

## Development and Performance Evaluation of a Thesis Circulation System for Graduate Studies at Thonburi University

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### Abstract

Study Circulation System for the Graduate School of Thonburi University, designed to replace traditional manual resource management with a secure and efficient digital platform. Utilizing the Agile Methodology for iterative development, the system was built as a web application using PHP and MySQL, with quality assessment conducted based on the ISO/IEC 25010 international standard.

The findings indicate exceptional technical performance, featuring an average search response time of 0.056 seconds and full-text (PDF) access time of 0.075 seconds, both of which significantly surpass international information system standards. Expert evaluation rated the system's Functional Suitability and Reliability at a "Very High" level ( $\mu = 4.73$ ,  $\sigma = 0.159$ ). Additionally, pilot testing with graduate students and administrative staff revealed a "High" level of user satisfaction, specifically regarding Operability ( $\mu = 4.44$ ,  $\sigma = 0.527$ ).

The developed system successfully achieves a complete digital transformation of library management, enhances workflow efficiency through barcode integration, and protects intellectual property via a Secure Full-text Viewing feature, offering a replicable and high-performance model for graduate-level academic resource management.

**Keywords:** Agile Methodology, Thesis Circulation System, ISO/IEC 25010, Digital Transformation

## Background and Statement of the problem

Theses and independent studies constitute vital intellectual property and academic assets for the Graduate School at Thonburi University, representing specialized knowledge derived from systematic research processes. Circulation statistics reveal a consistent upward trend in resource utilization: recorded loans rose from 54 in 2021 to 59 in 2022, 74 in 2023, and reached 82 in 2024. This increasing demand underscores the significance of research works to both students and staff (Graduate School Thonburi University, 2025), yet it simultaneously presents challenges in effective resource management and maintenance. Modern educational institutions are increasingly adopting digital and smart library systems to enhance information accessibility. The integration of information technology and the internet allows libraries to provide more efficient services, better addressing the evolving needs of researchers in the digital era (Le & Bui, 2020).

Currently, the Graduate School’s manual operational system faces several critical limitations. Locating specific physical copies is difficult due to poor searchability, while paper-based data management causes delays, increases the risk of document loss, and creates redundant workflows. Furthermore, the lack of real-time monitoring for overdue status hinders the tracking and timely return of resources. These physical-only storage constraints fail to satisfy the growing demand for convenient, online full-text access required by graduate students.

To address these challenges, this research aims to develop and conduct a Development and Performance Evaluation of a Thesis Circulation System for Graduate Studies at Thonburi University to facilitate a complete digital transformation. The proposed system will feature advanced search capabilities categorized by curriculum or popularity, comprehensive statistical dashboards, and secure web-based document viewing to protect intellectual property. Additionally, the system will streamline administrative tasks through barcode integration for loans and returns, facilitate physical book reservations, and establish a systematic membership database. These enhancements are designed to elevate the university's information service standards, ensuring optimal efficiency and academic benefit for the graduate community.

## Objective

1. To develop a Graduate Thesis and Independent Study Circulation System for Thonburi University with comprehensive functionalities, including searching, physical book reservation, circulation (borrowing and returning), and full-text access under a secure data protection system.
2. To test the technical efficiency of the developed system regarding search accuracy and system response time, in accordance with software testing standards.
3. To evaluate user satisfaction (among students and staff) towards the Thesis and Independent Study Circulation System in terms of usability and the practical benefits of its data management functions.

## Expected benefits

1. The acquisition of an efficient Graduate Thesis and Independent Study Circulation System for Thonburi University, which streamlines workflows by reducing paper-based processes and minimizing data management errors through barcode technology.
2. Graduate students will be able to conveniently search for and access full-text thesis documents via the network, supported by a security system that prevents copyright infringement from copying or printing.
3. A comprehensive understanding of the system's technical efficiency and user satisfaction levels, serving as a guideline for further improving information systems and library services at the Graduate School, Thonburi University, in the future.

## Conceptual Framework

This research framework illustrates the development and efficiency evaluation process of the Graduate Thesis and Independent Study Circulation System at Thonburi University. The development integrates Agile Methodology to ensure maximum flexibility and responsiveness to user requirements, alongside modern Information System Design principles. Evaluation criteria are established in accordance with the ISO/IEC 25010 international software quality standard. This framework is divided into two systematically interconnected components as follows.

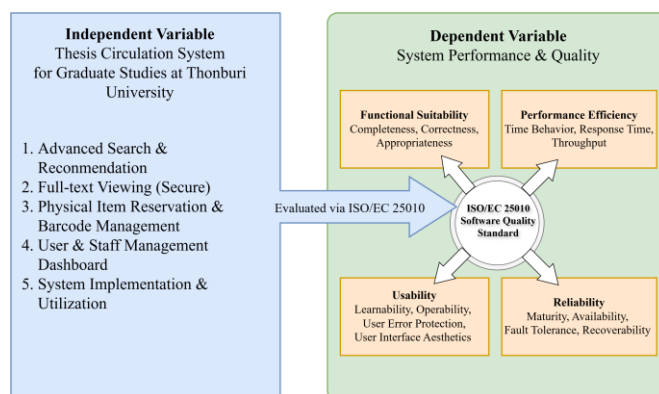


Figure 1 Conceptual Framework

This framework demonstrates the structural relationship between the developed system (independent variable) and the performance and quality outcomes (dependent variable), with details as follows

### 1. Independent Variable

The developed Graduate Thesis and Independent Study Circulation System for Thonburi University, which encompasses five core functional areas.

- Advanced Search & Recommendation, An advanced search engine and recommendation system for related items.
- Secure Full-text Viewing, Online access to full-text documents protected by a secure data system.
- Physical Item Reservation & Barcode Management, A reservation system for physical thesis copies managed through barcode technology.
- User & Staff Management Dashboard, A central management dashboard for both students and administrative staff.
- System Implementation & Utilization, The deployment and real-world application of the system within the university environment.

### 2. Dependent Variables

System Performance and Quality, representing the outcomes derived from the system development, evaluated based on the ISO/IEC 25010 standard across four primary dimensions.

- Functional Suitability, Assessing functional completeness, correctness, and appropriateness.

- Performance Efficiency, Measuring time behavior, response time, and throughput.

- Usability, Evaluating learnability, operability, user error protection, and user interface aesthetics.

- Reliability, Measuring availability, fault tolerance, and recoverability.

## Research Methodology

The study employs the Agile Methodology to ensure system flexibility and responsiveness. The process is divided into four key phases. (Abrahamsson et al., 2002)

### 1. Requirement Analysis

- Preliminary Study, Analyzed 4-year circulation statistics (2021-2024) and existing regulations of the Graduate School Library, Thonburi University.

- Elicitation, Conducted interviews with staff and students to define User Stories, focusing on advanced search, secure full-text access, and automated circulation management.

### 2. System Design & Development

The research team executed the development process under the Agile framework, organizing workflows into iterative cycles or "Sprints" to facilitate immediate feedback and continuous refinement. The details are as follows.

- Architecture & Database, Designed an ERD using a Relational Database model (InnoDB, UTF-8). It encompasses User data, Research metadata, Transaction logs (Borrow/Return/ Fines), and Security logs.

- UI/UX Design, Developed Information Architecture (IA), Wireframes, and Prototypes. The design follows the university's visual identity (Purple & White) and ensures Respon-sive Design across all devices.

- Implementation, Developed using PHP, HTML, CSS, JavaScript, and SQL. Integrated a Barcode system for operational efficiency and Anti-Copy measures (e.g., suspicious activity detection) to protect intellectual property.

### 3. Testing & Evaluation

- Expert Evaluation, conducted with 5 information technology and software development experts selected through Purposive Sampling. They verified Functional

Suitability, Reliability, and UI/UX Aesthetics. A panel of 5 experts is academically recognized as sufficient for software quality evaluation, as this number is capable of identifying the majority of significant usability and functional issues. (Nielsen & Landauer, 1993)

- Technical Testing, Measured Performance Efficiency, focusing on Response Time and Throughput during concurrent usage. (Thonghuapai, 2015)

#### 4. User Satisfaction Assessment

- Population and Sample, the sample consisted of 33 participants, including graduate students and relevant administrative staff from Thonburi University. The participants were selected using Purposive Sampling, focusing on those who actively engaged with the system during the pilot testing phase.

- Sample Size Justification, a sample size of 33 is considered adequate and academically sound for usability and performance evaluation. In information system research, a sample exceeding 30 is typically sufficient to achieve a normal distribution of data, allowing for reliable descriptive statistical analysis (Mean and Standard Deviation) to accurately reflect user satisfaction levels.

- A 5-point Likert Scale questionnaire was used to evaluate Usability (ease of use) and overall system satisfaction. The interpretation of mean scores was based on the criteria proposed by Likert (1932), whereby scores ranging from 4.51 to 5.00 indicate a "Very High" level of satisfaction, scores from 3.51 to 4.50 indicate "High," scores from 2.51 to 3.50 indicate "Moderate," scores from 1.51 to 2.50 indicate "Low," and scores from 1.00 to 1.50 indicate "Very Low."

- Data Analysis, Utilizing descriptive statistics, including Mean ( $\mu$ ) and Standard Deviation ( $\sigma$ ), to summarize the system's quality and performance outcomes.

Table 1 Summary Table of Evaluation Criteria

Evaluation Topics	Evaluation methods	Tools	Target Audience
1. Functional Suitability	Completeness, Correctness, Appropriateness	1. Software Quality Evaluation Form 2. Black-Box Testing Checklists	Expert
2. Performance Efficiency	Time Behavior, Response Time, Throughput	3. Automated Testing Tools (Apache JMeter)	Load Test
3. Usability	Learnability, Operability, User Error Protection, UI Aesthetics	4. User Satisfaction Questionnaire 5. System Usability Scale (SUS)	Users
4. Reliability	Maturity, Availability, Fault Tolerance, Recoverability	6. Test Scripts	Expert

Note: Evaluation Topics and Evaluation methods from Kongvasagunnee & Chooprayoon (2024)

## Research Results

The research findings for the "Development and Efficiency Evaluation of the Thesis and Independent Study Circulation System for the Graduate School, Thonburi University" are presented below, categorized according to the research objectives.

### Part 1 System Development Results.

The results in this section highlight the functional characteristics of the system developed as a web-based application. The system comprises key modules aligned with the operational scope, as illustrated in the following interface screenshots.

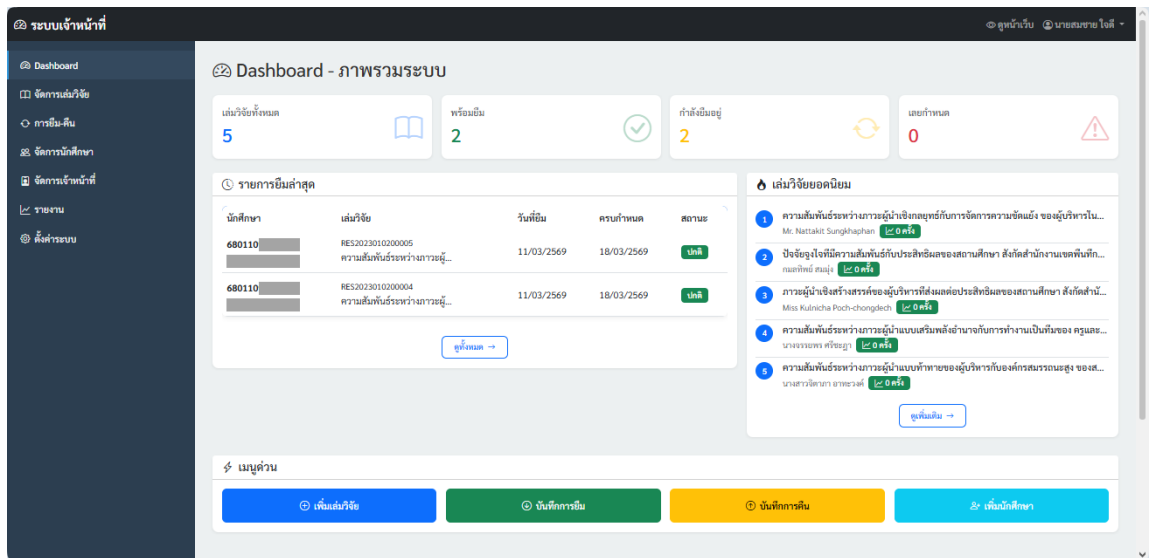


Figure 2 Display the system's main dashboard.

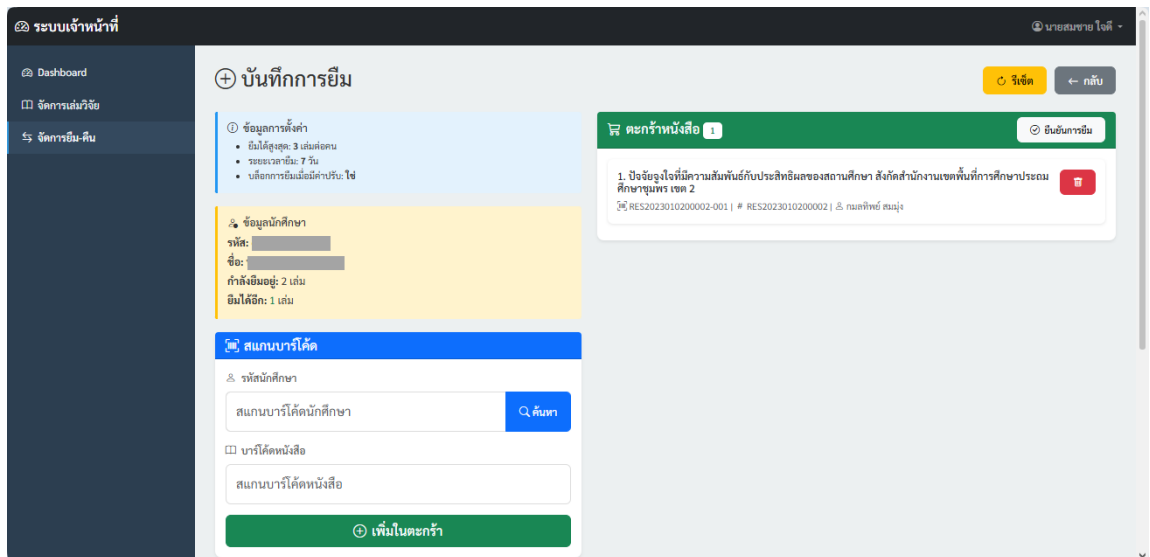


Figure 3 Borrowing Management Screen.

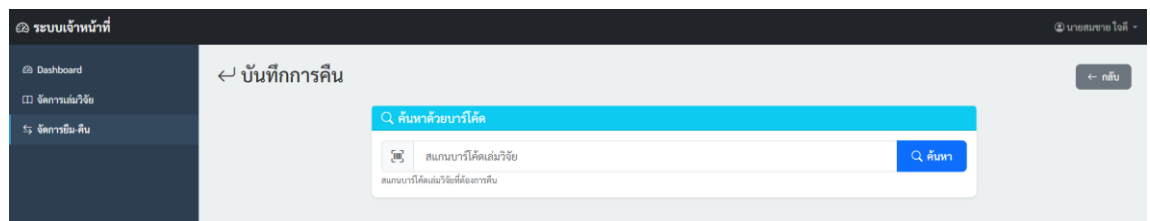


Figure 4 Barcode scanner page for book return.

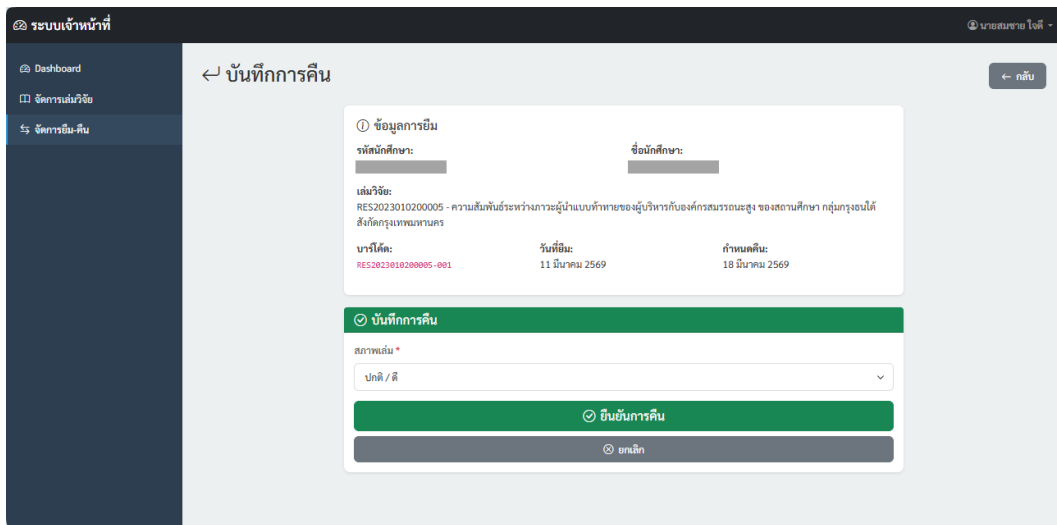


Figure 5 Return management Screen.

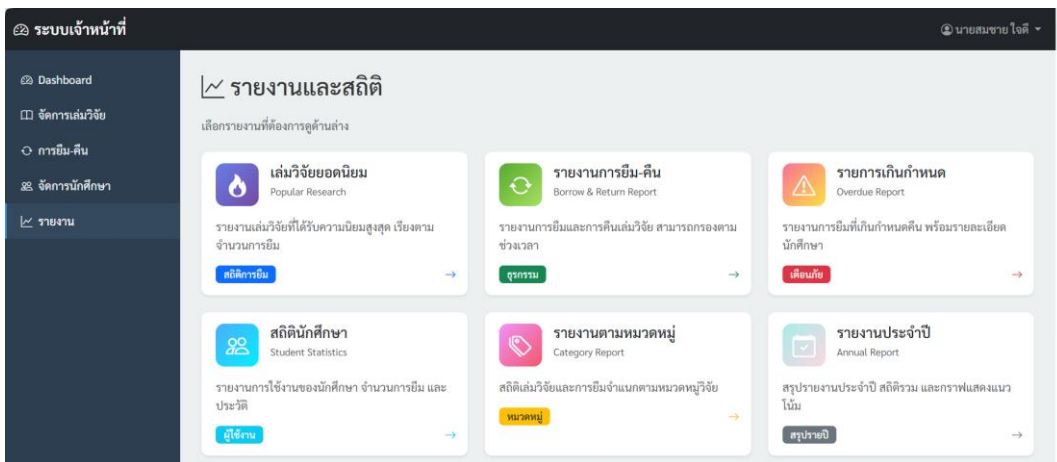


Figure 6 Data report Screen.

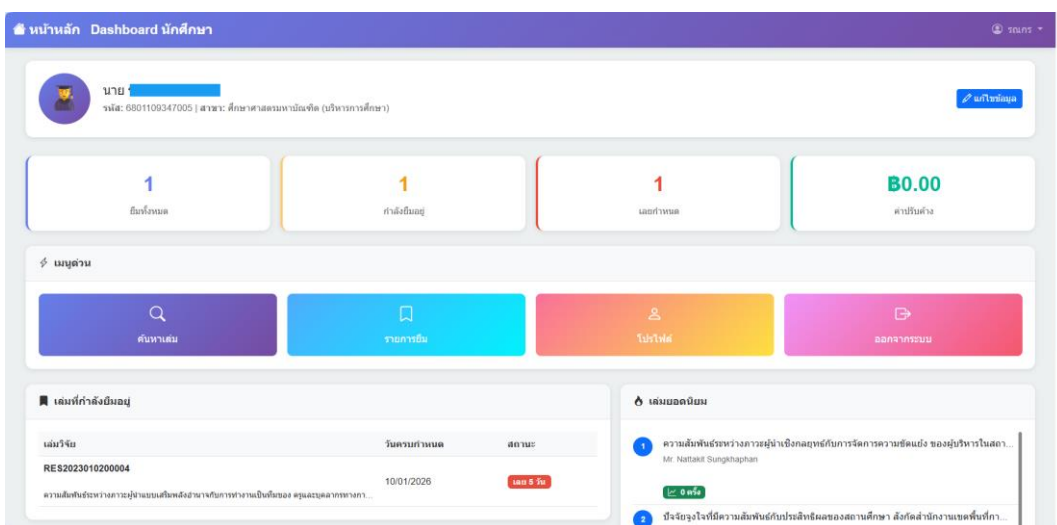


Figure 7 Student system main screen.

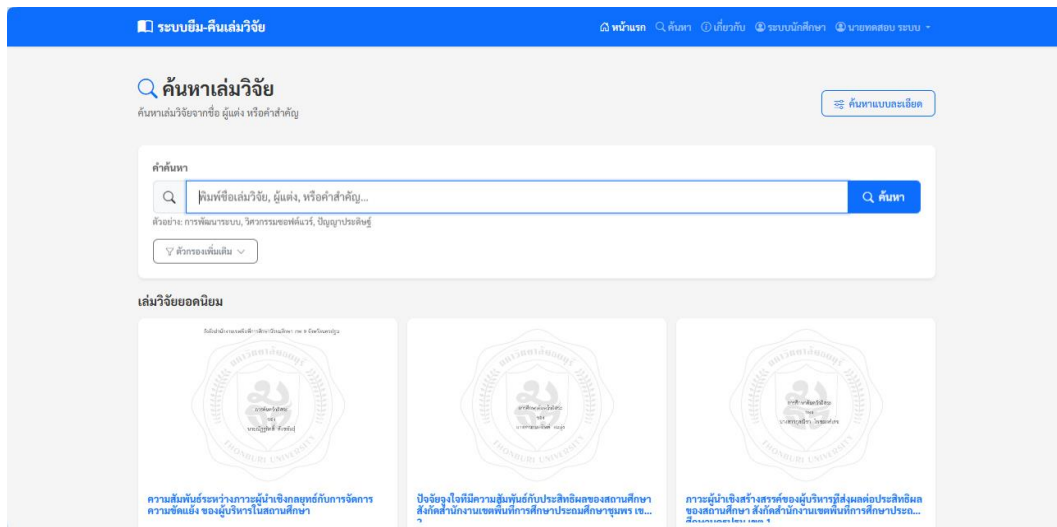


Figure 8 Volume search screen.

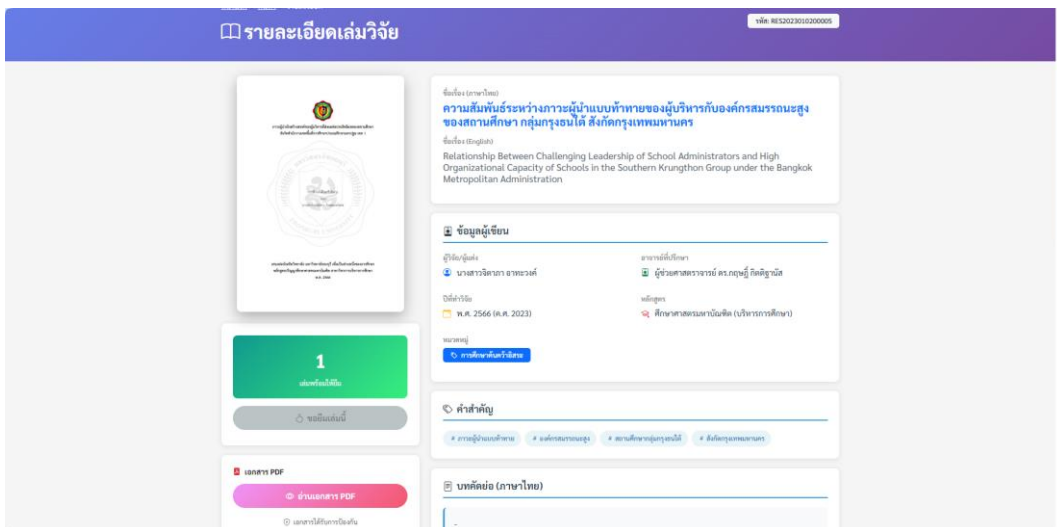


Figure 9 Thesis details page.



Figure 10 Full-text display page

## Part 2 Results of Technical Performance Efficiency Testing.

The research team conducted performance testing of the system utilizing the Apache JMeter tool to evaluate time behavior and throughput. The results of these tests are presented in Table 2.

Table 2 Results of the System's Technical Performance Testing.

Performance Testing Topics	Actual Result	Target	Std. Dev.	Pass / Fail
1. Response Time (Search Thesis)	0.056 s	< 2 s	0.0339	Pass
2. Response Time (Load PDF)	0.075 s	< 3 s	0.0131	Pass
3. Throughput	36.8 TPS	> 10 TPS	-	Pass
4. Time Behavior	0.065 s	< 5 s	0.0274	Pass

According to Table 2, the system recorded an average thesis search time of 0.056 seconds and an average full-text (PDF) access time of 0.075 seconds. These values are significantly below the established thresholds of < 2 seconds and < 3 seconds, respectively. This clearly demonstrates the system's ability to respond to user requests rapidly without perceived latency, making it highly suitable for an educational information system. Regarding the throughput test, the system achieved an average processing rate of 36.8 Transactions Per Second (TPS), which exceeds the minimum requirement of > 10 TPS. This indicates that the system possesses high potential for handling concurrent user sessions and can effectively accommodate future user growth. Furthermore, the Time Behavior analysis, which measures the system's capacity to maintain response times under high-load conditions, was tested with 20 simulated concurrent users. The results showed a Total Average Response Time of 0.065 seconds, well below the established limit of < 5 seconds. Following performance guidelines for web-based information systems, average response times should remain under 5 seconds to ensure a seamless user experience (Rempel, 2015). In conclusion, the system exhibits high stability and the capability to support concurrent usage without significant delay issues.

**Part 3 Results of Quality Evaluation by Experts according to the ISO/IEC 25010 Standard.**

The research team presented the developed system to five experts in information technology to evaluate its quality in terms of Functional Suitability and Reliability. The results of the expert evaluation are presented in Table 3.

Table 3 The results of the system quality assessment by experts.

Evaluation list	Evaluation		
	$\mu$	$\sigma$	Results
<b>Functional Suitability</b>	<b>4.75</b>	<b>0.167</b>	<b>Very High</b>
1. Functional Completeness (q1.1 - q1.4)	4.65	0.418	very high
2. Functional Correctness (q1.5 - q1.8)	4.70	0.274	very high
3. Functional Appropriateness (q1.9 - q1.12)	4.90	0.224	very high
<b>Reliability</b>	<b>4.71</b>	<b>0.185</b>	<b>Very High</b>
4. Stability, Integrity and Reliability (q2.1 – q2.4)	4.85	0.223	very high
5. Availability (q2.5 – q2.8)	4.65	0.335	very high
6. Fault Tolerance (q2.9 – q2.12)	4.55	0.447	very high
7. Recoverability (q2.13 – q2.16)	4.80	0.209	very high
<b>Total average</b>	<b>4.73</b>	<b>0.159</b>	<b>Very High</b>

The quality evaluation results from the five experts regarding Functional Suitability and Reliability, based on the ISO/IEC 25010 standard, revealed that the overall system quality is at a "Very High" level ( $\mu = 4.73$ ,  $\sigma = 0.159$ ). The top three items with the highest mean scores (out of 5.00) were: functional completeness of core features (q1.1), data processing accuracy (q1.8), and data accuracy following system recovery (q2.15). Conversely, the items with the lowest mean scores, averaging 4.40, were proper system resource management (q2.8) and protection against data loss due to user error (q2.12). The experts provided recommendations regarding server-side memory management efficiency and the development of a more granular proactive data entry validation system. In conclusion, these findings indicate that system development via the Agile methodology, combined with ISO/IEC 25010 quality assessment, ensures high levels of Functional Suitability and Reliability, effectively and securely supporting Thonburi University's intellectual property management processes.

#### Part 4 Results of User Satisfaction and Usability Assessment.

The research team implemented the developed system for pilot testing with a sample group consisting of 33 graduate students from Thonburi University and relevant administrative staff to evaluate usability satisfaction according to the ISO/IEC 25010 standard. The findings are summarized in Table 4.

Table 4 Results of the usability and user satisfaction assessments.

Evaluation list	Evaluation		
	$\mu$	$\sigma$	Results
1. Learnability	4.28	0.495	high
2. Operability	4.44	0.527	high
3. User Error Protection	4.33	0.498	high
4. User Interface Aesthetics	4.35	0.562	high
5. Overall benefits and satisfaction.	4.22	0.572	high
<b>Total average</b>	<b>4.35</b>	<b>0.446</b>	<b>high</b>

Based on the analysis of the satisfaction assessment for the Graduate Thesis and Independent Study Circulation System at Thonburi University, it was found that users expressed a "High" level of satisfaction across all dimensions. The most prominent mean score was observed in Operability or ease of use ( $\mu = 4.44$ ,  $\sigma = 0.527$ ), reflecting the success in designing simplified workflows that facilitate rapid access to full-text information. This was followed by user interface aesthetics (4.35) and user error protection (4.33), both of which contributed to a more refined user experience. However, while the dimension of perceived usefulness and overall satisfaction also fell within the "High" range, it received the lowest score among all categories (4.22). This suggests an area for developers to further consider in order to distinguish the system's value proposition more clearly, ensuring it matches the high level of convenience achieved in other dimensions.

#### Summary of the Study

The research project titled "Development and Efficiency Testing of the Online Thesis and Independent Study Circulation System at Thonburi University" successfully developed a system that addresses real-world operational needs through the Agile Methodology. This approach emphasized iterative development and flexibility centered

on user requirements (Panyadee & Mateesuwapap,2023). Technical performance testing revealed exceptionally high system speed, with an average search time of only 0.056 seconds and a full-text document access time of 0.075 seconds, both surpassing information system response standards. Furthermore, the expert quality evaluation based on the ISO/IEC 25010 standard resulted in a "Very High" level (average 4.73), with the highest performance observed in Functional Suitability. Concurrently, actual users expressed a "Quite High" level of satisfaction (average 4.35), particularly in Operability, which effectively reduced redundant workflows and accelerated access to information resources.

The practical application of this research focuses on the complete digital transformation of library management. Integrating barcode technology with physical copy management has minimized documentation errors and reduced operational time for administrative staff, aligning with the findings of Daorueng et al. (2025), which demonstrated the success of barcode implementation in library tasks. Additionally, the system ensures data security through the Secure Full-text Viewing function, which prevents unauthorized copying and printing, effectively protecting the intellectual property rights of graduate research. The utilization of an agile framework also enables the institution to refine system features in accordance with evolving market trends and student demands (Alsaqqa et al., 2020), ensuring that the university's research resource management meets international standards and provides maximum benefit to students and researchers.

Regarding future research directions and inquiries, experts have recommended enhancing server-side memory management and developing a more granular proactive data entry validation system. Future studies should explore the integration of advanced technologies aligned with the Smart Library concept. This includes implementing Biometric systems to elevate security and prevent identity theft, as suggested in the research by Choorod et al. (2013), or applying the Internet of Things (IoT) in conjunction with AI Chatbots to enable real-time resource tracking and automated user responses. (Hong & Hieu, 2021) Such advancements would expand the system's capabilities into a more intelligent framework, encompassing diverse and complex needs in the digital era.

## Discussions

The findings of this research demonstrate that the Thesis Circulation System for Graduate Studies at Thonburi University, developed in this study, achieves a high level of technical efficiency and system quality. This outcome can be attributed to the application of Agile Methodology in the system development process, which emphasizes iterative development cycles and active stakeholder participation. Through this approach, developers are able to continuously refine system functions based on user feedback throughout the development stages. This finding is consistent with the study by Alsaqqa et al. (2020), which reported that Agile methodologies enable development teams to rapidly adapt to changing requirements while minimizing communication gaps between developers and system users. Consequently, the developed system can more effectively address the practical needs of graduate students and academic staff within the university.

Regarding system performance efficiency, the evaluation results indicate that the developed system achieved response times for search and document retrieval between 0.056 and 0.075 seconds, which can be considered exceptionally fast. These results significantly exceed common usability expectations for academic information systems. According to the performance evaluation guidelines proposed by Rempel (2015), response times for information retrieval systems should not exceed 5 seconds in order to avoid user perception of latency and maintain satisfactory user experience. Therefore, the response time observed in this research is substantially lower than the recommended threshold, indicating that the system is capable of providing highly responsive services to its users.

When comparing these results with previous studies in the field of digital library systems and academic information systems, the performance outcomes of this research demonstrate comparable or superior efficiency. For instance, Breeding (2011) highlighted that rapid system responsiveness and efficient information retrieval are key determinants of user satisfaction and successful system adoption in academic libraries. Likewise, Candela et al. (2007) emphasized that digital library infrastructures play a critical role in enabling efficient access to scholarly resources and supporting research and knowledge discovery. In this regard, the extremely low response times achieved by the developed

system reflect strong technical capability and align well with international standards for digital library systems.

In addition to the system's performance capabilities, the integration of barcode technology for managing physical thesis collections has further improved operational efficiency within the circulation process. This result corresponds with the findings of Daorueng et al. (2025), who reported that barcode-based circulation systems significantly reduce transaction time and human errors compared with traditional manual record-keeping methods. By automating the loan and return procedures, the developed system enhances workflow efficiency and reduces administrative workload for library staff.

From an operational perspective, the integration of Agile-based development practices, high-performance system architecture, and barcode-supported circulation management contributes to the overall reliability and scalability of the system. These characteristics are particularly important for academic information systems that must accommodate increasing numbers of users and expanding collections of scholarly resources. Therefore, the Thesis Circulation System for Graduate Studies at Thonburi University, developed and evaluated in this study, demonstrates strong potential to sustainably support the future development of digital information services within the university.

## **Recommendations**

Based on the findings of this research, the researcher provides the following recommendations for practical application and future research.

1. Integration of IoT Technology: Future research should integrate Internet of Things (IoT) technology with online notification systems to enhance the efficiency of real-time monitoring and tracking of resource statuses and locations. This aligns with the approach of Pamungkas et al. (2025), who found that IoT systems facilitate resource management that is more transparent and rapid than traditional systems.

2. Enhancing Security with Biometrics: Further study and implementation of Biometric technologies, such as fingerprint scanning for identity verification during circulation transactions, should be explored. Replacing traditional passwords or member cards with biometric authentication would elevate security levels and prevent unauthorized access

or identity theft. As presented by Choorod et al. (2013), such advancements significantly increase satisfaction and bolster security for library users.

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