Elinvo (Electronics, Informatics, and Vocational Education)
Vol 10 No. 1, 2025, pp. 1-12
ISSN 2580-6424 (printed) | ISSN 2477-2399 (online)

Enhancing Collaborative Teaching Through Developing Website-Based Learning Materials for Lecturers at Makassar Aviation Polytechnic

Sukarwoto[1], Moch.Rifai [1*], Rusman [1] , Heru Prasetyo [1], Ahmad Fudholi [2], Fachrurrazi Burhanuddin [3]

[1]Makassar Aviation Polytechnic, Makassar, Indonesia
[2]Universiti Kebangsaan Malaysia, Selangor, Malaysia
[3]University of Bristol, Bristol, United Kingdom
[1] m.rifai@Poltekbangmakassar.ac.id*; [2] a.fudholi@ukm.edu.my; [3] f.burhanuddin@bristol.ac.uk
* corresponding author

Article Info

Article history:
Received September 16, 2024
Revised March 20, 2025
Accepted June 30, 2025

Keywords:
Learning Material Collaboration Website-based System;
Usability Testing;
Lecturers Collaboration;
LMCS Application;

Abstract

This study aims to develop a website-based Learning Material Collaboration System (LMCS) for lecturers at Makassar Aviation Polytechnic. The system is designed to facilitate online collaboration in preparing teaching materials, ultimately enhancing the overall quality of learning using the waterfall method. Currently, teaching materials at the institution are independently prepared by the lecturers responsible for their respective courses, which results in non-standardized materials and limited collaboration between lecturers, practitioners, and cadets. The resulting materials are more comprehensive and sustainable through collaborative efforts in preparing teaching materials. The application requires lecturers to create an account, ensuring only authorized individuals can contribute and compile the teaching materials. This study proposes a collaborative platform that allows teaching materials to be prepared online to improve the effectiveness of learning and the quality of teaching materials. The LMCS application was tested to evaluate its reliability, efficiency, and effectiveness. The test results showed that the application effectively supported the collaboration of teaching materials, although some obstacles remained in managing cadet groups. Based on usability testing conducted with 10 participants, the application was user-friendly, with most testers successfully completing nearly all tasks. Analysis of the questionnaire using a Likert scale revealed positive user feedback, with the ease of use aspect scoring 82.6% and usability achieving a high score of 87.3%. Users felt that the application accelerated and facilitated the collaboration of teaching materials among lecturers and improved operational efficiency. However, for further development, training on the application and improvements to the user interface (UI/UX) are needed to ensure optimal use by all levels of users. The results of this study are expected to contribute to improving the quality of teaching materials and institutional accreditation at Makassar Aviation Polytechnic.

Corresponding Author:
Email: m.rifai@Poltekbangmakassar.ac.id

INTRODUCTION

Makassar Aviation Polytechnic is a vocational higher education institution under the auspices of the Transportation Human Resources Development Agency, Ministry of Transportation of the Republic of Indonesia, which aims to produce competent graduates in the field of air transportation. As a higher

ISSN 2580-6424 (printed) | ISSN 2477-2399 (online)

education institution that focuses on the aviation sector, accreditation is one of the determinants of the quality of education. Based on the Decree of the National Accreditation Board for Higher Education (BAN-PT) Number 1020/SK/BAN-PT/Akred/PT/XII/2021, Makassar Aviation Polytechnic has institutional accreditation with a Good predicate, which is valid until 2026.

Good accreditation provides quality assurance to students and parents and improves the institution's reputation in the world of education and the aviation industry[1]. One of the key factors in achieving good accreditation is the quality of teaching materials prepared and used by lecturers[2]. Standardized and quality teaching materials play a major role in increasing the effectiveness of learning and the relevance of the curriculum to the needs of industry and students[3] [4].

However, at the Makassar Aviation Polytechnic, teaching materials are currently prepared independently by each lecturer teaching the course[5] [6]. This results in variations in the quality and standards of the teaching materials used, as well as limited opportunities for collaboration between lecturers, practitioners, and cadets[7] [8]. In fact, collaboration in preparing teaching materials is very important to enrich teaching materials with various perspectives and experiences[9], which ultimately has a positive impact on the quality of learning[10]. Collaboration is a process where two or more individuals or groups work together toward a shared objective by exchanging knowledge, skills, and resources. In the context of preparing teaching materials, collaboration involves the joint effort of lecturers or teaching staff to design, develop, and refine educational resources, either in person or through a technology-driven platform, with the aim of enhancing the quality of learning.

In addition, the development of technology and digitalization in the Industrial Revolution 4.0 era opens up opportunities to adopt technology in preparing teaching materials[11]. Collaboration based on information technology can accelerate and simplify the process of preparing teaching materials and increase the effectiveness of collaboration between lecturers[12] [13], industry practitioners, [14]and cadets. Thus, the Makassar Aviation Polytechnic needs to develop a teaching material collaboration system that utilizes digital technology to support academic activities and maintain the quality of education[15].

Based on this background, the main problem the Makassar Aviation Polytechnic faces is the lack of material standards used by lecturers when teaching the course. Because teaching materials are prepared individually, there is inequality in the quality and content of the material taught[16]. Compiling teaching materials individually also limits the depth of the material's content because it does not involve collaboration between lecturers and industry practitioners, so teaching materials are compiled from only one perspective[17]. This has an impact on the effectiveness of learning and the learning achievements of cadets.

This has an impact on the effectiveness of learning and the learning achievements of cadets. The accreditation of higher education institutions is highly dependent on the quality of learning outcomes. Teaching materials, as one component of learning, have a significant influence on this[18]. The learning process that is not supported by quality teaching materials can reduce the competitiveness of graduates in the aviation industry, which continues to grow rapidly along with digital transformation and new technologies.

In addition, Makassar Aviation Polytechnic also needs to utilize digital technology more widely to support collaboration and the preparation of teaching materials. Currently, there is no specific platform that allows lecturers, practitioners, and cadets to collaborate effectively in preparing quality and standardized teaching materials.

With this approach, the process of gathering instructional materials is projected to be more efficient and systematic, and the materials produced will encompass a wide range of perspectives from lecturers and industry practitioners[19]. Furthermore, this platform will enable instructors from other universities to cooperate, resulting in a broader exchange of knowledge and expertise.

LMCS will consist of multiple functionalities that facilitate online collaboration, including discussion boards, capabilities for uploading and downloading educational resources, and streamlined

ISSN 2580-6424 (printed) | ISSN 2477-2399 (online)

access for cadets to acquire learning materials. This method aims for all instructors to assemble standardized, relevant teaching materials that align with the newest advancements in the aviation industry[20].

The development of LMCS is expected to offer several key benefits, including (1) Standardization and quality improvement; the collaboration among lecturers, practitioners, and cadets will result in more standardized and better instructional materials, which will augment the efficacy of learning and guarantee that the resources are pertinent to the requirements of the aviation sector. Standardized teaching materials will facilitate the teaching process, as instructors will possess clear and complete instructions for imparting knowledge to cadets[21]; (2) Enriched collaboration, LMCS facilitates online collaboration between lecturers and practitioners to create teaching materials. This collaboration will enhance the content by incorporating practical insights from the industry, offering cadets an enhanced understanding of the real-world application of their acquired knowledge. It also enables lecturers to keep their teaching materials in alignment with the current advancements in the aviation sector[22]; (3) Efficiency via digital platforms, utilizing a digital platform, will accelerate the compilation of teaching materials. Instructors can effortlessly share content, offer feedback, and access resources from any location at any time[23], thereby substantially diminishing the time and effort needed for material preparation that enables instructors to allocate more time to teaching and mentoring cadets; (4) Improved educational quality and accreditation; the provision of high-quality, standardized instructional materials would improve the overall educational offerings at Makassar Aviation Polytechnic. This enhancement will favorably influence the certification of both academic programs and the institution, as instructional materials are a critical component of the accreditation process. Robust accreditation would enhance the institution's standing in the educational sector and the aviation industry, hence attracting a greater number of competent potential students; (5) Convenient access for cadets, a web-based collaboration system enables cadets to access educational materials anywhere and at any time. This accessibility will facilitate their exam preparation and enhance the efficiency of assignment completion. Moreover, cadets may provide comments and collaborate in the creation of instructional materials, thus enhancing a more dynamic and participatory learning experience. Student input is crucial for enhancing the quality of instructional materials and educational methodologies. Study shows that the incorporation of student evaluations and teacher reflections can markedly improve course content, promote increased student-teacher interaction, and enhance the overall educational experience; (6) Encouragement for lecturer innovation, this platform will promote innovation among lecturers in their pedagogical methods. They can readily examine instructional resources developed by other educators or industry professionals, fostering innovative strategies and procedures[24]. Additionally, features like discussion forums and online collaboration tools inside LMCS will enable lecturers to exchange ideas and share good teaching practices, facilitating broader diffusion of information and expertise; 7) Cost savings, implementing a digital system for collaborative teaching materials will enable Makassar Aviation Polytechnic to reduce operating expenses usually linked to the printing and distribution of physical resources. Moreover, the platform can save expenses related to educating instructors[25], as they can participate in self-directed learning via the system.

The LMCS is expected to significantly improve the quality of education at Makassar Aviation Polytechnic. This approach will enhance collaboration between lecturers and practitioners, augment operational efficiency, boost institutional accreditation, and provide substantial advantages for cadets.

This research relies on the creation of a web-based Learning Material Collaboration System (LMCS) for instructors at Makassar Aviation Polytechnic. The LMCS functions as a digital platform intended to enhance online cooperation among lecturers, practitioners, and cadets, allowing them to create standardized, high-quality teaching materials collectively.

ISSN 2580-6424 (printed) | ISSN 2477-2399 (online)

METHODS

This study uses the Waterfall Method, a systematic approach to product design and development comprising five stages: requirement analysis, design, implementation, verification, and maintenance. In this study, the fifth stage, maintenance, was excluded due to time limitations[26].

Stages of the Waterfall Method in Research

The first stage is requirement analysis. The principal objective at this stage is to improve collaboration among educators in the administration of educational resources. This method entails recognizing user requirements, including usability and system efficacy. Preliminary assumptions, derived from discussions with lecturers, inform the development of hypotheses that are subsequently evaluated through prototypes. The hypothesis predicts that the implementation of a real-time collaboration feature will enhance the quantity of educational materials co-created by educators.

The second stage is design. The design phase emphasizes developing a solution that is both functional and aligned with user expectations. This phase usually commences with a brainstorming session (Design Studio) in which the team produces preliminary design concepts. The design focuses on a simple, user-friendly interface to enable seamless collaboration and exchange of educational content among instructors.

The third stage is implementation. A preliminary prototype, typically represented as wireframes or mockups, is developed and evaluated by initial users, including lecturers. The system is subject to incremental enhancements based on user feedback. The system is incrementally built until it results in a product that is both pertinent and beneficial to its users.

The fourth stage is verification. In "Black box" testing, consumers interact with the prototype and provide comments during verification. This exam reveals improvement areas. Feedback is analyzed to improve system design. Through this iterative method, the final system meets user needs.

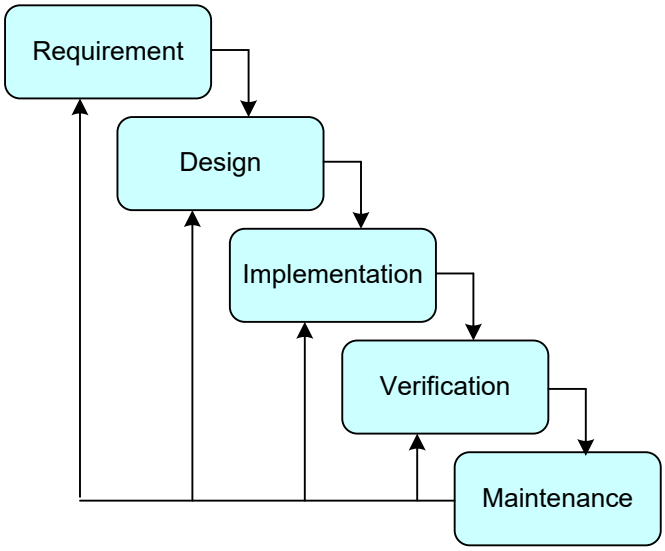


Figure 1. Waterfall Development Model

Research Subjects

This study was mostly about two groups, including (1) the lecturer group, in which responses were used to figure out what they were doing and what rules were in place to make sure that all teaching materials were consistent. The difficulties and steps needed to harmonize materials were studied to determine their effect; (2) the students were the main target when the system was being made. The study's goal was to find out what they needed to learn and where changes could be made.

ISSN 2580-6424 (printed) | ISSN 2477-2399 (online)

Data Collection Techniques

Three key methods were used to gather data (1) interviews, this qualitative method was used to gain deeper insights into the experiences and perspectives of lecturers concerning the system being developed; (2) questionnaires, a quantitative technique, questionnaires were used to measure the opinions of lecturers, practitioners, and students regarding the teaching materials collaboration system under development; 3) documentation, written sources relevant to the research topic were collected as part of the documentation process to supplement the analysis.

Data Analysis Techniques

This research employed Black Box testing, which focuses on the system's functional specifications without examining its internal code. Black Box testing went through the following steps, including (1) analyzing system requirements and specifications; (2) selecting input and output variables; (3) defining test scenarios; (4) conducting the test cases; (5) evaluating the results to identify system defects or issues.

Testing Methods

Two specific Black Box testing techniques were applied in this study, including (1) orthogonal array testing, this method is used to efficiently test all possible combinations of parameters within a system. It offers advantages such as testing efficiency, comprehensive coverage, and the ability to detect interaction problems between different parameters; (2) graph-based testing, which models test cases in the form of graphs, simplifies the understanding of component interactions within the system. It is particularly effective in identifying workflows and transitions between system elements.

Research Implementation

The research was conducted at the Makassar Aviation Polytechnic from January to August 2024. This timeframe was selected based on the availability of resources and access to the necessary data for the study.

.

RESULT AND DISCUSSION

Needs Analysis

This research adopts a Research and Development (R&D) model using the waterfall method, which consists of structured and sequential stages. The waterfall method was selected to ensure that each stage of the research is executed systematically, from needs analysis to solution implementation. The primary focus of this study is on addressing the accreditation challenges faced by Makassar Aviation Polytechnic, particularly concerning the quality of teaching materials utilized within the institution.

At present, the Makassar Aviation Polytechnic offers four study programs, three of which hold a B (very good) accreditation, while the remaining one is accredited C (good). According to PerBAN-PT regulation No. 5 of 2019 concerning IAPS - Diploma Three Program Assessment Matrix, several factors influence the accreditation status of study programs. One of these important factors is how well lecturers, students, and learning tools (like the teaching materials used) interact with each other. One of the main reasons the Makassar Aviation Polytechnic has a lower accreditation grade is that the teaching materials are not very good.

Presently, at Makassar Aviation Polytechnic, the teaching tools are made by each lecturer who is in charge of a specific course. This one-on-one method ensures that teaching materials don't meet the same standards for all study programs. This problem is made even worse by the fact that lecturers, field experts, and other professionals don't have many chances to work together. Working together in this

ISSN 2580-6424 (printed) | ISSN 2477-2399 (online)

way is important to make sure that teaching tools include a lot of different ideas and skills. This makes them more complete and up-to-date with the changing needs of education.

The negative impact of these substandard teaching materials is evident in both the learning model and the cadets' learning outcomes.. The low quality of teaching materials not only hampers the learning process but also directly affects the accreditation of study programs and the institution as a whole. High-quality teaching materials are expected to enhance learning effectiveness, relevance to students' needs, the integration of appropriate technologies, and the use of diverse learning approaches.

To gain a deeper understanding of the root causes of this issue, an analysis was conducted using a mind map (refer to Figure 2)[27]. This analysis identified several key causal factors contributing to the problem, including the accessibility of teaching materials, the depth of content, the variety of teaching materials, the static nature of the materials, limited usability, and the absence of uniform standards. For instance, most current teaching materials are available only in printed form, which makes them difficult to access at any time and challenging to modify or update as new knowledge emerges. Additionally, when teaching materials are developed by a single lecturer, they tend to reflect only that individual's viewpoint, potentially limiting the breadth of the material covered.

Based on this analysis, the researcher proposed a solution in the form of a mobile application that would facilitate collaboration among lecturers in developing teaching materials. This application is designed to meet several key criteria, including improved accessibility through the internet, enhanced content depth through interdisciplinary collaboration, a wider variety of teaching material formats (text, video, audio, and multimedia), and a dynamic nature that allows for easy updates and revisions to the materials.

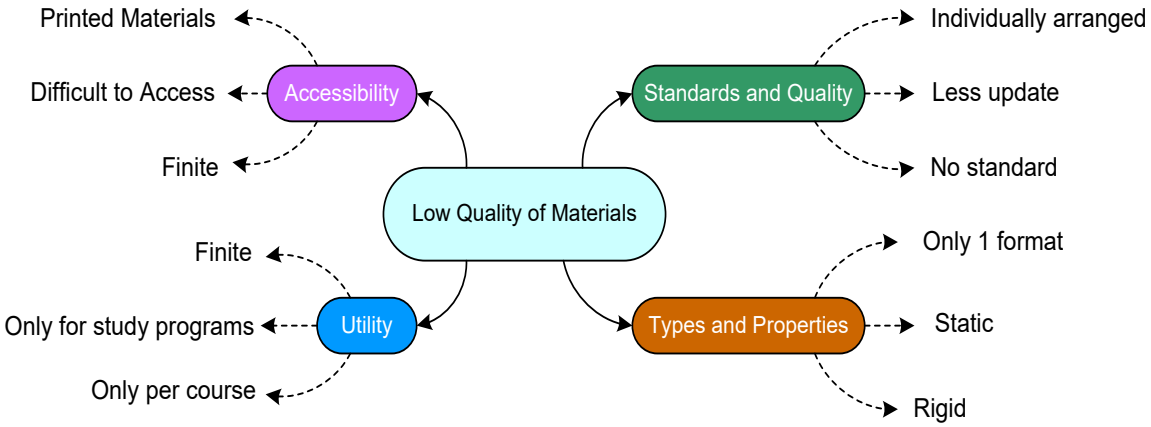


Figure 2. Mind Map Analysis

Moreover, this application is expected to broaden the use of teaching materials, enabling lecturers and students to access them at any time. It would also allow registered lecturers to download, upload, and edit teaching materials easily. Another important focus of this solution is the standardization of teaching materials. The materials produced are expected to be jointly agreed upon and recognized by lecturers and experts in related fields, thereby achieving uniform standards across all study programs.

The implementation of this collaborative application is anticipated to resolve the issue of low-quality teaching materials at the Makassar Aviation Polytechnic. Consequently, it would lead to improvements in the quality of learning and the accreditation of study programs.

In summary, this study employs the R&D model using a waterfall method approach, which involves clear, sequential stages. These stages include needs analysis, system design, implementation, testing, and maintenance. The main focus of the research is to address the challenges surrounding the quality of teaching materials at Makassar Aviation Polytechnic, which directly affect the accreditation of the institution's study programs and the overall quality of learning.

ISSN 2580-6424 (printed) | ISSN 2477-2399 (online)

Makassar Aviation Polytechnic currently offers four study programs, three of which have earned a B accreditation (very good), while the other is accredited C (good).

System Design

This application supports three primary types of users: operators, lecturers, and students/visitors, each of whom has distinct roles and permissions. Below is an overview of the system design for the collaborative platform used to compile teaching materials:

The first is the operator. Operators are responsible for managing lecturer and student data via a dashboard. Through this dashboard, operators can input, edit, and delete lecturer and student records. They can also display, download, or export data in various formats, such as Excel or PDF. Some important features that the operator can use are (1) Perform lecturer and student data entry, operators can add and change information about lecturers and students, such as name, student ID number, place of birth, home address, and phone number; (2) Data management, operators can pick which data columns to show, change or delete current student records, and use the name of a record to look for it; (3) Lecturer grouping, with this feature, operators can arrange teachers based on what they are good at. Putting teachers into groups makes it easier for people in the same group to work together on making lesson plans. Operators can change and add lecturer groups, as well as export the information in different forms.

The second is the lecturers. To use their functions, lecturers must log in with the USER ID and password given to them by the operator. After logging in, professors can handle their classes and give students materials to help them learn. Some important features that teachers can use are: (1) Adding teaching materials, teachers can share things to use for lessons, like PDFs, videos, or text files. They can also give each resource a title, a description, and a publication state; (2) manage teaching materials. Lecturers can see posted lesson plans, change them, delete them, or download them. They can also change the status of the release to limit students' access; (3) lecturer collaboration, this system allows lecturers within the same group to collaborate on creating more comprehensive and diverse teaching materials, thereby enhancing the student learning experience..

The third is students/visitors. Students and visitors can access teaching materials uploaded by lecturers. These resources are available for use as modules in teaching and learning activities. Students can view, download, and study materials directly published by lecturers.

System Implementation

The implementation phase involves the integration of all designed components into the final application. This system, called LMCS (Learning Material Collaboration System), is developed to streamline the process of managing and accessing teaching materials for both lecturers and students.

The main displays in the LMCS application include 1) homepage, the main page introduces the system and offers basic navigation for users; 2) login page, allows lecturers and operators to log into the system using their USER ID and password; 3) dashboard, enables operators to comprehensively manage lecturer and student data; 4) system menu, manages lecturer grouping and teaching material compilation; 5) lecturer panel, after logging in, lecturers can access teaching material management features, upload new content, and set the publication status; 6) teaching material submission, a page where lecturers input details about teaching materials, such as the title, description, and publication status.

ISSN 2580-6424 (printed) | ISSN 2477-2399 (online)

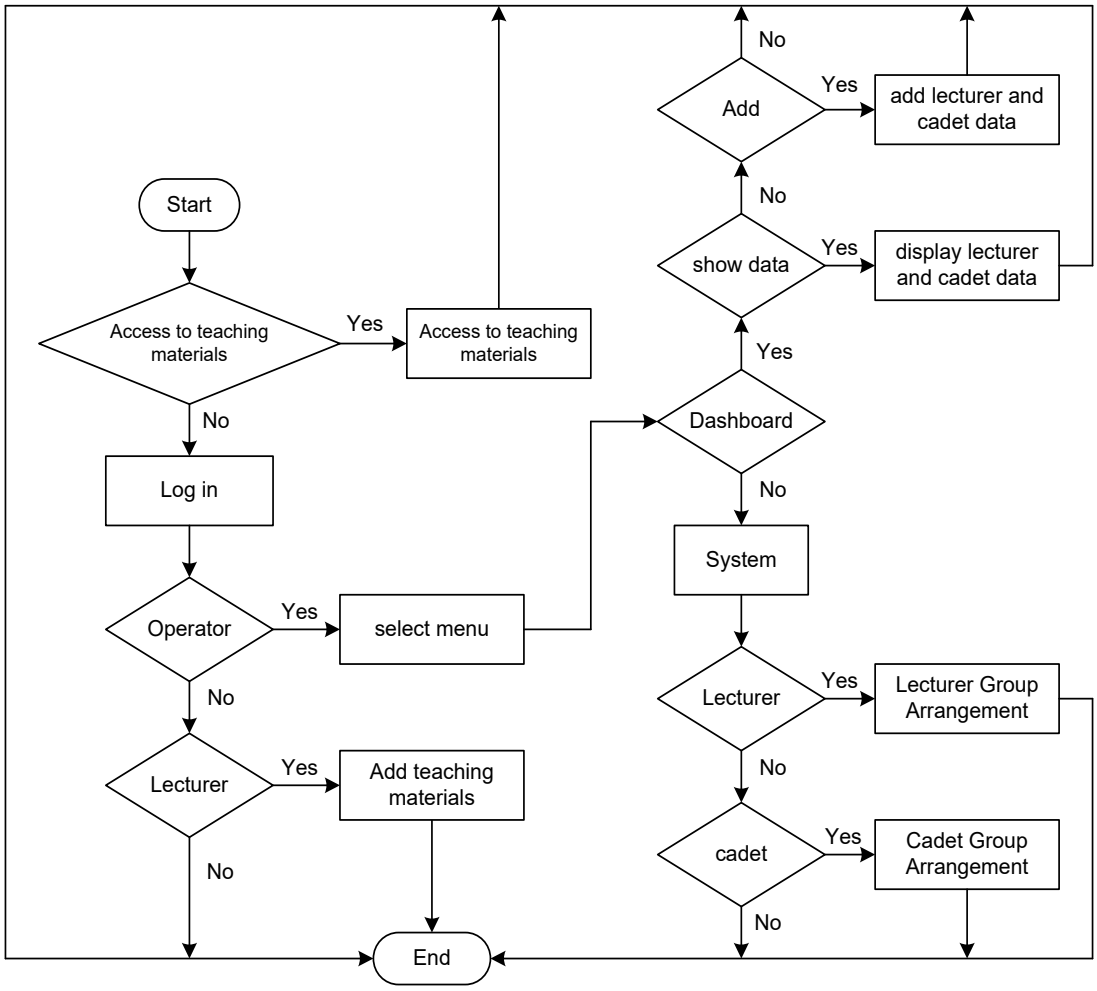
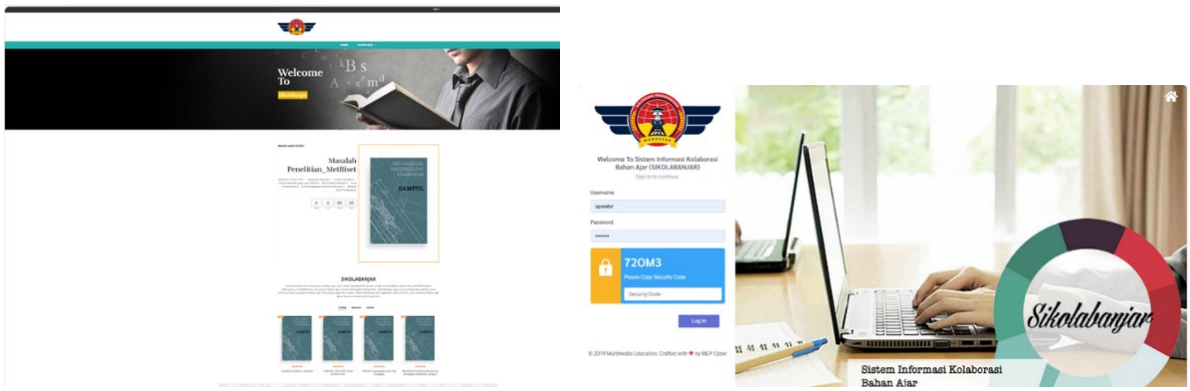


Figure 3. Application Design Flowchart



Homepage Login

Figure 4. Homepage view and login menu

This application is expected to improve the efficiency of compiling teaching materials, facilitate collaboration among lecturers, and make it easier for students to access educational resources.

Application System Testing

Application System Testing is the first technique of the Black Box method that is used in this study. The following are the test result graphs for the Login Menu and Operator Menu, which show all test results as valid. The first graph shows the test on the Login Menu, while the second graph shows the test results on the Operator Menu.

ISSN 2580-6424 (printed) | ISSN 2477-2399 (online)

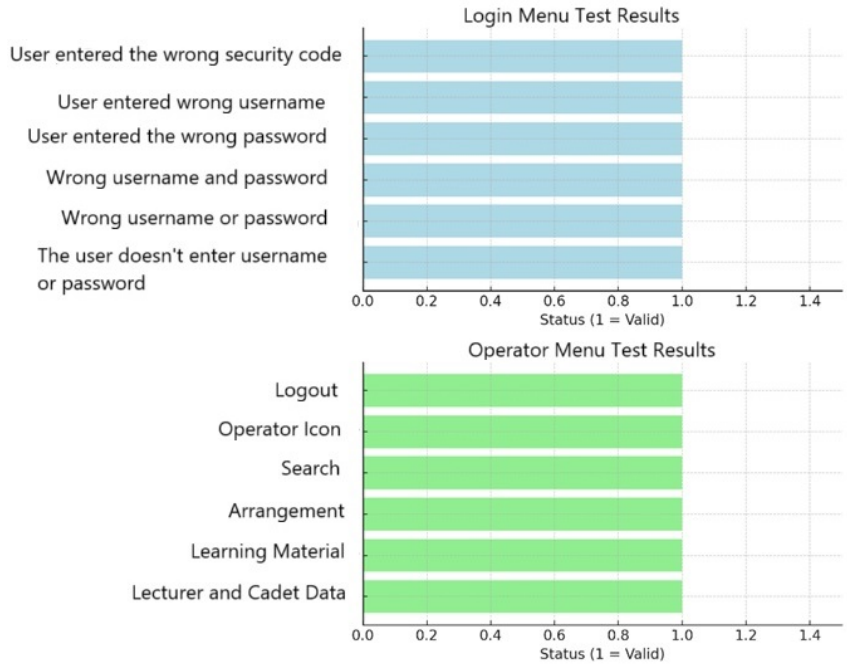


Figure 5. Graph of Operator Menu and Login Menu Test Results

Testing results for the lecturer menu are shown in Table 1 and Table 2. For the Adding Teaching Materials task, lecturers can add teaching materials to the database after joining the appropriate course group. Lecturers can view teaching materials and perform various actions like copying, downloading, editing, and deleting in the Viewing Teaching Materials task

Table 1. Test Results for Adding Teaching Materials

No.	Test Case	Expected Outcome	Actual Outcome	Conclusion
1	Click on "Add Teaching Material"	Click down	Click down	Valid
2	Click on "Teaching Material"	Click down	Click down	Valid
3	Click on "Lecturer Teaching Material"	Click down	Click down	Valid
...	...	...	...	...
12	Click on "Save"	Data saved	Data saved	Valid

Table 2. Test Results for Viewing Teaching Materials

No.	Test Case	Expected Outcome	Actual Outcome	Conclusion
1	Click on "Dashboard"	Click down	Click down	Valid
2	Click on "Teaching Material"	Click down	Click down	Valid
...	...	...	...	...
13	Click on "Previous/Next"	Navigate to the next or previous page	Navigate to next/previous	Valid

Usability Testing Analysis

This section involves feedback from 5 respondents on ease of use and usefulness of the application through Likert-scale questions, as shown in Table 3 and Table 4. To find out the maximum score, the formula is the number of respondents x the highest score. To find out the minimum score, the formula is the number of respondents x the lowest score. From this calculation, the assessment interval can be known as the maximum score: 41 x 5 = 205 and the minimum score: 41 x 1 = 41

After knowing the maximum and minimum scores, the next step is to calculate the assessment score interval. Here is the formula and the interval results obtained: I = 100/total score; I = 100/5; I = 20. The assessment interval is known as follows: (1) value 0% - 19.99% = Very Bad; (2) value 20% -

39.99% = Bad; (3) value 40% - 59.99% = Neutral; (4) value 60% - 79.99% = Good; (5) value 80% - 100% = Very Good. Finally, the index value of each question will be calculated. The index is obtained using the following formula.

$$Index\ (\%) = \frac{Total\ Score}{Maximum\ score} x100\% \quad \text{.....(1)}$$

Here are the charts summarizing the testing results based on formula (1). From the graph of Ease of Use, the index value is 76% to 88%, consisting of (1) question A1: 84%; (2) question A2: 88%; (3) question A3: 76%. From the graph of Usefulness, the index value is 78% to 100%, consisting of (1) question B1: 100%; (2) question B2: 84%; (3) question B3: 78%

Table 3. Ease of Use Scores

No.	Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Score
A1	Can registered users download and upload materials?	0	0	1	2	2	5
A2	Are materials available in Word, PDF, and PPT formats?	0	0	0	3	2	5
A3	Is the app easily accessible over the internet?	0	1	1	1	2	5

Table 4. Usefulness Scores

No.	Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Score
B1	Can teaching materials be compiled by multiple lecturers?	0	0	0	0	5	5
B2	Is the teaching material presented an agreement of the lecturer in 1 group of course teachers?	0	1	0	1	3	5
B3	Can teaching materials be changed at any time by registered lecturers?	0	1	0	1	3	5

Discussion of Research Results

This study aims to evaluate the reliability, efficiency, and effectiveness of a collaborative teaching material management application, focusing on the management and collaboration involved in preparing teaching materials. The evaluation was conducted through functional testing, interface assessment, and application flow analysis, which showed that overall, the application functioned as intended. However, there were some issues, particularly with the cadet group management feature, which was inaccessible. On the other hand, features such as access rights and downloading teaching materials operated smoothly. Scientific thinking skills are crucial for addressing complex problems in modern education and society, and the development of these skills can be achieved through reading scientific articles and project-based assessments[28]. Mastery of scientific thinking tools, such as language, logic, mathematics, and statistics, is also essential to support scientific endeavors.

Based on usability testing using the Blackbox model with 10 testers, it was found that not all tasks could be completed successfully. The task of managing cadet groups was the most problematic, with 7 out of 10 testers successfully completing 11 out of 12 tasks, resulting in a 92% success rate. This task involved organizing cadets into groups based on their class. However, upon evaluation, it was determined that grouping cadets by class was unnecessary, as all registered cadets had unrestricted access to view and download the teaching materials. Other testers were able to complete approximately 75% to 85% of the assigned tasks. Although some challenges were encountered, the application was generally easy to use, with room for improvement in the User Interface and User Experience (UI/UX).

The results of the usability test indicated that the application has an intuitive interface. Lecturers noted that adding teaching materials could be done in just three simple steps, and they could easily locate menus and sub-menus without extensive searching. Minor errors, such as incomplete entries, were promptly resolved with the help of clear pop-up instructions. Similarly, administrator users reported that they could update data within seconds, without navigating through complex or confusing steps. The main menu, consisting of "Operator/Admin," "Lecturer," and "Student" sections, could be easily accessed and utilized by users. Tasks were completed efficiently; for instance, administrators could quickly modify lecturer and cadet data, while lecturers could add and view teaching materials without significant difficulty. Although minor errors occurred, particularly when filling in lecturer data, system notifications and instructions allowed users to correct these mistakes promptly. Overall, most users were satisfied with the application's ease of use.

According to the questionnaire results analyzed using a Likert scale, the application was well received by users. In terms of ease of use, the application was considered easy to learn and operate, contributing to improved operational efficiency. Regarding usefulness, the application was deemed highly beneficial and effective in supporting the compilation of teaching materials. This demonstrates that the application has met user needs well and is ready for broader implementation, although certain aspects could still be enhanced to improve the overall user experience. To support future development, it is essential to explore the application's scalability in handling a growing number of users, teaching materials, and data as it is implemented across various departments or institutions. Additionally, ensuring interoperability with other systems will enable seamless integration with diverse information management systems used by different departments or institutions. The findings of this study suggest that the collaborative management of teaching materials through a web-based platform has significant potential to facilitate more effective management of teaching resources in the future.

CONCLUSION

Based on the testing and analysis results, the following conclusions can be drawn regarding the implementation of LMCS: (1) The application was successfully developed using a modified waterfall model up to the verification stage, achieving satisfactory results with a convenience level of 82.6% and a usability level of 83.7%; (2) During the verification stage, black box testing demonstrated task success rates ranging from 75% to 92%."

REFERENCES

[1] D. Aulia and M. K. Riefani, ‘Google Site as a Learning Media in the 21st Century on the Protista Concept’, vol. 3, no. 3, 2021.

[2] C. Medina and R. Mohamed, ‘Websites and Lectures: Higher Education at a Middle Eastern Women’s College’, *J. Educ. Pract.*, 2013.

[3] P. N. Azizah and A. Lutfi, ‘Development of a WordPress-Based Learning Website to Train Students’ Visual Intelligence on Chemical Equilibrium Material’, *J. Paedagogy*, vol. 10, no. 3, p. 692, Jul. 2023, doi: 10.33394/jp.v10i3.7994.

[4] W.-T. Tsai, W. Li, J. Elston, and Y. Chen, ‘Collaborative Learning Using Wiki Web Sites for Computer Science Undergraduate Education: A Case Study’, *IEEE Trans. Educ.*, vol. 54, no. 1, pp. 114–124, Feb. 2011, doi: 10.1109/TE.2010.2046491.

[5] P. Chaudhary and R. K. Singh, ‘A Meta Analysis of Factors Affecting Teaching and Student Learning in Higher Education’, *Front. Educ.*, vol. 6, p. 824504, Feb. 2022, doi: 10.3389/feduc.2021.824504.

[6] B. E. Priando Purba, I. D. Riris, and Z. Muchtar, ‘Development of Website-Based Learning Media Integrated Inquiri Learning Strategies in Learning Thermochemical Matter Chemistry’, *Bp. Int. Res. Crit. Linguist. Educ. BirLE J.*, vol. 4, no. 1, pp. 454–461, Jan. 2021, doi: 10.33258/birle.v4i1.1658.

[7] E. Suryawati, F. O. Rahmi, M. Rizki, and R. H. Arnan, ‘An Analysis and Design of Web-Based Learning GoProfTeach as Interactive Learning Tools’, *J. Phys. Conf. Ser.*, vol. 1655, no. 1, p. 012058, Oct. 2020, doi: 10.1088/1742-6596/1655/1/012058.

[8] S. Haridasan and S. Firdaus, ‘Application of Web-Based Sources and Services for Sustainable Development in University Libraries’.

[9] A. Widitiarsa Utoyo and Y. Sofiana, ‘Beevirale Multimedia Website for Distance Learning Introduction’, *E3S Web Conf.*, vol. 426, p. 01016, 2023, doi: 10.1051/e3sconf/202342601016.

[10] S. A. Putri and F. Candra, 'Design of a Web-Based Learning Management System for Physics Education FKIP University of Riau', *INOVTEK Polbeng - Seri Inform.*, vol. 8, no. 1, p. 14, Jun. 2023, doi: 10.35314/isi.v8i1.2921.
[11] M. A. Al-Gerafi *et al.*, 'Designing of an effective e-learning website using inter-valued fuzzy hybrid MCDM concept: A pedagogical approach', *Alex. Eng. J.*, vol. 97, pp. 61–87, Jun. 2024, doi: 10.1016/j.aej.2024.04.012.
[12] E. Mujahidin, A. R. Rosyadi, N. B. Ginting, R. Hartono, and H. B. Tanjung, 'Development of a Website-Based Sexual Violence Management Information System in Higher Education', *Int. J. Educ. Math. Sci. Technol.*, vol. 11, no. 2, pp. 375–387, Jan. 2023, doi: 10.46328/ijemst.3091.
[13] K. Anam, B. Asyhar, K. Saddhono, and B. W. Setyawan, 'E-SIP: Website-Based Scheduling Information System to Increase the Effectivity of Lecturer's Performance and Learning Process', *Ingénierie Systèmes Inf.*, vol. 26, no. 3, pp. 265–273, Jun. 2021, doi: 10.18280/isi.260303.
[14] H. J. Kim and S. Y. Hwang, 'Effect of Website-based Learning on Improved Monitoring of Adverse Drug Reactions by Clinical Nurses', *Asian Nurs. Res.*, vol. 16, no. 1, pp. 45–51, Feb. 2022, doi: 10.1016/j.anr.2021.12.004.
[15] A. Isroqmi, 'PENTINGNYA PENGUASAAN BEBERAPA APLIKASI KOMPUTER BAGI DOSEN DI PEMBELAJARAN DARING BERBASIS MOODLE', 2020.
[16] S. Ali, Y. Hafeez, M. Humayun, N. S. M. Jamail, M. Aqib, and A. Nawaz, 'Enabling recommendation system architecture in virtualized environment for e-learning', *Egypt. Inform. J.*, vol. 23, no. 1, pp. 33–45, Mar. 2022, doi: 10.1016/j.eij.2021.05.003.
[17] R. F. Ramadannisa and M. M. Hartina, 'The Design of Web-Based Learning Using Google Sites for Teaching Heat and Temperature Topic', *J. Penelit. Pengemb. Pendidik. Fis.*, vol. 7, no. 2, pp. 107–114, Dec. 2021, doi: 10.21009/1.07202.
[18] Istikomah, A. Puji Astutik, and M. Jannah, 'The Website-based Information Literacy system and Application in Education Facing the Age of Industrial Revolution 4.0"', *J. Phys. Conf. Ser.*, vol. 1779, no. 1, p. 012055, Feb. 2021, doi: 10.1088/1742-6596/1779/1/012055.
[19] Subandi, A. A. Syahidi, and A. N. Asyikin, 'Strategic Planning and Implementation of Academic Information System (AIS) Based on Website with D&M Model Approach', *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 407, p. 012101, Sep. 2018, doi: 10.1088/1757-899X/407/1/012101.
[20] C.-S. Chang, T.-S. Chen, and W.-H. Hsu, 'The study on integrating WebQuest with mobile learning for environmental education', *Comput. Educ.*, vol. 57, no. 1, pp. 1228–1239, Aug. 2011, doi: 10.1016/j.compedu.2010.12.005.
[21] W. Naro, A. Abubakar, A. Yani, K. Kurniati, M. M. Amiruddin, and A. Syatar, 'Developing learning method on post-graduated program: a blended learning based on web-blog and print technology design', *Cypriot J. Educ. Sci.*, vol. 15, no. 5, pp. 1404–1421, Oct. 2020, doi: 10.18844/cjes.v15i5.5178.
[22] W. Oktaviani, G. Gunawan, and S. Sutrio, 'Pengembangan Bahan Ajar Fisika Kontekstual Untuk Meningkatkan Penguasaan Konsep Siswa', *J. Pendidik. Fis. Dan Teknol.*, vol. 3, no. 1, pp. 1–7, Jun. 2017, doi: 10.29303/jpft.v3i1.320.
[23] Zubaidah, A. Kardena, S. Shalihah, O. Hodijah, Y. Afrida, and L. Safitri, 'Web-based e-learning Application for learning Arabic language', *J. Phys. Conf. Ser.*, vol. 1779, no. 1, p. 012011, Feb. 2021, doi: 10.1088/1742-6596/1779/1/012011.
[24] T. Suartini, A. Sukandar, F. F. Zadi, A. S. Fikadinda, and W. Maulana, 'The influence of the use of website-based learning media on engineering drawing materials', *Informasi*, vol. 52, no. 2, pp. 253–270, Dec. 2022, doi: 10.21831/informasi.v52i2.53194.
[25] L. John, 'Online discussion platforms for effective collaborative learning in higher learning institutions in Tanzania', Masters, Nelson Mandela African Institution of Science and Technology, Arusha, 2020. doi: 10.58694/20.500.12479/910.
[26] O. Purwanto and S. D. Y. Kusuma, 'Implementasi Learning Management System Pada Aplikasi Huawei Talent Unpam Dengan Model Waterfall', 2024.
[27] 'Efects of mind mapping-based instruction on student cognitive learning outcomes a meta-analysis.pdf'.
[28] H. Sahidu and A. Harjono, 'THE EFFECT OF PROJECT BASED LEARNING WITH VIRTUAL MEDIA ASSISTANCE ON STUDENT'S CREATIVITY IN PHYSICS', no. 2, 2017.