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OPTIMIZING LEARNING ENVIRONMENTS: A LITERATURE REVIEW ON MICROSERVICES FOR MOODLE QUALITY IMPROVEMENT

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ABSTRACT

This paper explores the optimization of Moodle, an open-source learning management system, with a focus on the role of its architecture in improving quality and functionality. Architectural innovation was emphasized as critical to improving the quality of Moodle, with its open-source nature enabling community involvement to improve resolution, security, and evaluation. Moodle is an open-source learning management system (LMS) designed to provide an online learning environment. This research uses a literature review method to collect data from previous studies and literature related to Architectural Innovation and its relationship with academic information systems, namely Moodle. The review introduces the concept of microservices as a potential solution to overcome challenges in content, interface, navigation and technical aspects. Microservices offer independent development opportunities, address usability issues and improve responsiveness. The conclusion highlights that implementing microservices in Moodle not only promises to improve quality but also provides a foundation for meeting the evolving and dynamic needs of users.

I. INTRODUCTION

An Academic Information System (AIS) is a system designed to assist the management and management of information in educational environments, especially in educational institutions such as schools, colleges or other educational institutions. Academic Information Systems (AIS) refer to web-based information systems that are used in higher education to manage various academic processes, including student registration, course registration, evaluation, graduation, and management of alumni information [1], [2]. In its implementation, AIS involves the use of database software and other components to automate processes and ensure efficient management of academic data [3]. As a technology-based system, AIS's main goal is to increase the efficiency and effectiveness of institutional academic services, provide support in decision making for students and lecturers, and facilitate access to academic-related information [4].

By utilizing information technology, AIS is able to provide accurate and timely information to students, lecturers and administrators, thereby increasing operational efficiency and reducing overhead costs [5]. Overall, Academic Information Systems include the use of computer technology or websites by educational institutions to design information systems that support various aspects, such as production, quality management, decision making, and problem solving in higher education [6].

Moodle stands out as a robust virtual environment, revered for its adept support of traditional learning systems and its facilitation of the effective organization of learning materials [7]. Its multifaceted functionalities encompass the creation and delivery of online courses, meticulous management of course materials, seamless communication channels between students and educators, and comprehensive tracking of student progress [8]. The inherent strengths of Moodle are rooted in its modularity, providing a flexible framework for managing the learning process, as well as its user-friendly features, allowing for the easy publication of training materials and adherence to

international standards [9].

Beyond its technical attributes, Moodle extends its reach into the realm of educational flexibility, offering a spectrum of services that cater to the diverse needs of both educators and students. This inclusivity translates into enhanced flexibility concerning the space, time, and pace at which students engage with their learning materials [10]. The widespread adoption of Moodle as a leading learning system and content management software package in North American and European universities is a testament to its adaptability, accommodating various teaching modes such as blended learning, ubiquitous learning, and flipped classrooms [11]. Acknowledged for its pivotal role, the utilization of Moodle is credited with improving the quality of distance learning and contributing significantly to the overall progress of educational initiatives [12].

Apart from Moodle, a number of other open source learning management systems are also popular and widely adopted by educational institutions, including ATutor and Edmodo. The Table I details a comparison between Moodle and the two open source platforms.

TABLE I
COMPARISON OF MOODLE WITH OTHER LEARNING MANAGEMENT SYSTEMS

Category Features	Moodle	Edmodo	Atutor
Implementation	- Requires server installation and detailed configuration. - Can be customized and modified.	- Cloud-based service, without the need for a local server. - User friendly user interface.	- Local server installation or in the cloud. - Suitable for various technical skill levels.
Functionalities	- Rich features like discussion forums, task management, quizzes. - Powerful scoring system.	- Focus on collaboration and communication. - Group feature for collaboration. - Third party application integration.	- Powerful learning tools, such as quizzes and discussions. - Increased focus on accessibility.
Architecture	- PHP based, uses SQL database. - Modular with extension and plugin support.	- Cloud based, provider managed backend infrastructure. - Responsive interface using modern web technologies.	- Based on PHP and MySQL. - Modular and focused on security.
Authorization	- Flexible role system, authorization levels can be customized. - Course and user level access control.	- Centralized authorization. - Simpler access control.	- Role system that supports authorization as needed.

Optimizing the quality of Moodle, an open-source learning management system, is critical to ensuring a positive learning experience for students. Moodle architecture plays an important role in improving its quality and functionality. According to Jackson, Moodle's architecture enables the implementation of pedagogical strategies that align with the three interconnected discourses of good education: qualification, socialization, and subjectification [13]. These strategies aim to enhance student learning, increase teaching effectiveness, and facilitate overall understanding and use of reading strategies.

Architectural innovation plays an important role in improving the quality of Moodle. According to [14] view, innovation can undergo changes depending on the core design concept of technology, and types of innovation can be differentiated based on core design relationships. The difference between Modular innovation and Incremental innovation is based on the extent of the intensity of the core technology concept. Likewise the difference between Architectural and Radical innovation also depends on the degree of significant modular innovation. Below in Figure 1 is the classification of types of innovation according to Henderson and Clark.

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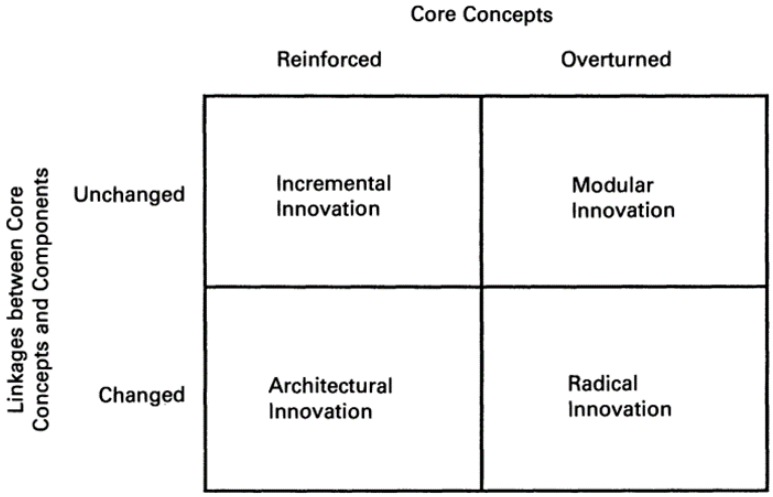

Figure. 1. A framework for defining innovation.
(Reference: Henderson and Clark (1990)

Architectural innovation refers to the reconfiguration of an existing system by connecting existing components in a new way while maintaining the core design concepts and knowledge underlying those components [15]. Architectural innovation plays a crucial role in directing the development of system effectiveness and efficiency, especially through the adoption of advanced technologies such as the Industry 4.0 approach and the Internet of Things (IoT) [16]. Successful architectural innovation not only creates attractive forms but can also provide significant competitive advantages [17]. This innovation is not limited to the creation of new structures, but also involves the reconfiguration of existing systems, connecting existing components in new ways to improve performance and adaptability [18].

Architectural innovation refers to the development of new structures or designs that not only increase the capacity of architectural representation but also improve the performance of the entire system [19]. In this context, [20] view emphasizes that architectural innovation, which involves the introduction of new and creative ideas in the field of architecture, has a significant connection with the development of information systems. The integration of information technology in architectural design not only creates smart buildings, but also strengthens sustainability and comfort through data analysis and better decision making. Thus, architectural innovation becomes an important basis for directing the evolution of built systems towards a more efficient, adaptive and competitive direction in the era of modern technology. Architectural innovation becomes crucial in advancing the effectiveness and efficiency of systems through the application of advanced technology such as the Industrial approach 4.0 and IoT [16].

Different online Learning Management Systems, such as Moodle, focus on their framework architecture to enhance the core functionality of e-learning systems [21]. The impact of architectural innovation strategies on the learning environment can be very significant. By implementing a flexible interface and being able to track student activity, Moodle can transform the collected data into valuable learning analytical information [22]. This allows educators and administrators to gain insight into student behavior and adjust their teaching strategies accordingly. Additionally, Moodle's architecture aligns with distance education principles and accommodates adult learning theories, such as experiential learning and project-based learning.

Through a deep understanding of the available literature, we aim to illustrate how the implementation of microservices can contribute to optimizations ranging from the user interface to improving the overall performance and responsiveness of the system. This literature review is aimed at providing comprehensive insights regarding the role and positive impact of microservices in optimizing learning environments, with a special focus on the Moodle platform.

II. RESEARCH METHOD

This research uses the literature observation method (literature review) to collect data from previous studies. The flow of the literature review can be seen in Figure 2.

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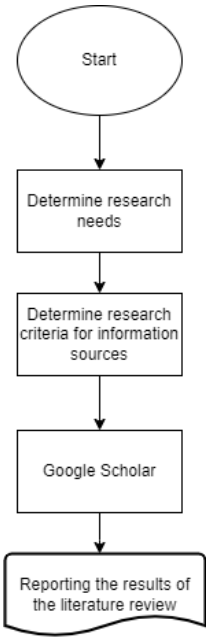

Figure. 2. Flow of literature review

The first step in conducting a literature review is to determine research needs, namely literature related to Architectural Innovation and its summary using an academic system, namely Moodle. Once research needs are determined, the second step involves establishing criteria for the sources of information to be used. This criterion covers publication years from 2017-2023 with source types including journal articles, books and conferences. Furthermore, literature related to academic information system architectural innovation, with Moodle case studies, was identified through an electronic database, namely Google Scholar. The author presents various literature to enrich insight and understanding regarding architectural innovation to support Moodle's sustainability. A literature search was carried out using keywords such as Architectural Innovation, Academic Information Systems, Moodle, and Microservices.

III. RESULT

A. Moodle Issues

Some of the challenges faced in developing and using a learning management system such as Moodle involve a number of aspects. These challenges include issues with content, interface, navigation, computer anxiety, and lack of social presence [7]. Apart from that, there are technical problems, such as only text-based communication between teachers and students, as well as system instability [23].

A study conducted by [24] revealed 15 main problems, including system status visibility, compatibility between the system and the real world, user control and freedom, consistency and standards, error prevention, uniqueness and efficiency of use, aesthetic and minimalist design, helps users recognize, diagnose, and remediate errors, as well as help and documentation. The most common issues encountered include system state visibility, compatibility between the system and the real world, consistency and standards, uniformity and efficiency of use, aesthetic and minimalist design, and help and documentation.

[25] highlighted students' difficulties in using Moodle due to its user-unfriendly interface and confusing range of functions. Some common usability issues with Moodle's desktop and mobile interfaces, including difficulty in submitting assignments, inconsistencies in font size and color, and screen size make it difficult for users to read and use Moodle effectively [26]. Challenges in submitting assignments and inconvenience in using desktop and mobile interfaces are also usability issues identified in previous research [27]. Additionally, students have reported difficulties with communication organization in Moodle, particularly in controlling discussions and managing daily updates and notifications [28].

Although Moodle is a popular learning management system, there are architectural issues that need to be addressed. [29] found scalability issues, lack of modularization, and difficulty in customization as some of the architectural challenges in Moodle. [30] highlights that an increase in the number of users can lead to technical limitations, especially in the aspect of scalability, and points out the weaknesses of existing solutions in Moodle.

Based on the literature above, the issues found in Moodle can be categorized as shown in Table II.

TABLE II
CATEGORIZATION PROBLEM

Problem Category
User Experience
Technical
Design and Navigation
Architecture

B. *Microservices for improving the quality of Moodle*

Implementing a microservices architecture can be a potential solution to overcome a number of challenges faced in the development and use of learning management systems such as Moodle. Microservices enable the design of systems consisting of independent services, breaking down the overall complexity into smaller units [31].

In the context of user needs such as unfriendly interfaces and functional complexity, microservices can provide a solution by allowing optimization and development separately for each service. Web-based platforms supported by microservices can provide a more intuitive and efficient interaction experience for users [32]. The implementation of microservice architecture allows flexibility and reuse of existing system parts, because microservices are independent and can be developed using programming languages and functions different [33]. This can increase flexibility and efficiency of use, especially in handling tasks such as submitting assignments and accessing the platform. This flexibility allows the system to adapt to changing and evolving needs, ensuring scalability and efficient utilization of resources [34]

Scalability and modularization issues can also be addressed with a microservices approach. By decomposing the system into separate units, microservices can also fix Moodle's architectural problems, including lack of modularization and difficulty in customization. Each service can be independently elasticized to respond to an increasing number of users, while modularity allows for more effective customization and development [35]; [36]. Microservices enable academic information systems to handle various workloads efficiently [32], [37], [38].

Using a microservices architecture in Moodle can provide a number of significant improvements and enhancements. Below in Table III are several things that can improve the quality of Moodle through the implementation of microservices.

TABLE III
IMPROVED QUALITY OF MOODLE WITH MICROSERVICES

Improved Moodle with Microservices	Description
User Interface Troubleshooting and Functional Complexity	Microservicing allows separate optimization and development for each service. Thus, the problems of unfriendly user interfaces and functional complexity can be addressed through independent improvements to each service.
More Intuitive and Efficient User Interaction	A web-based platform powered by microservices can provide a more intuitive and efficient interaction experience for users. The independence of each service allows the development of better functionality, increasing overall user satisfaction.
Handling Scalability and Modularization	Each service can be independently elasticized to respond to an increasing number of users. The modularity of microservices provides a solution to the scalability problem and allows for more effective development and customization as needed.
Handling Diverse Workloads	Microservices enable Moodle to handle a variety of workloads efficiently. This is crucial in an academic environment that often has varying demands regarding the use of information systems.

Successful implementation of microservices depends on proper design, good service management, and coordination between services to achieve efficient integration. Thus, microservices offer a potential approach to improving the responsiveness, scalability, and overall performance of learning management systems such as Moodle.

C. *Potential Risks and Challenges Implementation Microservices in the Moodle*

Microservices architecture has gained significant attention in recent years due to its ability to promote modularity, scalability, and maintainability in software systems [39]. Implementing microservices in the context of Moodle, an open-source learning management system, may present several risks and challenges. These include the potential for increased complexity in deployment and management, the need for efficient communication between microservices, ensuring data consistency among different services, and properly implementing security measures to protect sensitive information [40]. Furthermore, integrating microservices into an existing infrastructure may require significant changes to the current system, potentially disrupting user experience or causing compatibility issues with other functionalities [41]. Overall, successfully implementing microservices in the context of Moodle requires careful planning, thorough testing, and effective communication between development teams to address these potential risks and challenges [42]. Additionally, addressing the potential impact on performance and system monitoring is crucial to ensure that the overall system remains stable and responsive. Furthermore, it is essential to consider the potential impact on the user community and provide comprehensive documentation or support to assist users in adapting to the changes introduced by the implementation of microservices in Moodle.

IV. CONCLUSIONS

Implementing microservices architecture in learning management systems such as Moodle offers significant solutions to challenges such as content, interface and navigation issues. By enabling the development of independently optimized services, microservices increase the responsiveness and flexibility of the interface, addressing the complexity of functions and user needs. In terms of usability, microservices provide a more user-friendly interface, improving the overall experience and addressing student confusion. Additionally, separate development allows for improvements in task submission and platform access, either through desktop or mobile interfaces. Microservices can be a suitable solution to architectural challenges, offering modularity and elasticity to scale and adapt to a growing number of users. In conclusion, implementing microservices architecture in Moodle not only promises to improve the quality of learning management systems but also builds a strong foundation to meet the ever-evolving and dynamic needs of users.

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