Development of Database-Driven Multimedia Training Products

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Abstract

The current issues of developing a multimedia training complex based on SQL and NoSQL databases and which has high performance and scalability for collective use have been considered in the paper. The tasks of integration of the multimedia product into the Moodle educational system and connection of the necessary databases to the training module have been solved. A methodology for assessing knowledge assimilation using the entropy level has been proposed. The authors note that the use of multimedia databases enriches the learning process and contributes to the development of students' key competences necessary for successful adaptation in contemporary society.

Keywords

databases, multimedia training complex, performance issue, scalability, functional testing, test-cases, SQL, MongoDB

1. Introduction

Databases are organized data sets that are systematized and structured to efficiently store, manage and access information. In the context of modern multimedia projects, databases play a key role in providing access to a variety of multimedia data types such as images, video, audio, text and other multimedia elements. A multimedia project is one that uses different types of multimedia data to create visual or audiovisual content. This can be anything from websites and mobile applications to computer games and educational programs.

The importance of databases in modern multimedia projects is invaluable. Firstly, databases provide efficient storage of multimedia files. Secondly, databases provide convenient and efficient access to multimedia data. Thirdly, databases ensure data reliability and integrity. Through backup, replication, and transactional processing mechanisms, databases ensure the safety and integrity of multimedia data even in the event of system failures or malfunctions.

Thus, databases play an important role in modern multimedia projects by providing efficient storage, management and access to multimedia data, as well as ensuring its reliability and integrity. However, apart from the benefits, the use of databases in multimedia projects also comes with a number of challenges that can negatively impact the projects. Some of these challenges are as follows.

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One of the main problems when using databases in multimedia projects is the performance issue. Multimedia data such as video and images can take up large amounts of memory and require significant resources for processing and transmission. When dealing with large amounts of data, database performance can degrade, resulting in delays in data access and impaired user experience. Performance is a critical aspect of multimedia database design.

Besides, multimedia data often requires a large amount of storage, which can lead to database scalability issues. As the amount of data increases, the database may encounter performance and scalability limitations which can make it difficult to further develop the project. Scalability is an important aspect of multimedia database design especially when dealing with large amounts of data or high system load. Scalability issues can arise due to hardware limitations, inefficient database architecture, or other factors.

Thus, when creating multimedia training products based on databases, the problems of performance and scalability are relevant. Solving these problems requires a comprehensive approach which includes the selection of appropriate database technology, proper database design and implementation of appropriate data security measures.

The purpose of the paper is to develop a multimedia training complex based on SQL and NoSQL databases combining performance and scalability at the level of collective use.

In order to achieve this purpose, it is necessary to solve the following tasks:

1. To integrate the designed multimedia product into the Moodle educational system. This will allow for collective access to the multimedia training complex and address performance issues.

2. To connect the necessary database to the main training module. To provide for the connection of two types of database management systems: Oracle SQL Developer - for control tasks that contain numerical values and provide for their mathematical processing; MongoDB - if the control task involves working with textual information.

2. Related Works

Significant amount of multimedia information that has been accumulated so far makes it difficult to be used by classical teaching methods. Difficulties arise when trying to present all the necessary teaching material in the form of a lecture, a presentation or a video clip. Many teachers try to present new material using traditional teaching methods without the effective use of various media files.

Multimedia databases help to integrate a variety of material into a coherent learning system [2]. Multimedia databases include: graphics (drawings and sketches), images (photos, maps, paintings), video, audio and other content. Characterizing modern multimedia data, Kalipsiz [6] writes that they are often not quite structured, different types of media files impose different software requirements, database management systems require different algorithms of information compression.

All these features have to be studied for innovative teaching methods implementation. Multimedia databases develop cognitive engagement through their ability to attract and retain learners' attention and focus [3]. Multimedia learning packages can not only be used to help students integrate interrelated content areas, but also make learning more meaningful. For example, audio applications can actively engage learners in analyzing, synthesizing and evaluating information [9]. Using multimedia databases, learners can ask questions, interpret information, find answers, and then develop their critical thinking and shape their knowledge.

For example, Wang and Lin [8] have developed a new English language distance learning system using multimedia databases and Internet technology to store English articles, dialogues, videos, and also students' errors. Through the database, teachers can understand the most frequent errors and mistakes and students can improve and practice their English language skills in a realistic learning environment using several different approaches.

Modern multimedia technologies are designed to provide greater individualization of the learning process, to promote the development of students' personal abilities, sustainable development of professional competences [16, 17].

Jonassen [18] suggests some strategies for classroom application, e.g. learning should be gradual, starting with students working with ready-made databases, to partially completed databases, and then to databases created by students themselves. This process involves the availability of several databases for students with different learning skills. Critical thinking and problem-solving skills should be developed gradually through the teacher guided learning.

Rana AlSheikh [4] for multimedia learning proposes to exploit the potential benefits of generative artificial intelligence by focusing on the development and evaluation of an educational video assistant with artificial intelligence. The tool proposed by the author utilizes the principles of Cognitive Theory of Multimedia Learning (CTML) that consists of three modules: transcription, engagement and reinforcement each focusing on different aspects of the learning process. It integrates automatic speech recognition (ASR) using OpenAI Whisper and Google Large Language Model (LLM). CTML is a theoretical framework that explores how people process and understand information presented through different media modalities. It is essentially based on Mayer's research on multimedia learning, Wittrock's generative theory and Paivio's dual coding theory [5].

A number of papers [13 - 15] address the impact of multimedia learning applications on students' psychological state. Jinghui Zeng [7] notes the growing psychological problems faced by university students. His study consists of two main components: firstly, the analysis of the application of multimedia technology in education, and secondly, empirical research of students' psychological state through questionnaires. The results demonstrate that the introduction of group counselling through multimedia system has a positive effect on students' psychological state and brings new ideas in the process of educational programs creation. Jinghui Zeng emphasizes that the use of multimedia system in universities contributes to a positive and healthy psychological state.

When developing multimedia databases, it is important to remember that learning is enhanced when interesting but irrelevant words, images, symbols, sounds, music or animations are minimized [10]. Irrelevant details hinder learning in multimedia learning environments. While enticing details can pique learners' interest and evoke affects and emotions, they can also increase extraneous cognitive load and impede learning [11, 12]. Consequently, the imperative of designing multimedia training applications should be to minimize details that may induce extraneous cognitive processing even if developers suggest that such details may cause interest and emotions.

The importance of multimedia technologies and applications in education as a teaching or learning tool cannot be overemphasized. This has been confirmed in several studies examining the impact of multimedia technologies on the educational system [19 – 21]. Multimedia technologies help to accommodate differences between individuals and coordinate individual learning trajectory. Using computer technology as an interface between learners and what they are learning, using suitable knowledge bases, can be extremely valuable.

In [22], the authors emphasize the following advantages of interactive learning technologies: interactive technologies can be combined with traditional methods and forms of teaching; integration of interactive methods in the learning process increases the effectiveness of traditional learning by forming skills that help apply theoretical knowledge in close to real-life settings; interactive technologies form communicative skills, ability to work in a team, stimulate the development of creativity.

In [23], the authors analyze the work of neural networks for the financial stability of the economic system. The developed methods can be used to evaluate the effectiveness of training complexes. The authors justify the advantages of using feed forward neural networks (FNN) and recurrent neural networks (RNN). The constructed FNN, closed recurrent RNN, and long short-term memory RNN models have relatively high performance evaluation scores, indicating that they have a high probability of predicting the growth of interactive learning performance. Tools such as error matrix and accuracy are used to validate the performance of the constructed model. The combination of these tools gives an indication of how well the neural network model will perform when embedded in a training module.

Multimedia technologies enhance teaching and learning but there are a number of limitations of this technology for educational purposes. Some of these limitations include, among others, unfriendly programming or user interface, limited resources, lack of necessary knowledge and skills, limited time and high maintenance cost.

3. Methods

The assessment of the quality of the developed training complex includes two main stages. At the first stage, the software performance is evaluated, i.e. its testing is carried out. At the second one, the impact of interactive presentation of the learning material on the level of its mastering is assessed.

The testing of the developed training complex included the following stages:

Test strategy and approaches.

The specificity of the application consists in a one-time configuration of the task on demand by the module match.js and further assessment of results. The issues of the project security and scalability were further studied.

Levels of the functional testing:

- Smoke test: an automated one, with the use of Windows and Linux OS command files.
- Critical path test: is done manually.
- The advanced test is not carried out because for this application the probability of detecting defects at this level is negligible.

Due to the team's cross-functional nature, a significant contribution to quality improvement can be expected from code auditing combined with manual white-box testing. Code testing automation was not used due to the extremely limited time.

Criteria

- Acceptance criteria: successful passing of 100% of test-cases of the smoke test level and 90% of test cases of the critical path test level (Successful passing of test-cases metric) under condition of elimination of 100% of defects of critical and high importance (General defects elimination metric). The final coverage of the requirements by test-cases (Coverage of test-cases requirements metric) should be at least 80%.
- Test start criteria: build output.
- Test pause criteria: switching to the critical path test is only acceptable if 100% of test-cases of the smoke test level are successfully passed (Successful passing of test-cases metric); testing may be suspended in case, when performing of at least 25% of the scheduled test-cases, more than 50% of them end with a defect detection (Stop factor metric).
- Test resumption criteria: correction of more than 50% of defects detected in the previous iteration (General defects elimination metric).
- Test completion criteria: passing of more than 80% of test-cases scheduled for iteration (Test-case completion metric).

Resources.

- Software resources: virtual machines (Windows 11 Ent x64, Linux Ubuntu 14 LTS x64, Android OS, MAC OS).

Metrics.

Successful passing of test-cases:

$$T^{SP} = \frac{T^{Success}}{T^{Total}} \cdot 100\%, \quad (1)$$

where T^{SP} – success rate of the test-cases executed;

$T^{Success}$ – a number of successful test-cases;

T^{Total} – a total number of test cases executed.

Minimum value limits:

Initial phase of the project: 10%.

Main phase of the project: 40%.

Final phase of the project: 80%.

Total defect elimination:

$$D_{Level}^{FTP} = \frac{D_{Level}^{Closed}}{D_{Level}^{Found}} \cdot 100\% \,, \qquad (2)$$

where D_{Level}^{FTP} – percentage of elimination of critical level defects during the project lifetime;
D_{Level}^{Closed} – a number of critical level defects eliminated during the project lifetime;
D_{Level}^{Found} – a number of critical level defects detected during the project lifetime.

Test-case requirements coverage:

$$R^C = \frac{R^{Covered}}{R^{Total}} \cdot 100\% \qquad (3)$$

where R^C – percentage of the test-case requirements coverage;
$R^{Covered}$ – a number of requirements covered by the test cases;
R^{Total} – a total number of requirements.
Minimum value limits:
Initial phase of the project: 40 %.
Main phase of the project: 60 %.
Final phase of the project: 80 % (90 % and more is recommended).

Stop factor:

$$S = \begin{cases} Yes, T^E \geq 25\% \,\&\&T^{\,SP} < 50\% \\ No, < 25\% \,||\, T^{SP} \geq 50\% \end{cases}, \qquad (4)$$

where S – decision to suspend testing,
T^E – current metric value T^E,
T^{SP} – current metric value T^{SP}.

Text-cases execution:

$$T^E = \frac{T^{Executed}}{T^{Planned}} \cdot 100\%, \qquad (5)$$

where T^E – percentage of the test-case execution;
$T^{Executed}$ – a number of test-cases executed;
$T^{Planned}$ – a number of test-cases that are planned to be executed.
Levels (Boundaries):
Minimum level: 80 %.
Desired level: 95–100 %.

4. Experiment

56 students participated in the testing. The consistency of the received assessments was checked by the expert evaluation method.

A group of expert evaluation method is most commonly used in qualitative assessment of complex systems. When using expert evaluation, it is generally assumed that the opinion of an expert group is more reliable than that of an individual expert.

When formulating the purpose of the evaluation, the developer must have a clear idea of who and for what purposes will use the results. The methods of rank correlation theory are used in the processing of collective expert evaluation materials. If the number of ranked series is more than two, the concordance coefficient is calculated W_{K}.

$$W_k = \frac{12\sum_{1}^{n}\Delta d_i^2}{m^3(n^3 - n)}, \qquad (6)$$

where m – a number of ranked series;

n – a number of objects;

$\Delta d_i = \sum_{1}^{m} a_i - \overline{X}_p$ – a deviation of the rank sum for the *i-th* object from total arithmetic mean of all ranks.

$$\overline{X}_p = \frac{1}{n} \sum_{j=1}^{m} \sum_{i=1}^{n} a_{ij} \tag{7}$$

rank corresponding to the i-th object in the j-th row.

Concordance coefficient W_k shows the degree of relationship between ranked series according to various characteristics.

As mentioned above, at the second phase, the impact of interactive presentation of the learning material on the level of its mastering is assessed. The evaluation was carried out according to the author's methodology [1] which allows to trace the dynamics of changes in the learning of educational material.

The assessment of the level of knowledge acquisition involves the construction of a matrix (Table 1). The matrix consists of five lines of skills: A) ability to solve technical tasks; B) ability to work with technical literature and handbooks; C) ability to see a task; D) ability to explain a technical task; E) ability to plan work. The columns contain the topics to be studied.

Table 1
Morphological matrix of formation of the level of knowledge acquisition

		1 Quality parameters for printed products	2 Color measurement in printing	3 Densiometric and colourometric control methods	4 Moulding processes control	... ...	13 Organization of statistical quality control in printing houses
A	ability to solve technical tasks	P_{A1}	P_{A2}	P_{A3}	P_{A4}	...	P_{A13}
B	ability to work with technical literature and handbooks	P_{B1}	P_{B2}	P_{B3}	P_{B4}	...	P_{B13}
C	ability to see a task	P_{C1}	P_{C2}	P_{C3}	P_{C4}	...	P_{C13}
D	ability to explain a technical task	P_{D1}	P_{D2}	P_{D3}	P_{D4}	...	P_{D13}
E	ability to plan work	P_{E1}	P_{E2}	P_{E3}	P_{E4}	...	P_{E13}

Source: Authors' development

Here Pij coefficients express the weight coefficients of influence of the studied discipline on the formation of certain competences.

The methodology provides for the students' learning curve assessment in order to rank them (for example, using the method of expert evaluation and statistical processing of expert data).

In each discipline (general scientific, general technical, special) the student receives fundamental knowledge of the appropriate level. The problem of raising the level of competence is connected with the quality of the systemology of teaching disciplines with the presence of such qualities of knowledge as generalization, concreteness, completeness and effectiveness of their application.

The success of competence formation consists of several components. Firstly, the quality level of the professorship and teaching staff (academic degrees, teaching experience, number of publications, participation in scientific work, etc.). Secondly, students' willingness to perceive new knowledge (their thesaurus). The third component is the effectiveness of the knowledge transfer from the teaching staff to students, that is, determination of the function of transformation of knowledge into skills.

Next, it is necessary to assign the relative weights to each of the five skills (Table 2). That is, to determine their share in the formation of special competencies. The sum of the relative weights should be equal to one.

Table 2
Assignment of weight coefficients

	Skills	Weight coefficients
A	ability to solve technical tasks	P_A = 0,25
B	ability to work with technical literature and handbooks	P_B = 0,20
C	ability to see a task	P_C = 0,30
D	ability to explain a technical task	P_D = 0,15
E	ability to plan work	P_E = 0,10

Source: Authors' development

After this, the weight coefficients have to be normalized. This step consists of multiplying the weights obtained for each individual factor. The result is the overall coefficient for each factor.

$$P_A = P_{A1} \cdot P_{A2} \cdot P_{A3} \cdot \dots \cdot P_{A13}. \quad (8)$$

At the next step the value of entropy has to be calculated.

In technical and social systems, especially while constructing optimal diagnostic processes, the so-called «Information Theory» is widely used. Mathematical information theory originated in the works of Wiener and Shannon, and has been widely applied as a general theory of the relationship of statistical systems.

According to this theory, information is the difference between the entropy of a system before and after receiving information.

$$\Delta I = H_0(A) - H_1(A), \quad (9)$$

where $H_0(A)$ – initial entropy of the system;
$H_1(A)$ – entropy of the system after receiving information.

Information entropy is estimated by the formula:

$$H(A) = -\sum P_i \cdot \ln P_i \quad (10)$$

where P – the probability of the system being in the *i-th* state.

With successful learning, entropy will decline and ideally strive for zero.

5. Results

The authors have developed a training complex to check the correctness of the laboratory and practical work of the discipline «Technologies of printing production» (fig. 1). The complex is built on the Node.js platform with Oracle SQL Developer database connection. The training complex is integrated into the Moodle educational platform as an external application.

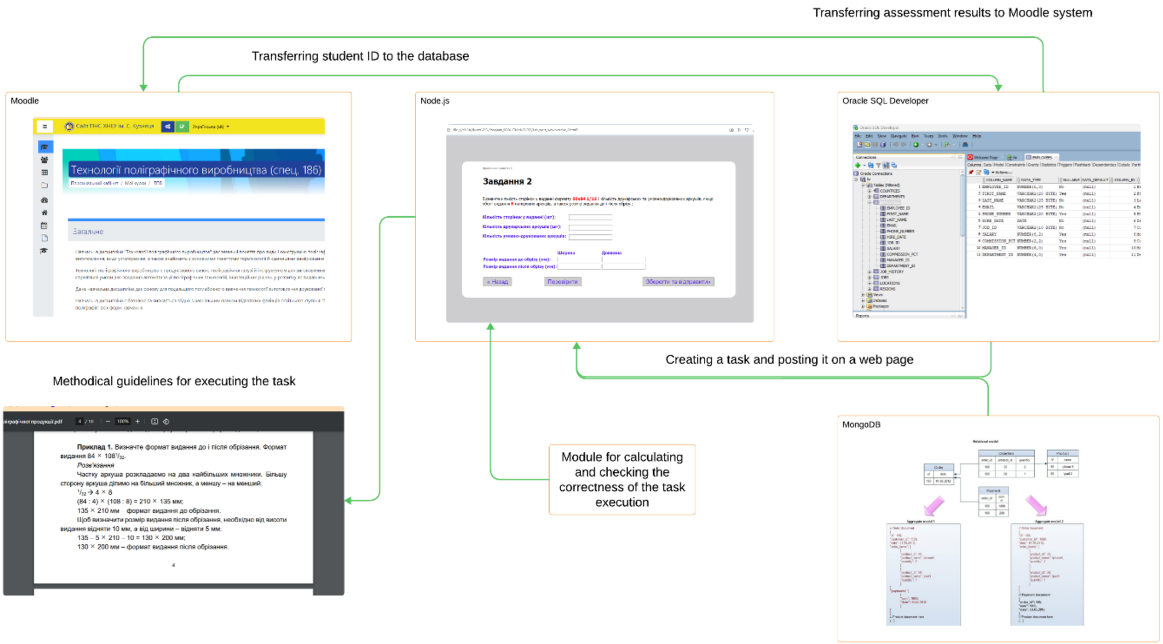

Figure 1: Training complex for checking the correctness of laboratory and practical tasks execution. Source: Authors' development

After authorization in the Moodle system, the student ID is transferred to the Oracle SQL Developer database where the individual assignment is generated. The task condition and the necessary components (input, button, label) are transferred to the web page. If the control task contains numerical values and their mathematical processing is envisaged, the Oracle SQL Developer database is used. If the control task involves working with textual information, then, in the authors' opinion, it is advisable to use NoSQL databases, for example, MongoDB.

It is not always convenient to use application variables or files on the host as data storages. In these cases, it is better to consider connecting an external database to the application. MongoDB is an excellent choice for integration with Node.js. In this database, data is represented in JSON-format, which is easy to work with in JavaScript.

The web page is made using adaptive interface technology, so it is correctly displayed on computer monitors and mobile devices (smartphones, tablets). The use of multi-paradigm programming language JavaScript on the Node.js platform allows not only to create dynamic web pages but also to embed modules for checking the correctness of the task execution.

It is possible to access the reference materials (a lecture on the given topic, an example of the practical task execution) from the web page. On request, the linking system requests data from the Moodle system. The program code provides automatic assessment of the correctness of answers. The score system is set up by the teacher. After pressing the «Save and send» button, the scores are transferred to the Moodle System Scores Log.

Automation of the laboratory and practical student tasks checking allows to reduce the load on the teacher, to make the assessment process objective, to exclude cases of erroneous assessment due to negligence of the examiner.

The results of the training complex testing are presented in Table 3.

Table 3
Numerical indicators of the multimedia training complex testing

Elements of testing	Metrics			
	Success rate of the test-cases executed, T^{SP}	Percentage of defects eliminated, D_{Level}^{FTP}	Percentage of the test-case requirements coverage, R^{C}	Percentage of the test-case execution, T^{E}
Functional testing: operability of all interactive elements (tests, tasks, calculations).	0,74	0,76	0,65	0,64
Compatibility: compatibility of the training application with different devices and operating systems	0,79	0,52	0,76	0,60
Load testing: to make sure that the training application works steadily and without lags when working with large amounts of data.	0,64	0,78	0,61	0,65
Security testing: to check user data security (data encryption, security against unauthorized access, etc.).	0,73	0,65	0,61	0,77

Source: Authors' development

The testing has demonstrated that the software part of the application meets all the performance requirements. Some shortcomings that need correction have been identified.

Functional testing: Most of the main functions of the application work correctly. Minor errors have been detected, registered and submitted to the developers for correction.

Compatibility: The application has been successfully tested on major browsers (Chrome, Firefox, Safari) and devices of different screen sizes.

Load testing: The application demonstrated good performance under average load. However, some bottlenecks requiring optimization have been identified.

Security testing: Some vulnerabilities have been discovered, such as lack of protection against XSS attacks and insufficient access rights to some functions. It is recommended to strengthen the application protection mechanisms.

Based on the testing results, the following changes were made: the detected bugs and vulnerabilities were fixed; application performance was optimized; application security mechanisms were improved. It was also decided to conduct additional testing on different devices and browsers to confirm compatibility.

At the second stage, the degree of knowledge mastery of the control group and the group of students studying according to the classical method has been compared. The results of the entropy calculation for the control group are presented in Table 4. The entropy of the control group decreased by 13.7 %. As it was mentioned above, entropy should decrease with the increase of knowledge mastery.

To confirm the obtained results, the control and main groups of students were tested using standard Moodle tools. The tests included multiple-choice questions on the covered topics. Evaluation was carried out according to a 100-score system. The results of testing are presented in Fig. 2.

Table 4
Calculation of the entropy level for the control group of students using the multimedia complex

	Competences	P_i	*Ln* P_i	Σ
A	ability to solve technical tasks	0,25	-1,39	-1,14
B	ability to work with technical literature and handbooks	0,20	-1,61	-1,41
C	ability to see a task	0,30	-1,20	-0,90
D	ability to explain a technical task	0,15	-1,89	-1,74
E	ability to plan work	0,10	-2,30	-2,20
				H(A) = 7,39

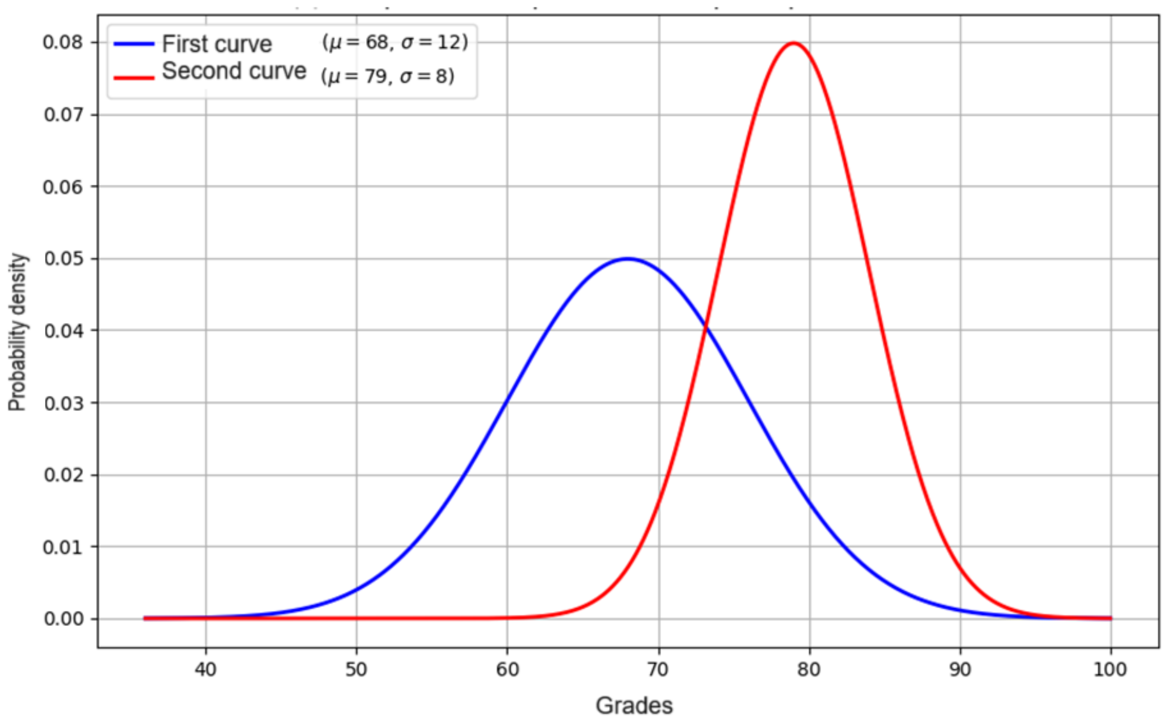

Figure 2: Students' results assessed with the standard Moodle tools: the first curve is the main student group, the second curve is the control group. Source: Authors' development

The use of multimedia training complex allowed to raise the average score from 68 points to 79. At the same time, the standard deviation decreased from 12 to 8.

6. Discussions

After analysis of the work that has been carried out by the authors and the current state of the issue under study, the following should be highlighted:

1. Performance and scalability issues remain relevant in the field of database-driven multimedia training products. With the growth of data volume and accessibility requirements, it is necessary to continue research and development of technologies that can provide efficient data management and scalability for collaborative use.
2. In the presented paper, an integrated approach has been proposed that includes the selection of appropriate database technology, database design and implementation of data security measures. This approach is also relevant in modern practice where successful problem solving requires the combined application of various methods and technologies.

3. Given the diversity of data types in multimedia projects, including both numerical and textual data, the use of different types of databases such as SQL and NoSQL remains relevant in the current context.

4. Integration of multimedia training products with educational platforms such as Moodle is a rational solution to the issue of integrating newly developed learning products with those that are already widely used. Ensuring collaborative access and convenient content management remain key factors for successful implementation of training projects.

5. Commitment to students' competences development including creativity, autonomy, critical thinking and communication skills, remains one of the most important goals of education. The use of multimedia databases in educational projects continues to contribute to this goal.

7. Conclusions

The use of multimedia databases for the training products development offers a number of significant advantages. Firstly, this approach is based on both a systematic approach in general and the software design and regulatory environment for the study of individual disciplines in particular. This contributes to a deeper and more comprehensive understanding of the material.

In addition, multimedia databases allow the implementation of laboratory workshops based on the competence approach where students gain the necessary competences in practice and apply them in the creation of projects of various formats. This approach promotes creativity and teamwork.

Individual trajectory of laboratory works gives students the opportunity to choose the content topics and assignment format, which stimulates their activity and autonomy. Besides, the development of complex interdisciplinary projects allows to integrate knowledge from different fields and form a holistic view of the problem.

Furthermore, the use of multimedia databases contributes to the development of students' critical thinking and communication skills. Teachers, in turn, can shape the educational space in such a way as to stimulate students' interest in quality design of multimedia publications. The analysis of disciplines has demonstrated the potential of using SMART components which opens new perspectives for the development of the educational process in the direction of STEAM technologies.

Thus, the use of multimedia databases in the preparation of educational products not only enriches the educational process with a variety of formats and methods but also contributes to the students' key competences development necessary for successful adaptation in the contemporary world.

In recent years, database technology has undergone significant development which has had an impact on multimedia projects. The further development of the project under development involves the use of cloud databases. The emergence of cloud technologies has made databases more accessible and scalable. This allows multimedia projects to efficiently store and process huge amounts of data such as video, audio and images without having to invest in their own infrastructure.

Building NoSQL databases can help to make training products more interactive. Traditional relational databases are often inefficient for storing and processing semi-structured data which is typical for multimedia projects. NoSQL databases such as MongoDB or Cassandra offer more flexible and scalable solutions for such tasks.

The third area to be realized is machine learning and big data analysis. This allows multimedia projects to extract valuable insights from their data and create more personalized content for users.

The analysis demonstrates that the development of database technologies has a significant impact on the development of multimedia learning complexes making them more flexible, efficient and secure.

In conclusion, it should be admitted that the creation of multimedia products with integrated databases is a key point for modern training complexes. This paper does not cover all aspects of developing such products. The authors continue to work on technical problems that affect the integrity of data and scalability of systems. It is possible to solve these problems by using modern technologies such as distributed databases and cloud computing. However, the implementation of these technologies requires careful planning and expertise to ensure effective database management in contemporary information environment. Overcoming these limitations and exploring new technologies in multimedia database management will enable the development of innovative products in education.

References

[1] O. Pushkar, Y. Hrabovskyi. and A. Gordyeyev, Development of a Method for Optimizing the Site Loading Speed. Eastern-European Journal of Enterprise Technologies, 6(2 (108)), 21-29, 2020, DOI: 10.15587/1729-4061.2020.216993.

[2] C. Yu, A. Williams, C. F. Lin and W. C. Yu, Planning effective multimedia instruction. Terry T. Kidd & Holim Song (Eds.), Instructional systems and technology, Vol. 1, 216-231. Hershey, PA: Information Science Reference, 2008.

[3] Y. Chien, T. Brandenburg, Multimedia Database Applications: Issues and Concerns for Classroom Teaching. The International journal of Multimedia and Its Applications 3 (1), February 2011, DOI:10.5121/ijma.2011.3101.

[4] R. AlShaikh, N. Al-Malki, M. Almasre, The implementation of the cognitive theory of multimedia learning in the design and evaluation of an AI educational video assistant utilizing large language models, Heliyon, Volume 10, Issue 3, 2024, https://doi.org/10.1016/j.heliyon.2024.e25361.

[5] M. Fyfield, M. Henderson, M. Phillips, Improving instructional video design: a systematic review, Australas. J. Educ. Technol. 38 (3), 2022, https://doi.org/ 10.14742/ajet.7296. Article 3.

[6] O. Kalipsiz, Multimedia databases. Proceedings of IEEE International Conference, 111-115. 2000,http://ieeexplore.ieee.org.proxy.library.msstate.edu/stamp/stamp.jsp?tp=&arnumber=859745&isnumber18614.

[7] J. Zeng, Y. Chen and Y. Zheng, Designing the multimedia system for improving promotion of college students' psychological capital, Heliyon, Volume 10, Issue 3, 2024, https://doi.org/10.1016/j.heliyon.2024.e25362.

[8] V. Adurangba, J. Nathaniel and M. Dominik, Virtual reality assisted engineering education: A multimedia learning perspective, Computers & Education: X Reality, Volume 3, 2023, 100033, https://doi.org/10.1016/j.cexr.2023.100033.

[9] Fu Jianping, Innovation of engineering teaching methods based on multimedia assisted technology, Computers and Electrical Engineering, Volume 100, 2022, 107867, https://doi.org/10.1016/j.compeleceng.2022.107867.

[10] Occa Aurora, E. Morgan, The role of cognitive absorption in the persuasiveness of multimedia messages, Computers & Education, Volume 176, 2022, 104363, https://doi.org/10.1016/j.compedu.2021.104363.

[11] N. Sundararajan, O. Adesope, Keep it coherent: A meta-analysis of the seductive details effect. Educational Psychology Review, 32(3), 707–734, 2020.

[12] J. Sweller, Cognitive load theory and educational technology. Educational Technology Research & Development, 68(1), 1–16, 2020.

[13] P.L. Chen, C.H. Lin, I.H. Lin, et al., The mediating effects of psychological capital and academic self-efficacy on learning outcomes of college freshmen, Psychol. Rep. 126 (5), 2489–2510, 2023.

[14] G. Joseph, W.E. Donald, Is it all about perception? A sustainability viewpoint on psychological capital and life well-being of management graduates[J], High Educ. Skills Work. base Learn. 12 (2), 384–398, 2022.

[15] Reetu Malhotra, Neelam Verma, An Impact of Using Multimedia Presentations on Engineering Education, Procedia Computer Science, Volume 172, 2020, Pages 71-76, https://doi.org/10.1016/j.procs.2020.05.011.
[16] N.A.H. Al-Ajmi, Z.M. Aljazzaf, Factors influencing the use of multimedia technologies in teaching English language in Kuwait. Int. J. Emerg. Technol. Learn. 15 (5), 212–234, 2020.
[17] Armaghan Montazami, Heather Ann Pearson, Adam Kenneth Dubé, Gulsah Kacmaz, Run Wen, Sabrina Shajeen Alam, Why this app? How educators choose a good educational app, Computers & Education, Volume 184, 2022, 104513, https://doi.org/10.1016/j.compedu.2022.104513.
[18] D. H. Jonassen, Computers as mind tools for schools: Engaging critical thinking (2nd ed.). Upper Saddle River, NJ: Prentice Hall, 2000.
[19] N. Ertugrul, Towards virtual laboratories: a survey of LabVIEW-based teaching/learning tools and future trends. Int. J. Eng. Educ. 16 (3), 171–180, 2000.
[20] C. Wang, T. Fang, Y. Gu, Learning performance and behavioral patterns of online collaborative learning: impact of cognitive load and affordances of different multimedia. Comput. Educ. 143, 103683, 2020.
[21] A. Shoufan, Estimating the cognitive value of YouTube's educational videos: a learning analytics approach. Comput. Hum. Behav. 92, 450–458, 2019.
[22] O. Sushchenko O. Akhmedova and O. Stryzhak, The use of interactive training technologies in teaching academic disciplines for students of tourism specialities. Access to science, business, innovation in digital economy, ACCESS Press, 2(1), 28-39, 2021, https://doi.org/10.46656/access.2021.2.1(3).
[23] V. Tyschenko, N.Vnukova, V. Ostapenko and S. Kanyhin, Neural Networks for Financial Stability of Economic System CEUR Workshop Proceedings, 3387, volume 1, 274-288, 2023, https://openarchive.nure.ua/handle/document/23121.