(*) Corresponding author
DOI: 10.20544/nhjsr.2026.600

EFFECTIVE STRATEGIES FOR SCALING AND PERFORMANCE OPTIMISATION IN MOODLE LMS

Antonela Naumoska (undergraduate student)*
Faculty of Information and Communication Technology
naumoska.antonela@uklo.edu.mk

Angela Petrova (undergraduate student)
Faculty of Information and Communication Technology
petrova.angela@uklo.edu.mk

Marija Mihajlova (undergraduate student)
Faculty of Information and Communication Technology
mihajlovska.marija@uklo.edu.mk

Andrej Toseski (undergraduate student)
Faculty of Information and Communication Technology
tosheski.andrej@uklo.edu.mk

Natasha Blazheska-Tabakovska (advisor)
Faculty of Information and Communication Technology
ORCID ID: 0000-0002-6796-7190
natasa.tabakovska@uklo.edu.mk

ABSTRACT

The adoption of a Learning Management System (LMS) offers numerous advantages, and universities should actively promote its use while prioritising effective and innovative learning strategies. As the platform becomes an essential part of teaching and assessment, the LMS database naturally grows over time due to the accumulation of course materials, user activity, logs, and gradebook data. Without proper monitoring and maintenance, this expansion can negatively affect system performance, response times, and overall user experience. Therefore, one of the key factors for ensuring the efficient use of an LMS is the systematic management of database growth and system performance. This paper examines practical strategies for manage database expansion and optimizing the performance of the Moodle system at the University "St. Kliment Ohridski" – Bitola. Through detailed database analysis, evaluation of archiving mechanisms, configuration options, and automation processes, a structured approach is proposed. The aim is to ensure long-term platform stability, improve efficiency, reduce server load, and maintain data integrity through well-designed archiving and cleanup policies.

Key words: Learning Management System (LMS), Moodle, system performance, archiving strategies, platform stability.

1. Introduction

The learning characteristics of the 21st century are shaped by new approaches in the use of ICT in education. Modern learners engage with technology-enhanced environments that promote interactive, personalised, and collaborative learning experiences. To support these

evolving learning needs, Learning Management Systems (LMS) have become essential tools. A Learning Management System is a web-based software application that is designed to handle learning content, student interaction, assessment tools and reports of learning progress and student activities (Nasser and et al. 2011). An LMS is characterised by its ability to integrate multiple media types, support different languages and resources, accommodate alternative technologies, and present information in a structured and organized manner. Its primary purpose is to facilitate learning through interaction and engagement (de Oliveira, de Almeida Cunha and Nakayama 2016). Among Learning Management Systems, there are two main types: commercial and open-source platforms (Kasim and Khalid 2016). Open-source LMSs offer flexible, customizable, and cost-effective alternatives. Moodle is one of the most widely adopted open-source platforms and is extensively used in higher education worldwide. The term Moodle is an abbreviation of Modular Object-Oriented Dynamic Learning Environment. It stands out due to its modular design, extensive plugin ecosystem, and strong community support, making it an ideal choice for institutions seeking a versatile and adaptable learning environment (Moodle 2025).

Like other Learning Management Systems, Moodle offers a wide range of features designed to enhance the learning experience. One important concept is the removal of physical location barriers (Holmes and Prieto-Rodriguez 2018), making eLearning especially beneficial for students with health problems or disabilities (Alam, Hadgraft and Alam 2014). Accessibility is a key feature, ensuring that all learners can engage with the content (Aldiab, et al. 2019). LMS platforms also provide an attractive learning environment, often incorporating gamification or educational video games to increase motivation and engagement. While some features may vary depending on the users' needs and requirements, LMSs are highly flexible and can be customised or integrated with additional tools to meet specific demands. In some cases, advanced integrations such as virtual laboratories or remote laboratories can further enrich the learning experience (Alkhaldi, Pranata and Athauda 2016). The adoption of an LMS offers numerous advantages, and universities should encourage its use while focusing on effective learning strategies through its rich set of tools and functions to achieve pedagogical objectives (Al-Hunaiyyan, Al-Sharhan and AlHajri 2020). However, the implementation of an LMS also brings many challenges. The LMS itself may not always be the optimal solution for student engagement in teaching and learning (Daniels, et al. 2013), as it demands significant responsibility and technical skill from instructors due to its technical nature. The complexity of the LMS interface can pose additional difficulties. Challenges can be categorised into personal, technological, and institutional limitations. Personal factors include instructors' confidence and awareness of the LMS's potential, as well as their ability to utilise tools and resources that enrich the teaching and learning process. Technological factors involve infrastructure, technical support, network bandwidth, and the availability of communication and collaboration tools. Institutional barriers include strategic planning, management support, motivation, and training. Another important type of challenge arises in the area of scaling and performance optimisation, which requires appropriate strategies to ensure that the LMS can efficiently handle growing numbers of users and resources without compromising system performance.

A scalable LMS dynamically adapts to an increasing number of users and the associated data volumes without compromising performance. Insufficient scalability can lead to system overload, causing slow response times that significantly hinder the learning process. To effectively address these challenges, the LMS's technological foundation must be carefully planned and implemented. Additionally, efficient data management and performance optimisation are crucial to maintaining system stability and speed as the user base grows.

This paper proposes a strategy for managing database growth and optimising the performance of the system at the University "St. Kliment Ohridski"– Bitola, noting that the implementation of Moodle at the University is still in its early stages (MoodleUKLO 2025).

Considering the system is at its initial development phase, it is crucial to plan carefully for database management and performance optimisation from the very beginning to ensure long-term stability and efficiency. The proposed strategy is based on four key components: investigation, analysis, policies, and configuration. Together, these components form an integrated approach that ensures long-term stability and optimal system performance, enabling the seamless operation of e-learning, which is a fundamental part of the modern academic process.

Within the database analysis, the tables that grow most rapidly are examined, and data that is retained for excessive periods is identified. Although the user table does not grow rapidly, it raises the question of whether student data should be retained after graduation. Additionally, storing multimedia resources such as videos, images, and assignments presents a significant challenge due to their substantial impact on database size.

The paper is structured as follows: Following the introduction, the first section focuses on archiving completed courses and creating new courses for the upcoming academic year in the context of database management. The subsequent section addresses the automatic organisation and allocation of storage space. This is followed by a section on cleanup and archiving mechanisms, including tools such as cron jobs, auto-delete, and trash functions, as well as other techniques to improve reading and system performance. Finally, the paper concludes with a summary of the key findings and contributions.

2. Course Archiving and Renewal Strategies

2.1. Archiving Strategies for Completed Courses

To maintain an organized and efficient learning environment, it is important to implement strategies for archiving completed courses. A good approach is that, at the end of each semester or academic year, courses that have been successfully conducted are moved into a separate category called “Archived Courses”. This approach ensures clear organization of the teaching process while reducing the load on the active Moodle system. Archived courses are not visible to the public and are accessible only to teachers and students who were enrolled in them.

During this phase, students have read-only access, which means they can review materials, grades, comments, and other content, but cannot edit or add new activities. Use a different Moodle theme: End-users are likely to be confused with many instances of Moodle archives and with the production Moodle instance. In order to prevent this, it is necessary to use some visual indications that will tell end-users that they are viewing a particular Moodle archive site, not the production site. Using a different Moodle theme with a distinct banner or background image can help (Sarker, Matthews and Gramp 2013). This ensures the preservation of academic history and allows valuable teaching data to be maintained for analysis, reuse of materials, or verification of achievements.

For instance, a course like *Business Information Systems – 2024/2025* could be moved to the *Archive → 2024/2025* category and remain accessible for a period of two to three years. After this period ends, the course may be deleted or transferred to a separate archival system, in accordance with university policies. This archiving model represents a best practice applied by several European universities, including the University of Rijeka, providing a sustainable solution for managing large volumes of teaching data within e-learning systems (University of Rijeka 2024).

2.2. New Course Development and Configuration

Creating new courses for the upcoming academic year is a crucial process that ensures continuity and efficiency in teaching. Teachers can make a backup of an existing course and

then restore its content into a new course intended for the next academic year. This way, all existing materials, such as lectures, assignments, quizzes, and resources, are easily transferred to the new version of the course.

After the transfer, teachers can update and adapt the materials by adding new lectures, assignments, activities, and deadlines according to current curricula. It is recommended that such resources be stored externally, while only references or file paths are maintained within the database. This approach significantly saves time and effort, as teachers do not need to create a course from scratch every year, but only make necessary adjustments and improvements. Other changes to this site configuration should include removing guest login, disabling e-mail sending etc (Sarker, Matthews and Gramp 2013).

This practice not only simplifies administrative processes but also contributes to continuous quality improvement and enhancement of teaching materials, ensuring a more effective and modern educational experience.

3. 3. Automatic Course Organization and Storage Management

For more efficient resource management and better data organization, the IT department can configure the Moodle platform so that processes are executed automatically and in a systematic manner. This includes several key functions:

- Automatic archiving of courses at the end of each semester, ensuring that all teaching materials and related data are preserved for future review or analysis.
- Deletion of courses older than three to five years, after notifying the teachers, to optimize storage and maintain an up-to-date and manageable database.
- Storage of backups in a secure location, either on a server or in the cloud, to guarantee data safety and accessibility even in case of technical issues.

This practice has already been implemented at the University of Rijeka, Croatia, where it has proven to be an effective model for maintaining system stability and organizational clarity.

Furthermore, with each academic year, the gradebook grows larger and more complex, which may affect system performance. Therefore, it is advisable to archive these data along with the course to reduce system load and ensure faster and more efficient functioning of the Moodle platform.

4. Strategies for Data Cleanup and Archiving Mechanisms

Ensuring the long-term stability and optimal performance of the Moodle system requires well-defined policies and automated mechanisms for database maintenance and archiving. These measures help keep the database organized, prevent unnecessary data accumulation, and enable faster access to current course information. For instance, to prevent new enrolments in archived courses, the archive site must restrict any additional student registrations. This can be achieved by disabling or hiding all enrolment plugins within the Moodle site administration settings (Sarker, Matthews and Gramp 2013).

Recommended policies may additionally include measures such as:

- **Course size limits**, to prevent excessive server load and ensure efficient use of storage resources.
- **Active course duration**, after which courses are automatically archived or transferred to a designated category.
- **Regular rotation of logs and backups**, ensuring outdated information is systematically removed and backups are refreshed.

Archiving plays a crucial role in sustaining database efficiency. Data that is no longer actively used can be moved to dedicated tables or archival databases, stored either on the main server or on a separate archival system. This frees up space in the active database,

improving system performance and the overall user experience (Hellerstein, Stonebraker and Hamilton 2007).

A practical example is the archiving of courses at the end of each semester, along with all associated materials, including assignments, grades, and activity records. These archived courses can then be retained until the following academic year, when they may be reactivated or updated as needed.

Automation of these processes can be achieved using cron jobs, which allow the system to perform tasks on a regular schedule without manual intervention:

- One cron job automatically archives completed courses.
- Another cron job deletes data that is no longer required.
- A third cron job performs regular database backups, for example, weekly, and retains them for a defined period, such as 30 days, on a dedicated server or external cloud service.

Implementing these strategies ensures high levels of data security, minimizes the risk of data loss, and maintains fast, stable, and reliable system performance over time.

5. Other Techniques to Improve Reading Performance

In addition to archiving and database cleanup, achieving faster and more efficient access to data in the Moodle system requires the implementation of additional techniques aimed at optimizing reading performance. These methods focus on reducing system response time and enhancing the overall user experience.

One of the most commonly applied techniques is **indexing** of columns frequently used in searches and filters, such as identification numbers (IDs), dates, email addresses, and similar fields. Indexes enable quicker retrieval of data without the need to scan entire tables. However, careful consideration is needed, as indexing increases memory usage and can prolong the time required to write new data. Therefore, indexes should only be created where they are truly necessary.

Another important technique is **reducing data duplication.** This can be achieved by normalizing the database at least to the third normal form (3NF), eliminating redundant information and saving storage space. While normalization may lead to slightly more complex queries due to the need to join multiple tables, the benefits outweigh the costs, resulting in a cleaner, more efficient, and easily maintainable database structure.

A third technique involves **caching**, which can be implemented at the API or client application level. By temporarily storing frequently accessed data, caching reduces the number of database queries and accelerates page loading. It is important, however, to distinguish between static and dynamic data—data that must always be presented in its most up-to-date version should not be cached, as its accuracy depends on each fresh query to the database.

In a particular day of every week, a two-hour scheduled Moodle maintenance outage can be advertised to the end-users. During this maintenance period, Moodle upgrades or occasional security patches can be applied to the production server. However for an outage occurring during standard work hours, or one that is longer than 2 hours, end-users must be contacted to see if there is any potential impact e.g. scheduled online examinations or online submission deadlines (Sarker, Matthews and Gramp 2013).

By applying a proper combination of these techniques—indexing, normalization, and caching—system performance can be significantly improved, database load can be reduced, and the Moodle platform can operate in a stable, fast, and reliable manner.

6. Conclusion

This study demonstrates that carefully managing database growth and system performance can greatly enhance the stability, efficiency, and sustainability of Moodle-based e-learning. Implementing strategies such as archiving, automation, and performance optimization policies is essential for maintaining a balance between accessibility, speed, and data security.

By adopting best practices from institutions like the University of Rijeka and integrating modern IT solutions, University “St. Kliment Ohridski”– Bitola can advance its Moodle system to a higher level of technical and pedagogical maturity. Systematic archiving and automated maintenance allow teachers to focus on improving course content and teaching methods, while students benefit from uninterrupted access to learning materials, historical records, and updated resources.

Furthermore, these strategies ensure the long-term sustainability of digital education by keeping the Moodle platform scalable, reliable, and efficient as the number of users and volume of content grows. Proper implementation guarantees high system performance, faster access to information, and a well-organized, secure environment for both instructors and learners.

Overall, this approach strengthens both the technological infrastructure and the quality of teaching and learning, establishing Moodle as a central tool for modern, flexible, and effective education.

REFERENCES

1. Nasser, R., and et al. 2011. "Factors That Impact Student Usage of the Learning Management System in Qatari Schools." *International Review of Research in Open and Distance Learning* 12 (6): 39–62.
2. Kasim, N. N. M., and F. Khalid. 2016. "Choosing the Right Learning Management System (LMS) for the Higher Education Institution Context: A Systematic Review." *iJET* 11 (6): 55-61.
3. Holmes, K.A., and E. Prieto-Rodriguez. 2018. "Student and Staff Perceptions of a Learning Management System for Blended Learning in Teacher Education." *Australian Journal of Teacher Education* 43 (3): 21-34.
4. Alam, F., R. Hadgraft, and Q. Alam. 2014. "eLearning – Challenges and Opportunities." In *Using Technology Tools to Innovate Assessment, Reporting, and Teaching Practices in Engineering Education*, by Alam F., 409. New York: IGI Global.
5. Alkhaldi, T., I. Pranata, and R.I. Athauda. 2016. "A review of contemporary virtual and remote laboratory implementations: observations and findings." *Journal of Computers in Education* 3 (3): 329-351.
6. Aldiab, Abdulaziz, Harun Chowdhury, Alex Kootsookos, Firoz Alam, and Hamed Allhibi. 2019. "Utilization of Learning Management Systems (LMSs) in higher The 15th International Symposium on District Heating and Cooling education system: A case review for Saudi Arabia education system: A case review for Saudi Arabia." *Energy Procedia* 160: 731-737.
7. de Oliveira, Paulo Cristiano, Cristiano Jose Castro de Almeida Cunha, and Marina Keiko Nakayama. 2016. "Learning Management Systems (LMS) and e-Learning Management: An Integrative Review and Research Agenda." *JISTEM - Journal of Information Systems and Technology Management* 13 (2): 157-180.
8. Al-Hunaiyyan, Ahmed, Salah Al-Sharhan, and Rana AlHajri. 2020. "Prospects and Challenges of Learning Management Systems in Higher Education." *(IJACSA) International Journal of Advanced Computer Science and Applications* 11 (12): 73-79.
9. Daniels, J., M. Jacobsen, S. Varnhagen, and S. Friesen. 2013. "Barriers to Systemetic, Effective, and Sustainable Technology Use in High School Classroom." *Canadian Journal of Learning and Technology* 39 (4).
10. University of Rijeka. 2024. *E-learning Infrastructure and Management.* Rijeka: University of Rijeka.

11. Sarker, Franque, Jo Matthews, and Jessica Gramp. 2013. "On Optimal Strategies for the Development and Operation of Moodle in Higher Education Institutions." *2nd Moodle Research Conference (MRC2013)At: Sousse, Tunisia Authors:*. Sousse, Tunisia. 5-13.
12. Hellerstein, Joseph M., Michael Stonebraker, and James Hamilton. 2007. "Architecture of a Database System." *Foundations and Trends in Databases* (now Publishers Inc.) 1 (2): 141-259.
13. MoodleUKLO. 2025. *Official Learning Management System of UKLO.* 11. Accessed 11 2025. https://moodle.uklo.edu.mk.
14. Moodle. 2025. *Moodle Official Website.* Accessed 11 2025. https://moodle.org.