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MONITORING AND LEARNING ANALYTICS MECHANISMS IN AN AI-BASED INTERACTIVE TEACHING SYSTEM FOR DEVELOPING STUDENTS' PROFESSIONAL COMPETENCE

Nosirova Shokhista Elmurodovna
PhD Student at Bukhara State University

Abstract

The rapid development of digital learning environments requires the implementation of innovative approaches that ensure continuous monitoring, personalization, and effectiveness of the educational process. This article presents the development of monitoring and learning analytics mechanisms within the SQLUSTOZ.UZ AI Mentor platform designed to improve students' professional competencies in teaching the "Database" course. The proposed approach integrates Learning Analytics (LA), Educational Data Mining (EDM), adaptive recommendations, and formative assessment mechanisms. The platform collects and analyzes students' learning activity indicators, including system usage frequency, task completion time, number of attempts, SQL query errors, usage of optimization tools, and assessment results. Based on analytical data, individual competency profiles and personalized learning trajectories are generated. The developed mechanism provides opportunities for identifying knowledge gaps, adapting educational content, and supporting evidence-based pedagogical decision-making.

Keywords: Learning Analytics, Educational Data Mining, Artificial Intelligence, adaptive learning, professional competence, interactive teaching system, database education.

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Introduction

The transformation of modern education under the influence of digital technologies has created new requirements for organizing the learning process. Traditional assessment approaches mainly focus on evaluating final learning outcomes; however, they do not provide sufficient information about students' learning processes, difficulties, and individual developmental dynamics. Therefore, modern educational systems require mechanisms capable of continuously monitoring learning activities and providing timely pedagogical support. Learning Analytics (LA) and Educational Data Mining (EDM) have become important components of digital education systems. These technologies enable the collection, processing, and interpretation of educational data generated during learning activities. Through analytical processing of learning data, it becomes possible to determine students' knowledge levels, identify learning difficulties, and develop individualized learning strategies. In professional training, particularly in teaching computer science disciplines such as Database courses, students require not only theoretical knowledge but also practical, analytical, and problem-solving skills. Therefore, the integration of artificial intelligence technologies into interactive teaching systems creates new opportunities for developing students' professional competencies. The purpose of this study is to develop and substantiate monitoring and learning analytics mechanisms integrated into the SQLUSTOZ.UZ AI Mentor platform for improving students' professional competence during the study of the Database course.

As a result of the development of the digital learning environment, it has become possible not only to evaluate the learning process based on final outcomes but also to continuously monitor, analyze, and support students' learning activities by making appropriate pedagogical decisions. Consequently, **Learning Analytics (LA)** and **Educational Data Mining (EDM)** have become essential components of modern educational systems. These technologies enable the collection,

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processing, and analysis of educational data generated during the learning process, making it possible to assess students' knowledge levels, learning engagement, and developmental progress.

Learning Analytics is defined by international experts as the process of collecting, measuring, analyzing, and interpreting data about learners and their learning environments. The primary objective of this approach is to improve learning outcomes, enhance the quality of instruction, and organize the educational process in a learner-centered manner. In adaptive learning systems, Learning Analytics serves as one of the fundamental mechanisms for constructing individualized learning trajectories.

Within the framework of this research, the monitoring and learning analytics mechanisms implemented in the **SQLUSTOZ.UZ AI Mentor Platform** were designed based on the principle of continuous monitoring and analysis of students' activities throughout their interaction with the platform. Every action performed by a user is recorded in the database and subsequently utilized for pedagogical analysis. This approach enables the evaluation not only of students' final performance but also of the entire learning process leading to that performance.

The platform is designed to collect and process the following ten key indicators:

1. Number and frequency of system logins;
2. Learning activity across different topics;
3. Time spent completing assignments;
4. Number of attempts made to complete assignments;
5. Success rate on the first attempt;
6. Number of syntactic errors in SQL queries;
7. Number of logical errors in SQL queries;
8. Frequency of using the **EXPLAIN** function;
9. Number of times the query execution plan is viewed;
10. Results of formative assessments and final examinations.

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Based on these indicators, an individual competency profile reflecting each student's knowledge and skill levels is generated. The profile is developed according to the four competency dimensions identified in the first chapter of this dissertation: **theoretical-conceptual**, **practical-procedural**, **analytical-optimization**, and **reflective-evaluative** competencies. The student's level of development in each competency is updated automatically as new learning data become available.

One of the most important functions of the learning analytics mechanism is the identification of learning gaps. If a student repeatedly makes errors while completing tasks related to a particular topic or requires an excessive amount of time to complete them, the system identifies this as evidence of insufficient knowledge in that area. Consequently, the platform recommends additional learning resources, including instructional videos, practical exercises, and explanatory examples tailored to the student's needs (see Figure 2.4.1).

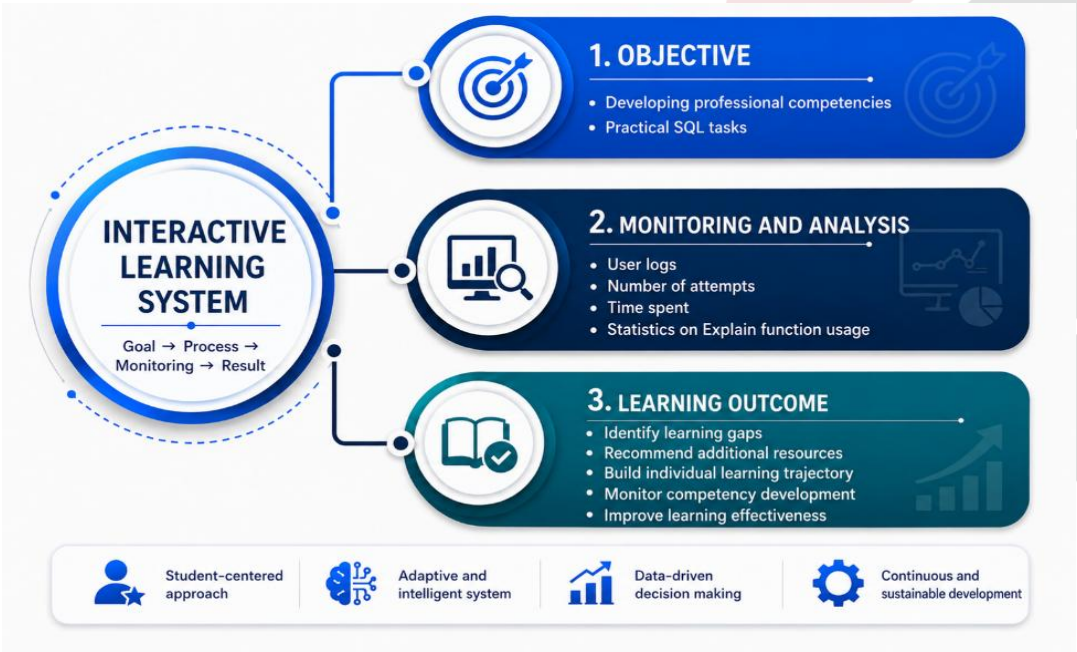

Figure 2.3.1. Interactive Teaching Systems Designed to Develop Students' Professional Competence

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An adaptive recommendation mechanism has also been implemented in the **SQLUSTOZ.UZ** platform. This mechanism operates based on students' previous performance, error history, and learning progress. The system selects learning tasks appropriate to each student's level of preparedness, gradually increases the level of difficulty, and provides additional explanations whenever necessary. In this way, the platform supports the development of an individualized learning trajectory.

The monitoring and learning analytics mechanisms serve as an important source of information not only for students but also for instructors. A dedicated monitoring dashboard has been developed within the platform for instructors, providing comprehensive information on student engagement, academic achievement, error statistics, challenging topics, and the dynamics of professional competence development. These data enable instructors to make informed pedagogical decisions, organize supplementary learning activities, and optimize the teaching and learning process.

Thus, the monitoring and learning analytics mechanisms implemented in the **SQLUSTOZ.UZ AI Mentor** platform facilitate continuous monitoring of students' learning activities, identification of knowledge gaps, generation of personalized recommendations, and effective management of professional competence development. The data generated through these mechanisms constitute the information base for analyzing the results of the experimental study presented in the following chapter and for evaluating the pedagogical effectiveness of the proposed methodology using mathematical and statistical methods.

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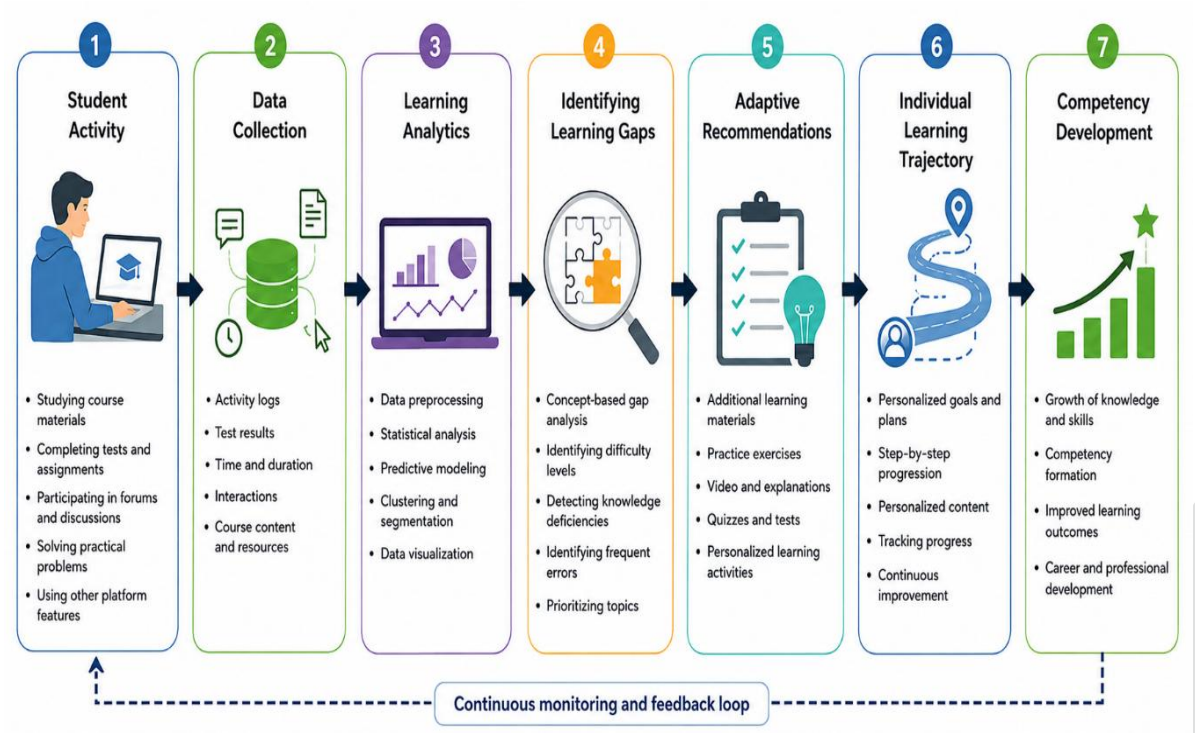

Figure 2.3.2. Monitoring Mechanisms of the SQLUSTOZ.UZ Platform

Figure 2.3.2 presents the conceptual framework of the monitoring and learning analytics mechanisms implemented in the **SQLUSTOZ.UZ AI Mentor** platform. The framework illustrates the logical sequence of collecting, analyzing, and utilizing data generated through students' learning activities to support individualized pedagogical decision-making. It consists of **seven interconnected stages**.

In the **first stage**, students engage in learning activities within the platform. During this stage, they study course materials, complete quizzes and practical assignments, participate in discussion forums, and work on project-based tasks. As a result, primary data related to the learning process are generated.

In the **second stage**, data on students' learning activities are collected. These include user logs, assessment results, duration of platform usage, task completion time, number of attempts, and other learning activity indicators, all of which are

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stored in the database. These data serve as the foundation for subsequent analytical processes.

In the **third stage**, the collected data are processed using **Learning Analytics** technologies. Statistical analysis, clustering, segmentation, and predictive modeling techniques are applied to identify hidden patterns in students' learning behavior. Consequently, students' learning progress and levels of knowledge acquisition are evaluated.

In the **fourth stage**, the analytical results are used to identify students' knowledge gaps. Specifically, the system determines which topics present learning difficulties, which competencies remain insufficiently developed, and which areas require priority attention for further improvement.

In the **fifth stage**, adaptive recommendations are generated based on the identified learning needs. The system recommends additional learning materials, video lectures, practical exercises, and reinforcement activities tailored to each student's needs. Furthermore, the difficulty level of assignments is automatically adjusted according to the student's level of preparedness.

In the **sixth stage**, an individualized learning trajectory is established. This trajectory is designed according to the student's current level of knowledge, learning objectives, and developmental progress, thereby ensuring the personalization of the educational process.

In the **seventh stage**, the outcomes of competency development are evaluated. This evaluation measures students' growth in knowledge, skills, and competencies, as well as improvements in their overall learning outcomes.

The continuous monitoring and feedback mechanism illustrated in the framework ensures the integration of all seven stages. Through this mechanism, the learning process is continuously monitored, analytical results are regularly updated, and pedagogical interventions are adapted to meet students' individual learning needs. Therefore, the proposed mechanism provides a methodological foundation for implementing adaptive learning based on continuous monitoring, timely

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identification of knowledge gaps, and targeted development of professional competencies.

The findings of the present study demonstrate that monitoring and learning analytics technologies play a crucial role in organizing the educational process within modern digital learning environments, continuously monitoring students' academic performance, and constructing individualized learning trajectories. Accordingly, the theoretical and methodological foundations for developing monitoring and learning analytics mechanisms within the **SQLUSTOZ.UZ AI Mentor** platform and integrating them into the teaching of the **Database** course were established.

Throughout the study, the pedagogical potential of **Learning Analytics** and **Educational Data Mining (EDM)** technologies was comprehensively analyzed. Their significance in continuously monitoring students' learning activities, diagnosing the state of their knowledge and skills, identifying knowledge gaps, and supporting evidence-based pedagogical decision-making was theoretically substantiated. The findings indicate that learning analytics mechanisms enable not only the assessment of learning outcomes but also the analysis of the learning processes that lead to those outcomes. Unlike traditional assessment systems, this approach provides deeper insights into students' learning progress and supports a more personalized educational experience.

It was further established that the monitoring mechanisms implemented in the **SQLUSTOZ.UZ** platform are designed to record user logs, assignment completion time, number of attempts, syntactic and logical errors in SQL queries, frequency of **EXPLAIN** function usage, formative assessment results, and other indicators of learning activities. Based on these data, a comprehensive profile of each student's learning activities is generated, enabling the evaluation of knowledge level, learning pace, and professional competency development.

As a result of the research, a conceptual mechanism for processing and pedagogically interpreting monitoring data was developed. This mechanism

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integrates the stages of data collection, statistical and analytical processing, identification of knowledge gaps, generation of adaptive recommendations, and construction of individualized learning trajectories. Consequently, a data-driven adaptive approach to educational process management was established.

In addition, an adaptive recommendation system was developed to support the enhancement of students' **conceptual-theoretical, practical-procedural, analytical-optimization, and reflective-evaluative competencies** based on monitoring results. This approach enables the timely identification of knowledge gaps, recommends supplementary learning materials and practical exercises to address those deficiencies, and promotes the personalization of the learning process.

Conclusion

The findings of this study demonstrate that integrating monitoring and learning analytics mechanisms into the SQLUSTOZ.UZ AI Mentor platform significantly enhances the effectiveness of the educational process in teaching the Database course. The proposed mechanisms enable continuous monitoring of students' learning activities, timely identification of knowledge gaps, analysis of competency development, and generation of personalized learning trajectories based on learning analytics data. Furthermore, the statistical and analytical information provided by the platform supports instructors in making evidence-based pedagogical decisions, adapting instructional strategies, and improving the overall quality of teaching and learning. The developed monitoring and learning analytics framework therefore provide a methodological foundation for adaptive learning and competency-oriented education. The practical effectiveness of the proposed approach will be validated through the experimental study presented in the subsequent chapter.

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