

DATABASE IMPLEMENTATION FOR E-LEARNING SUPPORT

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Abstract: E-learning represents a significant advance in the education sector, allowing students and teachers to access educational resources via the Internet. Within this work, the focus is on the implementation of a database that will effectively support e-learning. The proposed database system is designed to manage key data, such as information about users (students), courses, learning materials, grades and progress. The database allows efficient data storage and access, while its structure allows simple monitoring of student progress, as well as personalization of the educational experience. The system integrates data analytics, which enables the monitoring of educational trends, student evaluation and strategic decision-making at the institutional level. By addressing challenges such as scalability, data security, and system performance, this paper provides a foundation for effective database use in e-learning, thereby enhancing the overall education experience and optimizing the educational process. Through implementation, the paper shows the importance of databases in modern educational technologies, as well as their contribution to the improvement of the e-learning process and monitoring of individual student results.

Key words: Databases; SQL; E – learning; Educational system; Digital education

1. INTRODUCTION

Digital technologies have become a key part of modern education, enabling faster and more efficient organization of educational processes. Most experts emphasize the importance of databases as a key element in modern IT disciplines, with a special focus on their design, relational models and the use of the SQL language [1]. The integration of digital technologies has transformed traditional learning models, creating a global and inclusive environment for higher education, and literature analysis shows that e-learning has a positive impact on academic achievement, satisfaction and student collaboration. However, challenges such as technological limitations and Internet access present obstacles to the successful implementation of e-learning [2].

One of the most important aspects of e-learning is the management of large amounts of data, such as information about users, courses, assignments and results. When it comes to implementing a database in an e-learning context, it is crucial to carefully plan all development steps to ensure effective support for learning processes and progress monitoring [3][4][5][6]. E-learning platforms play a significant role in this case [7], because they enable the integration of theoretical and practical aspects of working with databases, thereby contributing to better organization and management of educational content [8].

Databases enable structured storage, search and analysis of data, which ensures accurate monitoring of user progress and effective organization of educational activities [9]. In the context of e-learning, databases support both teachers and students, enabling easy access to educational resources, assigning tasks and tracking individual progress.

This paper explores the process of implementing a database to support e-learning, with a particular focus on its structure, the use of SQL for data management, and the possibilities of integration with e-learning applications. The aim of the work is to show the key steps in the creation and use of the database, emphasizing its role in improving the quality of the educational process and enabling better monitoring of results.

Existing e-learning platforms, such as Moodle, Blackboard and Canvas, provide different approaches to implementing databases to effectively manage educational processes. Moodle, as an open platform, uses relational databases such as MySQL and PostgreSQL for a modular architecture

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that allows the extension of functionality [10]. Blackboard, a commercial solution, uses more complex databases to integrate with ERP and CRM systems, ensuring real-time data analysis, while Canvas offers flexibility through optimized relational models and support for API integrations [11]. Designing databases for e-learning relies on relational models, ER diagrams to define entities and relationships, and data normalization for efficient storage and management. In addition, NoSQL databases are being explored for the needs of working with large amounts of unstructured data, which is especially important for processing video materials and real-time interactions. These methods ensure organized and scalable data management, thereby supporting the quality of educational processes in e-learning platforms.

2. DATABASE IMPLEMENTATION

A database-based e-learning system consists of several interconnected components. The central role is played by the e-learning platform that integrates users (teachers and students), courses and contents, enabling interaction through a customized user interface on different devices [12].

The database is a key part of the system, as it stores information about users, content and ratings. Based on these data, reports are generated that provide feedback on progress and enable the optimization of the educational process [13]. All components of the system are connected in a continuous flow of data, which provides effective support to the learning process, shown in Figure 1.



Figure 1 –Architecture of a database-based e-learning system [13]

Implementing a database to support e-learning requires careful planning to ensure efficient organization, storage and access to data. The database must enable the storage of key information such as users, courses, educational materials, and evaluation results, while simultaneously providing appropriate functionalities for user authentication, progress tracking, and content interaction [14].

In this process, it is first necessary to design the structure of the database, which means defining the tables, their attributes and the connections between them. Tables such as Users, Professors, Courses, Content and Results form the basis for all activities on the e-learning platform. Each of these tables has a specific function in the system and is connected to other tables through foreign keys, which allows easy monitoring of user activities and organization of educational content.

2.1. Requirements analysis and system design

The implementation of a database to support e-learning requires a careful definition of all the data to be stored and the functionality that the database must provide. Key data stored in the database includes information about users, courses, educational materials and evaluation results. The results of the evaluations enable the monitoring of student progress, as well as the recording of grades and feedback from assignments and tests.

In addition to data storage, the database must provide functionalities such as user authentication and progress tracking. Authentication enables security of access to data, storage of encrypted passwords and verification of user identity. Progress tracking allows recording completed courses and assignments, as well as analyzing results in real time. Also, the database should enable efficient content management (adding, updating and searching for materials), as well as communication between professors and students for sending feedback and notifications.

Database design must be focused on performance and scalability, as e-learning often involves a large number of users. Also, data security is key, so it is necessary to implement appropriate safeguards, such as encryption and access control, to ensure the protection of personal data and educational information. By analyzing the requirements, the foundations are laid for the development of a functional, secure and scalable database that will support effective e-learning.

The database was created using the SQL language [15], including tables, while the SQL queries for creating the database and tables are shown in Figures 2 and 3.

```
1 CREATE DATABASE acche25
```

Figure 2 – Query to create bp

```
1 CREATE TABLE results
2 (ID_Results varchar(15) not null PRIMARY KEY,
3  Points numeric(3,2),
4  Date_results date(),
5  Description_results varchar(50),
6  ID_Course varchar(15),
7  ID_Student varchar(15),
8  FOREIGN KEY(ID_Course)REFERENCES course(ID_Course),
9  FOREIGN KEY(ID_Student)REFERENCES student(ID_Student)
10 )
```

Figure 3 – Query to create table bp

To support e-learning, it is necessary to define a database that includes key entities: Users, Professors, Courses, Content and Result, Figure 4. Each of these tables has a clearly defined role and mutual relationships that enable effective management of educational processes.

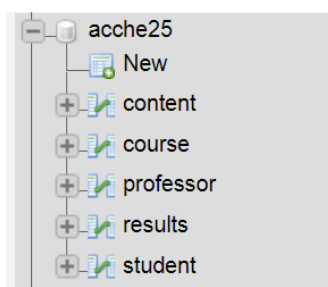


Figure 4 – Created database and tables

Figure 5 shows the relational links between tables in a database created to support e-learning. Tables student, professor, course, content and results are interconnected via primary and foreign keys. The student table contains data about student users and is connected to the course table via the ID_Student attribute, while the professor table stores data about lecturers and is connected to the course table via the ID_Professor attribute. The course table represents the courses and is connected to

the content table, which stores information about the content of the courses, and the results table, where the students' results are recorded. These links enable integrated management of user, course, content and achievement data, ensuring the functionality and efficiency of the e-learning system.

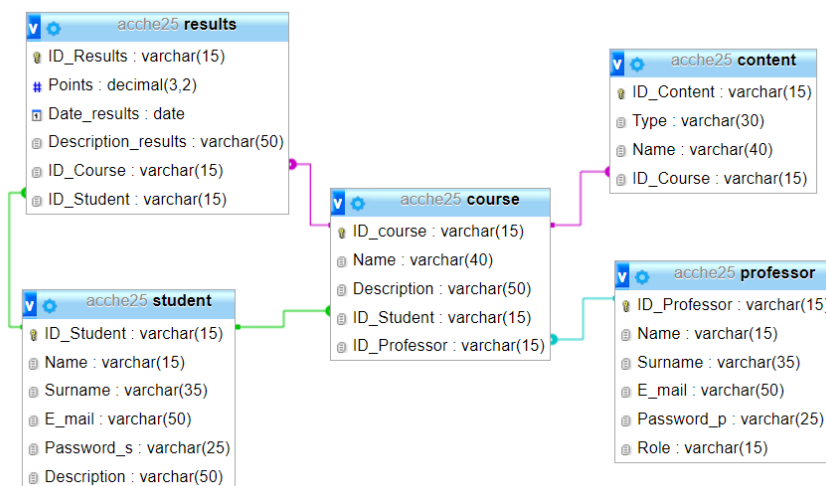


Figure 5–A relational diagram of an e-learning database

2.2. Integration with e-learning platforms

Connecting the database to the e-learning system enables efficient data management and dynamic user interaction with the application or user interface [16]. This connectivity includes the implementation of software solutions that enable functionalities such as user management, course creation, adding educational content and tracking progress. To implement the integration, APIs or drivers are used to connect the database with programming languages, such as Python, Java or PHP, depending on the technology used in the development of the system. Special attention should be paid to user authentication and authorization, which ensures data security and controlled access to system resources [17].

Interaction with the database is realized through basic SQL operations, such as entering, updating, reading and deleting data. When a new user is created, the application sends an SQL query to enter data into the user table in the Moodle database. The query uses the INSERT INTO command to enter information about the user, such as first name, last name, email address, username, and password. The password is encrypted before being entered into the database, using an appropriate algorithm (eg MD5 or bcrypt, depending on the system configuration) [18]. Also, the application sets the user status (confirmed or unconfirmed) and the time of the last modification of the user's data. This process allows for the automatic addition of new users to the system, while ensuring that all data is entered correctly and securely protected.

For example, when a new user is created, the application sends an SQL query to insert data into the user table, Figure 6.

```
1 INSERT INTO student
2 VALUES('1_2024','Pera','Perić','pera123@proba.com','Vs12#zy34','participant')
```

Figure 6 – SQL query to enter student data

Updating data in the database is critical to maintaining the accuracy and relevance of information within the system. In the context of e-learning, where data about users, courses and their activities are constantly changing, enabling updates ensures that the information in the system matches the actual state. For example, changes in user data, such as a change of email address or password, must be

updated in a timely manner in order to enable smooth communication and access to the system, Figure 7. Display of email address replacement, Figure 8.

```
1 UPDATE student
2 SET E_mail='newmail@rehearsal.com' WHERE ID_Student='1_2024'
```

Figure 7–SQL query to update student data

ID_Student	Name	Surname	E_mail	Password_s	Description
1_2024	Pera	Peric	newmail@rehearsal.com	Vs12#zy34	participant

Figure 8 – Updated data with changed email address

In addition to adding and changing data, it is also possible to list certain data by subject. This SQL query, shown in Figure 9, joins four tables (student, course, results, professor) to display information about students taking the "Database" course. The query extracts basic data about students (name, surname, ID), their results (points and date of the test), as well as data about the professor (name, surname). The tables are linked via common attributes such as student ID, course ID, and professor ID, and the WHERE clause filters the results for a specific subject.

```
1 SELECT a.ID_Student,a.Name,a.Surname,b.Name,c.Points,c.Date_results,d.Name,d.Surname
2 From student AS a
3 INNER JOIN course AS b ON a.ID_Student=b.ID_Student
4 INNER JOIN results AS c ON b.ID_Course=c.ID_Course
5 INNER JOIN professor AS d ON b.ID_Professor=d.ID_Professor
6 WHERE b.Name='Database'
```

Figure 9 – SQL query to display data from tables for the Database subject

The user interface is the bridge between the user and the database. Through the interface, users can easily access system functionalities, such as browsing courses or managing content. When a user enters a request, the application sends the appropriate SQL query to the database and then displays the results in an understandable format. This integration ensures the automation of many processes and improves the organization and access to data, thus increasing the efficiency and availability of the e-learning system.

3. CONCLUSION

The implementation of a database to support e-learning is a key point in improving the efficiency and organization of educational processes. Through a carefully designed structure of the database, which includes tables for users, professors, courses, content and results, efficient storage and processing of data is enabled. Integration of the database with applications and user interfaces allows easy input, updating of data, as well as generation of progress reports, thus optimizing work and improving interaction with the system.

The evaluation of the system confirmed that the implemented database model meets all requirements regarding functionality, efficiency and scalability. The speed of data processing and the ability to generate relevant reports allow users, such as professors and administrators, faster access to the necessary information, while the flexibility of the design allows for easy expansion of the system according to future e-learning needs. This makes the solution sustainable and scalable for wider applications.

For further improvement, the integration of advanced data analytics tools, such as AI-based predictive analytics and reporting tools, is recommended to enable even more accurate tracking of progress and personalization of user experiences. Also, the introduction of mobile applications for easier access to data and better interaction with the platform can further improve the user experience. The implementation of the database within the e-learning system not only improves the organization of educational processes, but also enables making informed decisions through data analysis, thus contributing to the further development and modernization of the education sector.

4. REFERENCES

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