Design And Development Of Mobile Testing Application For Agricultural Personnel

Jefrain M. Padre, MSIT and Ruth G. Luciano, Ph.D.

Abstract: This study was conducted to develop a Mobile testing application (MTA) designed to test soil fertility via the STK and leaf color recognition for the Agricultural Technicians of the 3rd district of Nueva Ecija. The MTA was developed through the Mobile Development Life Cycle (MDLC) which involved the development of the following modules: 1) Color Recognition; 2) Guides/Manuals Upload; 3) Activity Management; 3) Report Consolidation; 4) System Setting. The system works on a Local Area Network / Wide Area Network set-up wherein there are three sets of users. The Agriculture personnel evaluated the quality of the proposed system in terms of its beneficial contribution to their work process while IT Experts assessed its technical quality. The findings revealed that for all parameters measured, both the Agriculture personnel and IT experts rated the MTA as Excellent. The IT experts indicated that the MTA highly exceeds the ISO 25010 Software Product Quality Standards on the technical quality assurance as shown by their specific rating of highly functional, highly efficient, highly compatible, highly usable, highly reliable, highly secured, highly maintainable, and highly portable. Likewise, The Agricultural Officers and Technicians unanimously agreed that the MTA highly exceeds the ISO 25010 Software Product Quality Standards on the technical quality assurance. Their over-all rating of excellent demonstrated that the MTA is functionally suitable, performance efficient and usable for the end-users.

Index Terms: agricultural personnel, leaf color recognition, mobile testing application, soil fertility test

1. INTRODUCTION

Philippines is the 3rd largest rice producer in the world in 2017, it contributes 5% of global rice production [1]. In 2017, the total paddy rice output reached 93% of the country's annual requirement (Department of Agriculture Philippines). But establishing the country's food security is a constant challenging struggle [2]. The proliferation of mobile phones and internet connectivity may help farmers make better farming-related decisions [3]. For instance, soil condition may be monitored along with weather information which are very important factors in determining which crops to plant and when. Moreover, the use of fertilizer, seeds, and water can also be done by utilizing mobile and cloud computing technologies [4]. These may be very effective in assisting not only the large scale producers but especially the small-hold farmers. Mobile applications and agriculture may seem to be a mismatched endeavor, but promising developments suggest that mobile and cloud-based applications may have positive effects in addressing sustainable development and production which will contribute to a large extent toward food security. This study aimed to develop a mobile testing application (MTA) in particular for the Agricultural Technicians who conduct different tests by color of the leaves and soil using soil test kit. This MTA aka app provides not only an accurate tool for soil sampling but ensures faster conduct of soil testing which may help Agricultural Technicians cover a greater area per time, enabling them to be more productive in gathering results from the different areas assigned to them. This MTA would offer a solution to the most common problem encountered by the people in the field which is time constraints for the large Agricultural areas that they need to cover. Nueva Ecija, Philippines for instance, has 223,853 hectares of agricultural land with top five (5) crops namely palay, corn, coconut, mango and banana. In the third district of Nueva Ecija alone, a large percentage of the population depends solely in agriculture for livelihood. In the study conducted by Guillasper, et al. in 2013, they found out that the highest proportion of people lives in the municipalities of Gabaldon (94 percent) followed by San Antonio (84 percent). Moreover, an average of 27 percent of the provinces' total population is engaged in agricultural activities [5]. The soil test color using Soil Test Kit (STK) is a quick method of evaluating the fertility status of the soil [6]. It identifies what nutrient is present in the soil and its amount available for plant uptake. The leaf color, on the other hand, identifies the plant's nutrient deficiency. This method can be used on rice and other narrow leaf crops. Once identified, it can specifically be used as a basis in correcting Nitrogen deficiency by applying of the optimum dose of nitrogen. Needless to say, STK is a very good guide for farmers in identifying soil nutrient deficiencies and taking steps to fill in the required nutrients, thereby maximizing their yields. An MTA linked with the STK would provide the lesser-cost and quicker way of testing soil fertility via the STK. Specifically, this application focuses only on color recognition through soil test kit (STK) and leaf color to test the nitrogen deficiency of different crops like rice, wheat, sugarcane, onion, etc. This app is comprised of four different modules. The first module was assigned to data/sample collection. The second module was designed to setup the color which will serve as the standard of the color test both for the soil and leaves. The result was based on the colors set by the Agricultural personnel to test the leaf and soil color. The third module incorporated the activity management made by the head of office and has to be observed by the Agricultural technicians. The last part of the module was the consolidated report made by the Agricultural Technician on the different areas or places to which they conducted the test. This study focused on two major stakeholders: the Agriculture Technician (AT) and the Information Technology (IT) experts. Agriculture Technician assessed the quality of the proposed system in terms of its beneficial contribution to their work process. On the other hand, the application was evaluated by IT Experts in terms of its technical quality; that is, if it follows the ISO 25010 Software Product Quality Standards, specifically: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. This Mobile Testing Application aims to provide a fast, accurate, and reliable result to address the problem encountered by the people in the field which is time constraints for the large agricultural areas that they need to cover. This application would also give farmers an advice of the exact amount of fertilizer they need. This study henceforth aimed to equip Agriculture personnel with a mobile testing technology that may keep them abreast of the current technology. The Philippines is a country with

agriculture as its major pillar of industry. Research undertakings like this would not only enhance the IT sector but more importantly help provide a boost to the Agricultural sector as well. As of today, 94 percent of the arable land in the country had been planted with agricultural crops [4]. It is appropriate and desirable that researches in different fields are conducted to benefit each other collaboratively. Being a faculty of a University that has one of its major thrusts in Extension, IT developments like this would prove to be not only a very promising and exciting endeavor, but a very productive one in the same manner. The system that was developed would be quite useful for the farmers and other agriculture enthusiasts. This would probably be one of the University's proud accomplishments in terms of extending Agricultural know-how to farmers, especially through the College of Agriculture at Gabaldon Campus. One of the researchers had been first assigned to teach at this Campus and had a first-hand understanding on some of the agricultural needs both of Academe and other agriculture stakeholders. These aforementioned reasons were equally contributory factors toward the conduct of this study.

Conceptual Framework

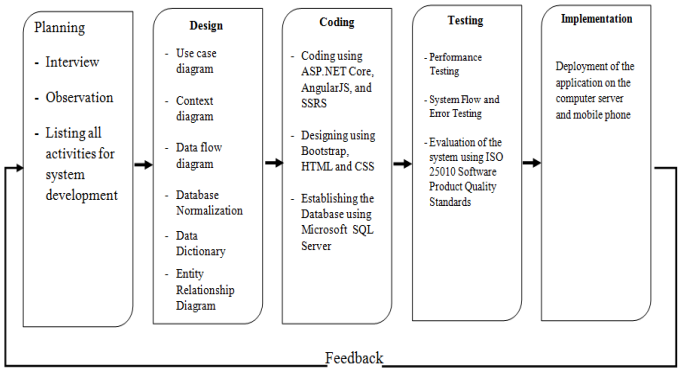


Figure 1. *Research Paradigm*

Figure 1 above shows the paradigm used for the development of Mobile Testing Application. The MTA project was conceptualized through the Mobile Software Development Life Cycle (MDLC). It is a process flow for a software development project that consists of a detailed plan and description on how to develop, maintain, and enhance the specific software [7]. The life cycle defines a methodology for improving the quality of software and the overall development process. Under the planning phase, interviews and observations were conducted by the proponent to identify the areas from the current procedures that need reinforcement or improvement. After which, the researcher created a list of activities and schedule of the application development phases through a Gantt chart and also the MTA system hardware and software requirements. In the design phase, the database of the system was designed based on the proposed workflow. The researchers used data normalization in order to eliminate redundancies and to determine which fields will be linked to certain tables. A data dictionary was formulated to show the data types used and length of each field. Lastly, an entity-relationship diagram was also design to explain the relationships between the tables used in the development of the study. Under the coding phase, the researchers utilized ASP.NET Core, AngularJS, and SSRS to write the source code of the MTA while Bootstrap, HTML and CSS used in designing the MTA graphical user interface. In establishing the database of the application, the researchers employed Microsoft SQL server to hold all the data and information. In the testing phase, the MTA was subjected to several tests and assessments: Performance Testing, System Flow and Error Testing to check for possible errors. And the evaluation was based on the criteria adapted from ISO 25010 Software Product Quality Standards, specifically: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability and portability. Both IT Experts and Agriculture Personnel made their respective evaluations of the MTA. Finally, for the implementation or deployment phase, the MTA was properly turned-over to the recipients. It was installed on their mobile devices and computer server. An orientation on how to use the MTA was likewise conducted to teach them its features and functionalities. After which, the feedback was gathered based on the assessment results, given by both stakeholders namely the IT experts and the Agriculture personnel. All of the respondents from both groups affirmed that the MTA was already highly functional for use, therefore no more revisions was done to the system itself and they thus recommended a large scale beta version for the system.

Statement of the Problem

This study generally aimed to develop and assess a Mobile Testing Application for Agricultural Personnel.

Specifically, this study sought answers to the following:

1. How may the MTA be developed using the Mobile Software Development Life Cycle in terms of:
   1.1 planning;
   1.2 designing;
   1.3 coding;
   1.4 testing; and
   1.5 deployment?
2. How do IT Experts assess the technical quality of MTA based on the following ISO 25010 Software Product Quality Standards in terms of:
   2.1 functional suitability;
   2.2 performance efficiency;
   2.3 compatibility;
   2.4 usability;
   2.5 reliability;
   2.6 security;
   2.7 maintainability; and
   2.8 portability?
3. How do Agricultural Officer and Agricultural Technician assess the quality of MTA based on the selected criteria of ISO 25010 Software Product Quality Standards in terms of:
   3.1 functional suitability;
   3.2 performance efficiency; and
   3.3 usability?

2 METHODOLOGY

Research Design

The developmental research design was used in this study. It intended to develop a Mobile Testing Application (MTA) designed to assist Agriculture personnel in testing soil fertility using the Soil Testing Kit (STK) and leaf color recognition. This

study was developed using the Mobile Software Development Life Cycle (MDLC).

Respondents

The respondents of this study were composed of 22 Agricultural personnel and IT Experts from selected offices and institutions in Nueva Ecija, Philippines. The Agricultural personnel were composed of 7 Agricultural officers and 15 technicians. The technicians were the ones who used the MTA in performing the test activities in the field. The IT experts were those who assessed the technical quality of the system based on the ISO/IEC Software Quality criteria. They were involved in all phases of the development especially in designing and testing.

Sample and Sampling Procedure

The purposive sampling procedure was used in selecting respondents for this study. This technique was employed because of the limited numbers of respondents who can serve as primary sources of information. In this study, the Agricultural personnel were purposively chosen on the basis of their need and ability to assess the quality of the system. The IT experts, on the other hand, were likewise purposively chosen on the basis of their technical knowledge about system functionalities and technicalities.

Research Instruments

The researchers used an assessment questionnaire as a tool in this study. The assessment questionnaire was based on the ISO/IEC 25010 Software Product Quality Standard [8]. The data gathering tool was divided into two parts. Part I was drawing the instruments for IT experts to assess the technical quality of the system based on the criteria of ISO 25010. Part II dealt on the Agriculture personnel's assessment of the MTA wherein they rated the product quality standard of the system based on the following criteria: (1) functional suitability, (2) performance efficiency and (3) usability.

Response and Scoring Mode

The items in the questionnaire were rated and scored according to the hereunder scale and criteria presented in Table 1.

Table 1
Interpretation of the Summary of Results of ISO 25010 Software Product Quality Standards

Verbal Interpretation	Software Product Quality Standards	Verbal Description
3.25 - 4.00	Highly Functional/Highly Efficient/Highly Compatible/ Highly Usable/Highly Reliable/ Highly Secured/ Highly Maintainable/ Highly Portable	Excellent
2.50 - 3.24	Functional/ Efficient/ Compatible/ Usable/ Reliable/ Secured/ Maintainable/ Portable	Satisfactory
1.75 - 2.49	Needs Improvement	Needs Improvement
1.00 - 1.74	Poor	Poor

The table shows the interpretation of the summary results from the assessment of IT experts and Agricultural personnel based on the ISO 25010 Software Product Quality Standards. There are four classes that characterize the Product Quality features of the MTA to which each of the descriptor falls under the verbally as Poor, Needs Improvement, Satisfactory and Excellent.

3 RESULT AND DISCUSSIONS

1. Development and Description of the MTA through the Mobile Development Life Cycle (MDLC):
   The MTA was successfully completed through the application of the different phases of the MSDLC where each phase is described and explained.

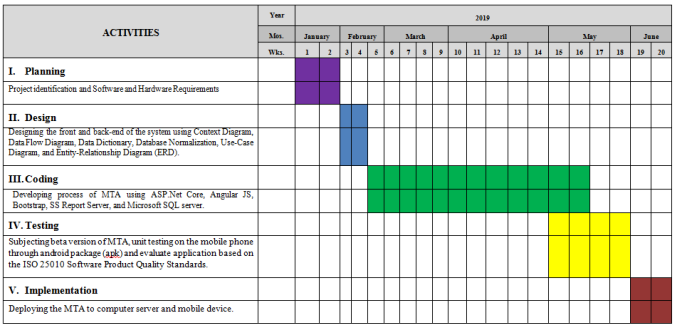
1.1 Planning

The planning phase of the mobile development life cycle involved different activities necessary for the identification of required resources, system requirements, and the work schedule to follow. Initially, the researchers conducted series of interviews with the personnel from the different Agricultural offices regarding the methods and procedures in conducting the different testing procedure in relation to soil and leaf color test done by color recognition as well as the problems and difficulties they encountered during testing. The researchers also conducted a thorough review on the current procedures, rules, guidelines and reports being used. Moreover, they made several consultations with other personnel who have knowledge in the development of mobile application concentrating on the color recognition of soil test and plants leaf color. The researchers created the list of activities toward the development plan and were plotted in the Gantt Chart as shown below:

1.2 Designing

In this phase, the designs and conceptual framework necessary for the development of the graphical user interface, functionalities and database of the system were created.

Figure 3 presents the Mobile Testing Application Use Case Diagram which shows the different roles and functions of the user based on their level of access to the particular modules. The created accounts had a limited access corresponding to their roles and were secured through a username and password.



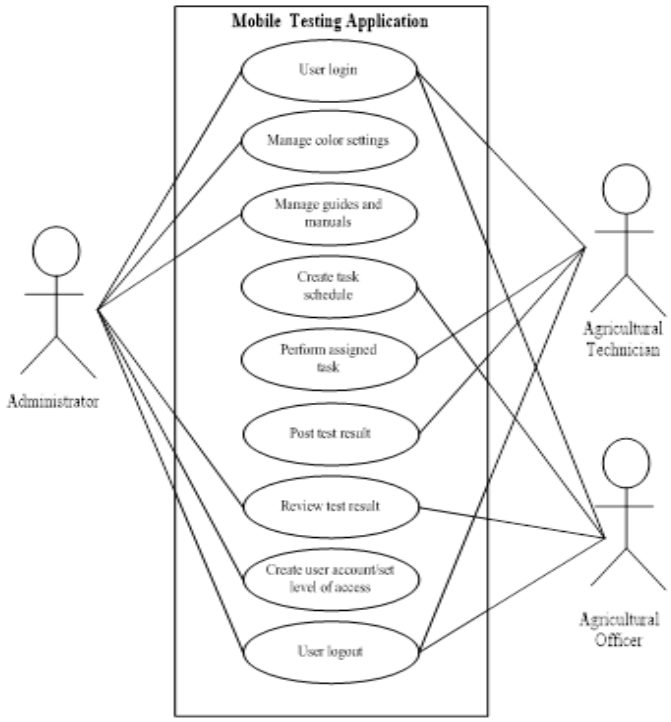


Figure 3.*Use Case Diagram*

On the other hand, the following data flow diagrams show the functionality of the mobile testing application. It further indicates that the developed system is composed of different users who are assigned with different levels of access and restriction as shown Figure 4 below. The next diagram, Figure 4, shows the four core modules with corresponding user accounts that are engaged with specified functions and data. It further depicts the interactions and flow of data.

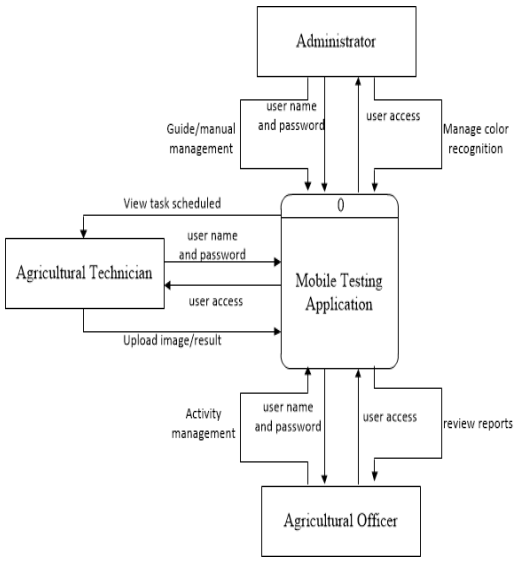


Figure 4*. Context Diagram*

1.3 Coding

In this development phase, the researchers used several software to create and develop the MTA. The researchers used ASP.Net core based on AngularJS scripting language for the actual coding of the system while Bootstrap, CSS and HTML were utilized in designing the system's graphical interface. Meanwhile, SSRS, and Microsoft SQL server were utilized for establishing the database of the system.

1.4 Testing

This phase is one of the most important phases of any development life cycle model. Through the successful development of the beta version, the researcher installed and tested the application to make sure that it was functioning well, with no arising errors or bugs, and all the needs of the users were met. Testing includes activities such as installation of MTA to a computer acting as a database server with minimum system requirements; the configuration of the database via Microsoft SQL server and the population of data records; and the deployment of MTA to the mobile device through which the application was run and used for color recognition testing of soil and leaf. Finally, all user accounts logged in with a different role, access, and interface to ensure the capabilities of each. After responding to all the respondents' inquiries and recommendations, they were eventually requested to evaluate the system using the questionnaire derived from ISO 25010 Software Product Quality Standards.

1.5 Deployment

At the implementation phase, the developed system was installed in a stand-alone computer having the role of a database server and then installed to the mobile device. Then orientation of the functionalities including how to use the application was conducted in order for the system users to be familiarized with the MTA.

2. Technical Quality Assessment of the Mobile Testing Application made by the IT Experts

Table 2 below shows the summary of evaluation made by the IT Experts on the Mobile Testing Application based on the ISO 25010 Software Product Quality Standards.

Table 2
Summary of Evaluation Results of the MTA as assessed by the IT Experts

Software Product Quality Categories	Weighted Mean	Verbal Description
1. Functional Suitability	3.70	Excellent
2. Performance Efficiency	3.63	Excellent
3. Compatibility	3.55	Excellent
4. Usability	3.73	Excellent
5. Reliability	3.70	Excellent
6. Security	3.83	Excellent
7. Maintainability	3.53	Excellent
8. Portability	3.77	Excellent

The results of the evaluation show that the Mobile Testing Application complied with the different software quality criteria of the ISO 25010 Software Product Quality Standards. This indicates that the developed MTA is a quality software product that can be implemented to different Agriculture Offices. These results specify that the MTA has satisfactorily met the product quality standards with no weaknesses. This is evidenced by the "Excellent" marks attained by the MTA from the IT experts in all criteria considered namely: Functional Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability and Portability. It is also noteworthy to mention that among the criteria, Security got the highest mark of 3.83. According to Boote (2016), robust software

security requirements help you lock down what your software does so that it can be used only as intended. [9] The excellent mark is equivalent to "Highly Functional", "Highly Efficient", "Highly Compatible", "Highly Usable", "Highly Reliable", "Highly Secured", "Highly Maintainable" and "Highly Portable" ratings. These results clearly suggest that from the perspective of the IT experts, the MTA is functionally suitable, performance efficient, compatible, usable, reliable, secure, maintainable and portable and thus ready for the trial stage of the end-users.

3. Assessment of the Agricultural Officer and Agricultural Technician on the Developed Mobile Testing Application

Table 3 shows the summary of evaluation made by the Agricultural Officers and Agricultural Technicians on the Mobile Testing Application based on the selected criteria from ISO 25010 Software Product Quality Standards.

Table 3

Summary of Evaluation Results of the of the MTA as Assessed by the Agricultural Personnel

Software Product Quality Categories	Weighted Mean	Verbal Description
1. Functional Suitability	3.36	Excellent
2. Performance Efficiency	3.39	Excellent
3. Usability	3.47	Excellent

The results presented in Table 3 indicate that the Agricultural Personnel were ready to accept and adopt the MTA. This indicates that the system is highly functional, highly efficient and highly usable as per the assessment of the stakeholders. Such ratings which equate to "Excellent" verbal description denotes that the Agricultural Personnel found the MTA as outstandingly adequate in meeting their needs as per the specific purpose of the MTA is concerned. This further implies their approval in adopting the MTA under consideration in their activities of soil fertility determination via STK and leaf color recognition. As such, these results reveal that the end-users found the MTA to be functionally suitable, performance efficient and usable at the time the software is implemented. The findings also support the statement from http://www.sqa.net/iso9126 .html that software requirement will be continually changing and with this change will come the continuing search to find useful characteristics that facilitate measurement and control of the software production process [10].

CONCLUSIONS

Based on the findings, the following conclusions were drawn:

1. The Mobile Testing Application (MTA) was successfully developed based on the different phases of the Mobile Development Life Cycle (MDLC).

2. The Mobile Testing Application (MTA) complied with the requirements specified in the ISO 25010 Software Product Quality Standards as evident by the ratings conforming to as Highly Functional, Highly Efficient, Highly Compatible, Highly Usable, Highly Reliable, Highly Secured, Highly Maintainable and Highly Portable given by the IT Experts.

3. The Agricultural Officers and Agricultural Technicians were ready to accept and integrate it in their process and workflow of transactions as proven by their qualitative rating of Highly Functional, Highly Efficient and Highly Usable for the three selected categories of Functional Suitability, Performance Efficiency and Usability.

Recommendations

Based on the findings, the following recommendations were made:

1. The Mobile Testing Application (MTA) may be implemented for beta or trial version, and conduct numerous series of test on color calibration/ configuration for nitrogen assessment and management.

2. Further studies may be conducted to:

a. determine the effectiveness of the Mobile Testing Application (MTA) as compared to the traditional or manual process being practiced in the Agriculture Offices;

b. further Assess the MTA's competence for gamma or final version implementation; and

c. develop similar MTA specifically designed to determine the moisture content of crops as this quality plays a vital role in both in production and post-harvest operations.

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REFERENCES

[1] World Atlas. (2017, April). The 10 Largest Rice Importers In The World. Retrieved from World Atlas: https://www.worldatlas.com/articles/thelargest-rice-importers-in-the-world.html

[2] Manila Bulletin. (2018, June). PH to achieve rice self-sufficiency by 2020 – Piñol. Retrieved from Manila Bulletin: https://news.mb.com.ph/2018/06/20/ph-to-achieve-rice-self-sufficiencyby-2020-pinol/

[3] Esteban, Allen Paul L. and Ruth Ann G. Santos (2019). Tubongpinoy: An Online Portal with Decision Support and Prediction System for Crop Production. MSIT Thesis, NEUST, Philippines

[4] Hori, Mitsuyoshi, et al. (2010). Application of Cloud Computing to Agriculture and Prospects in Other Fields. Retrieved from https://www.researchgate.net/ publication/ 292682309_Application_of_Cloud_ Computing_to_Agriculture_and_Prospects_in_Other_Fields

[5] Guillasper Z.R., et.al. (2013). Agricultural Land-Use Mapping for Environment Animal Health Management in Nueva Ecija Province, Central Luzon, Northern Philippines

[6] P.R. Owens, E.M. Rutledge (2005). Morphology in Encyclopedia of Soils in the Environment. Retrieved from: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/soil-color

[7] Prajapati, Vinay (2018) Mobile Software Development Life Cycle. Retrieved from https://www.techprevue.com/mobile-software-development-life-cycle/

[8] ISO 25010 Software Product Quality. Retrieved from: https://iso25000.com/index.php/en/iso-25000-standards/iso-25010

[9] Boote, Jamie (2016). Are you making software security a requirement. Retrieved from: https://www.synopsys.com/blogs/software-security/software-security-requirements/

[10]Software Quality Characteristics Retrieved from: http://www.sqa.net/iso9126.html