UNIVERSITY OF PLOVDIV PAISII HILENDARSKI
FACULTY OF MATHEMATICS AND INFORMATICS
DEPARTMENT OF COMPUTER INFORMATICS

MARIA METODIEVA GORGOROVA

INTELLIGENT COMPONENTS IN E-LEARNING ENVIRONMENTS

ABSTRACT

of a dissertation

for awarding the educational and scientific degree "Doctor"

Field of higher education: 4. Natural sciences, mathematics and informatics
Professional direction: 4.6. Informatics and Computer Science
Doctoral program: Informatics

Scientific Supervisors:
Prof. Stanka Hadzhikoleva, Ph.D.
Assoc. Prof. Silvia Gaftandzhieva, Ph.D.

Plovdiv, 2026

The dissertation was discussed and recommended for public defense by the Department of Computer Science at the Faculty of Mathematics and Informatics, University of Plovdiv Paisii Hilendarski, at a departmental meeting held on 9 July 2026.

The dissertation entitled “Intelligent Components In E-Learning Environments” comprises 187 pages. The bibliography contains 169 references. The author's publications related to the dissertation topic include 8 papers.

The public defense of the dissertation will take place on ..... at ..... in the Conference Hall of the University of Plovdiv Paisii Hilendarski (New Building, 236 Bulgaria Blvd., Plovdiv).

The dissertation and the related defense materials are available for public inspection at the Dean's Office of the Faculty of Mathematics and Informatics, University of Plovdiv Paisii Hilendarski (New Building, 236 Bulgaria Blvd., Plovdiv), on working days from 8:30 a.m. to 5:00 p.m.

Author: Maria Metodieva Gorgorova
Title: Intelligent Components In E-Learning Environments

Table of contents

INTRODUCTION

In recent years, educational institutions have faced significant challenges related to the transformation of the learning environment. Traditional teaching methods are, to a large extent, losing their effectiveness when applied to the contemporary digital generation. A decline in class attendance and a decrease in learners' motivation to participate actively in the educational process have been observed, negatively affecting both learning outcomes and the quality of the knowledge acquired (Limonova et al., 2024).

These challenges motivate educators to seek innovative solutions that can retain learners' attention, stimulate their interest, and thereby improve the effectiveness of education. Achieving these objectives requires educational institutions to encourage educators to develop their digital competences so that they can successfully integrate emerging technologies and apply contemporary interactive teaching methods.

The subject of the dissertation research is the potential for integrating intelligent and gamified educational resources into e-learning systems. ***The main objective*** of the present research is to develop conceptual models and a methodology for the design, development, and application of intelligent and gamified educational resources in higher education, based on artificial intelligence technologies, as well as tools for integrating the developed resources into e-learning environments. Another objective is to experimentally evaluate their effectiveness in enhancing students' motivation, engagement, and learning outcomes. To achieve this objective, the following tasks were set:

Task 1. **To conduct a review of the scientific literature** on contemporary approaches to e-learning, including game-based learning and the applications of artificial intelligence (AI) in education.

Task 2. **To develop conceptual models** for the design of intelligent and gamified educational resources that integrate pedagogical principles, game mechanics, and AI technologies within a unified methodological framework.

Task 3. **To design and implement** intelligent gamified educational resources for teaching informatics, including resources incorporating AI components.

Task 4. **To develop a methodology and tools** for integrating the created resources into an electronic learning environment.

Task 5. **To conduct an experimental study** evaluating the effectiveness of the developed resources.

Chapter 1 presents a review of the scientific literature and an analysis of the application of AI, gamification, and contemporary technologies in education. ***Chapter 2*** describes conceptual models for the design of intelligent and gamified educational resources. It presents the main components, architectures, user roles, and principles for integrating game mechanics and AI technologies. ***Chapter 3*** is devoted to the implementation of the developed gamified educational resources. It presents the technologies used, the software architectures, and the main functionalities of the software applications. ***Chapter 4*** describes the experiments conducted, the research methodology, and the analysis of the results obtained. The effectiveness of the developed educational resources is evaluated in terms of students' motivation and engagement.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my academic supervisors, Prof. Stanka Hadzhikoleva, PhD, and Assoc. Prof. Silvia Gaftandzhieva, PhD, for giving me the opportunity to conduct this doctoral research. I am grateful to them for sharing their experience, for the trust they placed in me, for the knowledge and skills I acquired, and for their dedicated support throughout my studies and the preparation of this dissertation.

I would also like to thank Prof. Emil Hadzhikolev, PhD, Chief Assist. Prof. Georgi Pashev, PhD, and Chief Assist. Prof. Kostadin Yotov, PhD, for their support, recommendations, and collaboration throughout the dissertation research.

CHAPTER 1. INNOVATIVE APPROACHES AND TRENDS IN CONTEMPORARY EDUCATION

Providing high-quality education is an important task faced by every educational institution. In recent years, education has undergone a profound transformation driven by the integration of new technologies and artificial intelligence (AI) into everyday life, as well as by the changing cognitive habits of the new generation of learners. To provide an overview and analysis of the field addressed by the present dissertation research, this chapter presents a systematic review of contemporary teaching and learning approaches, attitudes towards the application of AI in educational institutions, AI applications, tools, and good practices for improving the effectiveness of the educational process.

1.1. Digitalization of Education

Over the past decade, traditional teaching approaches have gradually begun to give way to more flexible, engaging, and practice-oriented approaches. The digitalization of educational content enables the transition to adaptive learning environments in which the pace and content are tailored to the individual profile of each learner (Miao & Holmes, 2021). ***The personalization of learning*** creates conditions for greater engagement and a stronger sense of control over the learning process.

Another important trend is the widespread ***integration of technology into education***. The use of online platforms, mobile applications, virtual reality (VR), augmented reality (AR) (Radianti et al., 2020), and AI transforms the learning environment into a dynamic space for exploration and simulation, thereby increasing the accessibility, interactivity, and effectiveness of the educational process.

There is also a sustained trend towards the application of project-based and problem-based learning (Guo et al., 2020), which encourages active learner participation and ***develops practical and soft skills***, such as critical thinking, teamwork, and problem-solving.

Contemporary education also strives towards ***interdisciplinarity***, enabling learners to acquire knowledge from different fields, develop critical thinking skills, and gain a comprehensive understanding of the world.

At the same time, the importance of ***formative assessment*** is increasing (Black & Wiliam, 2009). Rather than basing the final grade solely on final examinations, students

receive continuous feedback throughout the learning process, allowing them to assess their own performance, make adjustments, and improve their results.

Another approach increasingly applied in education is ***gamification***. Gamification combines and applies in synergy trends such as personalization through individual progress and the selection of learning pathways; a technological foundation through interactive platforms and visual environments; skills development through game-based scenarios and missions; interdisciplinarity through interconnected topics and contexts; and formative assessment through immediate feedback and progress tracking. In this context, gamification is becoming established not merely as a tool for entertainment, but as a ***comprehensive educational strategy*** that transforms learning into an engaging, meaningful, and effective experience (Dicheva et al., 2015). When properly applied, it can bring pedagogy and technology together and thereby enhance the quality of education.

Owing to rapid technological progress and the growing need for flexible forms of teaching, the introduction of ***e-learning*** has become a strategic priority for contemporary educational institutions (Garrison, 2016).

Contemporary ***e-learning environments*** support the administration, delivery, and monitoring of online courses. Their main advantages include the ability to provide flexibility in learning, interactivity through the integration of multimedia resources such as video and audio, and personalization of the process according to the individual needs of each learner. Typical components of contemporary platforms include modules for managing and presenting learning content, assessment and feedback, communication, and the monitoring of learners' progress (Watson & Watson, 2007).

1.2. Artificial Intelligence in Education

Artificial intelligence (AI) can be defined as a computer system capable of performing cognitive tasks traditionally associated with human intelligence, such as interpreting and processing information, learning, reasoning, problem-solving and decision-making, forecasting, and content generation (European School Education Platform, 2021).

The introduction of AI into education has been the subject of numerous scientific studies. Researchers have shown considerable interest in its potential to personalize learning, engage learners, improve learning outcomes, reduce costs, increase access to education, and automate teaching and administrative tasks. These applications include supporting assessment by providing effective and reliable methods for evaluating learner performance (Harry, 2023; Jackson, 2024).

Students' awareness of and attitudes towards AI tools are critical factors in their successful integration into the educational process. A number of studies have demonstrated that students are not only familiar with AI tools but also actively use them. Owing to their widespread adoption, educational institutions are developing frameworks for their use with the aim of improving the effectiveness of education. Most students are aware of the ethical considerations and potential biases associated with the use of such technologies (Gorgorova et al., 2025; Yotov et al., 2026).

The integration of AI into contemporary software solutions enables a comprehensive transformation of didactic models and creates opportunities to optimize the educational process and enhance its adaptability.

Personalized learning is among the most prominent contemporary educational approaches. ***Adaptive learning platforms*** employ machine learning algorithms to conduct detailed analyses of learner data through learning analytics. This enables the dynamic generation of personalized content and the modification of the learning environment in accordance with each learner's actual performance, specific cognitive style, and individual pace of progress (Johnson, 2023).

Intelligent tutoring systems (ITSs) simulate individual tutoring. They provide personalized guidance and support by using machine learning algorithms to assess learners' current performance, identify difficulties, and recommend corrective measures in real time (Johnson, 2023).

Natural language processing technologies are used in the development of virtual assistants, chatbots, foreign-language learning systems, and automatic translation tools. ***Speech analysis tools*** can provide learners with feedback on their pronunciation, grammatical accuracy, and lexical diversity (Weng & Chiu, 2023).

The combination of AI with augmented and virtual reality enables the creation of interactive simulations that support the visualization of complex concepts and the performance of safe experiments in a controlled digital environment (Tassilova et al., 2025). In educational games, AI can adapt the level of difficulty, content, and challenges according to the learner's performance (Wang et al., 2025).

Educational data analysis tools facilitate the identification of patterns and trends and can be used to improve teaching strategies, curricula, and institutional policies (Gaftandzhieva et al., 2023). AI is also applied in automated and adaptive assessment, in which the difficulty of tasks changes according to the learner's previous responses.

1.3. Gamification and Game-Based Learning

A key aspect of the contemporary educational paradigm is the application of innovative pedagogical approaches aimed at increasing learner engagement and motivation. In the context of digital transformation, there is growing interest in incorporating marketing strategies and game elements into the educational process (Nam, 2021) in order to encourage learners' active participation through mechanisms that attract, focus, and sustain their attention within the digital learning environment (Bittencourt et al., 2018; Cho & Kim, 2020; Balaquiao, 2024).

The effectiveness of gamification depends on its alignment with clearly defined learning objectives and mechanisms for the systematic assessment of progress. In this respect, two main models can be distinguished: shallow and deep gamification (Mozelius, 2021). Shallow gamification relies primarily on extrinsic incentives, such as points, badges, and leaderboards. Although it is relatively easy to integrate, its motivational effect may diminish rapidly, while learners' focus may shift from knowledge acquisition to the accumulation of game-based rewards. In deep gamification, game mechanics are embedded in the cognitive structure of the instructional design. They stimulate intrinsic motivation through challenges that require

critical thinking, strategic decision-making, and the gradual development of competencies. Intelligent game-based components should therefore be designed in accordance with the principles of deep gamification so that they support the pedagogical content rather than merely supplement it with decorative game elements.

The use of educational games in the learning process can motivate learners, encourage their more active engagement in learning, and lead to improved learning outcomes. The successful integration of educational games requires not only digital competences for their development, but also a sound pedagogical approach, clearly defined learning objectives, careful design, and an appropriate balance between entertainment and educational elements.

1.4. Conclusions

Based on the findings of the critical literature review and theoretical analysis of research on the digital transformation of education, gamification, and the application of AI, the following conclusions can be drawn:

- A number of learning management systems LMSs function primarily as static repositories of learning content and do not align with the cognitive profiles, behavioral patterns, and expectations of contemporary learners.
- Empirical evidence worldwide confirms that the mechanical incorporation of game elements, such as points and badges, has a short-term and uncertain motivational effect. To achieve sustainable outcomes, environments should be designed according to the paradigm of deep gamification, in which game mechanics and didactic objectives are interconnected and support the learning process through experience-based learning and case-solving activities.
- Despite the undeniable advantages of educational games, most existing software solutions are static and non-adaptive and fail to account for learners' individual learning styles, pace of knowledge acquisition, and current emotional and cognitive states.
- The integration of AI is emerging as the only technological solution capable of overcoming the static nature of traditional gamification by enabling real-time behavioral data analysis, dynamic reconfiguration of difficulty levels, and the automated provision of personalized feedback.
- To establish a comprehensive intelligent educational ecosystem, AI-based modules, such as chatbots, should be integrated into e-learning environments to serve as personal virtual assistants and provide learners with continuous support.

These conclusions indicate that, on the one hand, there is a demonstrated theoretical and practical need to introduce a set of intelligent components, including adaptive educational games, chatbots, content-generation tools, and others. On the other hand, well-developed architectural models, methodologies, and software components for their seamless integration into widely used e-learning environments, such as the Moodle LMS, are lacking. The research gap identified in this manner fully substantiates the aim and objectives of the present dissertation, which are addressed through the design and implementation activities presented in the subsequent chapters.

CHAPTER 2. CONCEPTUAL MODELS FOR THE DEVELOPMENT AND INTEGRATION OF INTELLIGENT GAME COMPONENTS INTO E-LEARNING ENVIRONMENTS

This chapter proposes conceptual models and approaches for the development of intelligent game components and their integration into e-learning environments. Methodologies for creating educational mini-games with the assistance of generative AI tools are presented, together with different types of games and their applications in education.

2.1. Criteria for the Selection and Integration of Intelligent Tools and E-Learning Environments

The selection of intelligent educational tools should be aligned with the pedagogical objectives, curricula, and technological characteristics of the learning environment (Chen, n.d.). The main criteria include alignment with the learning objectives and course content; capabilities for personalizing and adapting the learning process; progress monitoring and the provision of timely feedback; real-time identification of knowledge gaps and errors; promotion of learners' active participation and engagement; compatibility with the e-learning platforms in use and support for data synchronization; an intuitive user interface and clear documentation; personal data protection and compliance with applicable regulatory requirements, including the General Data Protection Regulation (GDPR); configurability according to the needs of educators, learners, and the institution; cost-effectiveness, technical support, and the potential for long-term use and further development.

2.2. Methodology for Creating Educational Mini-Games with AI

Developing educational mini-games for learners with different levels of knowledge and different learning styles is a challenging task that requires considerable time and specific programming skills. In the traditional development process, the creation of educational games requires substantial time and resources, including a team of programmers, designers, and educators. The rapid development of AI technologies offers new opportunities to automate and optimize this process.

The present study proposes a methodology for creating educational mini-games using generative AI tools based on large language models. In this particular case, the ChatGPT chatbot was used. The methodology is based on an iterative model for the development and refinement of educational mini-games and comprises five main stages:

Stage 1: Definition of requirements, including the game topic, target audience, and game type;

Stage 2: Creation of an initial version using an AI tool such as ChatGPT;

Stage 3: Testing of the game;

Stage 4: Implementation of corrections and improvements;

Stage 5: Finalization and deployment in an authentic learning environment.

During this process, the individual stages may be repeated several times until an optimal final result is achieved. Thus, game creation is an iterative process rather than a one-off activity.

To create a game, the educator should initially provide ChatGPT with a number of basic requirements, such as:

- **Scope of the game**: What educational content will the game be based on? The educator may provide specific learning content or specify only a topic, in which case the chatbot will rely on its own knowledge base.
- **Target group**: For which age group or level of knowledge is the game intended?
- **Game format**: What type of game should be created, such as a quiz, puzzle, flashcard game, or another format?
- **Number of questions or levels**: How many questions or levels should the game include?
- **Structure of the questions or levels**: For example, whether the questions should be multiple-choice, open-ended, a combination of different types, or another format.
- **Correct answers and explanations**: Depending on the type of game, an additional requirement may be specified that learners should be provided with the correct answers and brief explanations.
- **Design**: Any specific requirements regarding the visual design, colors, style, or other interface elements.
- **Additional game components**: For example, a timer, points, rewards, or other game mechanics.

From a technological perspective, the creation of games with ChatGPT involves the following stages:

- **Prompt processing**. The chatbot receives the text of the prompt containing the requirements for the game, including its topic, target audience, format, and specific requirements.
- **Analysis and interpretation of the requirements**. The content of the prompt is analyzed, and key words and concepts related to the topic are identified.
- **Content generation**. Depending on the type of game, its constituent elements are generated. These may include questions and answers, puzzles, scenarios, characters, and other components.
- **Creation of the game structure**. This stage comprises three components:
    - HTML structure: The basic structure of the web page containing the game is created. It includes elements such as a title, instructions, a game area, buttons, and other components appropriate to the type of game.
    - CSS styling: The web page is styled to make it visually appealing and user-friendly.
    - JavaScript logic: JavaScript code containing the game logic is generated. It includes functions for user interaction, validation of user actions, management of game elements, visualization of results, and other functionalities.
- **Content integration**. The HTML, CSS, and JavaScript components are combined into a complete application.

- **Testing and debugging**. At this stage, the game is tested, and any identified errors or problems are corrected.
- **Finalization and presentation of the result**. The completed game is delivered to the user.

2.3. Selected Types of Educational Mini-Games and Areas of Application

The proposed methodology for creating educational mini-games with AI is suitable for the development of different types of games. Since different game types support the development of specific cognitive skills and allow learning content to be adapted to particular educational objectives, this dissertation examines the possibilities for creating mini-games in the form of flashcards, quiz games, puzzle games, and fill-in-the-blank games (Table 1).

Table 1. Selected types of educational mini-games.

Game type	Learning objective	Format
Flashcards	Memorisation of information, review, and consolidation of key concepts	Each card has two sides: one contains a question, term, image, or fragment of content, while the other provides an answer, definition, or brief explanation.
Quiz games	Assessment of the extent to which specific learning content has been mastered	An interactive test containing multiple questions of different types, including single-answer, multiple-choice, true/false, short open-ended questions, and others.
Puzzle games	Understanding the structure, sequence, and relationships between individual elements	Arranging elements according to specific relationships, matching pieces of information, ordering fragments, or reaching the correct solution through a sequence of actions.
Fill-in-the-blank games	Consolidation of knowledge related to syntax, definitions, and logical expressions, as well as assessment of learners' understanding of their application in a given context	The task presents a context in which part of the information is omitted, and the learner must select or enter the correct element.

The selection of a particular game model should be aligned with the learning content, the learners' age and level of preparation, and the expected learning outcomes. In this respect, educational mini-games can be regarded as a flexible tool for personalizing and diversifying the learning process.

2.4. Conceptual Model of the SQL Escape Room Game

In recent years, the Escape Room format has become established as a popular game model. Participants complete a sequence of interconnected tasks and puzzles to achieve a specific objective, usually related to overcoming a particular challenge. Typical features of this type of game include a storyline, progressively increasing task difficulty, a time limit, and active problem-solving. Transferring this model to a digital learning environment creates conditions for enhancing engagement, critical thinking, and the practical application of knowledge.

In database education, the Escape Room approach enables learning content to be presented through a game-based scenario in which learners solve practical tasks using SQL queries.

The conceptual model of the SQL Escape Room game is intended to support the acquisition and consolidation of knowledge and practical skills related to relational databases and SQL (Fig. 1). The learner assumes the role of a specialist who is "locked" inside a virtual database and must restore access to the system by completing a sequence of SQL missions. Each mission represents a specific task, and progression to the next stage is possible only after the current mission has been successfully completed.

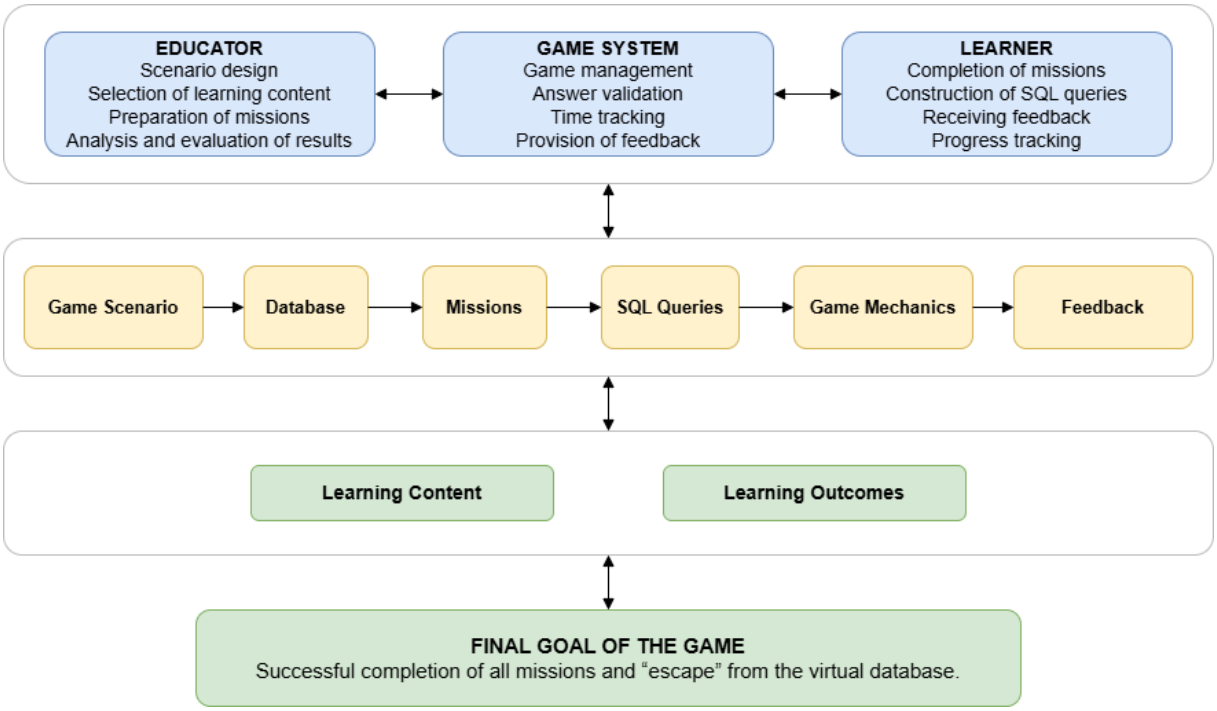

Figure 1. Conceptual model of the SQL Escape Room game: objects and actors.

The model includes three main actors: the learner, the educator, and the game system. The educator defines the learning content, data, and missions. The learner constructs SQL queries and completes the assigned tasks. The game system manages the levels, validates the solutions, tracks the time, and provides feedback.

The interaction between the learner and the game is implemented as a sequential cycle of actions. After becoming familiar with the scenario, the learner gains access to the first mission, analyses the task requirements, and uses the provided database schema and data to construct the required SQL query. The resulting output is entered into the game interface and automatically validated. A correct answer unlocks the next mission, whereas an incorrect answer allows the learner to make another attempt. The process continues until all missions have been completed or the allotted time has expired (Fig. 2).

Feedback is the primary mechanism for promptly informing learners about the outcomes of their actions. After each submitted solution, the system automatically validates the answer and displays an appropriate message. When the solution is correct, the next mission is activated and the participant's progress is recorded. When the answer is incorrect,

the learner is given another opportunity to attempt the task. In addition to providing immediate feedback, the system should also report the final outcome of the game through a message indicating either successful completion or failure due to errors or the expiration of the allotted time.

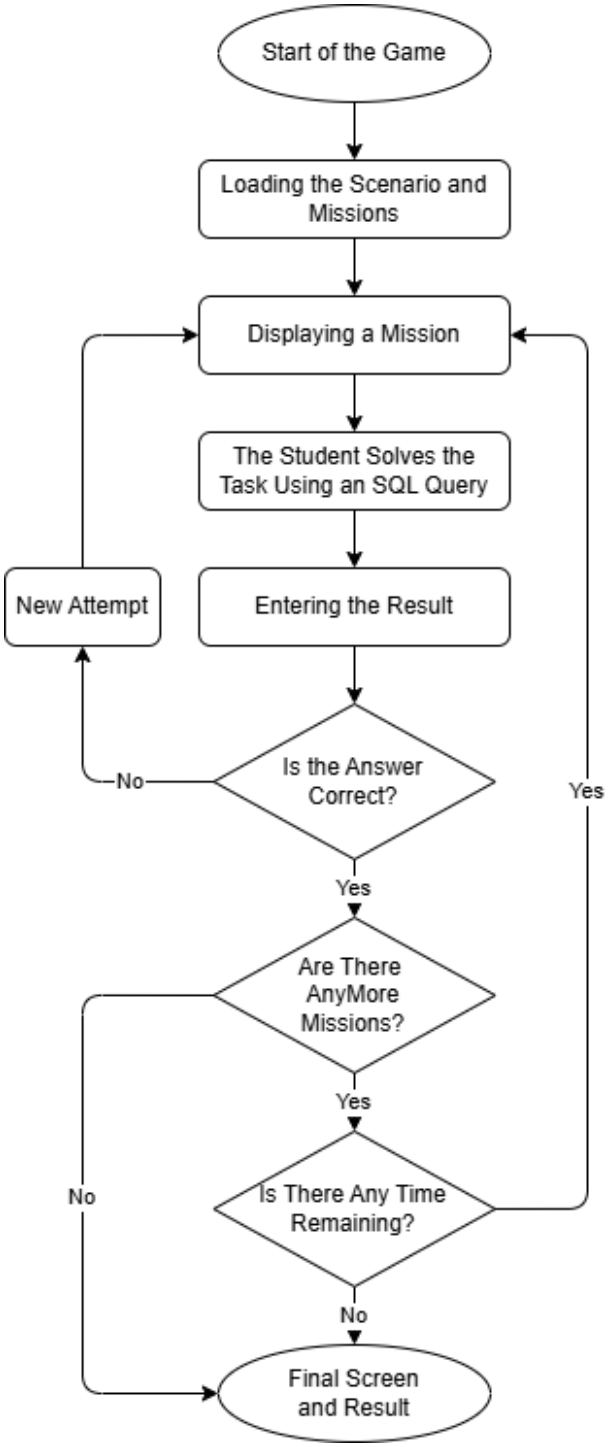

Figure 2. Algorithm of the gameplay process.

2.5. Conceptual Model of a Gamified SQL Learning Environment – Temple of Data

Database and SQL education is often perceived by students as abstract and difficult to apply in practice. At the same time, mastering SQL requires the active application of

knowledge, logical thinking, and repeated practice. The use of innovative approaches can increase learners' engagement and motivation. This motivated the development of the Temple of Data game environment for learning SQL and relational databases through a combination of interactive missions, puzzles, and practical tasks.

In the game, the learner assumes the role of an explorer who progresses through different levels of a mystical temple by solving SQL challenges. During gameplay, a virtual mentor provides instructions, theoretical explanations, and guidance to support the learner in completing the missions. The game environment combines theoretical content, the practice of SQL syntax through game-based puzzles, the actual writing of SQL queries, automated validation of solutions, and game mechanics such as points, a timer, hints, and a leaderboard. This approach creates an interactive and motivating environment that supports the practical acquisition of knowledge and increases learner engagement.

The system is organized into three main layers: the frontend layer, the backend layer, and the database layer (Fig. 3).

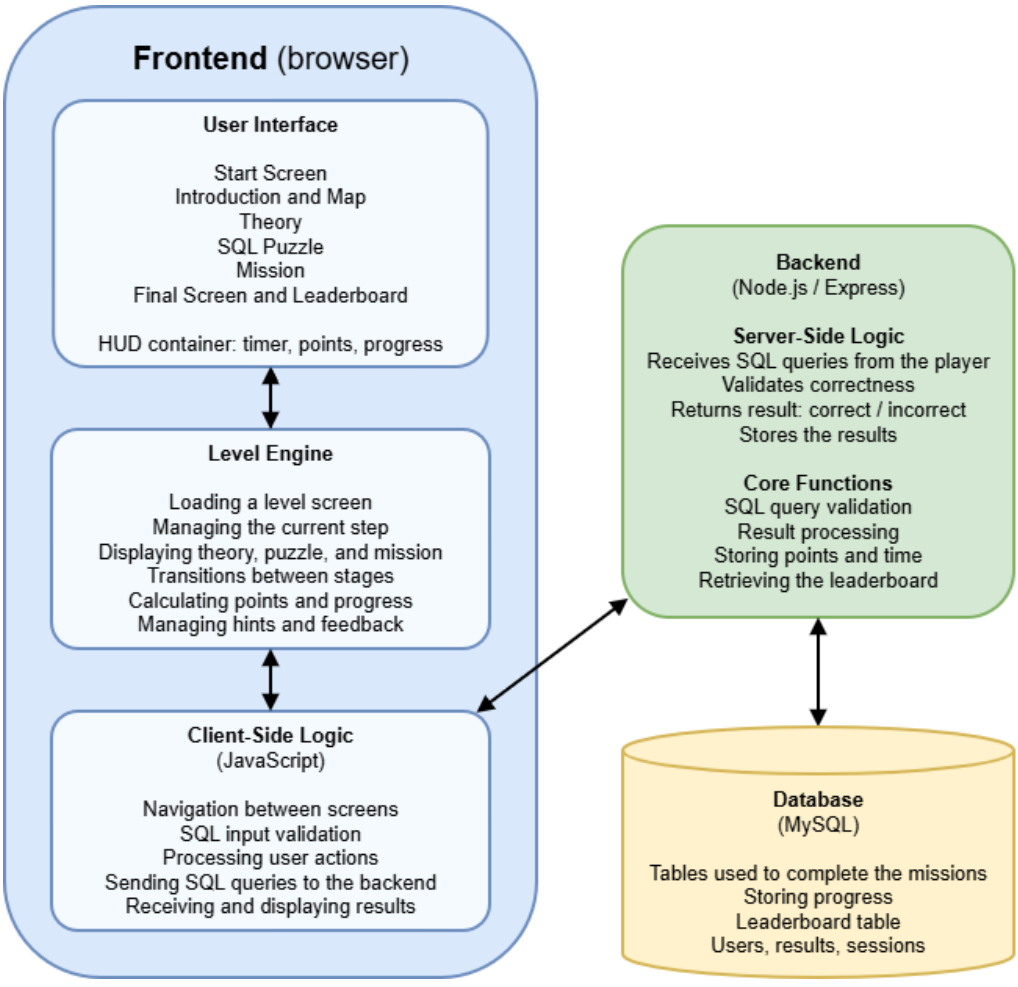

Figure 3. Architecture of the Temple of Data game.

2.6. Conceptual Model for Integrating Games into E-Learning Systems

To ensure broad applicability, the technology should support the integration of games developed using different technologies, such as HTML, CSS, JavaScript, PHP, and others, while providing a unified mechanism for data collection and processing.

The main objective is to enable the collection, storage, processing, and analysis of data on learners' game activity with minimal modifications to existing games. Based on these data, the system should calculate both a result for each individual game and an aggregate grade for the learner within a particular course.

The technology should support **various types of educational games (Game Types)**, such as flashcards, puzzles, fill-in-the-blank games, escape room games, and other stand-alone interactive games. Each game type should be adaptable to different subjects, learning topics, and courses.

To denote a specific implementation of a particular game type, we use the term **Game Instance**. A game instance is a functional game created through a specific configuration of a particular game type. It is parameterized according to the content, objectives, and context of the respective subject or course. The content of a game instance may be configured statically, through the manual entry of learning content by the educator-author, or dynamically, through the automated real-time generation of game elements by means of integration with large language models.

A single game type may have multiple instances used in different courses and contexts. These instances may differ in terms of:

- learning content;
- maximum number of points;
- assessment weight;
- mode of use – learning or self-study;
- specific settings, such as the interface, launch conditions, and others.

This approach ensures the flexibility and reusability of game types when creating diverse learning scenarios.

Each game may be used in two modes: learning and self-study. Only results obtained from games used in learning mode are stored in the database and included in the cumulative assessment.

Two possible approaches can be used to integrate educational games into e-learning systems: Approach A: External integration through an iframe and a REST API; Approach B: Internal integration through the development of an additional module

Integration Mechanism

The integration mechanism is intended to establish a connection between the REST API and educational games implemented using different technologies, such as HTML, CSS, JavaScript, PHP, and others. The main requirement is that the integration should require minimal modifications to existing games and use standard HTTP requests.

Basic Principle of Integration

All games communicate with the system through a REST API using HTTP requests, such as GET and POST. Regardless of the technologies used, each game should be able to initiate a gameplay attempt and submit results and game events.

Communication is performed using the JSON data format.

All games use the same interface regardless of their implementation technology. For this purpose, a unified API layer has been developed. Integration is implemented through a

central REST API that receives requests from the games, processes the data, stores the results in the database, and returns responses to the games.

Because the REST API uses standard HTTP methods, such as GET, POST, PUT, and DELETE, and the JSON format for data exchange, educational games can be integrated using various programming environments and technologies. Communication with the API can be implemented through standard HTTP request libraries available in different environments (Table 2).

Table 2. Technologies and methods for communicating with the API.

Technology	Method/Library
JavaScript	fetch
PHP	cURL
Python	requests
Java	HttpClient
Unity	UnityWebRequest

The main advantage of integration using Approach A is complete independence from the LMS platform, as the game code can operate in various e-learning systems, including Moodle, Canvas, and Blackboard. The disadvantages of this approach are associated with security risks, such as the possibility of submitting falsified grades to the API, and more complex session management.

Integration through the Development of an Additional Module

The development of an additional module for an e-learning environment allows the game to be fully integrated into the educational process and used effectively as part of formative assessment in a particular subject. Owing to its direct access to the API of the e-learning environment, the developed module enables the automatic recording of results, points, progress, number of attempts, and completion time directly in the course gradebook.

This type of integration provides a high level of security and simplified authentication through Single Sign-On. Because communication through the plugin is performed at the backend level through server-to-server communication, the manipulation of results by learners becomes considerably more difficult, thereby providing protection against fraud.

The specialized module also enables deep integration with the course ecosystem and provides options for:

- defining completion conditions, such as locking the next lesson until the learner achieves a specified minimum score in the game;
- automatically transferring the game settings and structure when the course is copied for the following academic year;
- generating detailed reports and analyses showing who played the game and when, where learners encountered the greatest difficulties, and which errors occurred most frequently.

Another major advantage of this approach is that it ensures a consistent user experience (UX) as part of the interface of the e-learning environment, as well as responsive design.

The disadvantages of Approach B include its higher cost and longer implementation time. The development process requires familiarity with the architecture of the e-learning environment and its API. Another disadvantage is the need for long-term maintenance and compatibility with new versions of the platform.

Furthermore, there is a risk of complete dependence on a particular platform. For example, a module developed for Moodle cannot operate in other systems, such as Canvas or Blackboard, without being rewritten. The risks associated with the security and stability of the learning environment itself should also be taken into account. Because the plugin operates directly at the server level, an error or vulnerability in its code may compromise personal data or disrupt the operation of the entire platform.

Because of these security considerations, system administrators in many educational institutions impose strict restrictions and frequently refuse to install external modules on their servers, resulting in cumbersome approval procedures.

Despite the challenges associated with higher costs, administrative barriers, and the need for long-term maintenance, the development of a specialized module is the preferred approach. It allows the game to be transformed from an external entertainment resource into an integrated, secure, and interactive educational tool.

2.7. Conclusion

Based on the comparative analysis of the architectural approaches, integration through the development of a specialized additional module (plugin) was selected for the purposes of the present study and the experimental validation of the proposed conceptual model for integrating educational games. Despite its theoretical limitation in terms of portability across different LMS platforms, this approach provides the highest level of security through server-to-server communication, thereby eliminating the risk of learners manipulating data in the client browser, and enables direct integration with the gradebook.

Accordingly, the following chapter of the dissertation presents the practical implementation of the architectural framework in the form of an AI Games software module for the Moodle platform, which supports the dynamic generation of learning content. The proposed architecture offers several advantages, including technology independence, minimal modifications to existing games, centralized data collection, straightforward LMS integration, and support for different game types.

CHAPTER 3. DEVELOPMENT AND INTEGRATION OF INTELLIGENT GAME COMPONENTS INTO E-LEARNING ENVIRONMENTS

3.1. Technologies and Tools for Developing Intelligent Components for E-Learning Environments

Contemporary tools for creating interactive educational resources provide ready-made templates, visual editors, and drag-and-drop functionality that can be used to develop tests, games, simulations, animations, and other multimedia materials. Platforms such as H5P, Genially, Kahoot!, GDevelop, Classtools.net, and Construct 3 facilitate the creation and

integration of gamified content into e-learning environments. Some of these platforms also include AI-based functionalities for generating, editing, translating, and providing voice-overs for content, as well as for automatically generating questions. Despite their ease of use, their free versions often provide only a limited range of features.

Generative AI tools further reduce the time and technical resources required to develop educational games. ChatGPT can support idea generation, scenario development, the explanation of programming concepts, and the generation of individual code fragments, while Canvas enables the editing of larger text and source-code files. Specialized programming agents, such as Codex, can work on complete projects, analyses their structure, generate and modify code, run tests, and debug errors. Regardless of the tool used, the generated solutions should be critically reviewed, tested, and, where necessary, revised by a user with basic programming knowledge.

3.2. Integration of AI Components into Moodle

Moodle is a widely used open-source e-learning environment that supports the straightforward integration of various components, including AI-based tools. Within the present study, several tools were tested: AI Connector, which provides access to external AI services through an API; OpenAI Chat Block, used as a virtual assistant to support learners, educators, and administrators; AI Text to Questions Generator, which generates and adapts test questions and stores them in the course question bank; and AI Text to Image, designed to create images from textual descriptions for use in educational resources.

The operation of these tools generally requires access to the OpenAI API, the use of which is charged according to the selected model and the volume of requests. Digital proctoring and plagiarism-detection solutions can also be integrated into Moodle, including Moodle Proctoring, Turnitin, Urkund, SafeAssign, and others.

3.3. Development of Educational Mini-Games for Teaching Databases

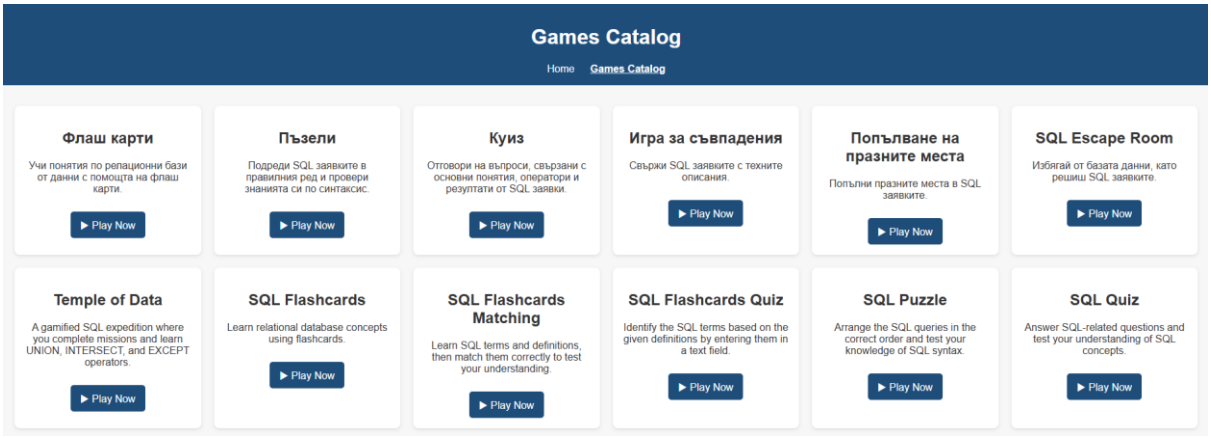

Figure 4. Catalogue of educational mini-games for Databases.

A variety of educational mini-games of different types have been developed for teaching Databases, including flashcards, puzzles, quizzes, SQL simulators, and escape rooms. They are organized in a catalogue that is freely accessible at https://sqledugames.onrender.com/. The games are suitable for self-study and practice in

Databases. Some of them were tested in the educational process at Paisii Hilendarski University of Plovdiv during the 2024/2025 and 2025/2026 academic years.

The catalogue was created using HTML and CSS, with each game placed in a separate container using the <article> element (Fig. 4). Each game is accompanied by a description and consists structurally of three files: index.html, styles.css, and script.js.

3.4. Development of an SQL Escape Room for Teaching Databases

The SQL Escape Room gamified educational resource implements the conceptual model proposed in Section 2.4. It was developed as a web-based application using the standard client-side technologies HTML5, CSS3, and JavaScript. The resource was designed to support the practice and consolidation of knowledge related to aggregate functions (SUM, MIN, MAX, AVG, and COUNT) and the GROUP BY, HAVING, and ORDER BY clauses through solving tasks in a game-based environment.

The tasks to be completed by learners were developed using a fixed dataset represented by a sales table containing sales information, including the date, region, salesperson, product, customer, quantity, and unit price.

The application has an entirely client-side architecture, with all components related to the game logic, data processing, game-state management, and answer validation executed locally in the user's web browser (Fig. 5).

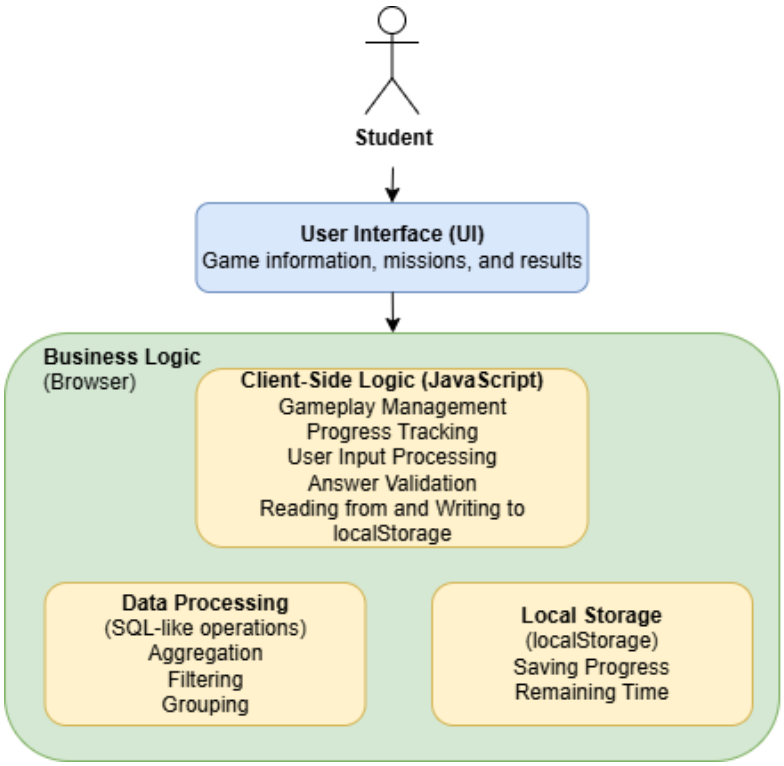

Figure 5. Architecture of the SQL Escape Room game.

The user interface is implemented through an HTML structure that divides the application into several main functional areas. The initial section contains an introductory screen presenting the game scenario, a description of the assigned task, and a button for starting the game (Fig. 6).

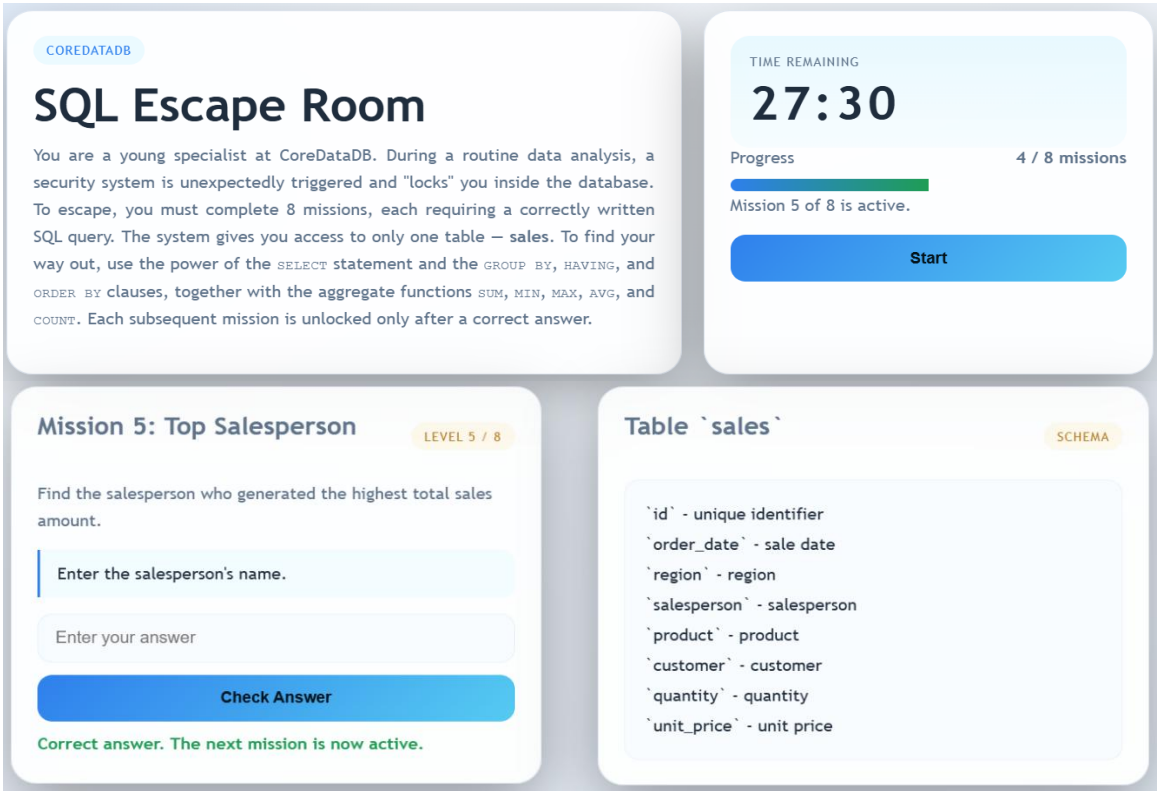

Figure 6. Completion of a mission in the SQL Escape Room game.

3.5. Gamified Environment for Learning SQL – Temple of Data

The web-based educational environment Temple of Data (https://temple-of-data.onrender.com), developed as part of the dissertation research, employs a game-based approach to SQL learning. Its main objective is to make database education more engaging, practice-oriented, and closely aligned with a real-world working environment. The game combines concise theoretical explanations, practical SQL challenges, an interactive query editor, and systems for points, time tracking, and ranking. Solutions are validated in real time by a server, ensuring accuracy and reliability. Participants assume the role of explorers who progress through different “rooms” of a mystical temple by solving tasks related to operators such as UNION, INTERSECT, and EXCEPT.

The Temple of Data game has a client-server architecture. Communication between the frontend and backend is implemented through a REST API.

The frontend was developed using HTML, CSS, and JavaScript (Fig. 7), with the main interaction taking place through a graphical user interface. Within this interface, learners receive missions and instructions from Prof. Databases. Ace Editor is integrated for entering SQL queries, providing a more realistic code-writing environment. After the user enters an SQL query, it is transmitted to the server through an HTTP request.

The server-side logic (Fig. 8) is implemented using Node.js and Express.js. The server receives requests from the client, preprocesses and validates the input data, including checking the SQL syntax where applicable, and then sends the query to an external database. For this purpose, the mysql2 library is used to establish a connection to a server-hosted database on freesqldatabase.com. The results of the SQL query are retrieved from the database and returned to the client for visualization.

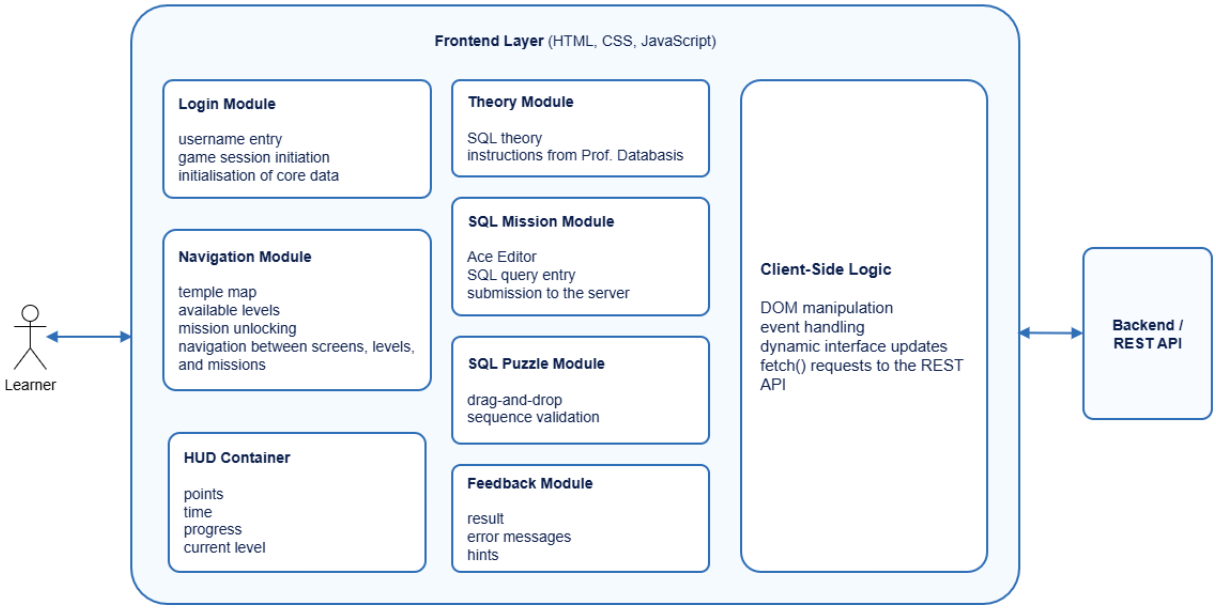

Figure 7. Frontend components of the Temple of Data game.

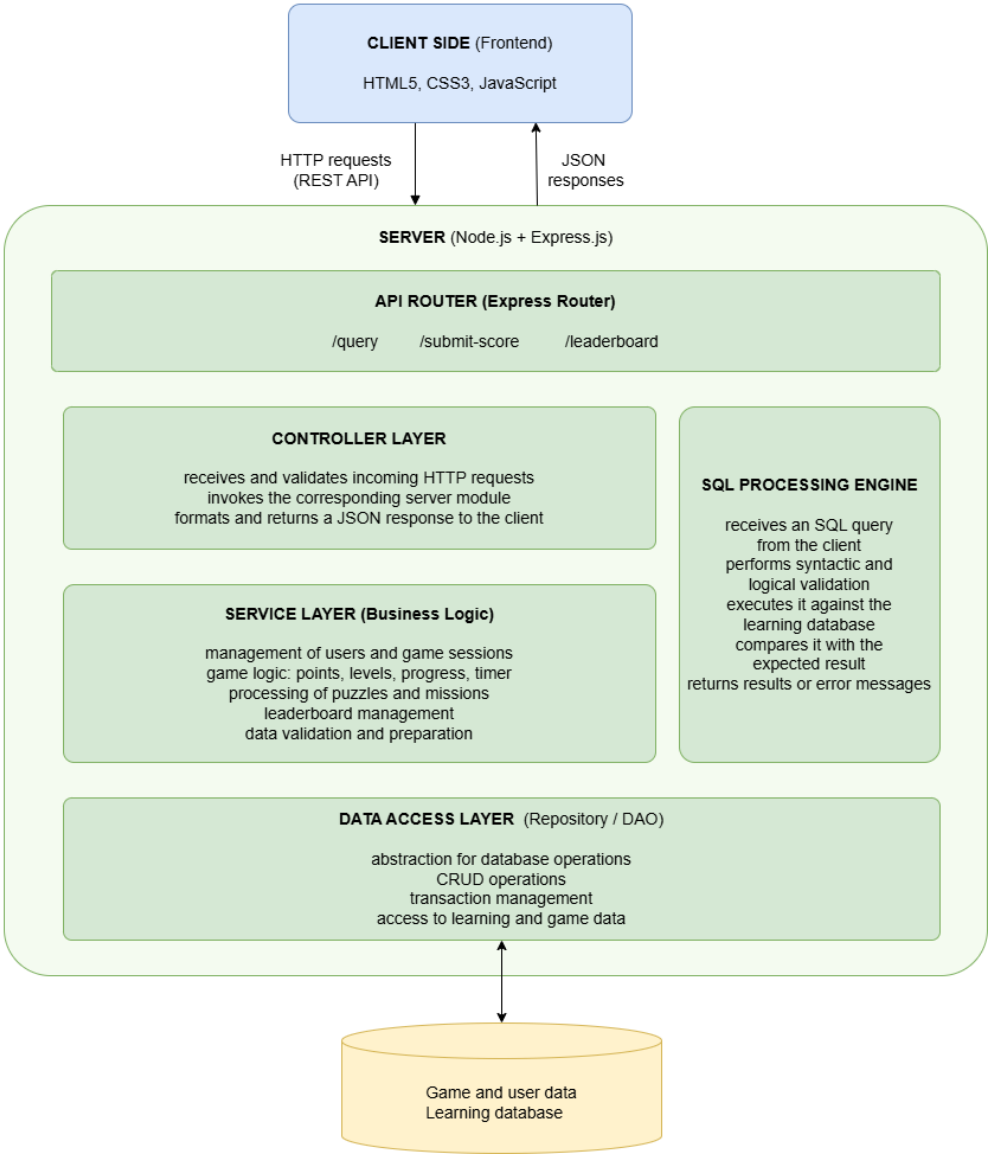

Figure 8. Server-side architecture of Temple of Data.

The external database plays a key role in the learning process. It contains predefined tables and data on which players perform their missions.

The client side was developed using HTML5, CSS3, and JavaScript. The HTML structure implements the individual game screens and interface components, CSS is used for visual design and animations, and JavaScript manages the dynamic behavior of the game environment.

The frontend components function as interconnected modules that ensure the sequential progression of the game scenario, from logging into the system and presenting the learning content to completing SQL missions and displaying feedback. The client-side logic manages the interaction between the individual modules, processes user actions, and supports the dynamic updating of the interface. Asynchronous communication with the backend layer enables SQL queries to be validated and results to be updated in real time.

3.6. Module for Integrating Educational Games into Moodle

The AI Games module enables interactive educational games to be added as activities within Moodle courses. The current version includes a flashcard game for matching terms with definitions and the SQL Escape Room game, with the individual game types implemented as subplugins. The architecture distinguishes between an activity, a user session, and a game item. The module was developed using PHP 8.2 for Moodle 4.3.3 and was integrated with Google Gemini 2.5 for the automated generation of content.

The limitations of the API used are managed by storing generated resources locally, limiting and monitoring the number of requests, and switching to predefined content when the applicable limits are reached. To ensure security, the API key is stored on the server, while communication with the service is performed through the backend layer without exposing the key to the client browser.

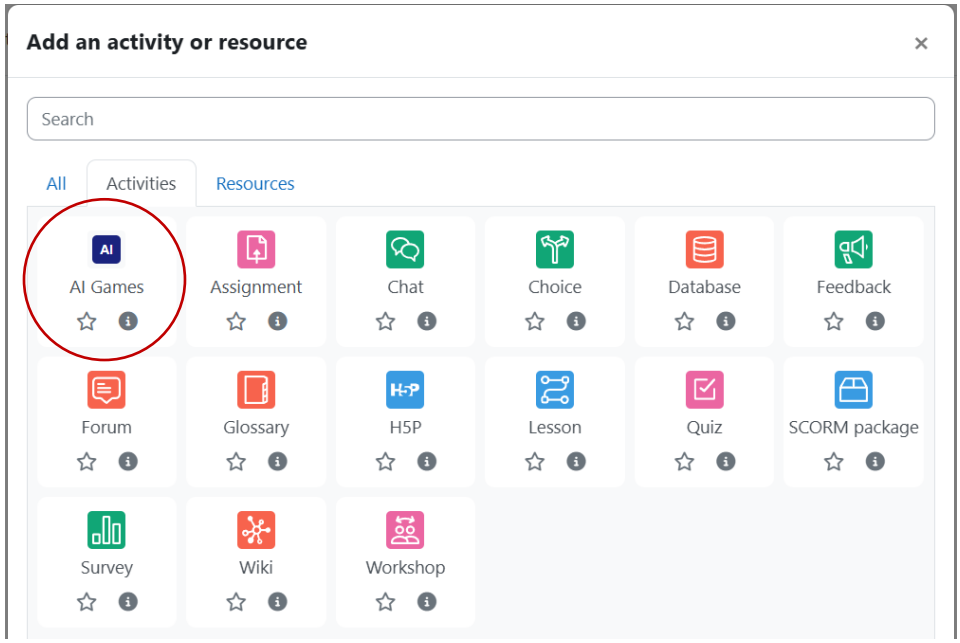

Figure 9. Adding an AI Games activity in Moodle.

Educators can configure game-based activities and associate them with assessment criteria. An AI Games activity is added while the course is in editing mode. The required

metadata, including the activity name and description, are entered for each activity, and the educator selects a specific game subplugin from a drop-down list. Depending on the selected game type, a form containing the corresponding game-specific settings is displayed (Fig. 9).

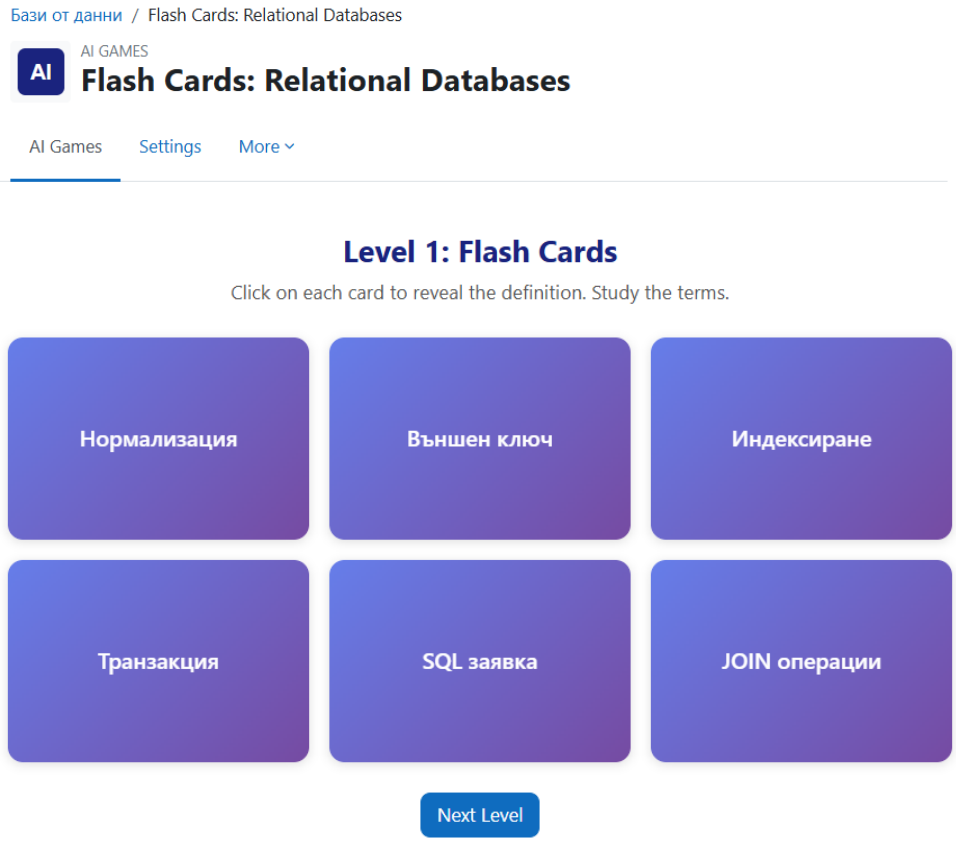

Figure 10. Flashcard game integrated as a learning resource in Moodle.

For the Flashcards game, the educator enters the subject topic, such as “Relational Databases”, selects the operating mode – static or dynamic with AI – defines the number of card pairs, ranging from 4 to 12, and specifies the level of cognitive complexity: beginner, intermediate, or advanced (Fig. 10).

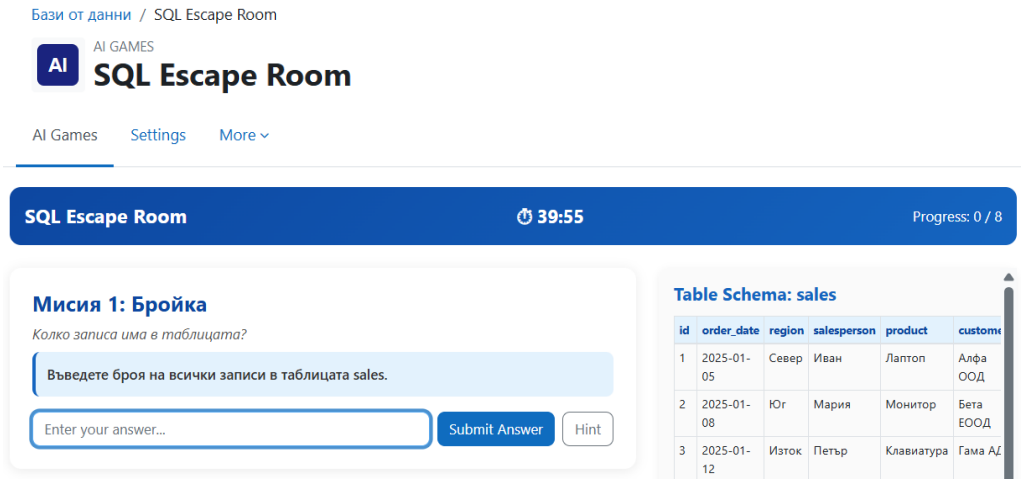

Figure 11. SQL Escape Room integrated as a learning resource in Moodle.

For the SQL Escape Room game, the educator configures the operating mode, the total number of sequential missions, with eight recommended, the session time limit in minutes, set

to 40 minutes by default, and the complexity of the relational queries that students will be required to construct (Fig. 11).

3.7. Conclusion

This chapter presented the practical implementation of the conceptual models proposed in the preceding chapter for the development and integration of intelligent game components into e-learning environments. Educational resources were implemented that combine game mechanics, artificial intelligence technologies, and integration capabilities for the Moodle platform, thereby creating a comprehensive technological environment to support the learning process.

The developed solutions confirm the applicability of the proposed conceptual models and demonstrate the potential for effectively combining artificial intelligence technologies, gamification, and contemporary web technologies in the development of intelligent educational resources. The software solutions created were used in the experimental studies presented in the following chapter.

CHAPTER 4. EXPERIMENTAL STUDY AND EVALUATION

4.1. Objectives and Methodological Framework of the Experimental Studies

The main objective of the experimental studies was to conduct an initial evaluation of the developed intelligent components and gamified educational resources and to analyze their applicability in an authentic university environment. The experiments aimed to examine learners' attitudes towards the use of the developed solutions, their level of satisfaction, their perceived usefulness, and their impact on motivation and engagement during the learning process.

It should be emphasized that the present experimental studies are primarily exploratory and evaluative in nature. They are not intended to establish statistically significant relationships or to derive generalizations applicable to the entire learner population. Their main purpose is to provide empirical feedback on the developed software solutions, identify their strengths and potential areas for improvement, and confirm the practical applicability of the proposed conceptual models.

The experiments were conducted with a limited number of participants. This does not allow the application of statistical procedures aimed at formulating statistically significant conclusions or generalizing the results to a broader population. The findings should therefore be regarded as indicative and as a basis for future studies involving larger samples and controlled experimental conditions.

Despite the limited size of the study groups, the experiments provide valuable information about the practical applicability of the developed intelligent components. The analysis of the collected data makes it possible to assess the extent to which the proposed solutions support the learning process, increase learners' interest, and create conditions for more effective acquisition of the learning content. The results may serve as a starting point for subsequent larger-scale experimental studies and for the further development of the proposed models and software tools.

4.2. Experimental Study of AI Plugins in Moodle

Two experimental studies were conducted using the intelligent components integrated into Moodle. They were aimed at evaluating the potential of AI to support educators and learners in generating educational resources, acquiring new knowledge, and solving practical tasks. The studies were carried out within the Database course during the 2023/2024, 2024/2025, and 2025/2026 academic years and involved students from several degree programs at the Faculty of Mathematics and Informatics of University of Plovdiv Paisii Hilendarski. Participation was voluntary and was encouraged through the award of additional points towards the final grade.

The first study involved 40 of a total of 87 students (46%) and examined the use of the Moodle virtual assistant for the independent study of the concept of views in relational databases. The students completed five sequential tasks: constructing SQL queries; studying the nature and syntax of views; completing a test; creating their own view and a query based on it; and identifying advantages and disadvantages. The test questions were created using the AI Text to Questions Generator, while the virtual assistant was used as a source of explanations and guidance. All 38 participants who completed the second task successfully used the assistant, and 33 of the 39 students answered at least four of the five test questions correctly. In the most complex practical task, 31 of the 35 participants created a view correctly, while 30 formulated a correct query based on it. The results indicate that the learners largely understood the generated explanations and were able to apply them when solving practical SQL tasks.

The second study focused on students' ability to critically analyses AI-generated solutions. It involved 39 of a total of 81 students (48.15%). The task required students to identify the reasons why a customer record could not be deleted from a database and to propose two solutions consistent with foreign key constraints. The students were allowed to use an AI chatbot but were required to provide their own explanation, describe the proposed solutions, and present evidence of their practical implementation. Almost all participants completed the task successfully, although some provided inconsistent or incomplete explanations, raising questions about the actual depth of their understanding.

The questionnaire survey conducted after the second experiment revealed positive attitudes towards the use of AI. Almost all respondents had used a chatbot, and the majority considered the explanations provided to be clear and the proposed solutions to be either directly applicable or applicable after further clarification. More than 90% reported increased confidence when working with relational databases, while a similar proportion stated that they would probably or certainly use a chatbot for comparable tasks.

The overall results confirm the potential of AI tools integrated into Moodle to support independent learning, the acquisition of new concepts, and the completion of practical tasks. Their effective application, however, requires critical evaluation of the generated responses, revision of the content, and pedagogical design that assesses not only the final result but also learners' understanding of the solutions applied.

4.3. Evaluation of SQL Escape Room Game

The gamified resource SQL Escape Room was tested in an authentic learning environment within the Database course at University of Plovdiv Paisii Hilendarski. The study involved third-year students enrolled in the degree programs Mathematics, Informatics and Information Technology; Information Technology, Mathematics and Educational Management; Mathematics; and Applied Mathematics. The experiment was conducted during the 2024/2025 and 2025/2026 academic years, with a time limit of 40 minutes for completing the game.

The study combined practical work with the game-based resource, observation of participant behavior, and an anonymous questionnaire survey. A total of 28 out of 81 students participated in the game, and 26 completed the feedback questionnaire. The majority of participants successfully completed the tasks within the allotted time. The difficulties identified were primarily related to the interpretation of certain task instructions rather than to the application of the SQL concepts studied.

The questionnaire results indicate a high level of satisfaction and engagement. More than three quarters of the respondents considered the game-based approach more beneficial than traditional instruction, while 22 of the 26 students stated that they would participate in a similar learning activity again. The dynamics of the game, its practical orientation, and the opportunity to apply knowledge while solving specific tasks were evaluated positively. At the same time, 10 participants reported that some of the task instructions were insufficiently clear, indicating the need for more precise wording.

The open-ended responses described the resource as an “unconventional way of learning”, a “dynamic and engaging format”, and an opportunity for “learning through practice”. Participants also expressed interest in expanding the game by adding more missions and different levels of difficulty. The results indicate that SQL Escape Room can support active participation, motivation, and the practical acquisition of knowledge. For students preparing for the teaching profession, the resource also provides an opportunity to develop a pedagogical perspective on the use of gamified approaches in their future professional practice.

4.4. Evaluation of Temple of Data Gamified Environment

The educational game Temple of Data was tested during the 2024/2025 and 2025/2026 academic years in the practical classes of the Database course at Paisii Hilendarski University of Plovdiv. The study involved 31 of a total of 81 third-year students enrolled in the degree programs Mathematics, Informatics and Information Technology; Information Technology, Mathematics and Educational Management; Mathematics; and Applied Mathematics. The game was used as a practical formative assessment activity through which students could earn additional points towards their final grade. Additional rewards were also provided for the highest-performing participants, thereby reinforcing the competitive nature of the activity.

The game was used simultaneously to introduce and practice the SQL constructs UNION, INTERSECT, and EXCEPT, with which the students had not previously been familiar. Observations indicated a high level of activity, mutual assistance, and willingness to discuss possible solutions despite the competitive format. The puzzles and missions placed

learners in a setting different from that of traditional practical classes and encouraged them to apply logical reasoning and acquire new knowledge through practical activity.

After the game, a voluntary and anonymous questionnaire survey was completed by 28 participants. All respondents reported that the game had maintained their attention and that they were satisfied with their participation, while 23 students rated their level of engagement as very high. According to 20 participants, learning through the game was more effective than a traditional lesson, and 25 expressed a willingness to participate in a similar format again. All respondents evaluated the interface as intuitive and easy to use, while 24 students considered the instructions sufficiently clear. The puzzles, drag-and-drop activities, code-writing tasks, point system, leaderboard, and hints were also evaluated positively.

The main recommendations for future development included adding more characters, missions, and rewards; providing clearer transitions between the individual stages; and displaying a warning when points are deducted for using a hint. The feedback obtained is particularly significant because some of the participants are preparing for the teaching profession and can evaluate the game both from the perspective of learners and as a potential pedagogical tool.

The results indicate that Temple of Data can support the acquisition of SQL constructs, the practical application of knowledge, and the development of logical reasoning, while simultaneously increasing students' motivation and active participation. However, the effective use of the resource requires alignment with the curriculum and an appropriate balance between game mechanics and educational objectives so that the competitive and entertaining elements do not shift the focus away from knowledge acquisition.

4.5. Conclusion

This chapter presented the results of the experimental evaluation of the developed intelligent game components and AI functionalities integrated into the Moodle e-learning environment. The studies conducted confirm the applicability of the proposed models and software solutions and demonstrate a positive impact on learners' motivation and engagement.

The results show that the developed educational games can be successfully used in an authentic university learning environment. They confirm the achievement of the research objectives and provide a basis for formulating the scientific and applied contributions and the general conclusions of the dissertation.

CONCLUSION

Within the framework of the dissertation research, the main tasks were successfully completed:

A review of the scientific literature on contemporary approaches to e-learning was conducted, including game-based learning and applications of artificial intelligence (AI) in education.

Conceptual models were developed for the design of intelligent and gamified educational resources that integrate pedagogical principles, game mechanics, and AI

technologies within a unified methodological framework. These include a conceptual model of the SQL Escape Room game and a conceptual model of the gamified SQL learning environment Temple of Data.

Intelligent gamified educational resources were designed and implemented on the basis of the developed conceptual models, including a set of educational mini-games for database learning. A unified platform providing access to the mini-games was also created as a tool for students' self-study and practice.

A methodology and tools were developed for integrating the created resources into an electronic learning environment. A methodology for creating educational games using artificial intelligence technologies was proposed. A conceptual model for integrating the developed components into an e-learning environment was also proposed, including a mathematical model, a database description, a REST API, and various mechanisms for integrating gamified resources into e-learning environments.

The developed models were implemented and tested in an authentic educational environment with students from Paisii Hilendarski University of Plovdiv.

An experimental study was conducted to evaluate the effectiveness of the developed resources, including the analysis and interpretation of the results obtained.

The completion of these tasks fulfils the main objective of the dissertation research: to develop conceptual models and a methodology for the design, development, and application of intelligent and gamified educational resources for higher education based on artificial intelligence technologies; to develop tools for integrating the created resources into e-learning environments; and to experimentally evaluate their effectiveness in increasing students' motivation, engagement, and learning outcomes.

Contributions

The main contributions of the dissertation can be classified as scientific, scientific and applied, and applied contributions.

Scientific Contributions

SC1. A conceptual model has been developed for designing intelligent and gamified educational resources that integrates pedagogical approaches, game mechanics, and artificial intelligence technologies within a unified conceptual framework for supporting learning.

SC2. A methodology has been proposed for the design and development of intelligent educational resources, combining the principles of gamification, adaptive learning, and the use of generative artificial intelligence in the creation of interactive educational applications.

Scientific and Applied Contributions

SAC1. A set of intelligent and gamified educational resources implementing the proposed conceptual models and intended for teaching Databases has been developed.

SAC2. Conceptual models of the individual educational applications have been developed, including mechanisms for integrating artificial intelligence technologies, game elements, and tools for interactive engagement with learners.

SAC3. A methodology has been developed for implementing and using intelligent educational resources in an e-learning environment. It includes learning scenarios, feedback mechanisms, and approaches to learner assessment.

SAC4. A module for integrating educational games into Moodle has been developed.

Applied Contributions

AC1. Software prototypes of intelligent and gamified educational resources have been implemented and can be used in teaching Databases to university students.

AC2. The developed resources have been experimentally tested in an authentic learning environment, confirming their practical applicability and effectiveness.

The results of the research provide a basis for the further extension and improvement of the developed conceptual models and implemented intelligent educational resources. Future development will focus on integrating additional adaptive mechanisms and generative artificial intelligence to personalize learning content and provide intelligent feedback. The development of new gamified educational resources for different academic disciplines and the expansion of their application in e-learning systems are also envisaged. Larger-scale experimental studies are also required to further validate the proposed models, particularly with regard to their impact on the quality of education.

Approbation

List of Publications Related to the Dissertation Topic

A total of eight scientific publications have been published on the topic of the dissertation. Three of the publications are indexed in the internationally recognized Web of Science and/or Scopus databases. One of the publications is indexed in Web of Science and has an Impact Factor of 0.3 (Q4):

1. Vazharova, M., **Gorgorova, M**., Gaftandzhieva, S., Doneva, R., Kostov, A., & Avgustinov, S. (2026). Digital transformation in education. Proceedings of the Union of Scientists in Bulgaria – Plovdiv, Series A: Social Sciences, Art and Culture, 9, 4–9. https://usb-plovdiv.org/wp-content/uploads/2026/06/2026_obshtestveni_nauki_tom_IX.pdf

2. **Gorgorova, M**., Hadzhikoleva, S., Gaftandzhieva, S., & Hadzhikolev, E. (2025). SQL Expedition: A game-based approach to database education through missions in the Temple of Data. In 2025 International Conference on Education Technology and Computers (ICETC) (pp. 491–495). IEEE. https://doi.org/10.1109/ICETC66579.2025.11387149. **Web of Science, Scopus**

3. **Gorgorova, M**., Gaftandzhieva, S., & Hadzhikoleva, S. (2025). Artificial intelligence-assisted learning in Moodle. Mathematics & Informatics, 68(2). https://doi.org/10.53656/math2025-2-2-aia. **Web of Science (Q4, IF = 0.3)**

4. **Gorgorova, M.,** Gaftandzhieva, S., & Hadzhikoleva, S. (2025). The use of artificial intelligence in educational games: Benefits and risks for the learning process. Proceedings of the Union of Scientists in Bulgaria – Plovdiv, Series B: Natural Sciences and Humanities, 26, 58–66. https://usb-plovdiv.org/wp-content/uploads/2025/06/2025_natural_sciences_and_humanities_vol_XXVI.pdf

5. **Gorgorova, M.,** Gaftandzhieva, S., Yotov, K., & Hadzhikolev, E. (2025, March). Students' attitude towards the use of AI in higher education. In 2025 24th

International Symposium INFOTEH-JAHORINA (INFOTEH) (pp. 1–6). IEEE. https://doi.org/10.1109/INFOTEH64129.2025.10959172. **Web of Science, Scopus**

6. Hadzhikoleva, S., **Gorgorova, M.,** Hadzhikolev, E., & Pashev, G. (2024, September). AI-driven approach to educational game creation. In Web Proceedings of the 16th ICT Innovations Conference: TechConvergence: AI, Business, and Startup Synergy. https://proceedings.ictinnovations.org/2024/paper/601/ai-driven-approach-to-educational-game-creation
7. Hadzhikoleva, S., **Gorgorova, M.,** Hadzhikolev, E., & Pashev, G. (2024). Creating educational games with ChatGPT. Education and Technologies, 15(1), 212–218. https://doi.org/10.26883/2010.241.5981
8. **Gorgorova, M.,** Gaftandzhieva, S., & Hadzhikoleva, S. (2024). The use of artificial intelligence tools in Moodle. In Proceedings of the National Scientific and Practical Conference "Digital Transformation of Education: Problems and Solutions" (Ruse, 25–26 April 2024). https://www.conf-dte.bg/docs/2024/p-91.pdf

Nine citations to four of the publications related to the topic of the dissertation have been identified.

The developed resources have been implemented in the educational process at Paisii Hilendarski University of Plovdiv within the Database course.

BIBLIOGRAPHY

Balaquiao, E. C. (2024). Optimizing students' performance through artificial intelligence (AI) technology: a gamified approach to smart learning environment. *Journal of Pedagogy and Education Science*, *3*(02), 104-114. https://doi.org/10.56741/jpes.v3i02.515

Bittencourt, I. I., Isotani, S., Wanick, V., & Ranchhod, A. (2018). Flow experience in learning: when gamification meets artificial intelligence in education. http://dx.doi.org/10.1007/978-3-319-93846-2

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability (formerly: Journal of personnel evaluation in education)*, 21(1), 5-31. https://doi.org/10.1007/s11092-008-9068-5

Chen, M. (n.d.). *31 best AI tools for education (2026): Free & paid*. Eklavvya. https://www.eklavvya.com/blog/ai-edtech-tools/

Cho, D., & Kim, H. (2020). The influence of visual design class using gamification on the learning motivation and academic achievement of first-year high school learners. *Archives of Design Research*, *33*(2), 215-228. https://doi.org/10.15187/adr.2020.05.33.2.215

Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. *Journal of educational technology & society*, 18(3), 75.

European School Education Platform. (2021, August 16). *How can artificial intelligence be embedded in education?* https://school-education.ec.europa.eu/en/discover/tutorials/how-can-artificial-intelligence-be-embedded-education

Gaftandzhieva, S., Hussain, S., Hilcenko, S., Doneva, R., & Boykova, K. (2023). Data-driven decision making in higher education institutions: State-of-play. International Journal of *Advanced Computer Science and Applications*, 14(6). https://doi.org/10.14569/IJACSA.2023.0140642

Garrison, D. R. (2016). E-learning in the 21st century: A community of inquiry framework for research and practice. *Routledge*.

Gorgorova, M., Gaftandzhieva, S., Yotov, K., & Hadzhikolev, E. (2025, March). Students' Attitude towards the Use of AI in Higher Education. In *2025 24th International Symposium INFOTEH-JAHORINA (INFOTEH)* (pp. 1-6). IEEE. https://doi.org/10.1109/INFOTEH64129.2025.10959172

Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International journal of educational research*, 102, 101586. https://doi.org/10.1016/j.ijer.2020.101586

Harry, A. (2023). Role of AI in education. *Interdisciplinary Journal and Humanity (INJURITY)*, 2(3), 260–268. https://doi.org/10.58631/injurity.v2i3.52

Jackson, E. (2024). The Evolution of Artificial Intelligence: A Theoretical Review of its Impact on Teaching and Learning in the Digital Age. https://www.econstor.eu/handle/10419/280893

Johnson, R. (2023, October 27). *The role of artificial intelligence in eLearning: Integrating AI tech into education*. eLearning Industry. https://elearningindustry.com/role-of-artificial-intelligence-in-elearning-integrating-ai-tech-into-education

Limonova, V., dos Santos, A. M. P., Mamede, J. H. P. S., & de Jesus Filipe, V. M. (2024). Maximising Attendance in Higher Education: How AI and Gamification Strategies Can Boost Student Engagement and Participation. In *World Conference on Information Systems and Technologies* (pp. 64-70). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-60224-5_7

Miao, F., & Holmes, W. (2021). AI and education: A guidance for policymakers. Unesco Publishing.

Mozelius, P. (2021). Deep and Shallow Gamification in Higher Education, what is the difference?. In *INTED2021 Proceedings* (pp. 3150-3156). IATED. https://doi.org/10.21125/inted.2021.0663

Nam, H. W. (2021). Design of AI-based gamification platform for effective educational service using child behavior prediction/change. *Turkish Journal of Computer and Mathematics Education*, *12*(5), 286-292. https://doi.org/10.17762/turcomat.v12i5.899

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & education*, 147, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Tassilova, N. A., Shashayeva, G. K., Yernazarova, Z. S., Akhmetova, A. I., Arynov, Z. M., & Karimova, Z. K. (2025). Communication technologies in STEM education: A systematic review. *Eurasia Journal of Mathematics, Science and Technology Education*, 21(10), em2719. https://doi.org/10.29333/ejmste/17178

Wang, T., Lund, B. D., Marengo, A., Pagano, A., Mannuru, N. R., Teel, Z. A., & Pange, J. (2023). Exploring the Potential Impact of Artificial Intelligence (AI) on International Students in Higher Education: Generative AI, Chatbots, Analytics, and International Student Success. *Applied Sciences*, *13*(11), 6716. https://doi.org/10.3390/app13116716

Watson, W. R., & Watson, S. L. (2007). An argument for clarity: What are learning management systems, what are they not, and what should they become?. TechTrends, 51, 28-34.

Weng, X., & Chiu, T. K. (2023). Instructional design and learning outcomes of intelligent computer assisted language learning: Systematic review in the field. Computers and Education: Artificial Intelligence, 4, 100117.

Yotov, K., Gaftandzhieva, S., Hadzhikolev, E., Hadzhikoleva, S., & Gorgorova, M. (2026, March). AI in education through the learners' eyes: practical experience, perceptions, and challenges. In *Frontiers in Education* (Vol. 11, p. 1717886). Frontiers Media SA. https://doi.org/10.3389/feduc.2026.1717886