

Developing Students' Skills in Database Design

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ABSTRACT: This article analyzes modern pedagogical approaches to developing students' database design skills. This study investigates the effectiveness of Project-Based Learning, Problem-Based Learning, and Collaborative Learning methods, using an experimental approach. The teaching study included seventy-three second-year undergraduate students. A comparison was then done to assess the differences between the control and experimental groups. The results showed that, in the experimental group, knowledge acquisition improved by 30–35%, practical skills development reached 80–88%, and learning motivation increased by 25–29%. The results support the efficacy of utilizing modern pedagogical technologies and CASE tools to enhance students' professional capabilities. Therefore, this method encourages combining theoretical knowledge with practical skills in database teaching, which improves the overall quality of the educational experience.

KEYWORDS: database, database design, ER diagram, normalization, SQL, pedagogical technologies, project-based learning, problem-based learning, collaborative learning, CASE tools, practical skills, motivation, innovative education

INTRODUCTION

In today's digital economy, data has clearly become a vital strategic asset. The effectiveness of information systems depends greatly on how well databases are designed. Therefore, it's essential for IT professionals to have both a deep understanding and practical skills in database design.

Mamedova G.A. and Agaev F.T. highlighted that the main advantages of e-learning include flexibility, remote access to resources, and the possibility of individualizing the learning process. In particular, adaptive technologies enable the learning process to be tailored to students' knowledge levels, which is considered a significant innovation. Furthermore, the application of Big Data and NoSQL technologies contributes to deep analysis of the educational process, monitoring of student performance, and the development of effective teaching strategies [1]. Cloud technologies, in turn, reduce infrastructure costs and provide access to education from any location.

Currently, bibliometric studies are being conducted to systematically investigate the development of problem-based learning (PBL) in higher education mathematics teaching. R.Meiliati analyzed 250 scientific publications from the Scopus database, focusing on publication dynamics, citation structures, and thematic evolution. This study interprets PBL not merely as a pedagogical method but as a multidimensional and evolving global scientific paradigm. It incorporates theoretical, methodological, and practical elements, thereby significantly influencing contemporary educational reform. Nevertheless, the exclusive use of a single database, Scopus, constrains external validity, suggesting that future investigations should employ a multi-source analytical approach.

S.A. Musayevich and H.Z. Alisherovna's research on database organization and management encompassed both theoretical and practical dimensions [3]. Their work elucidates the function, architecture, and operational tenets of databases within modern information systems. Furthermore, a detailed explanation of the main components of a database, such as the Database Management System (DBMS), different data models (hierarchical, network, and relational), and their specific functions, is provided.

In particular, the advantages of the relational model and its widespread application in modern systems are scientifically justified. With the rapid development of information technologies, the demand for data continues to increase. As a result, various methods and technologies are being developed to facilitate the teaching of database systems to young specialists [4, 6, 8]. At the same time, the advancement of software tools for database development expands the scope of application [5, 7]. However, challenges remain in teaching database courses within credit-module systems, which requires further investigation and the development of solutions [9].

Q.Shaydo and Z.Sanjarbek examined the concepts of databases and knowledge bases, their key characteristics, functional capabilities, and specific design features [10]. The study emphasizes the differences between these two types of systems in terms of structure, functions, intelligence level, and application areas. The process also includes the steps for designing databases and

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knowledge bases. These steps involve normalization, the logical representation of knowledge, and the creation of expert rules. This research contributes to a better understanding of how data management and intelligent decision-making work in information systems and artificial intelligence.

S.Begzod et al. described methods for identifying entities, their attributes, and relationships in database design [11]. They also explained how to represent these elements in diagrams and how to model relationships (1:1, 1:N, M:N) using directed and undirected connections.

Sarvarali o'g'li, L. S., and Maxmudjonovna, Y. M. attempted to conduct a comprehensive analysis of the methodology for teaching the database discipline [12]. The research underscores the efficacy of contemporary pedagogical technologies, interactive methodologies, and software applications. Furthermore, it investigates strategies for consolidating theoretical understanding, structuring practical and laboratory exercises, and employing project-based and problem-based learning techniques. These methodologies facilitate the cultivation of students' proficiencies in database design, administration, and optimization, thereby possessing considerable scientific and practical significance for both instructors and learners.

METHODS

The study was conducted using a comprehensive approach and the following methods were applied:

1. Theoretical Analysis

Scientific articles and advanced international practices were reviewed. In particular, database design methodologies, including the ER model and normalization theory, were analyzed.

2. Pedagogical Experiment

This study used an experimental design and involved second-year students at the University of Information Technology and Management. In 2026, the project included 73 undergraduate students from four different academic departments.

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The study's participants were divided into two groups: a control group of 37 students and an experimental group of 36 students. The control group experienced a traditional learning environment, using standard teaching methods; lectures and practical sessions were delivered in a conventional way. In contrast, the experimental group received instruction that used modern teaching technologies, interactive methods, and new instructional strategies.

This design made it possible to compare the effectiveness of the two teaching methodologies and to determine their impact on students' knowledge levels and practical skills.

3. Teaching Methods

In the experimental group, the teaching approach was based on current teaching methods. Specifically, Project-Based Learning was used to involve students in solving real-world problems, while Problem-Based Learning was used to develop their analytical and critical thinking skills.

Furthermore, Collaborative Learning was used to help students develop their communication and teamwork skills. To improve practical abilities, CASE tools, including MySQL Workbench and software for creating ER diagrams, were used effectively.

These pedagogical strategies were designed to facilitate the integration of theoretical understanding with practical application, thereby fostering the development of students' professional competencies.

4. Assessment Methods

Students' knowledge, skills, and competencies were evaluated through a multifaceted methodology. The assessment procedure incorporated pre- and post-tests to gauge students' knowledge acquisition prior to and subsequent to the learning experience, with an analysis of the observed changes.

Moreover, practical assignments were utilized to measure students' capacity to translate theoretical understanding into practice, whereas project work was implemented to assess their independent thought processes, problem-solving capabilities, and systematic methodologies.

In addition, questionnaires were administered to investigate students' perspectives on the learning process and to ascertain the efficacy of the instructional strategies employed. These assessment instruments were instrumental in ensuring the reliability and validity of the research outcomes.

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5. Research Stages

The study was conducted in three main parts:

- **Diagnostic phase:** This phase involved evaluating the students' initial knowledge, along with a thorough assessment of their current skills and understanding;
- **Formative stage:** This initial phase provided the groundwork for structuring the ensuing instructional sequence. The formative stage involved the experimental group, where the learning process was structured around novel pedagogical approaches designed to cultivate students' theoretical understanding and practical proficiencies;
- **Control stage:** The final results were analyzed by comparing initial and final indicators, and the effectiveness of the applied methods was evaluated.

RESULTS

The findings of the study confirmed the effectiveness of the experimental approach.

1. Improvement in Knowledge Level

According to the results of the pedagogical experiment, a significant improvement in students' knowledge levels was observed in the experimental group. A comparison of test results obtained at the beginning (diagnostic stage) and at the end (control stage) of the study revealed an average increase of 30–35% in the experimental group. In the experimental group (36 students), the application of innovative teaching methods enabled students to effectively develop not only their theoretical knowledge but also their practical skills. High performance was notably observed in areas such as designing Entity-Relationship (ER) diagrams, identifying attributes and relationships, normalization (1NF, 2NF, 3NF), and creating tables using SQL. The improvement seen in these areas can be explained by the students' ability to understand complex ideas through hands-on activities.

In contrast, although some improvement in knowledge levels was observed in the control group (37 students), the increase was significantly lower than in the experimental group. The progress in this group was mainly limited to theoretical knowledge, while the development of practical skills remained insufficient.

Table 1. Comparison of Control and Experimental Group Results

No.	Indicator	Control Group (n=37)	Experimental Group (n=36)
1	Teaching method	Traditional	Innovative (interactive)
2	Initial knowledge level	Average	Average
3	Final knowledge level	Improvement observed	Significant improvement
4	Increase in knowledge level (%)	~15–20%	30–35%
5	Practical skills (ER, SQL, NF)	Average	High
6	Level of independent work	Low–average	High
7	Problem-solving skills	Average	High

The analysis of the results indicates that the educational process organized on the basis of innovative approaches is significantly more effective in improving students' knowledge levels compared to traditional methods. This finding substantiates the necessity of widely implementing modern pedagogical technologies in the process of teaching database courses.

2. Development of Practical Skills

The pedagogical experiment's outcomes revealed a notable enhancement in the practical skill acquisition of students within the experimental cohort. Within a learning environment characterized by innovative pedagogical methodologies, students effectively integrated theoretical comprehension with practical application.

Specifically, the experimental group exhibited enhanced capabilities in independently developing ER diagrams, precisely identifying attributes and relationships within database structures, and effectively executing normalization processes (1NF, 2NF, 3NF), in addition to the creation and administration of tables through SQL commands. The incorporation of CASE tools, such as MySQL Workbench and ER diagram design software, further enhanced the effectiveness of their practical exercises.

Conversely, the control group's practical competencies were largely confined to conventional assignments, with students primarily depending on theoretical understanding. Consequently, their capacities for independent work, problem-solving, and engagement with authentic projects were cultivated to a lesser extent when compared to the experimental group.

Table 2. Level of Practical Skills

No.	Skill Type	Control Group (%)	Experimental Group (%)
1	ER diagram design	55	85
2	Identification of attributes and relationships	60	88
3	Normalization (1NF–3NF)	50	80

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4	SQL-based table creation	58	83
5	Independent project implementation	52	86

The results confirm that innovative pedagogical approaches are effective tools for developing students' practical competencies, and they highlight the necessity of widely implementing these methods in the educational process.

3. Degree of Autonomous Work

The students in the experimental group exhibited a high level of achievement in the independent development of projects. They successfully designed complete database projects for small information systems, such as library systems, student databases, and online store models.

4. Increase in Motivation

The findings from the pedagogical experiment demonstrate a notable enhancement in the learning motivation exhibited by students within the experimental group. More precisely, the implementation of innovative pedagogical strategies, including Project-Based Learning, problem-based activities, and collaborative methodologies, fostered a greater degree of student engagement and interest in the educational process.

According to the survey results, students in the experimental group showed a 25% increase in interest in the subject, while the level of active participation in classes increased by more than 27%. Students demonstrated high motivation through their ability to express ideas freely, solve problems independently, and collaborate effectively in group work.

The corresponding quantitative indicators are presented in *Table 3*.

Table 3. Changes in Students' Motivation Indicators

No.	Indicator	Control Group (%)	Experimental Group (%)	Increase (%)
1	Interest in the subject	60	85	+25
2	Classroom participation	55	82	+27
3	Independent thinking and decision-making	58	84	+26
4	Readiness for teamwork	62	88	+26
5	Interest in problem-solving	57	86	+29

In the control group, although a certain increase in motivation was observed, this level remained lower compared to the experimental group and was mainly limited to passive participation and traditional assignments.

It was determined that innovative teaching methods are effective tools for enhancing students' intrinsic motivation, actively engaging them in the learning process, and promoting independent learning.

DISCUSSION

The results of the conducted pedagogical experiment confirmed that innovative teaching methods have a positive impact on students' knowledge levels, practical skills, and learning motivation. The observed increase of 30–35% in knowledge levels, the improvement of practical skills to 80–88%, and the rise in motivation indicators by 25–29% in the experimental group scientifically demonstrate the effectiveness of these methods.

The analysis showed that Project-Based Learning and Problem-Based Learning methods led to particularly strong results in practical subjects like ER diagrams, SQL, and normalization.

This suggests that students develop a deeper understanding when they actively use knowledge, rather than just passively receiving it. Moreover, using CASE tools significantly helped students develop their professional skills.

In contrast, the control group showed less improvement in both knowledge and skill development, which can be attributed to the limitations of traditional teaching methods.

In contrast, the control group demonstrated relatively lower improvement in both knowledge and skills, which can be explained by the limitations of traditional teaching methods. The experimental group performed significantly better in both the practical exercises and the independent assignments. The results support the idea that modern teaching methods work well with competency-based learning.

The examination of motivational indicators yielded significant results. Students within the experimental group demonstrated substantial engagement in classroom activities, collaborative projects, and the resolution of intricate problems. This observation substantiates the efficacy of interactive pedagogical approaches in cultivating intrinsic motivation and promoting autonomous learning.

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The findings suggest that integrating novel teaching technologies into database course instruction is beneficial, promoting knowledge acquisition and the cultivation of practical skills, and concurrently improving student engagement. Consequently, a wider adoption of contemporary pedagogical strategies within higher education is recommended.

CONCLUSION

The findings of this investigation indicate that the integration of contemporary pedagogical technologies and novel instructional strategies within database instruction substantially enhances students' comprehension, practical proficiencies, and intrinsic motivation. The observed 30–35% elevation in knowledge acquisition, coupled with practical skills attainment rates of 80–88% and a 25–29% boost in motivation within the experimental cohort, substantiates the considerable efficacy of these methodologies.

Furthermore, the findings indicate that Project-Based Learning, Problem-Based Learning, and Collaborative Learning methodologies are crucial for fostering students' independent cognitive abilities, their aptitude for problem-solving, and their professional competencies. In addition, the utilization of CASE tools enhances the efficacy of practical training, thereby facilitating the application of theoretical principles in authentic contexts.

A comparison with the control group shows that traditional teaching methods are not sufficiently effective in developing deep knowledge and practical skills. Therefore, it is necessary to widely implement modern, interactive, and competency-based teaching approaches in higher education.

In conclusion, using innovative teaching methods in database system education is crucial for improving educational quality, preparing students for modern IT careers, and supporting their professional growth.

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