

Application for a Waste Management via the QR-Code System

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Abstract—This research aims in developing an application for the waste management via the QR code system: 1) to study the quality of the application and 2) to study the satisfaction of users of the application by using the system development life cycle (SDLC) principle. There were 388 people of sample groups in this research which consisted of community leaders, village health volunteers, youth and the general public of Ban Yang Sub-district, Mueang Buriram District, and Buriram Province. The research instruments were the application for a waste management via the QR code system, Application Quality Assessment Form, and the application satisfaction questionnaire. The statistics used in the data analysis were mean and standard deviation. The results of the research revealed that there were three main functions of the application for a waste management via the QR code system as follows: 1) The quality assessment of the application in all aspects at a high level (Mean = 4.41, S.D.=0.10). 2) Study of satisfaction of the application users in all aspects at a high level (Mean = 4.42, S.D. = 0.45). 3) The application of waste management application via the QR code system allowed group members in the community to reduce the process of managing household waste more conveniently and create a positive attitude in using waste to elevate through the work of the group members in the community.

Keywords—Application; QR-Code system; waste management; SDLC; community information

I. INTRODUCTION

Ban Yang Subdistrict Administrative Organization, Mueang Buriram District, Buriram Province has an area of approximately 30.24 square kilometers and a total population of 13,397 [1]. The community in Ban Yang is a model for waste management by sorting and has a management process within the group with the support of the Ban Yang Subdistrict Administrative Organization in which Panrak Pansuk Waste Bank was established. Household waste is classified as wet waste, general waste, recyclable waste and hazardous waste. This causes reduced waste in Ban Yang Sub-district and can be managed within the group using rules and agreements which has clearly divided the structure of the group, such as general administrative subdivision, sales management, and accounting and finance. Source operating profit rewards were shared among members within the group and used to manage other aspects of community welfare, such as funerals, scholarships, care for the poor, the elderly and the disabled, etc. From the strong operation of the group resulted in various awards, such as the Dhamma and Golden Land Village Award 1992, the Outstanding Development and Environmental Conservation

Village Award and the Outstanding Community Plan Village 2008 [2].

The development and expansion of the community since 1980 has resulted in the amount of waste, leftovers, scrap materials, as well as dense living; therefore, increasing population. This results in waste within the community of 1.52 tons per month, causing the cost of transportation in order to get rid of the waste approximately 277,120 Baht per year. This in turn causes environmental pollution problems and the problem of dengue fever due to the large number of Aedes mosquitoes in the community. In the past, the community had managed the waste by segregating it among households. However, it was always difficult to find a place to dispose of the waste. The municipality of Ban Yang Subdistrict, therefore had to dispose of it in the landfill of the municipality of Satuk Subdistrict, which is far away. This results in higher management costs. Furthermore, the behavior of community members remains unaware of the need to maintain a sanitary waste disposal system. The resolution of problems in the past had to depend mainly on government agencies, also the lack of integration of work, and the involvement of all agencies in concrete [3]. According to group leaders on waste management, neighboring communities still lack adequate waste management practices. As a result, the amount of waste in the community continues to increase.

The software development life cycle System Development Life Cycle (SDLC) means development of the system has been set to go in the same direction and set a procedure that is a guideline for analyzing the system by trying to have as few flaws as possible because the current system analysis work is more complicated than in the past. System analysts have to standardize in the development of such work system. Therefore, a system development cycle has been invented to meet the needs of system analysts. SDLC consists of 1) problem definition, 2) analysis, 3) design, 4) development, 5) testing, 6) implementation, and 7) maintenance. This provides an effective framework and method to develop software applications. This helps in effective planning before starting the actual development. SDLC allows developers to analyze the requirements, helps in reducing unnecessary costs during development. During the initial phases, developers can estimate the costs and predict mistakes which may cause expenses, enables developers to design and build high-quality software products. This is because they follow a systematic process that allows them to test the software before it is rolled

out, provides a basis when evaluating the effectiveness of the software. This further enhances the software product [4].

II. LITERATURE REVIEW

Developing the application for a waste management via the QR code system proposed the concept, related theories and research as follows:

1) *Application*: Application is a program that facilitates various aspects designed for Mobile phones, tablets, or any other mobile communication device that we know [5] – [8]. In each operating system, there will be many application developers to meet the needs of users. The author in [9] is available for both free and paid downloads including education, communication, or even entertainment, etc. Mobile applications are divided into three types which are Native Application, Hybrid Application and Web Application.

- Native Application is an application developed with a Library or SDK [10], an instrument for developing programs or applications of the operating system on a mobile phone, OS Mobile (Operating System Mobile), especially, for example, Android uses Android SDK, iOS uses Objective C and Windows Phone uses C#, etc. [11] – [17].
- Hybrid Application [18] – [19] is an application which has been developed for the purpose in order to run on every operating system by using the framework to be able to work on all operating systems [20] – [21].
- Web Application is an application [22] that is written as a browser for the use of various web pages, which are customized to display only the necessary parts in order to reduce the processing resources of the device of a smartphone or tablet. This enables the website load faster. In addition, users can use the internet and intranet in low speed as well [23] – [27].

2) *Theory of System Development Life Cycle: SDLC* [28]

- Planning: The purposes of this phase are to find out the scope of the problem and determine solutions, resources, costs, time, benefits and other items which should be considered here [29].
- System Analysis and Requirements: The second phase is where teams consider the functional requirements of the project of the solution [30].
- System Design: The third phase describes, in detail, the necessary specifications, features and operations that will satisfy the functional requirements of the proposed system which will be in place [31].
- Development [32]: Now the real work begins. The development phase marks the end of the initial section of the process. Additionally, this phase signifies the start of the production. The development stage is also characterized by instillation and change.
- Integration & Testing [33]: This phase involves systems integration and system testing (of programs

and procedures) normally carried out by a Quality Assurance (QA) professional to determine if the proposed design meets the initial set of business goals.

- Implementation: The sixth phase is when the majority of the code for the program is written, and when the project is put into production by moving the data and components from the old system and placing them in the new system via a direct cutover [34].
- Maintenance [35]: The last phase is when end users can fine-tune the system, if they wish to boost performance, add new capabilities to meet additional user requirements.

3) *Theory of QR-Code*: The QR code system was invented in 1994 by Masahiro Hara from the Japanese company Denso Wave. The initial design was influenced by the black and white pieces on a Go board [36]. Its purpose was to track vehicles during manufacturing; it was designed to allow high-speed component scanning.

ISO/IEC 18004: 2015 defines the requirements for the symbology known as QR Code [37]. It specifies the QR Code symbology characteristics, data character encoding methods, symbol formats, dimensional characteristics, error correction rules, reference decoding algorithm, production quality requirements, and user-selectable application parameters.

The amount of data that can be stored in the QR code symbol depends on the data type (mode, or input character set), version (1, ..., 40, indicating the overall dimensions of the symbol, i.e., $4 \times \text{version number} + 17$ dots on each side), and error correction level. The maximum storage capacities occur for version 40 and error correction level L (low), denoted by 40-L.

TABLE I. CHARACTER REFERS TO INDIVIDUAL VALUES OF THE INPUT MODE/DATA TYPE

Input mode	Max. characters	Bits/char.	Possible characters, default encoding
Numeric only	7,089	31/3	0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Alphanumeric	4,296	51/2	0–9, A–Z (upper-case only), space, \$, %, *, +, -, ., /, :
Binary/byte	2,953	8	ISO 8859-1
Kanji/kana	1,817	13	Shift JIS X 0208

From Table I, there are four input modes: 1) Numeric only: The maximum character is 7,089, and the minimum character is three and one third. 2) Alphanumeric: The maximum character is 4,296, and the minimum character is five and one half. 3) Binary/byte: The maximum character is 2,953 and the minimum character is 8. 4) Kanji/kana: The maximum character is 1,817 and the minimum character is 13.

4) *Waste management*: Solid waste refers to [38], the garbage generated from various activities in the community, such as homes, commercial establishments, business centers, shops, entertainment spot, fresh-food markets and institutions. The type of waste consists of organic waste: food scraps, leaf scraps, and grass clippings, etc.; recycled waste: glass, plastic,

aluminum, rubber, etc.; general waste: remnant of cloth, wood scraps; and other materials, including hazardous waste from the community. Solid waste management principles are as follows:

- Solid waste collection [39] is the collection of solid waste arising from various sources by considering the solid waste containers or trash cans, which can be classified and stored efficiently, as well as designated collection points for solid waste to facilitate the collection, save time and money.
- Transportation of solid waste [40] is the process of bringing the garbage that people from each household put in the solid waste bin to be transported for further disposal by solid waste truck. That should take into account the suitability of the area and the amount of solid waste that collects each day by demarcation of the solid waste collection route to be effective, save resources, and cost.
- Solid waste disposal [41], large-scale waste disposal technology, including composting system by decomposing organic matter through the biological process of microorganisms, the decomposition transforms them into minerals that are relatively stable. Sanitary landfill system, the solid waste is brought to the landfill in the area that has been prepared according to academic principles in terms of economic, social, environmental, engineering, architecture and public consent. There are measures to prevent potential impacts such as contamination of wastewater. In addition, measures must be taken to prevent flooding, smell pollution and impact on the landscape. The incinerator system is a solid waste management method in the incinerator that has been properly designed and constructed because it may cause air pollution, such as small dust particles, various toxic gases like sulfur dioxide, etc. Therefore, it is necessary to have an air pollution control system and to prevent the air passing through the flue into the atmosphere exceeds the air quality standard from the furnace.

III. METHODOLOGY

Develop an application for a waste management via the QR Code system. The principles of the System Development Life Cycle (SDLC) were used as follows.

1) *Requirement definition stage:* Studying documents and related research, as well as studying the problems and situations in the community regarding the classification of waste in order to determine the value of the purchase in the group, including waste management of Ban Yang sub-district communities to analyze and define the application development model.

2) *System analysis stage:* Analyzing and studying application patterns of applications in waste management via the QR code system to be consistent with community waste management activities; designed a context diagram containing information about the administrator, community

administrators, and community group members by defining the related work processes, including junk data management, member information management, QR code data management, reward information management, information management, and report display.

3) *System design stage:* Planning and defining work procedures to be consistent with the timeline, budget, and scope of the application for a waste management via the QR Code system. Determining the responsibilities for the working team and coordinated with people in the community involved, as is shown in Fig. 1.

4) *System development stage:* Developing the application for a waste management via the QR Code system, divided into two parts: 1) The user section, consists of the login screen, QR code scanning by managing the validation and designing with JAVA language and XML language, as well as managing database storage with MySQL engine. 2) The administrator section, manages application usage data to perform QR code scanning and the information management on the website, display Press release information, activity pictures, and display the household coordinates of the group members.

5) *System testing stage:* Testing the system using the application for a waste management via the QR Code system to check the operation of the system before it was put into actual use along with improving the syntax of the application's instruction set to meet the needs of users.

6) *System installation stage:* Executing the installation of the system to use the application for a waste management via QR Code system by using it in parallel with the existing community waste bank model and creating relevant documents such as a QR code diagram of the waste classification and application manual.

7) *System maintenance stage:* Improving the error from the operation of the application for a waste management via QR Code system including tracking the results of use and listening to suggestions on problems that arose in order to improve the system further.

After finishing the developing of an application for a waste management via the QR Code system, application technology dissemination is presented as is shown in Fig. 2.

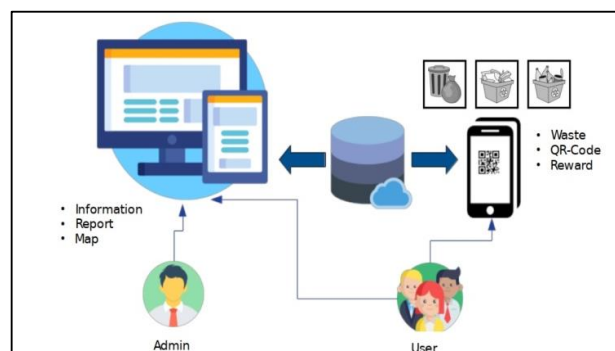


Fig. 1. Designing the Application for a Waste Management via the QR Code System.



Fig. 2. Presentation for Application Technology Dissemination.

IV. RESEARCH RESULT

A. Results of Analysis

Designing and developing of the application for a waste management via QR Code system use data from the study of problems in waste management in Ban Yang sub-district communities, Muang Buriram district, and Buriram province. These were analyzed and created a context diagram to show an overview of the system performance. The scope of the work studied in relation to the external environment of the system consists of the user menu. This can be checked by the member's points to be redeemed for rewards. Admin data management menu can manage member information, household coordinates, press release information, and QR code information, as is shown in Fig. 3.

B. Results of a Study

1) Results of a study on the quality of the application for a waste management via QR Code system by three experts and analyzed the data using mean and standard deviation according to the Likert method [42]. Details are shown in Table II.

From Table II, the results of the study on the quality of the application for a waste management via QR Code system by three experts revealed that the overall quality of the application was at a high level. The application design aspect was at the highest level. In terms of application usage and information security aspects were at a high level.

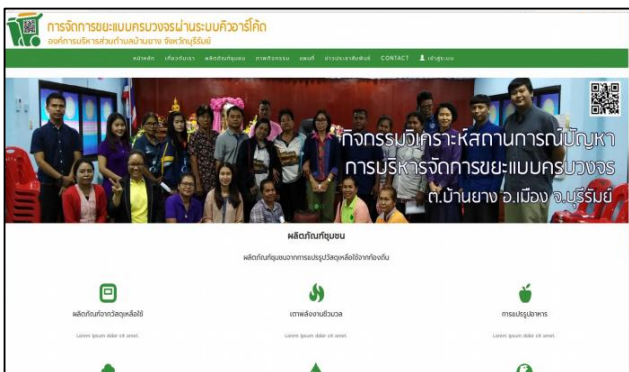


Fig. 3. Admin Data Management Menu.

TABLE II. THE RESULTS OF THE STUDY ON THE QUALITY OF THE APPLICATION FOR A WASTE MANAGEMENT VIA QR CODE SYSTEM

Appraisal item	\bar{x}	S.D.	Quality level
1. Application usage aspect	4.33	0.01	high
2. Application design aspect	4.46	0.30	the highest
3. Information security aspect	4.44	0.00	high
Total	4.41	0.10	high

Following Fig. 4 is a prototype of the application for a waste management via the QR-Code System.

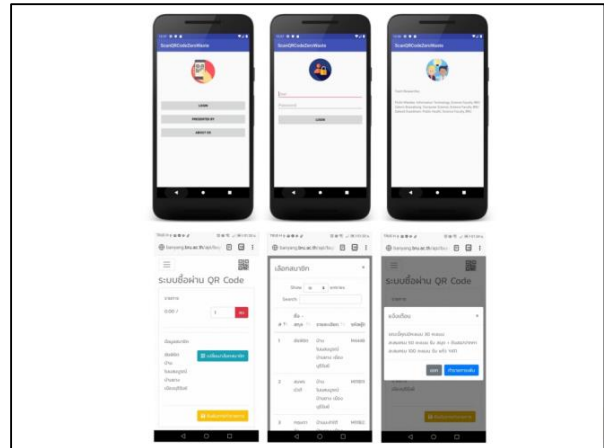


Fig. 4. Prototypes of the Application.

The system was installed and the developed application was tested with 388 people of sample groups, then the satisfaction study results were analyzed by basic statistical values compared to the criteria and summarized [43]. Details are shown in Table III.

TABLE III. THE RESULTS OF THE SATISFACTION ASSESSMENT OF THE APPLICATION USERS

Appraisal item	\bar{x}	S.D.	Satisfaction level
Application design aspect			
1. The font size was appropriate.	4.61	0.49	the highest
2. The topics used in the application were categorized appropriately.	4.27	0.62	high
3. Graphics used in the application were appropriate.	4.25	0.45	high
4. The use of color tones was appropriate and gorgeous.	4.23	0.42	high
5. The layout of the application components was uncomplicated to understand.	4.03	0.25	high
Performance in use aspect			
6. Users could scan the QR code easily and conveniently.	4.76	0.43	the highest
7. Users could manage information conveniently.	4.53	0.49	the highest
8. Users could speedily access information within the application.	4.91	0.45	the highest
9. The application performance overview was appropriate.	4.23	0.42	high
Total	4.42	0.45	high

The results of the satisfaction assessment of the users of the application for a waste management via QR Code system revealed that the overall was at a high level. When these were considered for each item, users were satisfied with the speed access to inform within the application at the highest level with the average 4.91 followed by users who could scan a QR code easily and conveniently with the average of 4.76. The font size was appropriate with the average of 4.61. The users could manage information conveniently with the average of 4.53. The topics used in the application were categorized appropriately with the average of 4.27. The graphics used in the application were appropriate and the application performance overview was appropriate with the average of 4.23. And the layout of the application components is uncomplicated to understand with the average of 4.03.

V. DISCUSSION AND CONCLUSION

From the research and development of the application for a waste management via the QR Code system, the related document was studied based on the System Development Life Cycle [44] through a process of participation in Ban Yang Sub-District Community, Mueang Buriram District, Buriram Province. The study analyzed the approach to waste management by applying application technology to store data and related information, divided into two parts: the application part was used in the QR scanning management to classify the types of waste in order to buy waste directly from the community group members by using the motivation to collect 100 points, and would receive a reward. That could check the history of buying waste of the group members, display a list of QR codes and report on the amount of waste by period [45]. This has been consistent with the research on QR CODE in Thailand and Application of QR Code Technology in the Hospitals in Thailand 4.0 by using QR code technology in service, thereby reducing errors streamlines the operations of various procedures, reducing redundant management, and making the service users get the most benefit.

The results of the quality assessment of the application by the experts were at a high level, which have been consistent with the research on Using QR-Code Technology for Public Relations of Community Enterprises Antique Hand-Woven Cloth Group, Padee Pha Tho, Tambon Bo Suak, Mueang district, Nan province. However, the users of the application for a waste management via QR Code system were satisfied with the system at a high level. The researchers in [46], in terms of application design and data accuracy [47] have been in line with the research on The Application of Two Dimension Barcode Technology for Providing Tourist Information Services at Tourism Destination Case Study: Doi Suthep Temple, Chiang Mai, which was designed and developed an application for information display that met the needs of users. That was easy access to information and convenient in service.

However, this should be further developed regarding the variety of applications in other uses, such as household location data in order to link the data to make it accessible to all. Local governments and community leaders should promote and support it as a learning area to be a role model in community waste management and to publicize knowledge and technology to nearby areas and people who are interested.

ACKNOWLEDGMENT

This research project was funded by the National Research Council of Thailand (NRCT). Thank you to the Research Progress Assessment Committee, Research and Development Institute, Buriram Rajabhat University. Thank you to the administrators of the Ban Yang Subdistrict Administrative Organization, Muang Buriram District, Buriram Province, officials, community leaders, seniors, youths, and people in the area for participating in research activities.

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