

Implementing lean principles for digital archiving of student projects: A case study in higher education

Kamthorn Sarawan¹, Rajarat Khalwipat², Witthaya Daengkasai³, Pornsiri Khumla^{4*}

^{1,2,3} Department of Computer Engineering, Kalasin University, Kalasin, Thailand

⁴ Department of Logistics Engineering and Transportation Technolog, Kalasin University, Kalasin, Thailand

*Corresponding author E-mail: pornsiri.kh@ksu.ac.th

Received Nov. 15, 2024

Revised Feb. 3, 2025

Accepted Feb. 12, 2025

Online Feb. 21, 2025

Abstract

This study applies lean principles to address organizational challenges by designing and developing a digital archiving system for student projects in higher education. The primary objective is to transition the case study institution from paper-based project documentation to a sustainable, paperless digital system, reducing the consumption of approximately 1,000–1,500 printed project books annually. We collected data from various stakeholders to construct an information system that utilized the PHP programming language and the MySQL database system. After the system's development, we evaluated its effectiveness across seven dimensions using input from thirty users. We obtained a mean score of 4.07. The application of lean ideas to evaluate and set standards for the management of an organization has the potential to foster sustainability.

© The Author 2025.

Published by ARDA.

Keywords: Lean principles, Digital transformation, Higher education, Sustainability, Paperless system

1. Introduction

Many Thai colleges that provide advanced degrees now mandate students to complete projects to evaluate their academic achievement. These projects differ according to the research topic; each requires a detailed study report, usually in printed form. Students at the evaluated institution must complete homework and submit a detailed printed report. Each academic year, we anticipate over 1,000 students to finalize projects [1]. Students generally collaborate in pairs, yielding around 500 project groups annually. Each group must generate 2–3 copies of their project report, amounting to around 1,000–1,500 copies per year. This strategy presents several practical issues, including increased student costs, excessive paper use, and restricted access for prospective students interested in related subjects. Excessive paper usage exacerbates existing and future climate change-related environmental difficulties.

The objective of this study is to conserve resources by transitioning from paper project reports to a completely digital archiving system. The objectives are to reduce students' paper consumption and associated expenses, facilitate the accessibility of project data, and ensure that future students may readily locate past projects for

learning and reference purposes. In past studies, digital technology has been applied in educational institutions to store files electronically, aiming at environmental conservation and environmental friendliness. [2], [3], [4].

Educational institutions can significantly benefit from transitioning to a digital archiving system grounded in lean principles [5]. Digital transformation in project management can significantly enhance operational efficiency and accessibility by reducing reliance on physical resources and optimizing the structure of academic material [6], [7], [8]. A digital system founded on lean principles facilitates the storage and retrieval of student projects while concurrently aiding the school in achieving its sustainability objectives by minimizing paper waste [9], [10], [11].

Moreover, this approach fosters more flexible and user-centric environments, so developing an academic culture that emphasizes environmental stewardship, operational efficiency, and accessibility. The digital archiving system enhances access to academic resources while reducing the environmental impact associated with traditional paper storage by streamlining processes and minimizing unnecessary resource use. This paper shows how the application of lean concepts to digital archiving can generate actual improvements in resource management, hence resulting in major decreases in paper use, printing expenses, and storage space [6], [12], [13], [14]. These developments support an academic institution's sustainable model by motivating faculty members as well as students to follow more ecologically friendly behavior. This strategy conforms with more general objectives of sustainable growth in education by including lean concepts in digital archiving, thus fostering a scalable and efficient system that other institutions may copy and so establishing a benchmark for responsible and sustainable academic practices.

2. Literature review

This section describes research and theoretical frameworks for implementing lean principles in digital transformation, more so when it comes to keeping documents in digital formats.

2.1. Lean principles

The goal of lean management, a business model that has its roots in industrial manufacturing operations, is to continually enhance operations by implementing solutions that reduce production and operating costs [5], [15]. Five fundamental principles are typically included in the lean methodology, and they are as follows [5]. Value, the first principle, stresses providing what the client deems valuable while removing any components that do not advance this objective. By mapping each process step, Value Stream finds actions that provide value and eliminates those that don't. Flow ensures a seamless workflow by minimizing delays and bottlenecks, allowing products or services to move continuously and efficiently from start to finish. Pull advocates for a demand-driven system that produces only what is required when it is needed, thus reducing waste and excess inventory. At the end of the day, perfection comes from a commitment to continuous growth. This is done by reviewing and tweaking processes all the time to get the best levels of quality and efficiency. All these ideas work together to make the ability to plan a way to improve value and cut down on waste in processes.

Certain research [16], [17], [18] show that lean principles have also been widely used in education. These principles are used to improve efficiency in both the industry and educational sectors. Narayanamurthy et al. [7] looked at how lean thinking (LT), which is usually associated with industry, could be used in education. During a span of 28 months, they employed action research to identify inefficiencies in the institution's procedures and implemented long-term solutions. This resulted in reduced absences and improved use of course seats. The study demonstrates that LT may be applied beyond manufacturing, indicating its potential to enhance the efficiency and sustainability of educational institutions. Kifokeris et al. [19] examine the transformation of lean design (LD) methodologies through the implementation of the Project Studio approach by a Swedish contractor, enhancing its digital aspects. Digitization facilitated outputs and access; nevertheless, it also engendered issues such as information misinterpretation, diminished collaboration, and more complex meetings. The research indicates that digital technologies must align with lean concepts to ensure efficient procedures and

maintain stakeholder engagement. Citybabu and Yamini [20] examine the application of Lean Six Sigma (LSS) in conjunction with Industry 4.0 technology, emphasizing its role in digital transformation. After reading more than 85 papers, they came up with a system that was based on people, methods, and technology. LSS 4.0 uses technology and automation to improve processes in terms of how well they make money, how they treat the environment, and how well they are run as a business. The piece talks about why digital technology and lean principles need to work together and how LSS 4.0 can be used for long-term growth. Davidson et al. [21] review Lean Six Sigma in higher education institutions, highlighting its role in addressing challenges like reduced funding and global competition. The study emphasizes LSS's potential to enhance administrative, academic, and operational efficiency, driven by leadership commitment, organizational culture, and effective communication. While demonstrating LSS's benefits, the authors stress the need for alignment with institutional strategies and customization for HEIs, calling for further research into its applications in teaching and learning. Carlos Almodóvar Rodríguez [9] examines the inefficiencies of paper-based systems in production with lean principles and Six Sigma technologies, identifying excessive wastes such as motion, waiting, and reprocessing. The study indicates that digitalization reduces production line downtime by 37.31%, resulting in a savings of \$30,836.67 per non-conformance incident. It enhances compliance, reduces inventory costs, and minimizes errors, thus facilitating the transition to paperless systems.

2.2. Digital transformation in education

Digital transformation in education refers to including digital tools in administration, education, and learning [22], [23]. This implies totally altering traditional methods of operation to meet modern demands. Thanks to advances in information and communication technologies (ICT), this transformation makes all kinds of educational activities more accessible, quick, and enjoyable. Nonetheless, multiple earlier research studies [19], [24] clearly reveal that it is a challenging and sophisticated choreography. Notwithstanding these challenges, digital transformation is still required to match the evolving needs of modern students and enhance instructional strategies. Rahman and Alhaidari [25] and Fauziyyah et al. [26] look at how information technology has changed library systems and services, focusing on how it has made it easier to store, find, and use data. Rahman and Alhaidari [25] suggest that educational institutions use XML to manage metadata and IBM Lotus Domino to query material in a digital library system. Their system uses an extract, transform, load (ETL) strategy to combine different data sources into a single repository. A custom retrieval method improves accuracy. Fauziyyah et al. [26] also talk about how library services are changing from doing things by hand to using technology instead. They stress the benefits of this change, such as being able to access digital materials from afar, making the user experience better, and making operations run more smoothly. Even with these improvements, both studies point out problems like digital differences and data privacy issues. This shows how important it is for modern library systems to have balanced IT integration to be as efficient and open to everyone as possible.

3. Research method

This study primarily aims to apply lean concepts to enhance the efficiency of handling and maintaining student project documentation by transitioning from paper copies to digital files. The process of research consists of the following actions.

3.1. Data collection

We collected data by watching a group of students from the Faculty of Engineering and Industrial Technology fill out surveys. We closely observed students' use of the current document management system to identify issues, inefficient workflow, and patterns in their system usage. This approach enabled a direct evaluation of the obstacles students face when accessing or managing project archives, thereby offering critical insights into the necessary enhancements. Additionally, we implemented surveys to accumulate quantitative and qualitative data regarding user satisfaction, accessibility requirements, and preference for digital or physical storage

systems. We used a specific type of question to evaluate the user experience and another type to gather suggestions for improvement. Integrating poll responses with observations provides a comprehensive understanding of the system's shortcomings and the desires of users. This suggests that we can apply agile principles to the development of the digital storage system.

3.2. Problem definition and process design

Lean concepts [5], [6], [7] form a guiding framework for this study, determining the research problem and organizing the process for developing a digital archiving system for student projects. Originally developed in manufacturing but generally applicable in many fields, lean methodology stresses waste reduction, simplified processes, and ongoing improvement, so helping to address inefficiencies in conventional document management systems in educational institutions.

We apply lean's concepts during the problem definition process to pinpoint specific inefficiencies in the current storage and accessibility of student project documentation. Currently, student work in hard copy consumes a significant amount of paper, time, and storage capacity. Because hard copies are difficult to obtain remotely and contribute to environmental waste, these issues not only increase operating expenses but also limit accessibility and sustainability. Lean's focus on Value directs attention to what users, students, faculty, and administrative staff find most valuable, namely quick and convenient access to project documents without unnecessary steps. Through the Value Stream principle, this phase maps the entire process from submission to retrieval, identifying unnecessary steps such as printing, binding, and shelving. Steps that do not contribute directly to user value, such as repetitive handling of physical copies, are marked for elimination in favor of digital alternatives.

The process design phase is structured to create an efficient digital archiving system that aligns with Lean's Flow, Pull, and Perfection principles. In terms of Flow, the new process eliminates interruptions and redundancies, enabling seamless and continuous access to digital copies of student projects through an online platform. The system is designed to save projects in an easily searchable PDF format that can be accessed through a centralized database, allowing for smooth operation free from the constraints associated with physical storage. By developing an on-demand system that enables users to access documents only when needed, the Pull principle is put into practice, reducing the need for proactive printing and storage. This strategy reduces the demand for resources related to the production and storage of needless duplicates, which is consistent with lean principles and the institution's sustainability objectives. To attain perfection, the process design ultimately integrates mechanisms for ongoing improvement. The digital archiving system incorporates feedback tools to collect user opinions about performance and usability, allowing incremental improvements. This feedback loop ensures that the system stays in line with user needs and adjusts to changing demands, reflecting Lean's dedication to the constant enhancement of quality and efficiency.

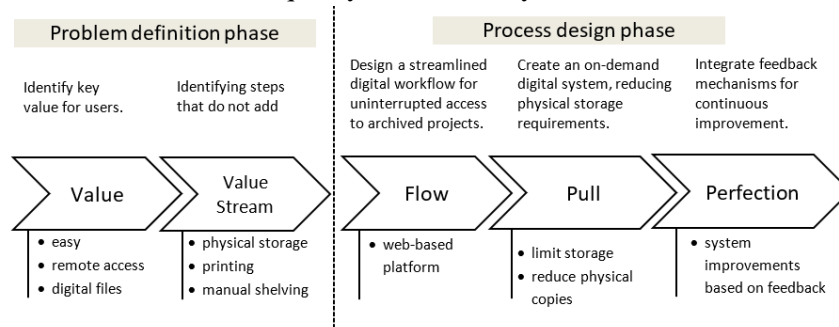


Figure 1. Application of lean principles in problem definition and process design phases

The application of lean principles throughout the problem definition and process design phases of the development of a digital archiving system is illustrated in Figure 1. During the problem definition phase, the principles of Value and Value Stream are employed to identify critical values for users, including ease of access, remote access, and digital file formats. This approach eliminates non-value-adding steps, such as physical storage, printing, and manual shelving. In the process design phase, the concepts of Flow, Pull, and Perfection

are employed to develop a digital system that is both on-demand and efficient. Flow is working on a web-based platform that will allow continuous access to archived projects. Pull aims to decrease the number of physical copies and minimize the expenses associated with physical storage. Perfection encompasses feedback methods that provide continuous system enhancement based on user input. This approach aligns the system with lean objectives, guaranteeing optimal and effective resource utilization.

3.3. System design and development

This research's system design and development method includes the following sub-steps: (1) requirement gathering and analysis, (2) system architecture design, (3) system implementation, and (4) testing and debugging. Each phase is delineated as follows.

3.3.1. Requirement gathering and analysis

System needs were gathered via user interviews, data collection on usage, and surveys. Previous steps involved utilizing observations and questionnaires with a sample of the target population in order to gain insights into their requirements and expectations. This approach focuses on important aspects such as safe data storage, file upload and download tools, and strong search capability. The definition of the functioning of the system depends on the examination of these criteria, which also offers a basis for guiding the later phases of design and execution.

3.3.2. System architecture design

The system was developed on a client-server model, which works well for web apps requiring to manage data collectively. The front end (the user interface), the back end (the processing server), and the database are the primary components of this framework. HTML, CSS (with Bootstrap), and JavaScript are used to make the user interface. PHP is used for server-side processing, and MySQL is used to manage the databases [27]. The suggested system also includes the university's main account database and uses LDAP (lightweight directory access protocol) to make sure users are exactly who they say they are. The client-server model lets users connect to the system through a web browser, which makes sure that the front-end and back-end parts run well together.

Lean concepts drive the design and development process of the student project file storage system since they underline the efficiency of file access and the responsiveness to user needs by means of operation simplification and minimization of pointless activities. Lean concepts drove every phase of development so that only value-adding actions were included to create a user-centered, resource-efficient system. In order to reach these goals, a centralized database system and web application technology were used to store, retrieve, and manage data perfectly. This method works well because it is easy to expand, files can be accessed quickly, and it is always being updated based on user feedback. The architecture incorporates a client-server model, in which the front-end interface facilitates user interaction while the back end manages data stored in a secure, organized database and processes requests. This architecture design enables students and faculty to remotely access, upload, and manage project files, thereby ensuring that the system is in accordance with both efficiency and usability objectives. Figure 2 illustrates the comprehensive system architecture, which is indicative of these design considerations.

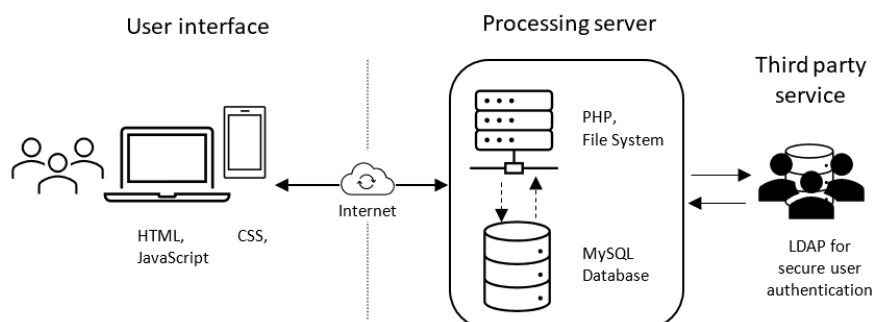


Figure 2. System architecture of the student project file storage system

This paper presents an entity-relationship (ER) diagram illustrating the data structure for a digital archiving system for student projects. Six main entities (Category, Project, Project Author, Author, Advisor, and Major) are included in this design grounded on relational database management. Every entity is built with characteristics and connections that fit the needs for effective data storage, retrieval, and management inside the system.

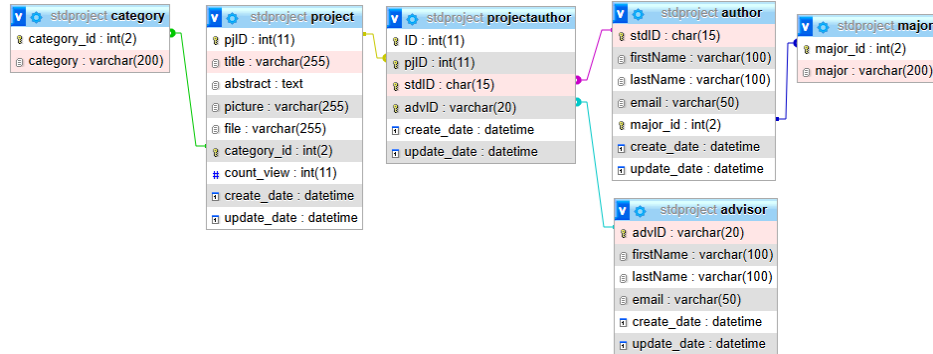


Figure 3. Entity-relationship diagram

- **Category:** The Category entity keeps data on the several categories into which student projects fall. It includes two elements: category (the name of every category) and category_id, a unique designation for every category. This entity links the Project entity such that every project can be categorized according to a particular criterion.
- **Project:** The Project entity is the most important part of the database. It has all the information that each student project needs. The most important parts are the project ID (pjID), the title, the abstract, the picture, the file (link to the digital file), the category_id (which links the project to a category), the count_view (number of times the project has been viewed), the create_date, and the update_date. This entity is essential for the database. It is linked to Category, Project Author, and, indirectly, Author and Advisor through Project Author. This entity is the basis of the database. It is linked to Category, Project Author, Author, and Advisor through Project Author.
- **ProjectAuthor:** The ProjectAuthor related entity shows the many-to-many relationship between projects, authors, and advisors. It connects the Project, Author, and Advisor entities. Some of the attributes are the create_date, the update_date, the stdID (the author's student ID), the advID (the advisor ID), the pjID (the project ID), and the ID (the unique identifier). This design principle allows one project to consist of multiple students and multiple advisors.
- **Author:** The Author entity stores information about each student working on a project. First name, last name, email address, major_id (which links the student to their major), create_date, and update_date are all covered. This is called a student identification, or stdID. This thing is linked to the Project through the Project Author and helps get student data that is relevant to each project.
- **Advisor:** The Advisor entity serves as a data storage system for project advisors. The Advisor entity holds the attributes First Name, Last Name, and Email, along with the creation and update dates (create_date, update_date). ProjectAuthor links this entity to itself.
- **Major:** The Major entity lists the degrees that can be earned at the university. It has two parts: major, which is the name of the major, and major_id, which is a unique number for each major. This entity is linked to the Author entity so that students can be put into groups based on their majors.

The structure and relationships of this ER diagram show the relationship of data in the database system, where each entity is necessary to store data for the system presented in this research. Designing a database with ER principles reduces data redundancy by storing only necessary data and allowing for flexible data display through text links based on each entity's relationship, such as organizing projects into categories, managing authors and consultants, and linking projects to academic fields.

3.3.3. System development

After completing the system design process, the information system will proceed to its development phase. This process consists of two main parts: the first part involves designing the system interface for the user, also known as the front end, using HTML, CSS, JavaScript, and the Bootstrap framework. The second part involves developing the data processing part using PHP and managing the data using MySQL. Overall, this research focuses on saving budget and having system security, so it chooses to use open-source technology that is quite popular.

3.3.4. Testing and debugging

To ensure that the proposed system is suitable for actual use, testing and evaluating the efficiency of the developed system is necessary. The researchers conducted usability tests on the main functions to identify and address any potential defects. Then, we deployed the system to the server and designed an evaluation of the system's efficiency in various aspects. We also evaluated the system with a sample group of users to gather additional suggestions and identify any errors, with the aim of improving the system to better align with lean principles.

3.4. Evaluation criteria

This study used usability evaluation as the main approach to evaluating the effectiveness and user experience of a digital storage system developed using lean concepts. The efficiency of a digital storage system depends upon its usability, accessibility, and responsiveness to user requirements. All vital elements of lean make usability evaluation imperative in this context. Focusing on usability aims to ensure that the system not only minimizes resource waste but also enhances the user experience in line with both functional and strategic goals.

Usability evaluation [28] covers several important dimensions relevant to this research, namely Ease of Learning, Efficiency of Use, Memorability, Error Frequency and Severity, and User Satisfaction. Each dimension provides valuable insights into how well the system meets user expectations and supports ongoing work, especially in an academic environment where students and lecturers interact with stored project documents. For example, Ease of Learning assesses how quickly new users can learn to use the system, while Efficiency of Use assesses how quickly and responsively the system is during work. Memorability of Use is another important factor that makes sure users can quickly remember how the system works when they go back to it after not using it for a while.

This assessment used a questionnaire distributed to a sample of 30 students. The questionnaire was designed to collect both quantitative and qualitative data, which provided a comprehensive understanding of the user experience and helped identify potential usability issues. The feedback obtained in this way was used to improve the current system and support iterative improvements in line with the lean concept of continuous improvement. The assessment items covered the following areas: Ease of Learning, Usability, recall, Error Frequency and Severity, Satisfaction, Accessibility, and Security. The scoring criteria and interpretation were defined as follows:

- Score 1: Indicates major deficiencies, with immediate improvements required.
- Score 2: Reflects significant shortcomings that need to be addressed to enhance usability.
- Score 3: Represents a moderate level, suggesting that improvements should be considered.
- Score 4: Shows that users are generally satisfied with the system performing effectively.
- Score 5: Demonstrates high user satisfaction and optimal system performance.

4. Results and discussion

The main objective of this research is to reduce the use of paper in documenting student research projects through the application of information technology. The outcome of this study is the development of a digital project information system that allows users to access it remotely at any time and place. This system facilitates

organizing and categorizing student projects by supporting the classification of projects and areas of expertise of students and advisors. The digital storage system for student projects, shown in Figure 4, is an example of the application of web technology for academic data management. The design of the user interface emphasizes user access and role-based operations to ensure that users can interact with the system according to their assigned access rights. The system has three main interfaces: the login page, the user page, and the admin page, each of which is designed to improve the user experience and increase the efficiency of the system.

- **Login Page:** The login page will be the initial page for using this system. The user must fill in the username and password, which is the account of the user in this case study institution. This follows the principles and security standards. This authentication of the proposed system will be connected to the organization's user database with the LDAP protocol. When the account is correct, the system will check the user's rights as a general user or an administrator. The system will then send the user to the page with access rights.
- **User Page:** User Page refers to the system page for general users, such as students and other stakeholders. This page allows users to view, search, and download project files. It also displays important project details such as project name, academic level, student name, and number of downloads in an organized table format. This design facilitates the search and retrieval of the desired project documents. The addition of a search function facilitates easy navigation, making this system a valuable resource for academic research and reference.
- **Admin Page:** It provides more functionality than the general user page, allowing administrators to add, edit, and delete project data, enabling continuous updates and maintenance of the digital system. Additionally, displaying project download statistics helps administrators understand the popularity and usage trends of the project, which can be used to plan future content management and curation. Tracking download counts supports data-driven decision-making for resource allocation and system optimization.

The figure displays three screenshots of the 'Student Project Database System' interface. The 'Login page' shows a simple form with 'Username' and 'Password' fields and a 'Login' button. The 'User page' features a navigation sidebar, a search bar, and a table of student projects. The 'Admin page' shows a similar table but with an 'Action' column containing edit, delete, and download icons.

picture	Branch Group	Project name	Education level	Students	year	Number of downloads	details
	Internet of Things	Radio-controlled lawn mower	Bachelor's degree	Kesem Chaiyawari Sirinpa Kasoi Wimonrat Wilachai	2565	7	
	Artificial Intelligence	Stock price prediction system using machine learning	Bachelor's degree	Thanathip Phu-ngam-sang, Phasakon Sritnarang	2565	2	
	Web Application and Database	Development of Cooperative Education and Internship Information System	Vocational Certificate	Piyaphon Siripramai Chamaiporn Udonthak	2565	2	
	Game	Development of learning media for fire escape	Vocational Certificate	Amorntep Yampha Thitakorn Sriphongchai	2565	3	
	Internet of Things	Smart Parking System Model with Internet of Things	Vocational Certificate	Chaiyanant Phasadorn Parami Yanasarn Phutthinan Chaisorn	2565	7	
	Web Application and Database	Development of student project database system	Vocational Certificate	Rajarat Kharawiwat Witthaya Daengkasai	2565	2	

year	Project name	Education level	Students	Number of downloads	Action
2565	Radio-controlled lawn mower	Bachelor's degree	Kesem Chaiyawari Sirinpa Kasoi Wimonrat Wilachai	7	
2565	Stock price prediction system using machine learning	Bachelor's degree	Thanathip Phu-ngam-sang, Phasakon Sritnarang	2	
2565	Development of Cooperative Education and Internship Information System	Vocational Certificate	Piyaphon Siripramai Chamaiporn Udonthak	2	
2565	Development of learning media for fire escape	Vocational Certificate	Amorntep Yampha Thitakorn Sriphongchai	3	
2565	Smart Parking System Model with Internet of Things	Vocational Certificate	Chaiyanant Phasadorn Parami Yanasarn Phutthinan Chaisorn	7	
2565	Development of student project database system	Vocational Certificate	Rajarat Kharawiwat Witthaya Daengkasai	2	

Figure 4. User interface of the digital archiving system for student projects

We conducted a usability evaluation using a structured questionnaire to assess the effectiveness and ease of use of the digital storage system. The survey concentrated on seven primary areas: Ease of Learning, Efficiency of Use, Memorability, Error Frequency and Severity, Satisfaction, Accessibility, and Security. Each topic consisted of specific statements that users rated on a Likert scale, reflecting the user's perceived ease of use and satisfaction with the system's design and functionality. The results presented below are an analysis of the mean scores, standard deviations, and modes for each question in the questionnaire, providing insights into the user experience and helping to identify strengths and opportunities for further improvement. The findings illustrate how well the system meets user expectations in terms of accessibility, security, and overall satisfaction, and they support further discussion on the alignment of the system's features with lean principles.

The usability evaluation results demonstrate that the system generally performs well across various aspects, particularly in Ease of Learning and Security. High average scores in these categories indicate that users find the system easy to use without requiring intensive training and view the system as secure in storing and protecting data. In particular, the Ease of Learning category received an average score of over 4, indicating that users felt that the system was easy to use from the start and that no additional training was required.

The system has a moderately high Efficiency of Use score. However, some aspects, such as processing and storage efficiency, were rated slightly lower. This implies that even though consumers thought the system was responsive in most cases, data processing times may be improved. Notably, the Memorability aspect scored well, indicating that users found the system's functions and design memorable, which reduces the need for repeated learning and reinforces the system's usability. The evaluation of Error Frequency and Severity revealed positive results, with users reporting low error rates and the ability to resolve issues independently. This result reduces disruption during use and increases the reliability of the system. However, the user experience could be further improved with minor adjustments to make error notifications more understandable. Although the aesthetics and design of the user interface received a slightly lower score, the overall satisfaction score showed a positive response, meaning that while the system meets the usability requirements well, improvements in the aesthetics and design of the interface could increase user satisfaction even more. Accessibility received high scores, especially in terms of ease of access from multiple locations, which is consistent with the system's goal of providing access to project files anywhere, anytime. In addition, users expressed confidence in the system's data protection and authentication processes, resulting in Security receiving the highest score among all categories. These scores reflect the system's good adherence to basic security principles, which are important in academic and research environments.

Table 1. Summary of usability evaluation results

	Questionnaire Topic	Mean	SD	Mode
1.	Ease of Learning			
1.1	The system is easy to start using without additional training	4.17	0.65	4
1.2	The user manual is clear and easy to understand	4.07	0.69	4
1.3	Learning how to use various functions of the system is quick	4.17	0.79	5
2.	Efficiency of Use			
2.1	The system is fast and responsive to data requests	4.03	0.72	4
2.2	Searching for documents and information is convenient and not complex	3.97	0.76	4
2.3	The system can efficiently process and store data	3.87	0.73	4
3.	Memorability			
3.1	The system is easy to remember how to use without needing to relearn	4.27	0.74	5
3.2	The system's functions and design make it easy to remember how to use	4.07	0.69	4
4.	Error Frequency & Severity			
4.1	The frequency of errors while using the system is low	4.13	0.73	4
4.2	Errors can be easily fixed without needing assistance	4.00	0.64	4
4.3	The system provides clear alerts and information when errors occur	3.93	0.52	4

	Questionnaire Topic	Mean	SD	Mode
5.	Satisfaction			
5.1	Overall satisfaction with the system	4.00	0.74	4
5.2	The system has a user-friendly interface and is well-designed	3.80	0.71	4
5.3	The aesthetic and design of the system meet user needs	3.87	0.73	4
6.	Accessibility			
6.1	The system is easily accessible from anywhere, anytime	4.07	0.83	5
6.2	The system supports use on various devices (computer, mobile)	3.83	0.79	3
7.	Security			
7.1	The system is secure in storing and protecting data	4.47	0.51	4
7.2	The system provides user authentication before accessing the data	4.57	0.50	5

In conclusion, it can be concluded that the proposed system can meet the research objectives in terms of accessibility, security, and ease of use, which is consistent with the Lean concept in reducing process complexity and user satisfaction. However, the evaluation results highlight the need for improvement, particularly in the design of the user-friendly interface.

This study applied Lean principles to identify and address organizational challenges, particularly those related to resource inefficiencies and environmental sustainability. The focus was on designing and developing a student project file storage system that supports the transformation of the case study organization into a digital, paperless entity [10], [11], [29], [30]. User evaluations have been implemented. In general, users expressed satisfaction with an average score of 4.07 for all aspects, which is in line with the research [31] that assessed users' satisfaction with a very high score because of the implementation of lean principles to enhance the book return process. This transformation targets the management of project book production, which annually consumes approximately 1,000 to 1,500 paper books, significantly contributing to the organization's resource expenditure. By emphasizing sustainability [2], [3], [32], the developed system aligns with modern organizational goals of reducing waste, improving operational efficiency, and minimizing environmental impact. Furthermore, this approach provides a scalable model that can be extended to other institutional activities, supporting broader digital transformation efforts.

Table 2. Comparative analysis of Lean implementation of other studies

Studies	Platform	Functionality	Usability	Lean Principles	Environmental Sustainability
This Study	Web-based	Document storage, search, and retrieval	User-friendly, minimal training required	Eliminates redundant processes, improves accessibility	Reduces paper usage by 1000-1500 books annually
[7]	Not specified,	Process improvement in academic administration	Enhanced academic process efficiency	Waste reduction in educational processes, structured framework for Lean implementation	Encourages digitization and efficient resource use in education
[29]	Not specified	Curriculum revision and internship placement process	Streamlined internship and course selection process	Value Stream identification, elimination of waste, and continuous improvement in academic processes	Encourages the use of online systems to reduce physical documentation

Studies	Platform	Functionality	Usability	Lean Principles	Environmental Sustainability
[30]	Not specified	Operational efficiency and customer service improvement	Focused on reducing process inefficiencies	Identifies inefficiencies in banking operations and proposes Lean-based improvements	Minimizes paperwork in banking operations but lacks a full paperless transition
[31]	Web-based	Interlibrary loan (ILL) and document delivery (DD) management	Improved turnaround time, user satisfaction increased	Lean Six Sigma applied to optimize request handling and response time	Digitized interlibrary loan system, reducing paperwork

Table 2, a comparative analysis of lean implementation across various studies, highlights distinct approaches in different domains. The first study, a web-based system, focuses on document storage, search, and retrieval, ensuring user-friendly access with minimal training while eliminating redundant processes and reducing paper usage by 1,000-1,500 books annually. Another web-based study [31] targets interlibrary loan (ILL) and document delivery (DD) management, where Lean Six Sigma is applied to enhance turnaround time and user satisfaction, leading to a digitized interlibrary loan system that minimizes paperwork. In academic administration [29], an unspecified platform is used to enhance process efficiency, incorporating Lean waste reduction strategies and promoting digitization for better resource utilization. Similarly, another study addresses curriculum revision and internship placement, emphasizing streamlined selection processes, continuous improvement, and Value Stream identification, with a focus on reducing reliance on physical documentation through online systems. Lastly, in the banking sector [30], Lean principles are applied to improve operational efficiency and customer service, identifying process inefficiencies while promoting paperwork reduction, though the transition to a fully paperless system remains incomplete. These studies collectively showcase how Lean methodologies are leveraged to optimize workflow, enhance efficiency, and support environmental sustainability across different industries.

5. Conclusions

This research successfully applies lean principles to the design and development of a digital storage system for student projects, addressing key challenges in process efficiency, sustainability, and resource optimization in higher education. By transitioning from a paper-based archival system to a streamlined digital platform, this study demonstrates how lean methodologies can eliminate waste, enhance workflow efficiency, and improve accessibility for students, faculty, and administrators. A key advantage of adopting a lean approach in digital archiving is its ability to reduce redundant processes, minimize resource consumption, and lower operational costs. The developed system optimizes document retrieval, enforces secure access control, and provides an intuitive, user-friendly interface that facilitates efficient searching, viewing, and downloading of project documents. Through role-based access and seamless integration with institutional authentication protocols, the system enhances security while improving usability. The usability assessment confirmed the system's effectiveness, highlighting ease of use, remote accessibility, and secure data management. While some areas for enhancement remain, such as processing speed, error notifications, and interface design, the overall positive user experience aligns with Lean's core principle of continuous improvement. This research presents a scalable and cost-effective model for higher education institutions aiming to modernize document management systems, fostering a culture of efficient, sustainable, and environmentally responsible information access. Future work could expand system scalability, explore advanced data analytics integration, and further optimize automation to enhance decision-making and resource utilization. By emphasizing lean-driven digital transformation, this

study provides a blueprint for higher education institutions seeking to improve workflow efficiency, reduce waste, and achieve long-term sustainability goals in academic project management.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

Funding information

No funding was received from any financial organization to conduct this research.

Author contribution

The contribution to the paper is as follows: Kamthorn Sarawan; back-end design, database design, and development, testing, analysis, and interpretation of results; Rajarat Khalwipat, Witthaya Daengkasai: data collection, back-end, and front-end development; Pornsiri Khumla: study conception and design, lean's concept design, draft preparation and approved the final version of the manuscript.

References

- [1] 'Statistics and information – Registration and processing work'. Accessed: Nov. 14, 2024. [Online]. Available: https://re.ksu.ac.th/th/?page_id=528
- [2] S. Menon and M. Suresh, "Synergizing education, research, campus operations, and community engagements towards sustainability in higher education: A literature review," *International Journal of Sustainability in Higher Education*, vol. 21, no. 5, pp. 1015-1051, 2020.
- [3] A. M. Aleixo, U. Azeiteiro, and S. Leal, "The implementation of sustainability practices in Portuguese higher education institutions," *International Journal of Sustainability in Higher Education*, vol. 19, no. 1, pp. 146-178, 2018.
- [4] L. Elshof, "Toward sustainable practices in technology education," *International Journal of Technology and Design Education*, vol. 19, pp. 133-147, 2009.
- [5] J. P. Womack and D. T. Jones, "Lean thinking—banish waste and create wealth in your corporation," *Journal of the operational research society*, vol. 48, no. 11, pp. 1148-1148, 1997.
- [6] A. A. Nikolaeva, O. V. Demyanova, R. R. Aetdinova, and Y. I. Mestnikova, "Application of lean manufacturing methods in improving the quality of educational services in conditions of digitalization," *Multidisciplinary Social Science and Management*, vol. 9, no. 2, pp. 157-163, 2018.
- [7] G. Narayanamurthy, A. Gurumurthy, and R. Chockalingam, "Applying lean thinking in an educational institute an action research," *International Journal of Productivity and Performance Management*, vol. 66, no. 5, pp. 598-629, 2017.
- [8] M. Rawewan and F. Kojima, "Digital lean manufacturing-Collaborative university-industry education in systems design for lean transformation," *Procedia Manufacturing*, vol. 45, pp. 183-188, 2020.
- [9] C. Almodóvar Rodríguez, "Lean Wastes Caused by Using Hard Copy Paper Forms on Manufacturing Processes," *Manufacturing Competitiveness*, 2022.
- [10] H. Iqbal and F. Ahmed, "Paperless campus: the real contribution towards a sustainable low carbon society," *IOSR Journal of Environmental Science, Toxicology and Food Technology*, vol. 9, no. 8, pp. 10-17, 2015.
- [11] H. S. Tatlı, T. Bıyıkbeyi, G. Gençer Çelik, and G. Öngel, "Paperless Technologies in Universities: Examination in Terms of Unified Theory of Acceptance and Use of Technology (UTAUT)," *Sustainability*, vol. 16, no. 7, p. 2692, 2024.

-
- [12] G. Yadav, S. Luthra, D. Huisingh, S. K. Mangla, B. E. Narkhede, and Y. Liu, "Development of a lean manufacturing framework to enhance its adoption within manufacturing companies in developing economies," *Journal of Cleaner Production*, vol. 245, p. 118726, 2020.
- [13] S. Schumacher, A. Bildstein, and T. Bauernhansl, "The impact of the digital transformation on lean production systems," *Procedia cirp*, vol. 93, pp. 783-788, 2020.
- [14] R. d. C. Freitas and M. d. C. D. Freitas, "Information management in lean office deployment contexts," *International Journal of Lean Six Sigma*, vol. 11, no. 6, pp. 1161-1192, 2020.
- [15] Y. Thangarajoo and A. Smith, "Lean thinking: An overview," *Industrial Engineering & Management*, vol. 4, no. 2, pp. 2169-0316, 2015.
- [16] D.-L. Gómez-Molina and J. Moyano-Fuentes, "Lean management in universities: a systematic literature review," *International Journal of Lean Six Sigma*, vol. 13, no. 1, pp. 156-177, 2022.
- [17] N. Kumar, S. S. Hasan, K. Srivastava, R. Akhtar, R. K. Yadav, and V. K. Choubey, "Lean manufacturing techniques and its implementation: A review," *Materials Today: Proceedings*, vol. 64, pp. 1188-1192, 2022.
- [18] S. A. Chentoufi and A. Ennadi, "Lean Six Sigma in Higher Education: Systematic Review," in *2024 IEEE 15th International Colloquium on Logistics and Supply Chain Management (LOGISTIQUA)*, 2024: IEEE, pp. 1-8.
- [19] D. Kifokeris, J. Tjell, M. Viklund-Tallgren, and L. Nygren, "Challenges in the digital transformation of lean design methods: A case study," in *Proceedings of the 36th Annual ARCOM Conference*, 2020, vol. 445, p. 454.
- [20] G. Citybabu and S. Yamini, "Lean six sigma 4.0—a framework and review for lean six sigma practices in the digital era," *Benchmarking: An International Journal*, 2023.
- [21] J. M. Davidson, O. M. Price, and M. Pepper, "Lean Six Sigma and quality frameworks in higher education—a review of literature," *International Journal of Lean Six Sigma*, vol. 11, no. 6, pp. 991-1004, 2020.
- [22] A. Balyer and Ö. Öz, "Academicicians' Views on Digital Transformation in Education," *International Online Journal of Education and Teaching*, vol. 5, no. 4, pp. 809-830, 2018.
- [23] A. Bilyalova, D. Salimova, and T. Zelenina, "Digital transformation in education," in *Integrated science in digital age: ICIS 2019*, 2020: Springer, pp. 265-276.
- [24] K. K. d. S. Oliveira and R. A. De Souza, "Digital transformation towards education 4.0," *Informatics in Education*, vol. 21, no. 2, pp. 283-309, 2022.
- [25] A. ur Rahman and F. A. Alhaidari, "The digital library and the archiving system for educational institutes," *Pakistan Journal of Information Management & Libraries*, vol. 20, pp. 94-117, 2018.
- [26] R. A. Febriyanti, T. Nurtino, M. L. Huzairah, and D. A. R. Kusumawardhani, "Information Technology Development's Impact On Library Services," *International Transactions on Education Technology*, vol. 2, no. 1, pp. 24-30, 2023.
- [27] K. Sarawan, A. Sarnthong, P. Khumla, and N. Nasinprom, "Improvement of Time Attendance Online System: Case Study in the University", *Journal of Advanced Development in Engineering and Science*, vol. 11, no. 30, Art. no. 30, 2021.
- [28] P. Khumla and K. Sarawan, "Improving material requirements planning through web-based: A case study Thailand SMEs," *Applied Computer Science*, vol. 19, no. 4, pp. 39-50, 2023.
- [29] Singh, J. "Applying lean methodology to curriculum revision and internship placement process—a case study". *Journal of Research in Innovative Teaching & Learning*, vol. 14, no. 2, 288-305. 2021.
-

- [30] Khan, Z. A., Ahmad, M., & Butt, S. "Implementation of lean practices in banks: a qualitative research". *Independent Journal of Management & Production*, vol. 10, no. 2, 489-498. 2019.
- [31] Amno, h., jais, n. A., abdullah, m., & shaharuddin, b. "A lean case study on managing interlibrary loan and document delivery service in an academic library". *Asia-pacific journal of information technology & multimedia*, vol. 11, no. 1, 2022
- [32] A. Krdžalić and L. Hodžić, "Sustainable engineering challenges towards Industry 4.0: A comprehensive review," *Sustainable Engineering and Innovation*, vol. 1, no. 1, pp. 1-23, 2019.