AN INSTRUMENTAL SYSTEM FOR THE EVALUATION AND MODERNIZATION OF EDUCATIONAL CONTENT

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Abstract: This article presents an ontological model and evaluation system for assessing and modernizing educational content, based on a combination of automated and expert criteria. This approach facilitates the development of a mathematically grounded modernization plan. Additionally, original algorithms and methodologies have been developed for evaluation and improvement, relying on a knowledge base and instrumental system. As a result, a flexible and cost-effective software product can be created to meet various institutional requirements.

Keywords: ontological model, educational content, instrumental system, genetic algorithm, suboptimal plan.

Annotatsiya: Ushbu maqolada avtomatlashtirilgan va ekspert mezonlari uyg‘unligiga asoslangan holda o‘quv kontentini baholash va modernizatsiya qilish uchun ontologik model va tahlil tizimi taqdim etilgan. Taklif etilayotgan yondashuv asosida matematik asoslangan modernizatsiya rejasini ishlab chiqish imkoniyati yaratiladi. Shuningdek, baholash va takomillashtirish jarayonlari uchun bilimlar bazasi va instrumental tizimga tayanuvchi original algoritmlar va metodikalar ishlab chiqilgan. Natijada, turli ta’lim muassasalari ehtiyojlariga moslashuvchan va iqtisodiy jihatdan samarali dasturiy mahsulot yaratish imkoniyati yuzaga keladi.

Kalit so‘zlar: ontologik model, o‘quv kontenti, instrumental tizim, genetik algoritm, suboptimal reja.

Аннотация: В данной статье представлена онтологическая модель и система оценки для анализа и модернизации учебного контента, основанные на сочетании автоматизированных и экспертных критериев. Такой подход способствует разработке математически обоснованного плана модернизации. Кроме того, разработаны оригинальные алгоритмы и методики для оценки и улучшения, опирающиеся на базу знаний и инструментальную систему. В результате возможно создание гибкого и экономически эффективного программного продукта, соответствующего различным требованиям образовательных учреждений.

Ключевые слова: онтологическая модель, учебный контент, инструментальная система, генетический алгоритм, субоптимальный план.

1. Introduction

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In recent years, the higher education system of Uzbekistan has undergone rapid digital transformation, particularly with the expansion of distance learning programs at leading institutions such as the Muhammad al-Khwarizmi Tashkent University of Information Technologies (TUIT). As of the 2023/2024 academic year, TUIT offers over 311 electronic educational-methodological complexes (EEMCs) through its elms.tuit.uz platform [13]. These include 5 general education subjects, 148 core professional courses, and 158 elective and specialized disciplines, all delivered in a digital format. This scale of development has positioned TUIT as a national leader in implementing e-learning methods [14].

However, the sharp increase in digital courses has brought significant challenges in ensuring consistent content quality and pedagogical coherence. Currently, the university follows a multi-level evaluation process involving initial faculty-level reviews, expert committee assessments, student feedback collection, and statistical monitoring via the ELMS platform. Evaluation criteria encompass clarity of content, structural logic, use of media, and topical relevance. While this system supports basic quality control, it remains time-consuming, manual, and subject to subjective human judgment [15].

To address these limitations, this study proposes an ontology-based instrumental system for evaluating and modernizing educational content. The proposed system integrates automated and expert-based evaluation criteria, enabling objective, adaptable, and cost-effective analysis of EEMC components. Automated metrics such as readability, abstraction level, information richness, keyword density, and creolization index are calculated algorithmically, while expert inputs are integrated using weighted decision matrices. Additionally, the system employs a genetic optimization algorithm to generate modernization plans within defined resource constraints.

This novel approach is designed to overcome the following four issues. First, eliminate redundancy and inefficiencies in expert reviews. Second, enable the reusability of evaluation knowledge via ontological modeling. Third, support decision-making for administrators by prioritizing areas needing updates. Fourth, dynamically adapt to various disciplines and instructional formats.

The primary aim of this research is to establish a scientifically grounded, modular, and flexible system for evaluating and improving educational contents published in TUIT and other higher education institutions across Uzbekistan. By combining ontological modeling, expert evaluation, and algorithmic analysis, the proposed system provides a reliable and effective path ensuring sustainable and high-quality digital education.

Chapter 2 describes research articles related to this research.

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Chapter 3 presents the proposed methodology, including the design of the evaluation model, the classification of criteria, and the integration of a genetic algorithm for modernization planning.

Chapter 4 outlines the implementation and experimental results of the system, along with performance analysis and comparative evaluations.

Chapter 5 provides the final conclusions, confirms the effectiveness of the system, and suggests directions for future research focused on increasing learner engagement in online education.

2. Related Works

Various researchers have investigated the evaluation and modernization of educational content from different methodological perspectives.

In Uzbekistan, Saliev and Fayzullaev [1] explored the role of digital content quality in improving the effectiveness of e-learning platforms. Their research focused on the development of localized electronic resources and emphasized the importance of content relevance to national educational standards. However, their model did not utilize ontology-based structuring or hybrid evaluation techniques.

Similarly, Yakubov [2] examined the integration of structured data exchange systems in education, emphasizing the technical and organizational aspects of implementing electronic document flow in academic institutions. While comprehensive, the study lacks a dedicated mechanism for evaluating educational content quality.

From a Russian context, Gorodovich et al. [3] proposed a methodological framework for the software and instructional support of e-learning technologies at TUSUR. Their model incorporates modular instructional design but relies heavily on manual content review and lacks algorithmic support for optimization or modernization.

In Western literature, Garcia and Kim [4] introduced an ontological model to categorize and evaluate course components in digital education. Although their ontology is well-structured, it does not support automated decision-making or adaptive modernization planning.

In contrast, the present study proposes an integrated system that combines ontology, automated criteria, and expert evaluations. Moreover, it introduces a genetic algorithm-based approach to generate optimized modernization plans, which distinguishes it from the above-mentioned models.

3. Proposed Methods

There are hundreds of criteria for evaluating educational content, most of which require expert input and vary significantly across different systems. The

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components of an EEMC—text, images, audio/video materials, tests, and navigation elements—are analyzed based on specific quality indicators [5].

The main objective is to develop an information system capable of assessing content quality and generating a modernization plan. This involves the following stages:

- Designing the structure of the evaluation system;
- Selecting the EEMCs to be evaluated;
- Calculating evaluation vectors;
- Formulating an optimization function;
- Defining cost constraints;
- Developing the final plan.

Although this is a classical decision-making problem, no universal evaluation system for electronic content currently exists. Since each institution has a unique approach, the following are proposed:

- Development of evaluation and monitoring tools;
- Creation of a knowledge base for evaluation criteria;
- Establishment of a system for analyzing EEMC development.

This research involved the creation of an evaluation ontology with the help of the Protégé software. The ontological model includes evaluation classes, EEMC components, and development history classifications[4, 1].

Evaluation criteria are divided into two main types:

- **Automated criteria** – determined through specialized algorithms;
- **Expert criteria** – established based on expert assessments.

Automated criteria must meet the following requirements:

- Be practically simple and clear;
- Allow interpretation in the form of scores;
- Be based on previously applied practices.

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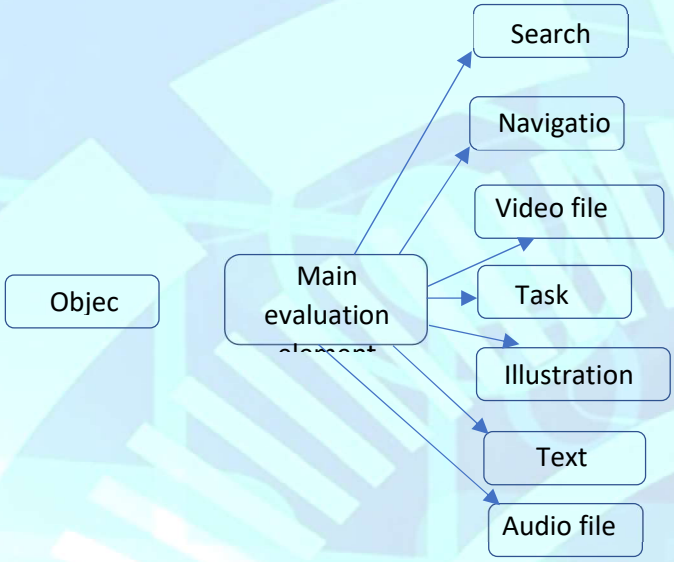


Figure 1. Hierarchy of Main Classes of EEMC Elements to Be Evaluated.

In addition, other evaluation criteria include the quality of illustrations and the organization of references[5, 2].

To implement expert-based evaluation, specialized questionnaires have been developed, with each question assigned a specific weight coefficient. The proposed methodology involves:

- Formation of the evaluation criteria system;
- Storage within the knowledge base;
- Normalization and aggregation of indicators.

For example, all local textual indicators are aggregated into a unified text metric. This approach simplifies evaluation and improves objectivity.

$$C_i = \sum_{j \in ord(V)} a_j Y_j$$

Where:

- α_j – weight coefficient of the j-th criterion,
- Y_j – normalized value of that criterion.

The evaluation process consists of:

1. Selecting EEMCs to be evaluated;
2. Calculating quality indicators and recording them in a table;
3. Determining the current rating of the EEMC.

To develop a modernization plan, a mathematical model was formulated. Suppose we have a set of objects:

$$O = \{O_j\}_{j=1}^{m}$$

- O - the set of electronic courses (or objects) to be evaluated.
- O_j - the *j-th* course (or object) in that set.

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□j=1 to m - indicates that there are m total courses in the set.
representing the collection of electronic courses to be evaluated, and a set of evaluation criteria:

$$Q = \{Q_i\}_{i=1}^{n}$$

□Q - the set of evaluation criteria.
□Q_i - the *i-th* evaluation criterion.
□*i*=1 to n - shows that there are n total criteria used to evaluate each object or course.
Each criterion has an evaluation function:

$$Aq_j(O_j)$$

Aq_j - the **evaluation function** associated with the *j-th* evaluation criterion
O_j - the *j-th* object (or course) being evaluated
which may be continuous, discrete, or interval-based.
The rating of an object is calculated as:

$$R_j = \sum_{i=1}^{n} w_i v_{ij}$$

where w_i – are the weight coefficients of the criteria.

The objective is to maximize the overall rating within a given budget. If C is the total budget, R^* the current rating, and C^* the current cost, the optimization problem is expressed as:

$$\begin{cases} \sum_{j=1}^{n}\sum_{i=1}^{m} w_i v_{ij} \rightarrow R^* + max, \\ \sum_{j=1}^{n}\sum_{i=1}^{m} g_i(o_j) \leq C^* + C, \end{cases}$$

To solve this, an approach based on a genetic algorithm is proposed. The main components include:

Fitness function – evaluates the proximity of the solution to the resource constraint. If mutation exceeds the threshold, the original solution is preserved as an elite and retained in the population;

Mutation function – randomly increases the value of a criterion for an object with a 0.6% probability;

Crossover – a one-point mechanism that generates a new solution from two parents;

Selection function – removes individuals that exceed the budget or deviate significantly from the objective, and selects the best-performing individuals.

4. Results and Discussion

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Based on statistical experiments, 150 iterations across 9 criteria ensured convergence with an error margin of around 3%. The genetic algorithm showed linear computational complexity, proving its efficiency similar to the knapsack problem.

A specialized SWEBOOK-based software system was developed to evaluate educational content. It supports database creation, evaluation matrix management, score calculation, expert reporting, and archiving — enabling a fully automated and optimized evaluation process.

Figure 2 illustrates the general architecture of the software system.

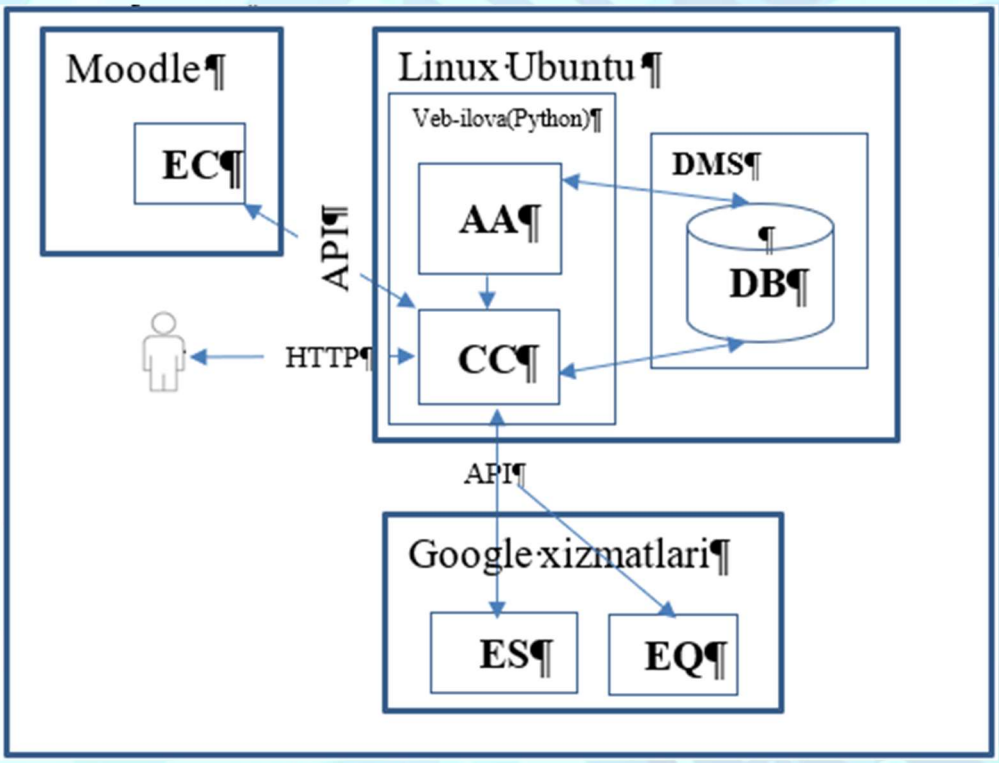


Figure 2 – General Architecture of the Instrumental System

Legend: **EC** – Electronic Course, **AA** – Analysis Algorithm, **CC** – Core Component, **DB** – Database, **ES** – Electronic Spreadsheet, **EQ** – Expert Questionnaire, **DMS** – Database Management System

Let us examine the general structure of the instrumental system in more detail:

The software package is installed on a Linux Ubuntu server and consists of a web application and a database built on Django and MySQL. The application includes components such as the analysis algorithm (AA) and the core component (CC), which serves the user interface. Users interact with the system via HTTP protocols. The system is integrated via APIs with services like Moodle and Google Forms[1, 2].

The developed system is built using Python, Django, and Bootstrap, and was tested within the framework of the TEACHER-ELMS.TUIT system at Muhammad

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al-Khwarizmi TUIT[6]. The following evaluation criteria were used during testing: abstraction, readability, redundancy, information richness, creolization, illustrations, and reference quality.

Analysis revealed the following common deficiencies across many courses: high levels of abstraction, low information richness and clarity, insufficient illustrations, and average reference organization. These results highlight the need to improve the quality of EEMCs.

Based on expert evaluations, test assignments were also analyzed. The following factors were considered:

- Level of competence;
- Alignment with theoretical material;
- Number and distribution of test items;
- Availability of generative test tasks.

The evaluation system is based on both automated and expert criteria, with weight coefficients assigned to each criterion. A final rating was generated, and the following conclusions were drawn:

The overall rating amounted to 41.6% of the maximum possible score, indicating significant room for improvement in content quality;

The courses were not grouped by academic discipline, allowing for cross-comparison across different subject areas.

Table 1

Final Rating of EEMCs

EEMC Code	Composite Coefficient	**EEMC Category**
153	0.52159	F
287	0.5067	G
95	0.50456	F
97	0.49921	F
…	…	…
34	0.33442	F
140	0.32449	G
40	0.32219	G
75	0.30439	G

To develop a modernization plan for educational content, it is necessary to construct cost functions. For this purpose, linear, quadratic, and exponential regression models were tested. According to the analysis, the linear model proved to be the simplest and most effective, demonstrating statistically significant

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coefficients of determination. These functions were applied at Muhammad al-Khwarizmi TUIT to construct a modernization plan for educational content.
The modernization methodology includes the following stages:
1. Selection of the EEMC set;
2. Determination of the current rating;
3. Identification of the cost level;
4. Development of a detailed plan;
5. Analysis of the results.

In the third stage, the cost level is determined. Experiments conducted on 30 EEMCs demonstrated an almost linear correlation between the workload and the overall rating. This relationship is clearly illustrated in Figure 3.

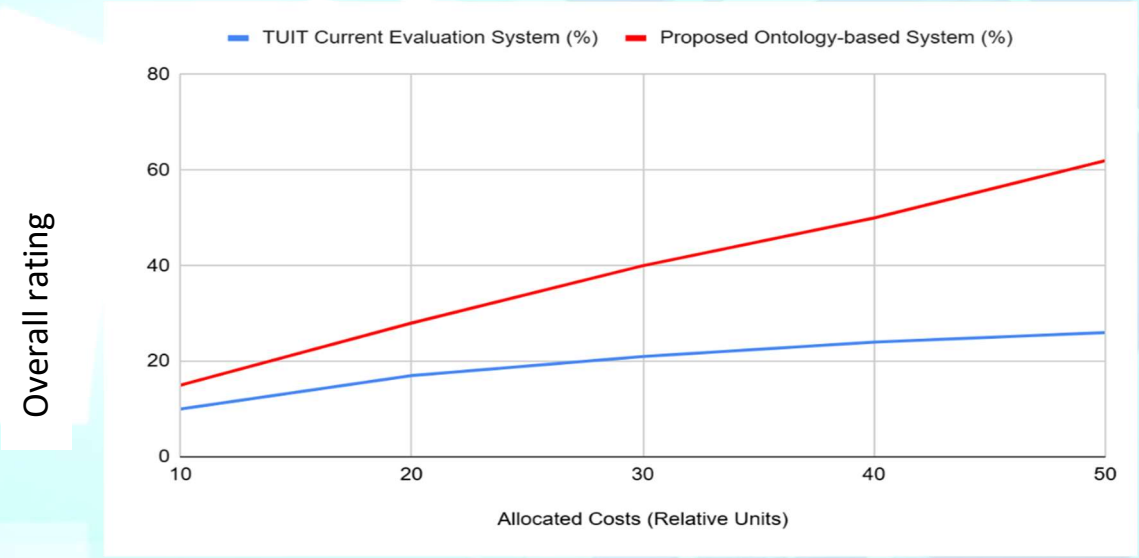


Figure 3 – Comparative line graph of evaluation efficiency between TUIT's current system and the proposed ontology-based model.

Various instrumental systems were comparatively analyzed. According to the results, the newly developed system stands out from others in the following ways:

It includes a knowledge base of evaluation criteria, allowing users to dynamically generate the evaluation matrix by adding or removing specific criteria;

It enables comprehensive evaluation by combining quantitative and qualitative aspects — through both automated calculations and expert assessments;
One of its key advantages is its ability to automatically generate a modernization plan for EEMCs based on the evaluation scores — a feature not currently offered by other systems.

Implementation Results of the instrumental system demonstrate the following:

- Effective modernization plans can be generated using a genetic algorithm;
- Costs are calculated accurately;

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- The plan is generated 50 times faster than via traditional methods;
- Human errors are eliminated;
- The system can evaluate not only EEMCs, but also institutional websites and portals.

In Uzbekistan's full-time education system, the evaluation and modernization of EO‘UMs are often carried out based on expert opinions, student feedback, and decisions of methodological councils. These approaches are prone to issues such as subjectivity, inconsistent interpretation of standards, and a lack of systematic evaluation criteria. Furthermore, most existing assessment methods are not automated, making the process heavily reliant on human input when analyzing content.

In contrast, the system proposed in this study introduces a new level of theoretical and practical sophistication by employing ontological modeling, the integration of expert and automated criteria, and genetic algorithm-based optimization to assess and modernize EO‘UM.

Table 2.

Key differences are outlined below:

Indicator	Traditional Approach	Proposed System
Evaluation Method	Expert judgments, decisions of methodological councils	Ontological model+ automated and expert-based criteria
Level of Standardization	Low; evaluation is subjective	Structured via a defined set of evaluation criteria in a knowledge base
Automation	Low; mostly manual analysis	Evaluation, rating, and modernization are automated
Modernization Planning	Typically provided as general suggestions	Suboptimal planning using genetic algorithms
Resource Efficiency	Time-consuming and dependent on human effort	Up to 50 times faster with reduced error probability

Additionally, the proposed system evaluates the individual components of EO‘UMs such as text, quizzes, images, audio/video, and navigation elements—based on dedicated criteria for each. This allows for a more precise and component-wise quality analysis.

5. Conclusion

The current state of educational content assessment and modernization within distance learning systems was thoroughly analyzed. Existing models, methodologies, and tools were reviewed to identify limitations and gaps in current

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practices. An ontological model was developed to support a structured and scalable evaluation framework. Evaluation criteria were categorized into two types: automated criteria, derived through algorithmic methods, and expert criteria, based on professional judgment.

A structured knowledge base for evaluation was constructed, and a genetic algorithm was proposed to generate optimized modernization plans for EEMCs. Experimental results showed that the algorithm performs efficiently with linear computational complexity.

The developed system enables users to dynamically manage expert criteria, assign weighted importance to evaluation metrics, and construct hierarchical evaluation structures tailored to institutional needs.

Overall, the concept of an instrumental system for educational content evaluation and modernization was successfully validated. A functional web-based prototype was implemented based on the SWEBOOK standard and tested at the institutional level.

Finally, this research achieved a satisfactory result by demonstrating that the proposed system can effectively enhance the quality, adaptability, and modernization of electronic educational resources.

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