Architecture Design Development of LMS-based e-Learning for Primary School Learning in Madiun City

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Abstract— *Learning quality can be improved by utilizing technology and digital media in teaching and learning. Based on a survey conducted in 2021 at 33 elementary schools in Madiun City, most teachers still use WhatsApp Group media in delivering material. However, schools with good technological facilities can better understand technology for both teachers and students. This research is downstream from previous research that recommended the development of LMS-based e-learning in elementary schools in Madiun City. The importance of good management in documenting the teaching and learning process that can be used as monitoring and evaluation material to improve the quality of learning. Data collection in this study was carried out by direct observation at SDN 01 and SDN 03 Manisrejo Madiun City, as well as surveys conducted at 33 elementary schools in the Madiun City Education Office. The results of this research are internal and external condition analysis, business process analysis, Data, and Information architecture design, application architecture design, technology architecture design, and people architecture design which can be used as Pecel-AE application development framework documents.*

Keywords—*Madiun City, LMS, Business Process Analysis, architecture design, Pecel-AE*

I. INTRODUCTION

The development of technology today greatly affects various life activities. The influence of technological developments can be seen in the impact on the social behaviour of people who are highly dependent on technological advances [1][2]. One of the forms of activity that depend on technological developments is in the world of education. Learning tools are a medium that teachers can use to deliver material to their students.

The COVID-19 pandemic has changed the learning methods applied to educational institutions. The method of delivering learning which is all done face-to-face in person (offline/outside the network), switches to the online method (in the network) [3][4]. This change in learning methods requires teachers and students to master an understanding of digital literacy. In addition to learning with the online method, in this 21st-century era, teachers are required to

have the ability to utilize Digital Technology in delivering material or making learning materials by utilizing digital media [3][4][5].

Research [6] analyzed the readiness of teachers, students, and educational institutions in preparing abilities, facilities, and policies in carrying out the online learning process with the results of a survey on 33 elementary school education institutions in Madiun City. There are still 75 teachers who use Whatsapp Group and only nine teachers who use Learning Management System in the learning process. Based on the results of the survey shows that the learning process that utilizes technology has a significant impact on student abilities [7].

The benefits of e-learning in the learning process can be used as a medium that can manage the learning process [8][9][10]. The use of e-learning can be optimized using the LMS (Learning Management System) method [11]. In this study, the Architecture Design of the development of LMS-based e-learning in Elementary Schools in Madiun City will be described as a downstream of the results of the previous research [6][7]. The e-learning application will be named Pecel-AE (Primary School Learning Madiun), which will function as an application for learning management in elementary schools within the scope of Madiun City.

The development of an application must be adjusted to existing business processes so that the application can become an application that has a positive investment value for an agency. The development process is carried out by creating an architectural design that will be a guideline for application developers [12][13]. The results of this study are architectural design recommendations in the development process of the Pecel-AE application.

II. RESEARCH METHOD

The development of the Pecel-AE e-learning application architecture design uses several stages adopting from the development of the method [14][15] as follows:

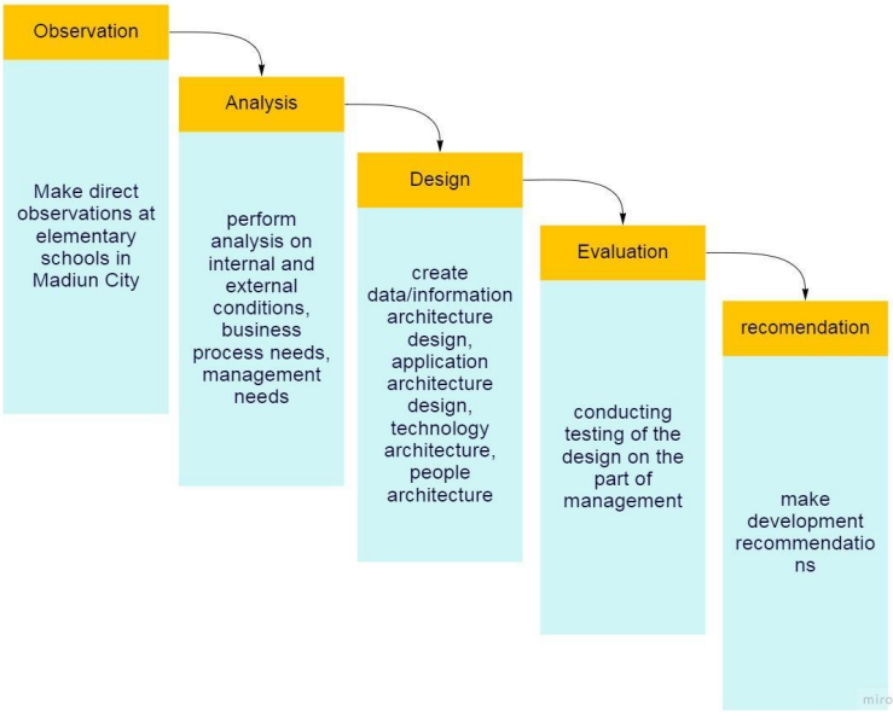

Figure 1. Pecel-AE e-learning application development research method

The development of the Pecel-AE e-learning application includes several stages, as shown in figure 1 above. At the observation stage, observations and data collection is carried out referring to the study [6]. The observation was carried out with Focus Group Discussion activities with principals and teachers from 33 schools within the Madiun City Education Office. The activity continues with data collection to determine the need for developing e-learning applications and utilizing digital media in the learning process.

At the stage of the analysis is carried out an analysis of internal and external conditions, an analysis of the needs of business processes, and the needs of the management in the development of applications. The third stage carries out data/information architecture design activities, application architecture, technology architecture, and human resource architecture for application development. From the results of the analysis and design that has been made, it is continued in the evaluation process on the part of the management/decision maker. The evaluation stage was carried out at two pilot schools, namely SDN 01 Manisrejo and SDN 03 Manisrejo, Madiun City. In the final stage, namely the formulation of short-term and medium-term recommendations for the development of the Pecel-AE e-learning application.

III. RESULT AND DISCUSSION

This study produced an architectural design that will be used as a guide in the development of the Pecel-AE application. The importance of application development design architecture can be an application development framework [12][16][17]. In developing the Pecel-AE e-learning application, it begins with the identification of application development needs that are adapted to running business processes, analyzing internal and external needs, making data/information architecture designs, technology, applications, and human resources [18][19] in providing improved quality of learning at SDN 01 Manisrejo and SDN 03 Manisrejo Madiun City. To produce the results of the appropriate analysis and design, it will be continued with evaluation activities at the policy maker/decision maker. These activities are carried out to align the business process of the learning process with the application to be developed so that the application developed will have investment value for the school. The description of the discussion of each activity is explained as follows:

1. Analysis of internal and external conditions

Aligning application development to suit an agency's objectives can be done by observing the agency's internal and external conditions. Therefore, a study of the internal and external conditions of two experiment schools, SDN 01 and SDN 03 Manisrejo, Madiun City, was conducted at this stage. The results of the analysis of the internal and external conditions of the two experimental schools are as follows:

Table 1. Analysis of internal and external conditions

Analysis of Internal	Analysis of External
1. Human Resources Teachers are more than 50% of the productive age (< 45 years) in the use of technology	1. Digital device users who have penetrated all circles, especially Android phones 2. there are government instructions to

Analysis of Internal	Analysis of External
2. Teachers' understanding of the use of digital media for learning is good, showing a figure of 60% 3. The use of an existing LMS is still challenging to implement 4. Absence of adequate tools to support online learning 5. There are still class teachers/ subject teachers who are still unable to use digital devices as online learning media 6. absence of policies that lead to the readiness of online learning in Internet schools network difficulties	conduct online learning during the pandemic 3. There are free internet network facilities up to 1,750 wifi points in each area within the city of Madiun. 4. Students' level of understanding when receiving online learning is 30% reduced compared to offline learning. 5. There are several systems that teachers must use that will be a burden in their implementation. 6. There are limitations for parents in providing learning facilities for their children

In table 1, there are six analyses of internal conditions, which are the strengths and weaknesses of the experimental school. External conditions were identified; there were six analysis results: threats and challenges. The analysis results will be the source of strategy formulation for developing the Pecel-AE application.

2. Business process analysis of e-learning development

Business process analysis can be a management strategy to carry out activities that run in the industry[20]. The business process needs for the development of Pecel-AE e-learning applications are as follows:

Table 2. Business Process Analysis of e-learning development

Business Process	Description Business Process
Create User	Registering users according to the access provided by the super admin
Log in	Log in to the application by entering the user and password according to the data entered at the time of registration
Add learning class	Creating a class group is carried out by the subject teacher; according to his access, the teacher can carry out several activities in the class
Add learning activity	Conduct learning by adding activities that will record/save activities carried out in each meeting
Add materials	Add material in the form of file files, video files, or descriptions of materials to be delivered to students
Add Assignment	Adding assignments to be given to students, the assignments given can be essay assignments, multiple choices, or files uploaded by students
Create discussion class	Chat rooms can be used as a medium for discussion between teachers and students
Attendance	The attendance of students is carried out by the teacher at each learning meeting
Grade	Assessment of the results of the work done by students, at the end of the meeting, the teacher can recapitulate the grades that

Business Process	Description Business Process
	are generated into Nilai_akhir in the form of numbers and letters. Nilai_akhir can be used as an indicator of the report card value
Print grade recapitulation	The grades of each assignment have been recapitulated and can be printed by the teacher and the administrative officer as a reporting document or archive
Join class	Students can join the meeting class for each course that has been created by the teacher
View materials	Students can view the material that has been uploaded by the teacher at each meeting
Download materials	In addition to viewing materials, students can also download learning materials sent by the teacher .
Send task answer	Assignments undertaken by students can be sent in the form of files (by uploading files) or sending answers/answer choices directly
View grade	Students can see the grade of the work on the work if the submitted work has been graded by the teacher
Print a learning activity recapitulation report	Scoring activities and recapitulation of learning activities can be carried out by teachers, Tus, and Super admins, who will be used as material for monitoring the process and learning outcomes that are held
Add users	Adding data to users who can access it can only be done by super admins
View learning activity	As one of the monitoring activities carried out by the Principal

Based on the description of business processes in table 2 above, the relationship of each business process with the design of the BPMN (Business Process Modeling Notation) business process diagram is depicted. Business process modelling with BPMN is a business process model design that describes the interaction between several related parties in messaging to describe communication between parties in an organization [21][22]. For example, the business process design of BPMN can be seen in figure 2 below:

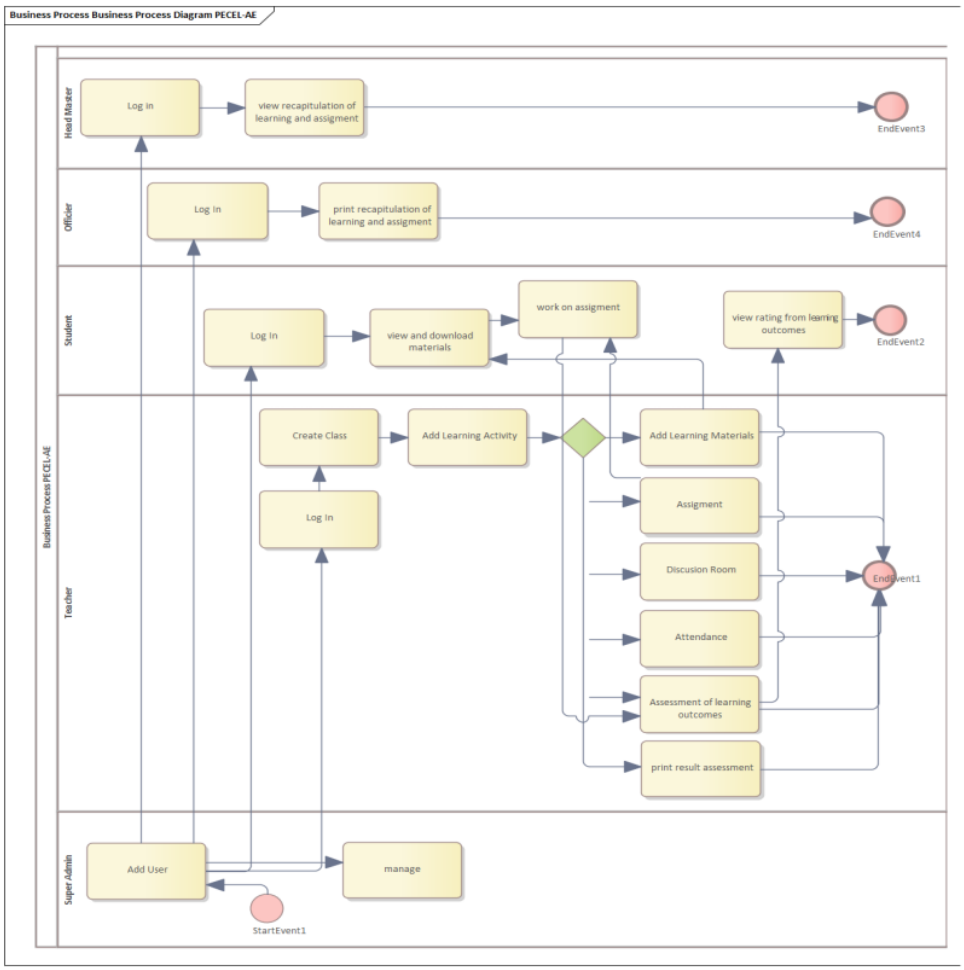

Figure 2. BPMN Business Process Model

Figure 2 depicts the flow of information conveyed by several interrelated parties as users of the Pecel-AE application. From the picture, there are five users who integrate data and information in every business process that runs. The process flow starts from a super admin who has access to add users (teachers, students, operators/Administrative Officers, and principals). Furthermore, the teacher will add several activities to each business process, where the information generated can be used by students, operators/Administrative Officers, and principals.

3. Architecture Desain

Architectural design adjustments to the conditions and business processes running at the agency can be described by the Enterprise Architecture design [23][24][25][26]. In the sub-discussion of architectural design, the development of Pecel-AE will be made of four designs, including: (1) Data / Information Architecture Design, (2) Application Architecture Design, (3) Technology Architecture Design, and (4) People's Architectural Design.

a. Data/Information Architecture Desain

The design of the data and information architecture is depicted in a matrix below:

Table 3. Data and Information Matrix

	user	Log in	Student	Teacher	Subject_Learning	Class	Class_Study	Announcement	Activity	Materi	Materials	Assignment_Essay	Assignment_Upload_File	Assignment _Choice	dt_file_ assignment	Grades	det_grade_ student	attendance_ student	room_ chat
users application	■		■	■															
Data of users who are active with the application	■	■	■	■															
value of learning outcomes			■		■						■	■	■	■	■	■	■		
learning materials				■	■					■									
learning assignment			■	■	■						■	■	■	■	■	■	■	■	
student attendance			■		■	■	■											■	
discussion			■	■	■	■	■												■
recapitulation of the grades of each class			■			■	■									■	■		
recapitulation of the grade of each subject			■		■											■	■		
recapitulation of learning			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■


activities

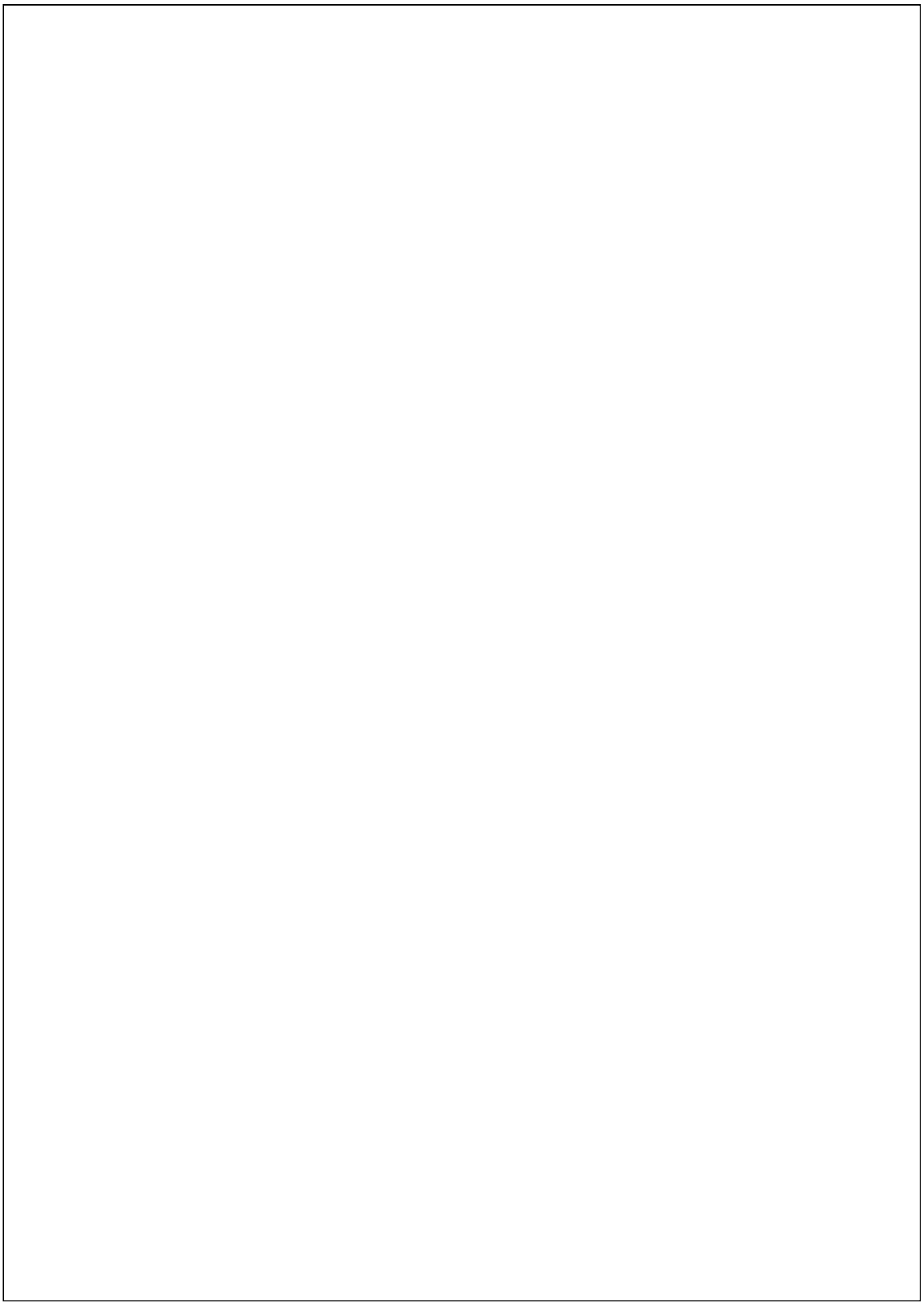

Table 3 above identifies the data needs used in each information processing. From the matrix, there are 19 data and ten information needed. Developers can use the results of this matrix to analyze the integration between data that has been defined so that it is able to produce information as needed.

b. Application Architecture Desain

Application architecture is a conceptual design used to generate information from data processing as a support for the business processes of an agency [14][27]. The application architecture design in figure 3 below illustrates the relationship between business processes that have been identified with users who have access rights in Pecel-AE applications as recipients of the information. For example, the architectural design

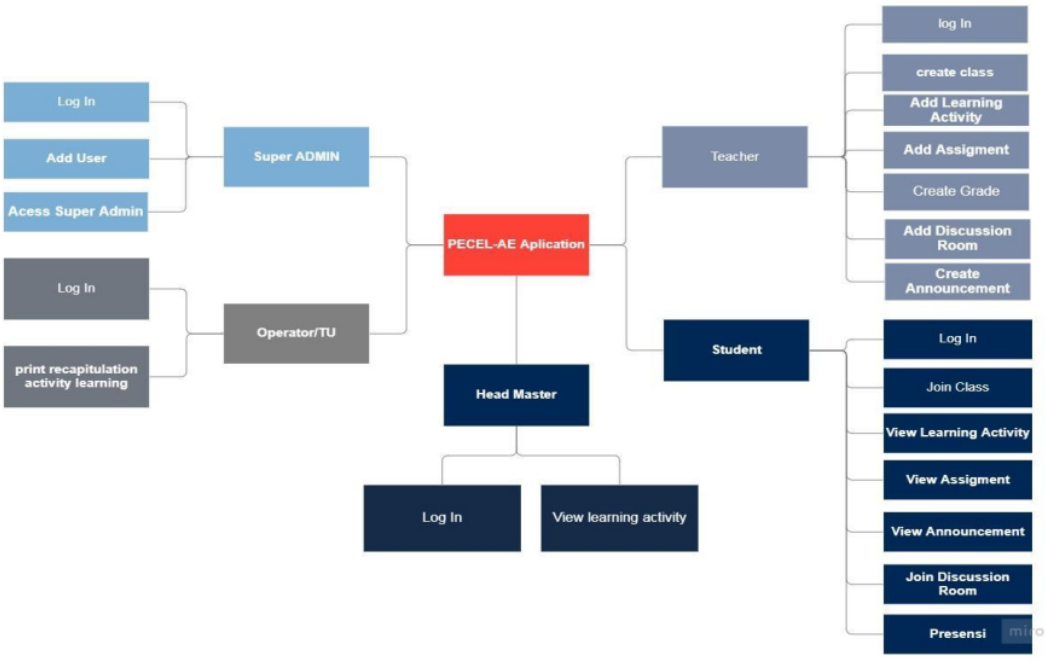

Figure 3. Application Architecture Design Pecel-AE

The portfolio design of the Pecel-AE application describes the integration between application users and the information needs of each defined business process. Therefore, this portfolio design can be used by application developers as a conceptual guide to align information needs with running business processes.

c. **Technology Architecture Design**

The technology architecture describes the hardware, software, and network requirements needed for application development [27][28]. Figure 4 shows the network topology design used in the architectural design of the Learning Management System technology for elementary schools in Madiun. The network topology used is the Topology Ring with the Data Center scheme divided into each region with users according to the regions that have been divided. Server workloads are not centralized on a single server. Periodically the data can be pulled or backed up to the Madiun City data center. By using a topology ring, if there is a problem on one server, you can use another closest server.

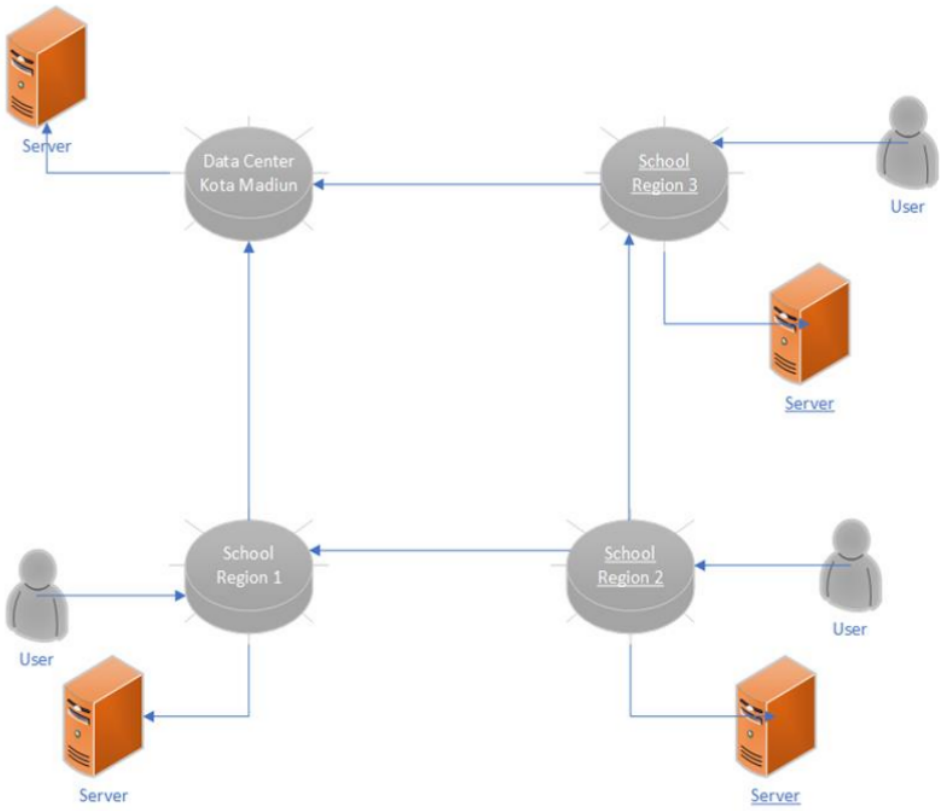

Figure 4. Topology Image Network design architecture technology Learning Management System Madiun City.

Figure 5 is an N-Tiered Client-Server Architecture design in each School Region

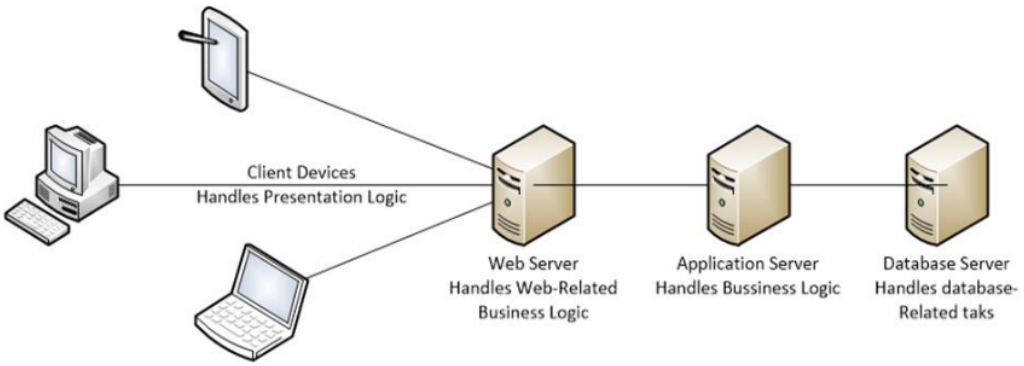

Figure 5. N-Tiered Client-Server Architecture

From the architecture design of LMS elementary school in Kota Madiun, table 4 describes the minimum specifications required by its use

Table 4. Specification of Device Requirements for Server and Client

	Standard Client	Standard Web Server	Standard Application	Standard Database Server
Operating System	a) Windows : Win7 or Later b) Mac : OS X El Capitan 10.11 or later c) Linux : 64-bit Ubuntu 18.04+, Debian 10+, openSUSE 15.2+, or Fedora Linux 32+ d) An Intel Pentium 4 processor or later that's SSE3 capable e) Android Android Marshmallow 6.0 or later	Linux	Linux	Linux
Special Software	PDF Reader	Apache	Java	MySql Postgree Sql
Hardware	a) Webcam/Camera phone b) Intel Dual Core or later c) 16 inch lcd Monitor	a) 1 TB DISK Drive b) Intel® Xeon® E-2200 c) Quad Core	a) 1 TB DISK Drive b) Intel® Xeon® E-2200 c) Six Core	a) 2 TB DISK Drive b) RAID c) Eight Core
Network	Always-on Broad-brand, preferred Dial-up at 56 Kbps,	Dual 100 Mbps Ethernet	Dual 100 Mbps Ethernet	Dual 100 Mbps Ethernet

	Standard Client	Standard Web Server	Standard Application	Standard Database Server
	possible with some performance loss			

d. People Architecture Design

According to the architectural design of the Pecel-AE application development, human resources are needed who will carry out the execution and implementation of the results of the analysis and design that has been designed. The need for human resource specifications is stated in table 5 below:

Table 5. Specification of Human Resources needs Pecel-AE application development

Job	Qty	Job Descriptions
Project manager	1	Controlling the development of the Pecel-AE application
Analyst System	1	performs an analysis of functional needs and non-functional needs, designs the process design of Pecel-AE application development and is responsible for the results of application development in accordance with the objectives
Programming	2	design the application development flow with a FLOWCHART/SEQUENCE diagram which will then be used as a reference for the application development flow. Write application development program code according to predetermined specifications
Designer UI/UX	1	design the appearance of the application and define the flow of application usage so that an application can be easily used by users.
Networking Administrator	1	Make network planning, implementation of network installation, maintenance, and troubleshooting of network use in application development
Database administrator	1	conducting analysis of data and information needs. Make data designs, configure database hardware and software, perform data security, and optimize data operations so that they are able to present information according to to needs.

From table 5, there are two levels of human resource needs. First, at the management level, there is a Project Manager who has the authority to exercise control over the course of application development. Meanwhile, at the implementing level, each development process is controlled by human resources who have competence and expertise in their fields.

4. Evaluation

In this study, an evaluation was carried out on the results of the design of the architectural design for the development of the Pecel-AE application. In addition, the evaluation was carried out on the policy determinants, namely 2 principals and 35 teachers as prospective users from SDN 01 and SDN 03 Manisrejo, Madiun City. Table 6 below is the result of an evaluation of the architectural design of the Pecel-AE application.

Table 6. Pecel-AE Application Evaluation

	Testing components	Percentage weight	Feedback	Analysis
		Business process		
A1	Proposed business processes in accordance with the activities required on the Pecel-AE application	84%	Agree	adjusting for optional changes in activity
A2	Business process analysis according to user access needs	81%	Proposals can be piloted in stages on a limited scale	Reviewing the suitability of business processes to user access needs
A3	Analyze business process alignment with application usage flow	88%	Agree	Reviewing the changes that have occurred
		Information and Data		
B1	suitability identification information required on Pecel-AE applications	86%	Agree	Assessing any changes that occur
B2	Conformity of data identification to information needs	81%	Proposals will be adapted to changes to information needs	Assessing any changes that occur
		Application		
C1	Pecel-AE application developed in line with the needs of the learning business process	86%	Agree	Assessing any changes that occur
C2	The suitability of each user's access to obtain relevant information	81%	The proposal will be piloted on a limited basis in the design of UI/UX design	Adjusting to your needs
		Technology		
D1	The design of the proposed technology in accordance with the investment capabilities	81%	There needs to be a reassessment	Adjusting to your needs
		People		
E1	Proposed human resources in accordance with the budget	81%	There needs to be a reassessment	Adjusting to your needs

The presentation of the evaluation results in table 6 is obtained from the analysis of survey questionnaires filled out by the management level (Principal) and user level (Class Teacher) from SDN 01 Manisrejo and SDN 03 Manisrejo with a total of 37 respondents. To get the percentage weight in the evaluation, use the formula below:

$$Percentage\ weight = \frac{answer}{Total\ Respondents} + 100 \quad (1)$$

5. Recommendation

The recommendations presented in this study are in the form of a development picture of the results of architectural analysis and design in the short term (1 year) and medium term (5 years) in the form of a roadmap. Figure 6 below describes the recommendations given at the development, maintenance, and operational stages of the Pecel-AE application.

	DATE: 2022 - 2023	DATE 2023 - 2028
	Short Term	Long Term
Development	limited evaluation and trial of the implementation process	adjustment of business process needs by providing access to integration with other applications in the elementary school environment in Madiun City adjustment of mobile-based application needs increased use of technology tailored to the number of users
MAintenance	limited evaluation and trial of the implementation process	limited evaluation and trial of the implementation process

Figure 6. Recommendation Development Pecel-AE

IV. CONCLUSION

Research on developing LMS-based e-learning applications produces architectural analysis and design that can be used as a guidance document for developing Pecel-AE applications. The analysis carried out includes an analysis of internal and external conditions that will examine the formulation of application development strategies. In addition, a business process needs analysis that is integrated with the information needs of each application user can be a guide for developers in processing data. The architectural designs made are data/information architecture, application architecture, technology architecture, and people architecture. In the final stage, an evaluation is carried out on stakeholders as a policy basis that will be used to formulate recommendations for developing the Pecel-AE application.

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