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LEARNING MANAGEMENT SYSTEM SUPPORTED SMARTPHONE (LMS3): ONLINE LEARNING APPLICATION IN PHYSICS FOR SCHOOL COURSE TO ENHANCE DIGITAL LITERACY OF PRE-SERVICE PHYSICS TEACHERS

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Abstract

This study aimed to examine the development of an online learning application in the physics for school course using the ADDIE model. The application is Learning Management System Supported Smartphone (LMS3), which facilitates pre-service physics teachers to enhance digital literacy. The need assessment was analysed based on learning objectives and designed LMS3 using a flow chart and storyboard. LMS3 was developed by professional programmers, filled with content, and validated by experts. It was then implemented and evaluated in the physics for school course. This descriptive study involved media and pedagogical experts and 40 pre-service physics teachers in Tasikmalaya. Data were collected through literature reviews, expert validation, and pre-service physics teacher perception questionnaires obtained using a Likert scale. The expert validation results were processed using the value equation developed by Aiken. The results showed a validation value of 1, meeting the minimum application requirements. Additionally, pre-service physics teachers positively responded to LMS3, which has good display, function, and effect on their learning motivation and digital literacy.

Keywords – Learning Management System, Online learning, Physics for school, Digital literacy, Smartphone, Preservice physics teachers.

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1. Introduction

Rapid information and communication technology development significantly impacts people's lifestyles and community needs (Rizal, Rusdiana, Setiawan & Siahaan, 2020c; Shopova, 2014). It promotes teachers to use information and communication technology professionally to organize educational development activities (Rizal, Setiawan & Rusdiana, 2019). The need to use technology in education is manifested in learning reformation (Means, Blando, Olson & Middleton, 1993). It was initially influenced by facts that communities outside of education use technology in communication, information, searching, and commercial activities. There is pressure on the educational community to familiarize students with technology. Therefore, technology should be utilized as an important and potential media to support learning reformation goals.

Woodbridge (2014) stated that ICT creates pleasant and exciting learning conditions or emotional effects, enables students to use high technology, accelerates work, and increases analysis and interpretation variations (Hussain & Safdar, 2008). The use of technology in educational activities is compiled by digital literacy or competencies and skills needed for internet, ICT, information, and media literacy. It focuses on problem-solving and critical, creative, flexible, and ethical knowledge building through technology and media (Ferrari, 2012). Vuorikari, Punie, Carretero and Van Den Brande (2016) stated that digital literacy competence comprises information and data literacy, communication and collaboration, content creation, safety, and problem-solving. Moreover, Rizal, Rusdiana, Setiawan, Siahaan and Ridwan (2020a) examined digital literacy trained through physics for school teachers covering information and data literacy, communication and collaboration, and digital content creation.

Learning Management System (LMS) is a digital technology applicable in learning. The software application automatically handles the administration, implementation, and reporting of a training activity. LMS is a system application that assists in administration as an e-learning content platform (Gutman, 2017). Also, it enables students to learn various information without space-time limitations. They learn various materials such as words or text from visual, audio, and other multimedia (Kean, Embi & Yunus, 2012). LMS has several functions in learning and training activities. It concentrates and automates administration, provides services and guidelines for independent use, and regularly arranges and presents learning content. Additionally, it supports flexibility and better standardization and manages the reuse of learning content (Ellis, 2012).

LMS has provided positive benefits for its users, specifically in academic achievement. According to Marineo and Shi (2019), the literacy module integrated into the LMS positively impacted the students' academic achievement. Students who use LMS perform better with a positive outcome on academic achievement (Mijatovic, Cudanov & Jednak, 2013). Although LMS provides several benefits in learning, inappropriate use by teachers results in opposite outcomes, where students become confused about what they must do to achieve their academic goals (Kidney & Puckett, 2003). For instance, Moodle cannot be used optimally in learning due to the failure to achieve usability and reliability (Costa, 1985). Students stated that LMS makes learning slow and boring because they do not interact face-to-face with teachers. Also, LMS focuses more on administration than on students (Cho, Yung & Im, 2014). According to Kraleva, Sabani and Kralev (2019), some recent LMS did not provide synchronous learning, increase effective and efficient management, or modify freely according to learning needs.

There is a need to eliminate negative students' perceptions and lack of recent LMS. This necessitates developing an innovative LMS that enlarge students' opportunities in accessing teachers material through easy-to-use and familiar devices such as smartphones (Chelliah & Clarke, 2011; Turnbull, Chugh & Luck, 2019). The use of LMS with smartphones provides new meaning and benefits in learning activities (Dreamson, Thomas, Hong & Kim, 2018; Rapp & Duncan, 2012) and develops scientific inquiry and digital literacy (Marty, Alemanne, Mendenhall, Maurya, Southerland, Sampson et al., 2013). LMS should enable users to communicate synchronously through online learning activities (Hu, Ng, Tsang & Chu, 2019). In line with this, Wang and Chen (2008) found that synchronous online learning helps improve students' performance. It should also help students search for and share information (Lonn & Teasley, 2009). This requires an LMS application that could be used with smartphones to facilitate synchronous online learning. Therefore, the compiled LMS should contain all learning administration, including tests, assignments, and teaching materials.

LMS was developed to prepare the main course for pre-service physics teachers called physics for school. This course is the main subject that prepares the pre-service teachers in mastering physics concepts and skills supporting teaching in schools. The course objectives focus on digital literacy skills and understanding of physics concepts. Therefore, LMS was developed to support pre-service physics teachers in enhancing digital literacy and understanding the concepts through the physics for school course. The LMS was named the Learning Management System Supported Smartphone (LMS3). It was developed using the ADDIE comprising instructional design processes, including Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009; Reinbold, 2013). These five stages are guidelines for making an effective learning application. The model was selected because it describes a systematic approach to instructional development. It is sequential and interactive, general and appropriate for development.

2. Method

This study used quantitative and qualitative methods conducted in five stages in the ADDIE model, including analysis, design, development, implementation, and evaluation. The ADDIE model is the most used framework by instructional educators (Morrison, Ross, Kemp & Kalman, 2011). In general, the model allows feedback based on continuous assessment in creating materials (Nadiyah & Faaizah, 2015). All phases in the ADDIE model intersect and impact each other while all development stages depend on each other. The changes in one phase has a universal effect, meaning all the phases should be synergistic. However, ADDIE does not limit the program steps but guides a designer towards the best solution. The following description of the ADDIE model is written in linear order for exposition purposes, though many phases succeed simultaneously (Aldoobie, 2015). The activities at each stage of the ADDIE model are shown in Table 1.

There were two learning media and pedagogic experts and 40 pre-service physics teachers in Tasikmalaya, Indonesia. The instruments used were digital literacy multiple-choice tests, expert validation questionnaires, and perception questionnaires from pre-service physics teachers. Table 1 shows the instruments in the ADDIE model in LMS3 development.

No	Stage	Activities	Instruments
1	Analysis	• Analyzing the initial digital literacy of pre-service physics teachers • Analyzing the learning objectives of physics for school • Developing instructional analysis	Digital literacy test
2	Design	• Adapting the digital literacy assessment • Designing physics for school learning to train digital literacy and cognitive ability • Designing LMS3 flowchart • Designing LMS3 storyboard	-
3	Development	• Developing LMS3 application by professional programmers • Filling in the content of LMS3 according to the learning objective • Validation by pedagogical and media experts	Validation expert questionnaire
4	Implementation	• Brief socialization and training in using the LMS3 • Conducting synchronous learning on limited material by LMS3 • Measuring digital literacy through LMS3	Digital literacy test
5	Evaluation	• Collecting data on pre-service physics teacher perceptions of the use of LMS3 in physics for school course and interview • Analyzing the weaknesses and obstacles of using LMS3 in the physics for school course	Perception questionnaire from pre-service physics teachers

Table 1. The ADDIE Activities and Instruments in Developing LMS3

The digital literacy multiple-choice test was a valid and reliable test developed by previous studies. The test accommodated digital data and information literacy competencies, communication and collaboration, and content creation (Rizal et al., 2020a). The expert validation and the perception questionnaires from pre-service physics teachers used a Likert scale (1-5).

The validation of LMS3 was determined by the Aiken value using Equation (1) (Aiken, 1985).

$$V = \frac{\sum s}{n(c-1)} \quad (1)$$

Where V is the validation value, s is the difference between the expert and lowest scores, n is the number of experts or evaluators, and c is the highest value on the scale. LMS3 is valid when it meets the minimum validation value requirements. The requirements depend on the number of raters and rating categories, as shown in Table 2 (Aiken, 1985).

No of item	**Number of Rating Categories**									
Raters (*n*)	**3**		**4**		**5**		**6**		**7**	
	V	***p***	***V***	***p***	***V***	***p***	***V***	***p***	***V***	***p***
2					1.00	0.040	1.00	0.028	1.00	0.02
3					1.00	0.008	1.00	0.005	1.00	0.003
3	1.00	0.037	1.00	0.016	0.92	0.32	0.87	0.046	0.89	0.029
4			1.00	0.004	0.94	0.008	0.95	0.004	0.92	0.006
4	1.00	0.012	0.92	0.020	0.88	0.024	0.85	0.027	0.83	0.029

Table 2. Aiken Minimum Validation Value

Perception questionnaires from pre-service physics teachers were obtained quantitatively to determine the percentage approval of positive statements based on their experience using LMS3 during implementation.

3. Result and Discussion

Results and discussion were described according to the ADDIE model steps, including Analysis, Design, Development, Implementation, and Evaluation.

3.1. Analysis

The analysis involved identifying the problem and what students need to improve performance. Teachers need to craft educational objectives and determine what should be taught to accomplish academic goals (Cheung, 2016). The analysis phase involves detective work, background studies, and information gathering. This phase must be completed carefully using a thorough and complete analysis to avoid failure. Moreover, analysis involves observation, interviews, focus groups, or written materials such as syllabi, articles, course materials, and reliable and trustworthy information from the internet (Peterson, 2003). The analysis of physics for school teachers' documents showed that they have the following specific learning objectives:

1. Analyzing the circuit and work principle of Direct Current (DC) equipment in daily life.
2. Conducting experiments through simulations to investigate the characteristics of Direct Current (DC) circuits.
3. Finding, evaluating, storing, and sharing digital information from reliable sources in physics problem-solving.
4. Communicating digitally concerning relevant physics problems.
5. Reporting experiment results using a word application, power points, and spreadsheets.

The physics for school teachers focused on cognitive abilities, digital literacy, and conducting virtual experiments. This study prioritized digital literacy without underestimating cognitive abilities and the skills of conducting virtual experiments. The digital literacy of pre-service physics teachers was low. Moreover, three important aspects of digital literacy for pre-service physics teachers with a maximum range of 100 each had unexpected scores. Three digital literacy competencies showed that information and digital data and content creation had low mean scores of 36 and 47, respectively, while communication and collaboration had a medium mean score of 68 (Rizal, Rusdiana, Setiawan & Siahaan, 2020b). This is attributed to the tendency of the pre-service physics teachers to use digital devices for communication and entertainment. The results of analyzing the learning objectives and students' conditions were used to develop instructional analysis. Development of LMS in physics for school aims to provide online facilities to improve cognitive abilities or understanding of concepts. Additionally, it aims to enhance pre-service physics teachers' digital literacy through the activities and conduct online experiments more easily (Susilawati, Satriawan, Rizal & Sutarno, 2020).

The needs analysis results outlined in teachers are described in Table 3.

No	Competencies	Pre-service physics teacher activities	Features needed in LMS3
1	Browsing, searching and filtering information and digital content	Search valid and credible information concerning the topic or problem	The availability of an information search engine integrated with LMS3.
2	Storing data, information, and digital content	Store information in easily-accessible spaces	Availability of storage space to save and report search results.
3	Evaluating data, information, and digital content	Filter information using comparative sources	The availability of tools to easily filter data and information.
4	Sharing information through digital technologies	Actively involved in scientific discussions on the ethics of digital communication Solve problems based on facts and valid and credible information	Availability of an interactive and synchronous discussion space in limited groups or one large class. Teachers could monitor the discussion room to achieve their objectives. Interactions could be between students or students and teachers.
5	Interacting through digital technologies		
6	Engaging in citizenship through digital technologies		
7	The ethics in using the internet		
8	Developing digital content in various formats	Engage in virtual physics experiment activities Report their activities in various formats by inputting data sources or supporting information	Availability of file storage space for reports of virtual experiments in various formats. The availability of a facility to conduct and report online experiments.
9	Copyright and licenses		

Table 3. Need Analysis of LMS3 in Physics for School Teachers

3.2. Design

The first activity in the design stage is developing the assessment storage in LMS3. The assessment conducted in the physics for school teachers program is digital literacy and cognitive tests. Also, an assessment is conducted on the activities during online learning. The valid and reliable multiple-choice tests of digital literacy are applied to the physics for school course. This test comprises 18 questions covering the competency areas of information and data literacy, communication and collaboration, and digital content creation. Cognitive ability tests were made in multiple-choice and open essays and covered five domains, including remembering, understanding, applying, analysing, and evaluating. Therefore, the LMS3 developed needs to accommodate multiple-choice questions and essay formats.

The physics for school course is conducted through online learning using Problem Based Learning (PBL) integrated into the LMS3 system to support the digital literacy of pre-service teachers. The learning process follows the synchronous system regulated by LMS3. Learning activities only occur when teachers open a space, where each step starts simultaneously and gradually under the time limit set by them. The PBL model is integrated into LMS3 because it helps achieve the learning objective. PBL is characterized by student-centered and group learning, uses authentic problems, and requires new information through self-directed learning (Liu, 2005). Barrett (2017) explained the five steps of PBL as follows:

1. Problem finding. Pre-service physics teachers uncover problems independently.
2. Group discussion. Teachers engage in group discussions to define and clarify problems, exchange ideas based on their understanding, and determine the problem-solving mechanisms.
3. Independent study. Teachers conduct independent studies on the problem. They search information in libraries, databases, the internet, personal sources, or observations.
4. Problem-solving. Pre-service physics teachers return to the initial group discussion to exchange information, learn from peers, and work together to achieve an agreed solution.
5. Presentation of results. Students present solutions and evaluate learning activities in the class.

The system flowchart in Figure 1 was prepared to visualize the LMS3 design that implemented problem-based learning.

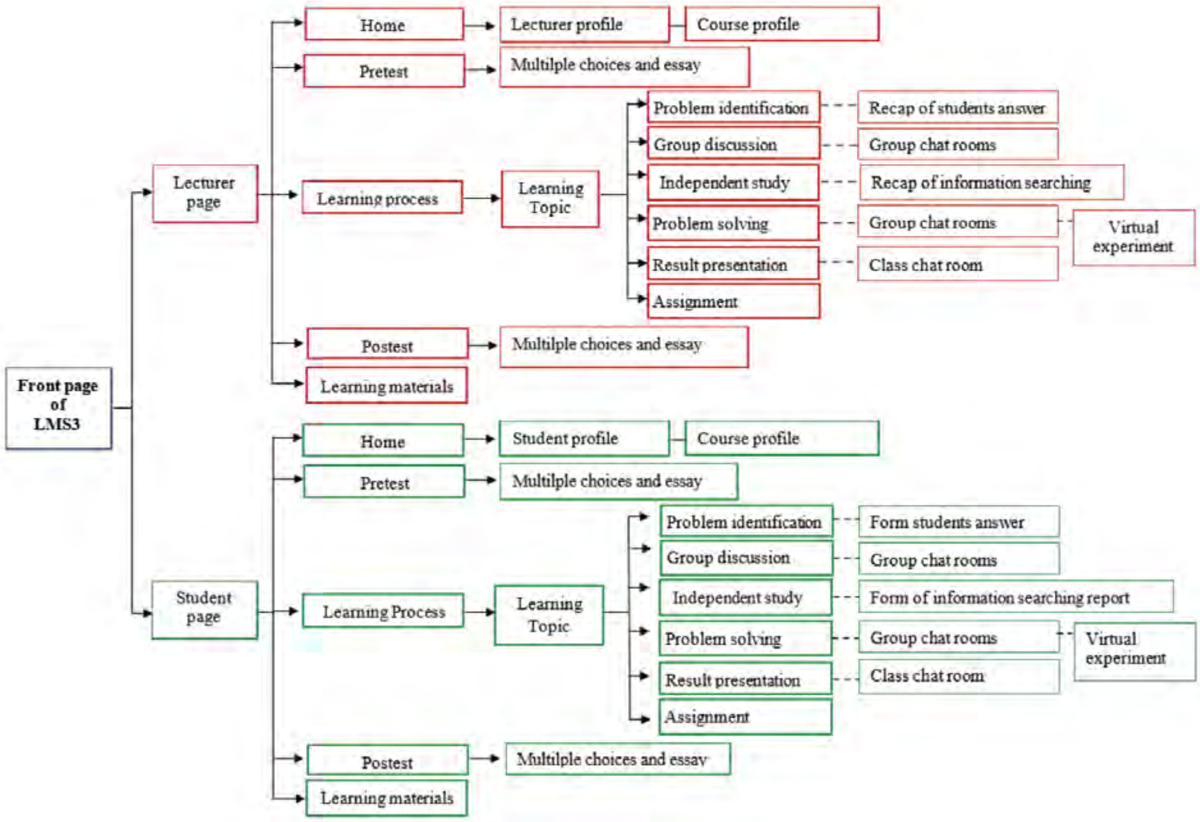

Figure 1. Flow chart system of LMS3 in Physics for school teachers

Storyboard is designed after creating a flowchart. It is an illustration displayed sequentially to help a program or application maker visualize the appearance on each page and ensure it matches the expectations (Truong, Hayes & Abowd, 2006). Designers use activity scenarios to introduce main ideas about how user requirements could be met through high-level functionality created by systems that inherently influence current user activity. Moreover, they create information design scenarios that determine object representations and task actions that help users understand and interpret the proposed functionality (Mou, Jeng & Chen, 2013). The storyboard used shows the design and the functions of each part of the LMS display.

3.3. Development

The development stage involved creating resources and activities in preparing program or application readiness (Swanson, 2006). The storyboard was prepared, submitted, and discussed with professional programmers. The development process was monitored to ensure that each page component remained as desired. LMS production was completed in four months, while LMS3 was developed as a Web-based application accessible from various digital devices. However, this study focused on using LMS3 from a smartphone, where the application is accessed on http://lms3.saena.web.id/. Alternatively, the application is accessible from android by downloading on http://lms3.saena.web.id/LMS3.apk. Figure 2 shows several displays on LMS3 after completion.

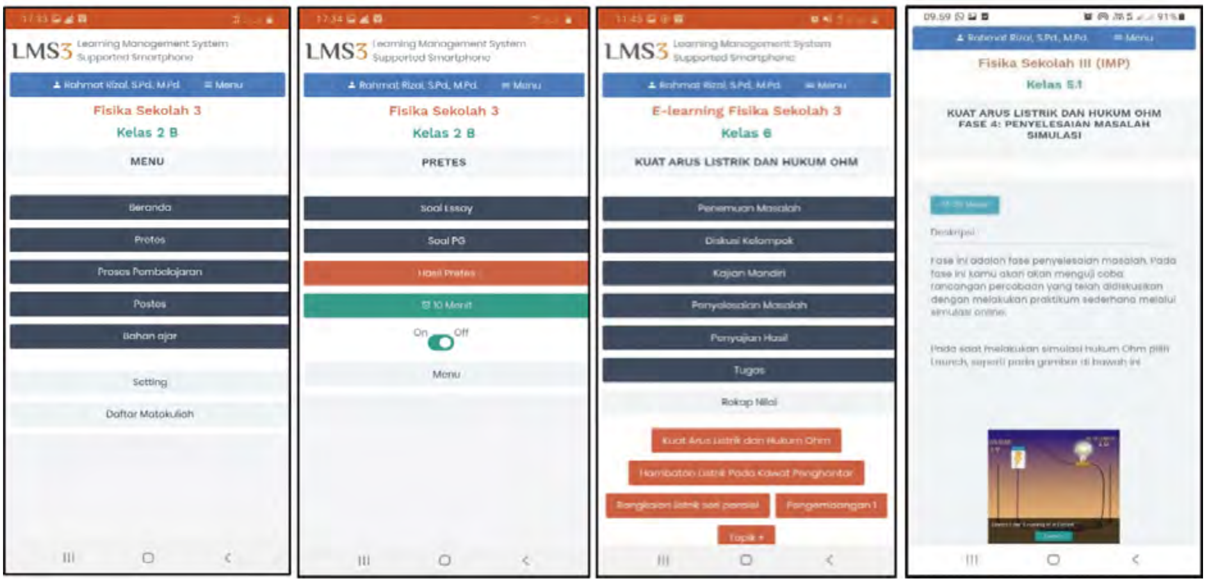

Figure 2. The example of the page display of LMS3

Expert validation helped determine the application's quality by assessing the seven important items related to LMS3, including layout, user interaction, usability, navigation, typography, learning process, and material substance. These seven factors positively impact the ease of access to applications, the effectiveness of a conducive learning environment, and high-quality outcomes. Judgments of expert validation were assessed on Likert scale approvals ranging between 1-5. The LMS3 application assessment involved pedagogical and media experts. According to Lewis (Engel, 2019), media validation requires a minimum of two experts or raters with five rating categories (Aiken, 1985). The expert judgment results were processed by the Aikens validation value calculation in Equation 1. Table 4 shows the LMS3 expert validation results.

	Layout		User Interaction		Useability		Navigation		Typography		Learning Process		Material substance	
Raters	***R***	***s***	***R***	***s***	***R***	***s***	***R***	***s***	***R***	***s***	***R***	***s***	***R***	***s***
1	5	4	5	4	5	4	5	4	5	4	5	4	5	4
2	5	4	5	4	5	4	5	4	5	4	5	4	5	4
$\sum s$	8		8		8		8		8		8		8	
V	1		1		1		1		1		1		1	

Table 4. Item validation in LMS3 by Two Experts

The expert validation results showed that the V value for each item is 1. This fulfilled the minimum criteria of V value for two raters using five rating categories, as shown in Table 4. Therefore, the LMS3 developed has good validation, meets the criteria, and is ready for implementation.

3.4. Implementation

At the implementation stage, LMS3 was used by 40 pre-service physics teachers in the physics for school course. They synchronously tried the digital literacy and cognitive ability tests after the activity was opened and engaged in online learning activities on three topics. Furthermore, they conducted learning processes sequentially for each stage without repetition or jumping to the next stage. Each stage had limited time set by teachers, and the learning stage moved automatically when the time was up. Therefore, online learning activities were held simultaneously for all pre-service physics teachers.

The test did not measure pre-service physics teachers' competencies but obtained feedback for LMS3 evaluation (Trust & Pektas, 2018). The learning implementation verified all LMS3 stages, including the teaching materials, the learning process for each syntax of Problem-Based Learning, and the assignment system.

3.5. Evaluation

The evaluation stage examined the effectiveness of LMS3 in the physics for school course. The effectiveness of a course program and supported application was examined by pre-service physics teachers' perception (Stappenbelt, 2010). The implementation activities were monitored directly, and data were collected through questionnaires and interviewing pre-service physics teachers' perceptions. The direct monitoring of learning activities showed several obstacles, including:

1. Some pre-service physics teachers were late in conducting online learning activities at every stage.
2. Some teachers had difficulties accessing LMS3 when used simultaneously by many users.
3. LMS3 access was occasionally interrupted by weak network coverage.

Questionnaires contained questions related to pre-service physics teachers' perceptions of LMS3 content and changes in knowledge and skills. Their perceptions were valuable in the evaluation process because they directly tested the implemented program (Ceroni, Carpigiani, Castanheiraa & Silvi, 2016). Their perceptions were the basic considerations to improve the learning process and LMS3 into a desired application for the user. Table 5 shows the pre-service physics teachers' perception results.

Table 5 shows that the average percentage of teachers' perception of 71.3 % is in the high category. This indicates that the LMS3 received a positive rating from the pre-service teachers, meaning it could be used in the physics for school course. Teachers' perceptions expressed through the questionnaire were reinforced by representative sample interviews, which resulted in several key points. Most pre-service physics teachers felt motivated by the LMS3 application because they could conduct synchronous learning. Systematic and mutually supportive stages in learning stimulated them to practice problem-solving enhanced by valid internet-sourced information. In this case, every problem-solving opinion was proven using virtual experiments and communicated in group and class discussions. Teachers were trained on communication skills without blaming the opinions of others. Consequently, they focused longer on learning because synchronous learning is strict on time management. Continuous assessment in LMS3 was well received by pre-service physics teachers during the learning process. The application LMS3 provided an access link to conduct virtual experiments, enabling teachers to make observations, process data, and make reports in one system.

Pre-service physics teachers also revealed provided responses that led to LMS3 revision. They stated that LMS3 is strongly influenced by internet network coverage. They experienced difficulties in synchronous learning when the network was weak. In these cases, they could not share pictures during group and class discussions. Therefore, the questionnaire and interviews results were used to improve the quality of LMS3. The evaluation results were also discussed with a professional programmer to be revised according to the complaints and problems during implementation. This means all LMS3 systems have been upgraded to guarantee effective and efficient use.

No	Statement	Frequency of Score					Mean	Category
		SA (5)	A (4)	N (3)	D (2)	SD (1)		
1	The LMS3 application is easy to use	12	23	3	2	0	66	Moderate
2	The LMS3 application is easy to download	20	17	1	1	1	69.6	Moderate
3	The LMS3 application operates smoothly on the device	17	15	4	4	0	66	Moderate
4	The display on the LMS3 application is simple and attractive	26	11	2	1	0	72.8	High
5	The combination of colors in a harmonious display	16	18	3	1	1	65.6	Moderate
6	The letters used in the application are readable	30	9	1	0	0	75.6	High
7	Display the menu in the application is attractive and interactive	22	16	2	0	0	72	High
8	The navigation is clear and works well	29	6	4	1	0	73.2	High
9	Virtual experiments can be accessed and used easily	20	16	0	3	1	68.4	Moderate
10	The LMS3 application presents online learning interactively	27	10	1	2	0	72.8	High
11	LMS3 application provides communication facilities between users in learning	24	11	4	0	1	70.8	High
12	LMS3 application increases learning motivation	31	8	0	1	0	75.6	High
13	LMS3 application provides a new atmosphere in learning activities	35	3	2	0	0	77.2	High
14	LMS3, which was integrated into learning, supports mastery of concepts	21	17	0	1	1	70.4	High
15	LMS3 facilitates skills in digital literacy	26	14	0	0	0	74.4	High
Average							**71.3**	**High**

SA = Strong Agree; A = Agree; N = Neutral; D = Disagree; SD = Strong Disagree

Table 5. Summary of pre-service physics teacher perception

4. Conclusion

LMS3 is a management system application accessible using a smartphone. It was developed using the ADDIE model comprising the Analysis, Design, Development, Implementation, and Evaluation stages. LMS3 development began by analyzing school physics teachers' needs and learning objectives. The analysis results scope the learning objectives of the physics for school course on digital literacy. Furthermore, the LMS3 design provided facilities in developing three learning objectives. It was designed by highlighting synchronous online teachers' activities using a problem-based learning model. This model focuses on problem discovery and solving, group discussion, independent study, and results in presentation. Additionally, several facilities for virtual experiments at the problem-solving stage were considered. LMS3 was designed by preparing a flowchart system and storyboard to be delivered to professional programmers.

LMS was produced by professional programmers, filled with content, and validated by experts. Validation evaluated the functionality and validity of the LMS content before implementation. The expert validation showed that the LMS3 met the Aiken equation's validity requirements. The LMS3 implementation involved 40 pre-service teachers in the physics for school course to provide an overview of its functionality and effectiveness in supporting synchronous online learning. The implementation results were evaluated through questionnaires on pre-service physics teachers' perception and representative sample interviews. The evaluation results indicated positive teachers' responses concerning LMS3. Professional programmers also implemented the key feedback concerning LMS3 changes to ensure the application is ready for use.

LMS3 integrates PBL syntax, as well as is accessible using a smartphone and the main learning tool that regulates the school physics teachers' process. It has positive potential to enable students to practice digital literacy skills. Furthermore, school physics teachers' could use LMS3 to provide a learning environment that enables students to search for, evaluate, and store information, perform synchronous communication and collaboration and develop digital content. This learning environment would reinforce and stimulate students to develop new skills.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest concerning the authorship and publication of this study.

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