Research Article

Implementation of Lean Principles and QR Code Technology to Enhance Durable Articles Management System at Rattaphum College: A Process Efficiency Analysis

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ABSTRACT

Rattaphum College, Rajamangala University of Technology Srivijaya, previously managed its durable articles through a document-based system, leading to frequent issues such as data loss, redundancy, and difficulty in searching and editing information. This research aimed to (1) develop a durable articles management application using QR Code technology, (2) analyze operational efficiency after applying lean principles, and (3) assess user satisfaction with the new system. The research was conducted using lean principles to reduce steps and time in the operation. The efficiency was calculated from the ratio of total working time to the sum of valuable time. The developed application includes features for QR Code scanning, searching, adding, and editing durable articles, as well as user management. Results showed that, for staff, the application reduced work processes by one step, saved 12.84 minutes, and increased efficiency by 56%. For general users, work steps were reduced by three, with the same time savings and a 72.22% increase in efficiency. User satisfaction was also evaluated, with application design receiving a very good rating ($\bar{x}$ = 4.50, S.D. = 0.70), and overall system usability rated as good ($\bar{x}$ = 4.46, S.D. = 0.69). The study also revealed that an easy-to-use user interface design and the perceived usefulness of the system are important factors influencing its acceptance. This system demonstrates significant improvements in efficiency and usability and can serve as a model for implementation in other educational institutions with similar needs.

1. Introduction

The management information system in educational institutions is a structured system that stores and manages the data necessary for decision-making. The system can facilitate efficient operations in various areas such as academic management, student affairs, finance, durable articles management, and human resources by providing accurate, timely, and integrated information (Colarika and Zahro, 2023). These systems support educational goals and increase the overall efficiency of the management process. The durable articles management information system is an important system for managing resources within the university. The Rajamangala University of Technology Srivijaya, Rattaphum College, still manages durable articles through a document system and records data in Microsoft excel. Currently, the number of durable articles is increasing. The old

system is ineffective because there is a delay and lack of speed in searching for information, no search system, the need to travel to ask for information, and wasted time; data loss occurs due to no system to check for duplicate data and no data storage system; there is a lack of flexibility in use since information cannot be viewed all the time and someone must manage the system; and it causes waste by using excessive paper and requiring staff to provide services.

From the above problems, it can be seen that the system is inefficient. If the lean principle is applied to reduce the time and steps in the unimportant work process (Smith *et al*., 2012; Ghelani, 2021; Lojarernrat *et al*., 2024). the lean principle focuses on cost-effectiveness, avoiding losses in work, increasing efficiency in system operations, and enhancing ease of use. The use of lean principles can be done by writing the current work

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steps, timing each step, analyzing the necessity of each step, then calculating the efficiency, and proposing a new work approach by cutting out unnecessary steps and calculating the efficiency according to the new process. The convenience of use can be increased if QR Code technology is used, which is a convenient and popular channel for using the system today. QR Code can store more information than the original barcode and is fast in reading data (Moonsrikaew *et al.*, 2021). It is an important tool that increases the convenience of retrieving durable articles quickly. This format is accepted in warehouse management. For example, in research (Krajungduang *et al.*, 2021), a QR code scanning application was developed to record product code data. It is used to record data instead of the old way of writing. This allows for a reduction in the time and accuracy of recording product code numbers. Research by Kongmuang and Kandee (2023) has developed a system for applying QR code technology to verify durable articles. Research by Pitjamit *et al.* (2024) has applied the principles of Lean and Kaizen, where Kaizen refers to the continuous improvement of the work process. It presents the integration of technology with the concept of Lean-Kaizen. This research uses IoT and Automation systems to reduce waste and improve the production process. Research by Fomina and Yumatova (2022) applies the principles of Lean Production with information systems to increase the efficiency of organizational management and production processes. Research by Amit and Cholli (2021) applies Lean principles to the software development process, focusing on reducing waste and increasing the efficiency of the development team. Research by Monserrat *et al.* (2023) applies Lean principles to improve the teaching process in a software project management course to analyze the value chain and eliminate non-value-added processes in teaching.

From the above research, it can be seen that Lean principles are applied to reduce the steps and time of the operation. QR Code is applied to the information system, and both Lean principles and information system development are applied. This research focuses on solving the problems of the original system as mentioned above. It also integrates lean principles, applications, and QR Code technology to manage equipment in an educational context. It also adds a highlight of easy-to-use system design to achieve a high level of system acceptance. The research aims to 1) solve the problem of inefficient manual durable articles management at Rattaphum College by using Lean principles to increase the efficiency of the durable articles management system and develop it into an application that uses QR Codes; 2) analyze the efficiency of the process; and 3) evaluate the satisfaction of using the system. This research can reduce work steps, decrease the use of documents, reduce data redundancy, increase the speed of searching durable articles, and provide convenience for use at all times. It is beneficial to the departments, procurement officers, and personnel at Rattaphum College.

2. Materials and Methods

2.1 Research methodology

2.1.1 Research Scope

In terms of system capabilities, there are two types of users: administrators and general users. The administrators can scan and search for durable articles, add durable articles, edit durable articles, and add users. As for users, they can search for durable articles. The data will be stored in a relational database. The sample group is 30 personnel of Rattaphum College, Rajamangala University of Technology Srivijaya, using a purposive sampling method (Phoksawat *et al.*, 2025) who use the durable articles management system, consisting of procurement officers, lecturers, and staff. The research team explained the details of the research project and protected the rights of the research participants. They also explained the rights of the sample group to refuse to participate in the study without affecting the services they will receive. All data are confidential and only the overall results are presented.

2.1.2 Development of the Rattaphum College Durable articles Management System using QR Code via Mobile Application was developed using System Development Life Cycle (SDLC) Waterfall Model.

The waterfall model is a traditional approach to the systems development life cycle (SDLC), characterized by linear and sequential steps, often used for projects where requirements are well understood and unlikely to change. The model is ideal for general systems or software, where the development process can follow a structured path from planning to maintenance as shown in Figure 1. The structured nature of the waterfall model ensures that each step is completed before the next task begins, which can help maintain quality and reduce errors (Wusidagama and Marikkar, 2024).
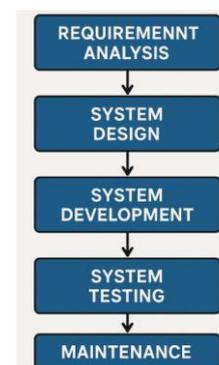

Figure 1 System Development Life Cycle (SDLC) waterfall model

2.1.2.1 Requirement Analysis

The needs of users of the system in the organization were analyzed through interviews. It was found that a durable articles management system that can be used via mobile phones, scanned by QR codes to search for durable articles,

add new durable articles, and edit durable article information, was needed.

2.1.2.2 System Design

System design includes overall system design, data flow diagram design, database design, and process design and performance analysis before applying lean principles.

From Figure 2, the system is designed using a client-server architecture by first developing a website system, which uses PHP (Mothongkul and Namcode, 2019) for development and a MySQL database (Satjabundanjai *et al*., 2023) that is fast to use and free to use. The user interface design uses the Technology Acceptance Model (TAM), which focuses on designing for perceived ease of use and perceived usefulness (Scherer *et al*., 2019; Natasia *et al*., 2022) to achieve higher system acceptance. Draw.io is used to help design, which is free to use. Users can use the website using various devices such as PCs, smartphones, and tablets on the ethernet network within the organization. For portable devices, the application was developed using Android Studio via the WebView method, which retrieves data from the website to display in the application. The advantage is that the system can be updated quickly. When the website is updated, the application will be updated immediately without having to edit it in the application.
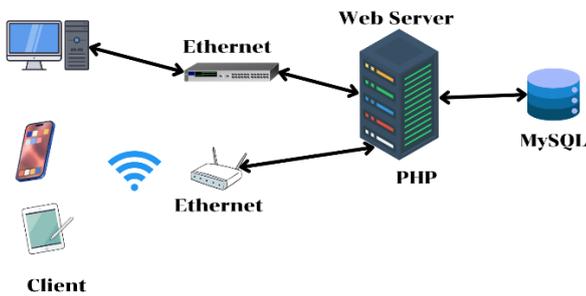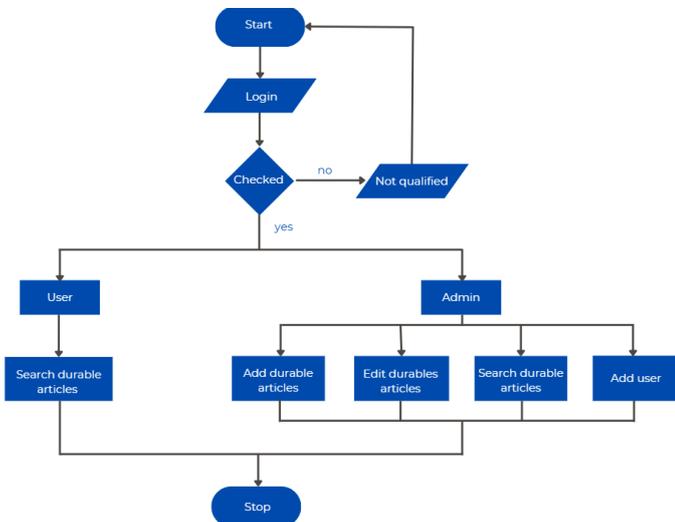

Figure 2 System Design

Figure 3 Flow chart showing the operation of the system

Figure 3 is a flow chart showing the operation of the system, starting from logging in to the system, filling in the username and password. The system will check with the database. If there is no username or the password is incorrect, the system will ask you to log in again. But if the username and password are correct, the system will check the type of user. If you are a user, you can scan the QR Code to search for durable articles. If you are an administrator, you can add durable articles, edit durable articles, search for durable articles, and add users.

(1) Data Flow Diagram (DFD) design

DFD is a representation of the flow of data within the system and the operations that occur in the system. The information in the diagram shows where the data comes from, where the data goes, where the data is stored, and what events happen to the data along the way. The data flow diagram shows the overall picture of the system from external factors flowing into the system through various work steps through data collection, showing data according to the direction of data flow. DFD Level 0 is the overall data flow, also called context diagram.
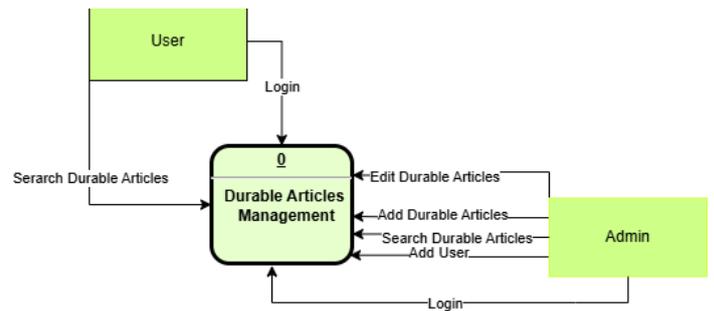

Figure 4 Data Flow Diagram level 0 or Context Diagram

From Figure 4, it is a context diagram showing the main process of durable articles management system, which is a central system that links the data exchange between external entities, namely user and admin, with clear data input and output characteristics for each role.
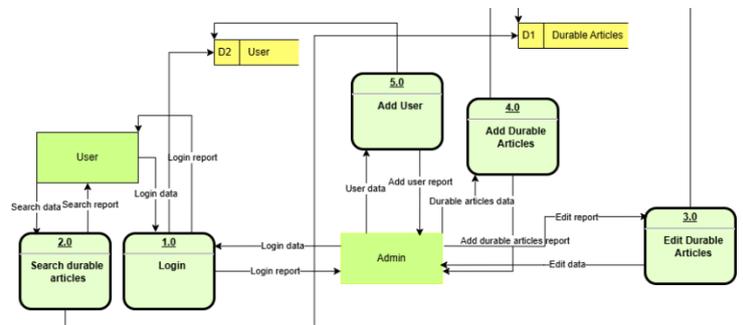

Figure 5 Data Flow Diagram level 1

From Figure 5, it is a DFD level 1 showing the breakdown of the sub-processes within the durable articles management system. The details are extracted from the context diagram (level 0) to clearly show the internal structure of the system,

especially the data flow between users, administrators, and the database.

(2) Database Design

The database design uses ER-Diagram, which is an easy-to-use and understandable database design tool. It is the main tool used in designing relational databases (Jaimez-González and Martínez-Samora, 2020). ER-Diagram is used to represent the structure of the data, show the relationship between entities, and define attributes and primary keys. Figure 6 is a model of the relationship between entities. It consists of 2 main entities: user and durable articles, which are related through a relationship called 'have' with a cardinality of 1: M, meaning that one user can own many items of durable articles, but each item of durable articles can be associated with only one user. Each entity has a clear primary key: User ID for the user entity and Durable articles ID for the durable articles entity.
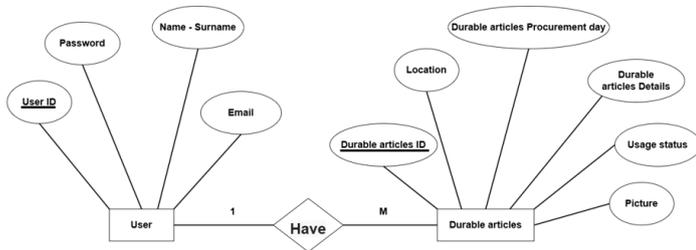

Figure 6 ER- Diagram

### (3) Process and efficiency before using lean principles (Pre-LEAN)

Lean is a strategic concept that aims to increase the efficiency of the organization by eliminating waste and improving the process to meet customer needs. It is based on the Toyota Production System (TPS) and has been further developed with theoretical concepts such as Kaizen (continuous improvement), Just-In-Time (JIT) (just in time) and Theory of Constraints (TOC) (management of constraints) to be applied to all types of organizations, not limited to the manufacturing sector (Shah and Ward, 2007).

The Lean principle has the following methods:

Step 1: Write the current work process from the beginning to the end of the work process in detail, called Pre-Lean, by visiting the field to observe the actual work steps and interviewing staff to understand all steps.

Step 2: Time each work process, including the distance between steps and the waiting time at each step, using a timer application.

Step 3: Analyze the activities that occur to determine which activities are necessary or not necessary to do, or not necessary but must be done, by defining them as symbols as follows:

☐ Necessary
☐ Not necessary
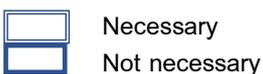
☐ Not necessary but must be done

Conduct meetings with operators to analyze activities together.

Step 4: Calculate the efficiency of the Pre-Lean work process using the formula:

$$\text{Efficiency} = \frac{\text{Sum of valuable time}}{\text{Total time}} \times 100$$

Step 5: Hold a meeting with the operators to analyze and find a new way of working (Post-Lean) by cutting out unnecessary processes (Waste) and cutting out unnecessary processes that must be done (Necessary non-value) or to the minimum, and collecting real data according to the new method to find efficiency.

Step 6: Calculate efficiency according to the new process or Post-LEAN that will have only things that do not need to be done but must be done and things that need to be done.

Figure 7 Durable articles management process for staffs before using lean principles
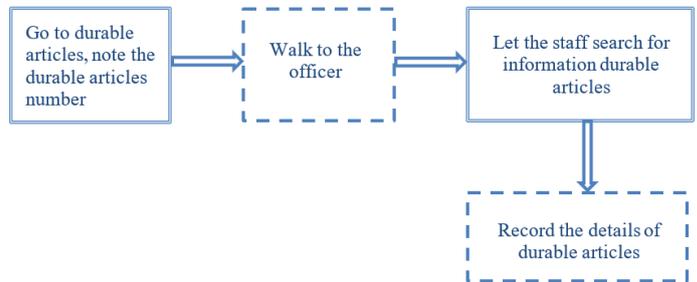

Figure 8 Durable articles management process for users before using lean principles

Durable articles management procedures for staff
1. Walk to take a photo of new durable articles. It takes 10 minutes.
2. Go back and add new durable articles to Excel. It takes 12 minutes.
3. Find durable articles yourself. It takes 2 minutes.
4. Edit durable articles. It takes 1 minute.
Steps 1 and 4 are necessary steps and therefore represent valuable time. Step 2 is unnecessary, while Step 3 is unnecessary but currently required. Step 3 can be eliminated if a digital application system is developed to replace the existing system. Therefore, the total valuable time for Steps 1 and 3 combined is 11 minutes.

$$\text{Efficiency} = \frac{10+1}{25} \text{ x } 100$$
$$\text{Efficiency} = 44.00 \text{ \%}$$

Durable articles management procedures for users

1. Go to durable articles and note the durable articles number. It takes 5 minutes.

2. Walk to the officer. It takes 10 minutes.

3. Let the staff search for information durable articles. It takes 2 minutes.

4. Record the details of durable articles. It takes 1 minute.

Step 1 is necessary and therefore represents valuable time. Steps 2 and 3 are unnecessary, while Step 4 is unnecessary but currently required. Step 4 can be eliminated if a digital application system is developed to replace the existing system. Therefore, the valuable time for Step 1 is 5 minutes.

$$\text{Efficiency} = \frac{5}{18} \text{ x } 100$$
$$\text{Efficiency} = 27.77 \text{ \%}$$

2.1.2.3 System development

After designing the data flow in the system, the user interface, and the database, the database system was developed using MySQL, and the system website was developed using PHP so that the system can be used via a web application. For mobile devices, to make the usage smoother, the application was developed using Android Studio (Tewari and Singh, 2021) in the form of using WebView to retrieve data from the website in the developed system. This method allows for fast system updates. If the website is updated, it will affect the application immediately. However, the display format may not be as beautiful as a native application.

2.1.2.4 System Testing

When the system development was completed, the system usage was tested under the rights of the Admin user, from adding durable articles information, scanning QR codes to search for durable articles, editing and updating information, and adding new users and users to scan QR codes to search for durable articles. When errors were found, the system was returned to the system development process to be improved.

2.1.2.5 Maintenance

During actual usage, user satisfaction was evaluated to guide further development and improvement. System training was also provided.

2.2 Creating a satisfaction questionnaire for durable articles management systems using QR codes via android applications.

1. A closed-ended questionnaire divided into two sections with 12 questions: Section 1: Personal information of the respondent, a 2-item survey: gender and age; and Section 2:

Satisfaction with the development of the Rattaphum College durable articles management system using QR codes via mobile applications. The questionnaire was in the form of a rating scale, divided into two dimensions with 10 questions: application design and durable articles management system usage.

2. The questionnaire was examined for content validity by five experts, with an average validity ranging from 0.60-1.00.

3. The system users were asked to test the system and collect data.

4. Statistical data analysis used a ready-made statistical program to help with the analysis to find the arithmetic mean (Arithmetic Mean: $\bar{x}$ and standard deviation (Standard Deviation: S.D.) (Carifio and Perla, 2008), which uses a 5-level Likert scale as follows: 5 = most satisfied, 4 = very satisfied, 3 = moderately satisfied, 2 = slightly satisfied, 1 = least satisfied. The interpretation uses the following levels: 4.50-5.00 most satisfied, 3.50-4.49 very satisfied, 2.50-3.49 moderately satisfied, 1.50-2.49 slightly satisfied, and 1.00-1.49 least satisfied.

3. Results and Discussion

The research results and discussions are presented in three parts: the first part is the results of developing a durable articles management application using QR Code, the next is the results of analyzing the efficiency of the process after using lean principles, and the last is the results of evaluating the satisfaction of using the system, which is divided into application design and system use.

3.1 System Development Results

System development results include the system, login, adding durable articles, editing durable articles, scanning for durable articles, and adding users. From Figure 9, it is the system login page. When the user and password information is entered, the system will check the user database. If there is information, the system will continue to log in. If no information is found, the system will ask you to try logging in again.
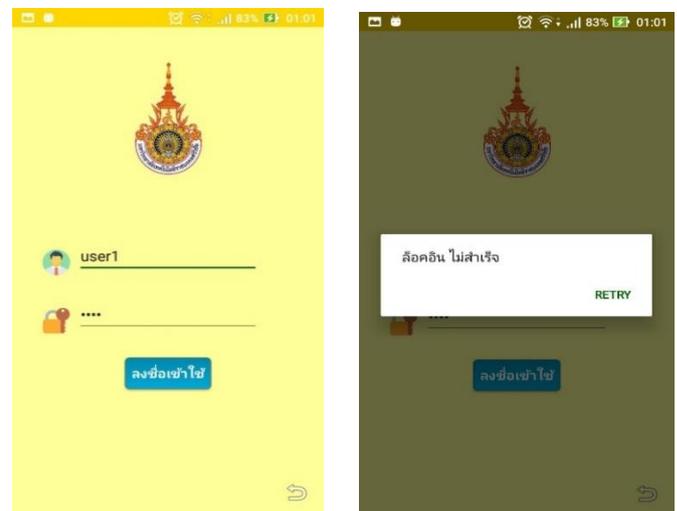

Figure 9 Login system

To scan QR codes for durable articles search, when users tap the QR code scan button, the system requests permission to access the mobile device's camera. Upon scanning, the system retrieves the durable article code as shown in Figure 10a. As illustrated in Figure 10b, users then press the search button. If the item exists in the database, its details are displayed on screen as shown in Figure 10c. If no matching item is found, the system notifies the user.

To add durable articles information, fill in the durable articles details, select a picture or take a photo, and press the add information button. The information will be added to the database system. You can also create a QR code to attach to the durable articles for further searching, as shown in Figure 11a. After scanning to search for durable articles, you can edit the durable articles information as desired. The system will save the information in the database as shown in Figure 11b.
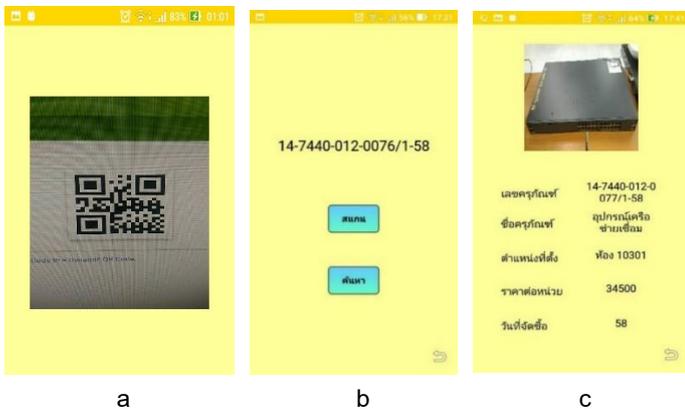

a   b   c

Figure 10 Scan QR code to search for durable articles

a   b

Figure 11 Adding and editing durable articles data

The system design in this research focuses on simplicity but has the ability to manage data effectively. The database design separates data into different tables, namely, durable articles table and user table, so that it is possible to add, search, edit durable articles and add user data. There is a clear link between data. This approach is consistent with the concept of (Aleryani, 2024) who proposed that a relational database structure should be designed together with a data flow diagram (Data Flow Diagram: DFD) to help understand the flow of data in the system more clearly, especially in information systems that must support access to multiple functions.

3.2 Process and efficiency after using lean principles (Post-LEAN)
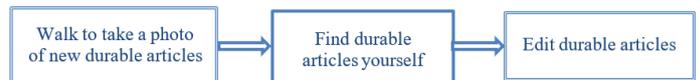

Figure 12 Durable articles management process for staff after applying lean principles

Durable articles management procedures for staff
1. Walk to take a photo of new durable articles. It takes 10 minutes.
2. Find durable articles yourself. It takes 2 minutes.
3. Edit durable articles. It takes 1 minute.

After implementing the lean principles (post-lean), steps 1 through 3 were identified as essential steps in the process, with a total combined duration of 12.16 minutes.

$$\text{Efficiency} = \frac{11+0.16+1}{12.16} \times 100$$
$$\text{Efficiency} = 100.00\ \%$$

Durable articles management procedures for users
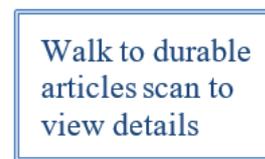

Figure 13 Durable articles management process for users after using lean principles

1. Walk to durable articles section to scan and view details. It takes 5 minutes.

Following the post-lean implementation, the process was streamlined to a single essential step, requiring only 5.16 minutes to complete.

$$\text{Efficiency} = \frac{5.16}{5.16} \times 100$$
$$\text{Efficiency} = 100\ \%$$

Table 1 Comparison of performance between pre-lean and post-lean

List	Pre-Lean: Staff	Post-Lean: Staff	Pre-Lean: Users	Post-Lean: Users
Process	4	3	4	1
Duration (minutes)	25	12.16	18	5.16
Efficiency (%)	44	100	27.77	100

Table 2 Application design satisfaction assessment results

Assessment Topics	$\bar{x}$	S.D.	Level
The screen design is suitable	4.67	0.56	Highest
Font and text layout	4.43	0.79	High
Able to understand the display of system information	4.76	0.43	Highest
Application background	4.14	0.77	High
Total	4.50	0.70	Highest

Table 3 Assessment of satisfaction with system usage

Assessment Topics	$\bar{x}$	S.D.	Level
Ease of use of the system	4.71	0.55	Highest
Appropriateness of font selection	4.43	0.66	High
System suitability	4.19	0.59	High
Accuracy of data verification via the system	4.48	0.66	High
Accuracy of data correction via the system	4.24	0.75	High
Speed of system use	4.71	0.70	Highest
Total	4.46	0.69	High

From Table 1, the comparison results between Pre-Lean and Post-Lean found that it helped reduce the staff's work steps by 1 step from 4 steps to 3 steps, reduced the time by 12.84 minutes from 25 minutes to 12.16 minutes, and increased the system efficiency from 44 to 56 to 100 because the staff still had many steps to do, resulting in not much improvement in efficiency. For general users, it helped reduce the work steps by 3 steps from 4 steps to 1 step, reduced the time by 12.84 minutes from 18 minutes to 5.16 minutes, and increased the system efficiency from 66.67 to 33.33 because the users had many steps that did not need to be done, resulting in a significant increase in efficiency.

The application of lean principles in this research focuses on reducing unnecessary steps in the durable articles management process, such as duplicate data entry, manual document search, and unsupported counting. The research results are in the same direction as the two (Krajungduang *et al*., 2021; Lojarernrat *et al*., 2024), who used lean principles to reduce steps and work time in developing an information system for managing warehouse and parcel work. And it is consistent with the by Teerapraipruek and Supakul (2024), which used lean principles to reduce work steps and increase efficiency in drug warehouse management. It is consistent with the research by Smith *et al*. (2012), which used lean principles to reduce waste, reduce waiting time for patients and personnel, reduce redundant paperwork, and increase personnel satisfaction. It is also consistent with the research by Contreras Castañeda *et al*.

(2024), who used lean principles to reduce waste and improve the process in the production of raw sugar from sugarcane.

In addition, research by Marques *et al*. (2022), which applied lean principles in retail stores and e-commerce systems, also showed a reduction in waste in order and inventory management processes using digital systems combined with value stream mapping, similar to the approach in this research that analyzed the original process before improvement (Pre-Lean) to find waste and design a new system using lean tools such as timing, activity classification, and process efficiency assessment.

3.3 Satisfaction evaluation results

It is divided into two aspects: application design and system usage, as shown in Table 2-3.

According to Table 2, the satisfaction analysis of the Rattaphum College durable articles management system using QR codes via mobile application, regarding application design, shows that overall satisfaction was at the highest level ($\bar{x}$ = 4.50, S.D. =0.70). When considering individual items, the system's information display comprehensibility received the highest satisfaction ($\bar{x}$ = 4.67, S.D. =0.43), followed by appropriate screen design ($\bar{x}$ = 4.67, S.D. =0.56), and text and message layout ($\bar{x}$ = 4.43, S.D. =0.79).

The evaluation results are in the same direction as the research by Kongmuang and Kandee (2023), which evaluated the development of the QR code technology application system for checking durable articles in terms of meeting the needs of the

system users at the highest level. It is also consistent with the research by Nadee (2022), which has evaluation results showing satisfaction with the application design at a very satisfactory level as well.

According to Table 3, the satisfaction analysis of the Rattaphum College durable articles management system using QR codes via mobile application, regarding system usage reports, shows overall satisfaction at a high level ($\bar{x}$ = 4.46, S.D. =0.69). When considering individual items, system ease of use and system speed received the highest satisfaction ($\bar{x}$ = 4.71, S.D. =0.55), followed by accuracy in system data verification ($\bar{x}$ = 4.48, S.D. =0.66), and appropriateness of font selection ($\bar{x}$ = 4.43, S.D. =0.66).

From the evaluation results, the ease of use of the system and its speed resulted in users having a positive attitude towards the use of technology and accepting its use, which is consistent with the research by Phoksawat *et al.* (2025). The increased satisfaction of users after using the new system reflects the system's ability to meet the needs of actual use, especially in terms of fast access to information via QR Code and reducing redundant steps, which is different from the original system that required filling in paper files and searching manually. This research result is consistent with the study by Jaroenchart and Phookanngam (2023), which used QR code technology to check the safety system of forklifts and found a satisfaction evaluation result in terms of ease of use, convenience, and simplicity at a very good level as well.

Problems and obstacles found during the operation are that it is difficult for users to accept the use. Therefore, it is necessary to design the system to be easy to use and fast to use. And from the results of the research that applied lean principles and information system development to manage durable articles, it reduces the steps and time of work, increases convenience in using the system, and can be applied to other educational institutions.

4. Conclusion

The durable articles management system has the ability to add durable articles, scan and search for durable articles, edit durable articles, and add new users. There are 2 types of system users: general users can scan and search for durable articles, while administrators can use all systems. In developing the system, the database system was developed using MySQL and PHP was used to develop various systems. The mobile application was developed using Android Studio. In terms of the results of the evaluation of satisfaction with the system, it was found that satisfaction with the application design was at the highest level, while satisfaction with the use of system reports was at a high level. Satisfaction in terms of ease and speed of using the system was at the highest level, and the perception of the benefits of the system, both in terms of reduced work

steps and increased efficiency, resulted in greater acceptance of its use. The research results clearly achieved the objectives of using lean principles to reduce steps and time in working, eliminate redundancy, and increase work efficiency. However, the research still has limitations: it was used by only one department and is also a small-scale example of use. However, it can be applied to other asset management systems. The future development guidelines will include developing a database to be stored in the cloud system that offers better flexibility in use, testing the system in a larger department to evaluate its efficiency, accuracy, and precision, and studying artificial intelligence technology to reduce the steps of the system, making it more automatic and more efficient.

5. Acknowledgments

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