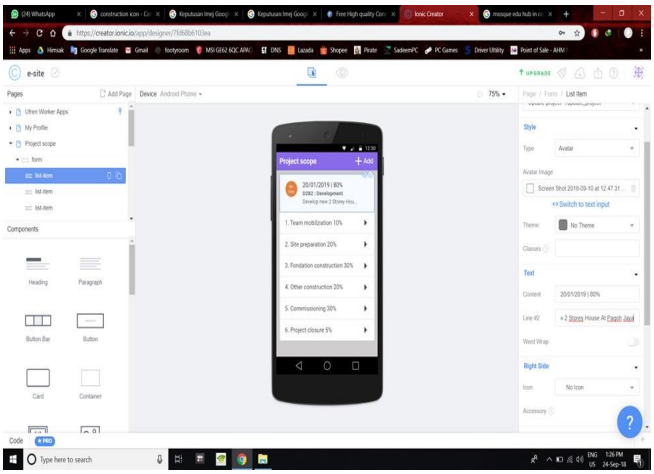


Figure 7 Features and function add-on

3.3.4 Main Function Development

In Android Studio, the application interface layout is defined in HTML while the behavior of the interface is programmed by using JavaScript. The overall interface design of mobile apps is most influenced by Components Design, which design was developed by Google as a guideline to ensure the design consistency across Android application. All design work on Ionic.io is in a coded form, so it needs to be exported for coding

and programming purpose that was done in collaboration with industry (Esra Technology) as shown in Figure 8. All coding and programming of application are necessary to put logic on the item that was designed and make them function and clickable on the smartphone.

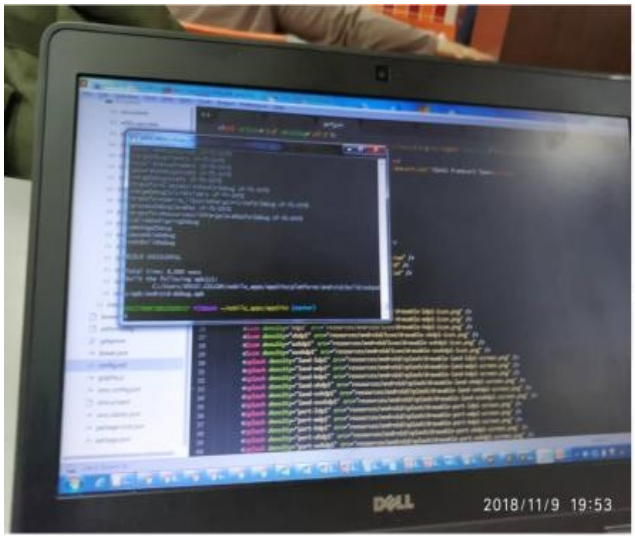


Figure 8 Code and programming process by industry

3.3.5 Testing and Validation

There are mainly two methods of software testing; White-box testing and Black-box testing (in collaboration with industry) and Validation Test on beta users. White-box testing is a software testing technique that inspects the application's code, its algorithms and their efficiency as opposed to its functionalities. Black-box testing is a technique of software testing that tests functions of an application. For the validation test, beta-users were required to install the app on their smartphone and validate its functionality with the validation form. Results passed and failed are based on minimal lagging issue and functionality of button from different kind of processor performance and ram availability. Figure 9 shows the validation test by beta users.

Figure 9 Validation test by beta-users

4.0 RESULTS AND DISCUSSION

This chapter explains the results and discussion towards the development of user-friendly prototype of the mobile application project monitoring system using real-time progress tracker to help communication on construction industry especially at field site work. This chapter also shows validation data of using mobile apps practically and data analysis toward satisfaction level of features on apps created based on the requirement that has been researched before. There were two types of the questionnaire given to targeted workers which is validation form and satisfaction form that will help to analysis data toward mobile apps implementation.

4.1 Data Analysis of Satisfaction over Using Ufren Workers Mobile Apps Toward Construction Sites

In this section, 23 questions were given to the respondents regarding respondents' satisfaction over their experience when using Ufren Workers Mobile Apps. The questions given are related to the user preferences, user interface design, system data, updating progress and apps performance. Users were asked to give their level of agreement or of disagreement with the items using five points Likert scale. Each question was scored according to the respondents' satisfaction based on Likert Scale score. Summary of data was tabulated into bar charts as shown in Figure 10 to Figure 14.

In general, the Ufrens Workers Mobile Apps receive satisfactory responses from the users. Users find that the app is easy to use. This is shown by the majority of user preferences in Figure 10, receiving an average of 4.6 scores among 10 users. Users also find that the design user interface meets their needs because as shown by the mean point of 4.5 by 7 respondents (very good) in Figure 11.

The system data by application of Ufren Workers provided scored an average score of 4.7 (very good) by 8 out of 11 respondents in Figure 12. In Figure 13, users were satisfied when conducting the test of the application. This is seen by a mean score of 4.6 (very good). The performance of the application was also perceived to be smooth, sleek and worked well with user satisfaction over the smooth display applications. Users gave an average rating of 4.8 (very good) in Figure 14.

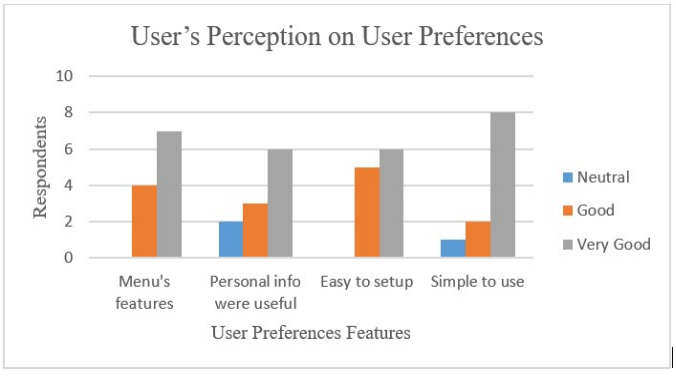


Figure 10 User's perception on user preferences

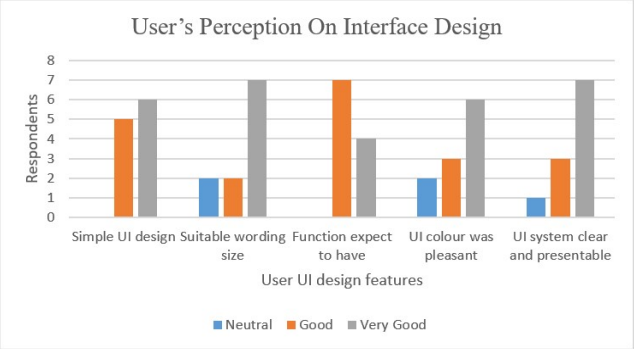


Figure 11 User's perception on interface design

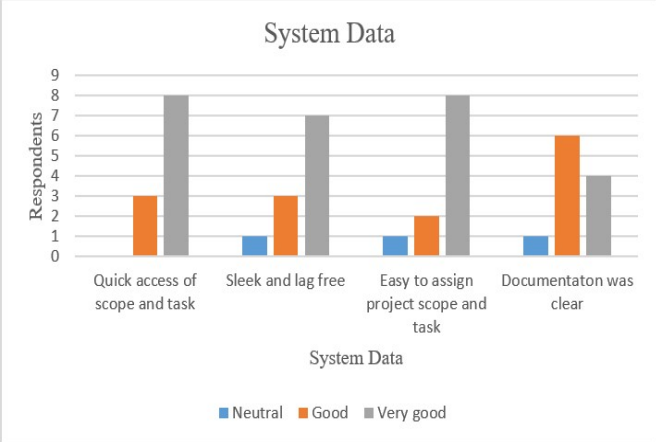


Figure 12 User's perception on system data

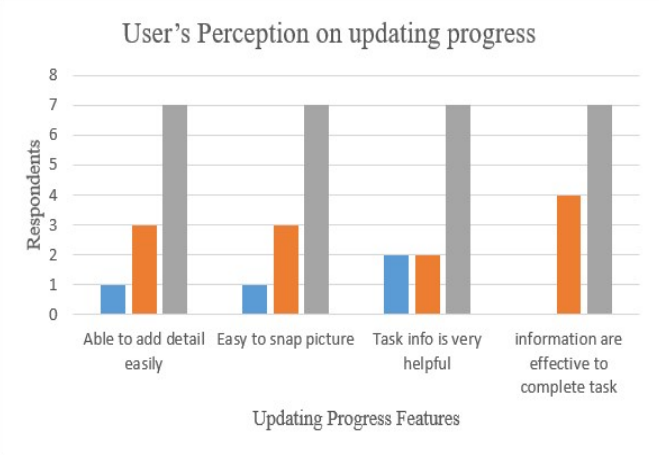


Figure 13 User's perception on updating progress

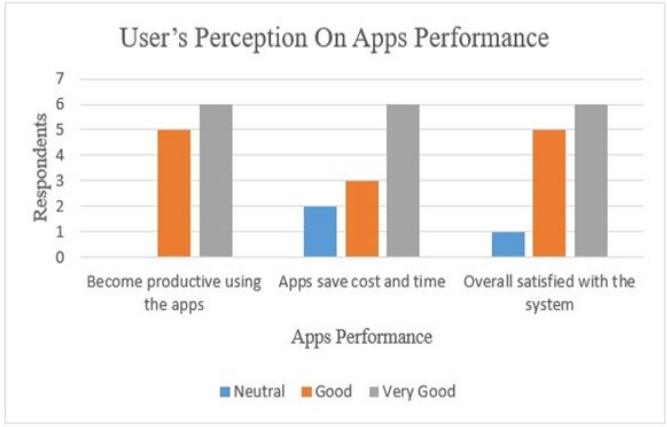


Figure 14 User's perception on apps performance

4.2 Results of Ufren Workers Mobile Apps Validation

In the study, validation and testing were carried out by a total of 11 beta-user has confirmed the feasibility of mobile apps application Ufren Workers Mobile Apps. Figure 15 below shows an analysis of passed failure rate that run by beta-user who has used the apps. It can be seen that most of the validation tests conducted were passed by all of the 11 beta users. However, there are two items failed, namely 'navigation to project list' (2 respondents) and 'back and add button are functioning' (2 respondents) with 18% and 18% respectively. This is because some of the smartphones that were used had less than 2 gigabyte RAM and caused the app to lag.

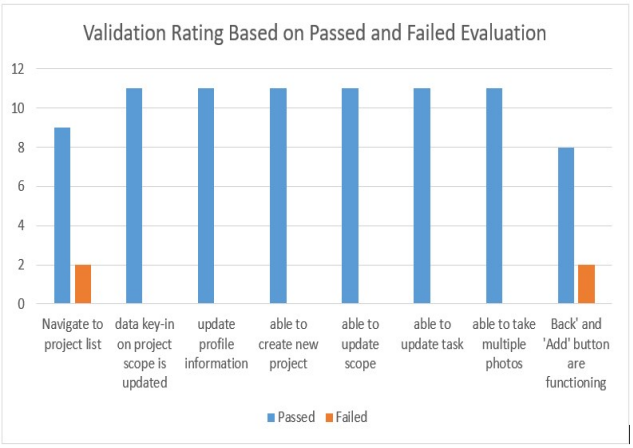


Figure 15 Validation rating based on passed and failed evaluation

5.0 CONCLUSION

The objectives were to study current requirement of existing web-based project monitoring system on construction sites; develop user-friendly prototype of the mobile application project monitoring system using real-time progress tracker and validate practicality user-friendly mobile-based project management system to construction site team had been obtained. As a whole, the satisfaction level toward the development of Ufren Workers Mobile Apps was achieved through satisfaction evaluation with an average score of 4.5 in total based on the survey conducted. The current existing

mobile apps requirement to develop a prototype of user-friendly mobile app features and its validation on real-time project tracking mobile-based project management system to construction site team were approved through findings from collaboration with industry partners, Ufren Workers Apps targeted users and researchers who did researches on mobile apps related issues.

5.1 Limitations

The limitation of this study is the lack of optimization on apps performances. The lack of optimization had caused issues such as slower performances on all types of smartphone chipset and availability of RAM. As a result, there are two items rated "fail", namely that were 'navigate to project list' and 'back and the back button is not functioning'. Also, the issue of the absence of application trials on its use in the project is part of the limitation in this study.

5.2 Recommendation

The features of Ufren Workers Mobile Apps should be upgraded due to the current demand for technological growth. This is because there are many competitors in developing mobile worker apps in the market that provide the latest features with good optimization and apps performance. Besides, some costs need to be invested for Ufren Workers Mobile Apps to create its own cloud web server storage.

5.3 Future Study Plans

The proposed work can be extended to address the development of user-friendly mobile apps for project monitoring at non-construction sites, which is important for solving communication problems among workers.

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper

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