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INTELLIGENT COMPETENCE AND LEARNING OUTCOMES MANAGEMENT SYSTEM: ADAPTING EDUCATIONAL PROGRAMS TO THE LABOR MARKET

Abstract. *The article presents an intelligent information system (IIS) developed to automate the formation of competencies and learning outcomes based on professional standards. A distinctive feature of the IIS is the integration of professional standards with the Atlas of New Professions, which allows adapting educational programs to the dynamically changing requirements of the labor market and technological transformations. The key functional capabilities of the system are described, including user authentication, generation of competencies and learning outcomes for the design of educational programs. The implementation of the system includes an interactive JavaScript interface with support for asynchronous sending of requests to the server using AJAX technologies. OpenAI generative models are used to automatically generate competencies and learning outcomes. The presented system has a wide range of potential applications: from designing curricula based on competencies to creating career guidance systems, analyzing and forecasting changes in the labor market, as well as adapting educational programs to the requirements of high-tech industries. Thus, the developed model contributes to the digitalization of education, improving its quality and ensuring that educational standards meet the modern challenges of the knowledge economy.*

Keywords*: Competency management, Learning outcomes, Curriculum development, Intelligent information system, Professional standards, Atlas of New Professions.*

Introduction.

Modern educational systems face the need to adapt to new challenges associated with digitalization, globalization and changing labor market requirements. In the conditions of rapid technological progress, the key task is to develop educational programs that ensure the formation of relevant competencies and adaptation of graduates to complex and dynamic professional environments [1,2,3]. In the face of rapid technological progress, modern educational systems face the imperative to evolve and align their programs with the emerging demands of the digital age [1]. The key task is to develop educational curricula that cultivate the relevant competencies and enable graduates to thrive in complex, dynamic professional environments [2]. The need for educational reform is driven by the profound transformations occurring in the labor market, fueled by the accelerating pace of digitalization. As stated in the 'Formation of Requirements to the Competency Model for a University Graduate in the Digital Economy' study, digital technologies can increase company productivity by up to 40% [4]. Accordingly, the key competencies required by modern employers include systems thinking, adaptability, proficiency in IT systems, creative problem-solving, cultural awareness, and teamwork [2]. Alongside this framework, an important

tool for formalizing digital skills and competencies is the Skills Framework for the Information Age (SFIA), a model that classifies digital skills and competencies into seven levels. SFIA is used by international organizations to define the requirements for IT professionals, which makes it an important reference point when designing digital education programs [5].

However, traditional methods of educational programs development and competence formation have a number of limitations:

- Time-consuming processes due to the need for expert analysis of normative documents,
- Subjectivity of competence formulations depending on different interpretations,

Difficulties in scaling and adaptation to changing market requirements [6,7,8].

Overcoming these challenges requires the adoption of innovative approaches to curriculum design and competence development.

As the authors note [9] the key areas for improving educational systems in the digital age, as identified in this research, include:

- Developing adaptive, personalized curricula aligned with evolving labor market demands
- Leveraging data analytics and generative AI to accelerate the design and iteration of educational programs
- Strengthening the connection between educational institutions and industry to ensure graduates' readiness for complex, dynamic professional environments [3,10,11].
- Promoting lifelong learning and continuous upskilling to empower individuals to thrive in the face of technological change [2,11,12,13,14,2,1].

Modern educational systems must undergo a profound transformation to equip graduates with the competencies required by the digital economy and global labor market. Innovative approaches to curriculum design, digital tools for program development, and strengthening academia-industry collaboration are crucial to enabling this evolution [3,2,15].

By addressing these critical challenges, educational systems can fulfill their vital role in equipping the next generation with the competencies required to succeed in the 21st century world of work. The emergence of generative AI provides new opportunities to address these limitations. Generative AI systems are able to automate the creation of competencies and learning outcomes, significantly accelerating the process of designing educational programs and adapting them to the current requirements of the professional environment [16,17,18,19]. Additionally, AI-powered analytics can be leveraged to analyze large datasets of job postings and educational program information, empowering educators to identify emerging skill gaps and inform the development of relevant curricular changes that better prepare students for the evolving labor market demands [20,21,22]. By harnessing the power of technology, educational institutions can become more agile and responsive to the rapidly transforming landscape of work, equipping the next generation with the competencies necessary to thrive in the digital age [2,1,23]. The paper [24] proposes an AI-powered learning recommendation system that utilizes educational data mining to enhance educational outcomes. It employs machine learning algorithms to predict student success and offers personalized, data-driven learning strategies to improve academic interventions. The research [25] proposes a hybrid intelligent system for assessing educational outcomes, utilizing expert systems and fuzzy simulation to structure databases of learning elements, thereby facilitating the formation of competencies and learning outcomes through interactive communication between the system and experts. The results [26] of this research underscore the tremendous potential of leveraging advanced technologies, such as generative AI and educational data analytics, to transform educational systems and better prepare graduates for the dynamic professional environments of the future.

The aim of this study is to create intelligent information systems capable of autonomously generating competencies and learning outcomes based on professional standards, as well as adapting educational programs in real time using a competency map. Thus, this work will open up new prospects for the complete digitalization and intellectualization of the competency modeling

process, which will lead to the creation of more effective, personalized and adaptive educational systems.

Materials and methods.

The proposed system utilizes a combination of data sources and generative AI systems to automate the process of generating competencies and learning outcomes.

The system integrates professional standards, Atlases of new professions, and industry requirements, enabling the automatic formation of competencies that align with user requests and current trends in the professional field.

Additionally, the system aligns the generated competencies and learning outcomes with Bloom's taxonomy verbs, adapting them for integration into educational programs. The generated data is stored in a database, ensuring the possibility of further editing, refinement, and use in the development of educational courses.

Mathematical representation

To build an intelligent information system for comparing professional standards and educational programs, we formalize the relationships between key components: labor functions (LF), knowledge, skills and abilities (KSA), and learning outcomes (LO).

Let $\mathrm{PS} = \{\mathrm{PS}_1, \mathrm{PS}_2, \mathrm{PS}_3, \ldots, \mathrm{PS}_\mathrm{n}\}$ be a set of professional standards, $\mathrm{LF} = \{\mathrm{LF}_1, \mathrm{LF}_2, \mathrm{LF}_3, \ldots, \mathrm{LF}_\mathrm{m}\}$ be a set of labor functions, and $\mathrm{KSA} = \{\mathrm{KSA}_1, \mathrm{KSA}_2, \mathrm{KSA}_3, \ldots, \mathrm{KSA}_\mathrm{p}\}$ be a set of knowledge, skills, and abilities. The set $\mathcal{M}$ is a three-dimensional matrix in which each $\mathrm{LF}_{\mathrm{i,l}}$ element is associated with the corresponding knowledge, skills and abilities $KSA_{i,j}$ and learning outcomes $LO_{i,j}$. This structure allows modeling interdependencies between labor functions and educational outcomes.

$$\mathcal{M} = \begin{bmatrix} \mathrm{LF}_{1,1} & \mathrm{KSA}_{1,1} & \mathrm{LO}_{1,1} \\ \mathrm{LF}_{1,2} & \mathrm{KSA}_{1,2} & \mathrm{LO}_{1,2} \\ \vdots & \vdots & \vdots \\ \mathrm{LF}_{\mathrm{m,n}} & \mathrm{KSA}_{\mathrm{m,n}} & \mathrm{LO}_{\mathrm{m,n}} \end{bmatrix}$$

To simplify the representation, we construct a matrix $\mathcal{N}$, where each professional standard PS_k groups the corresponding labor functions LF and relates them to competencies C_k. Thus, the matrix $\mathcal{N}$ allows us to formalize the correspondence between professional standards and educational programs.

$$\mathcal{N} = \begin{bmatrix} \mathrm{PS}_1 & \mathrm{LF}_{1,1} & \mathrm{LF}_{1,2} & \ldots & \mathrm{LF}_{1,2} & \mathrm{C}_1 \\ \mathrm{PS}_2 & \mathrm{LF}_{2,1} & \mathrm{LF}_{2,2} & \ldots & \mathrm{LF}_{2,2} & \mathrm{C}_2 \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ \mathrm{PS}_\mathrm{k} & \mathrm{LF}_{\mathrm{k},1} & \mathrm{LF}_{\mathrm{k},2} & \ldots & \mathrm{LF}_{\mathrm{k},2} & \mathrm{C}_\mathrm{k} \end{bmatrix}$$

We define a correspondence operator φ that maps the set of labor functions, knowledge, skills and abilities to the set of learning outcomes:

$$\varphi = (\mathrm{LF}_{\mathrm{i,j}}, \mathrm{KSA}_{\mathrm{i,j}}) \rightarrow \mathrm{LO}_{\mathrm{i,j}}$$

The matching function f(y) can be represented as:

$$\mathrm{f(y)} = \sum_{\mathrm{i}=1}^{\mathrm{n_k}} \omega_\mathrm{i} \cdot \mathrm{LO}_{\mathrm{i,j}}$$

where ω_i - are the significance coefficients for each learning outcome.

Thus, the proposed model allows to automate the process of building educational trajectories aligned with the requirements of professional standards, as well as to formalize the rules for an intelligent system engaged in the generation of competencies and learning outcomes.

System Architecture

The intelligent information system is built according to the modular principle and includes several interrelated components to ensure smooth management of competencies and learning outcomes. The system consists of three main levels: user interface (Frontend), server part (Backend) and data storage level (Database).

The user interface (Frontend) is designed using JavaScript and AJAX to provide dynamic interaction without reloading pages. This allows users to enter queries (knowledge, skills, abilities) and instantly retrieve the generated competencies. The interface also includes tools for visualization and customization of specialization focus selection, which makes the process of working with the system convenient and intuitive.

The server part (Backend) processes input requests, passes them to the generative model (GPT/OpenAI) and receives the generated results. It also interacts with the database to store and update competency information.

The Database is based on MySQL and is designed to store structured information about new occupations, professional standards and competencies. It provides high performance when executing complex SQL queries, and also contains tables for storing the history of user queries, training results and dynamic changes of competencies. The system architecture is presented in Figure 1.

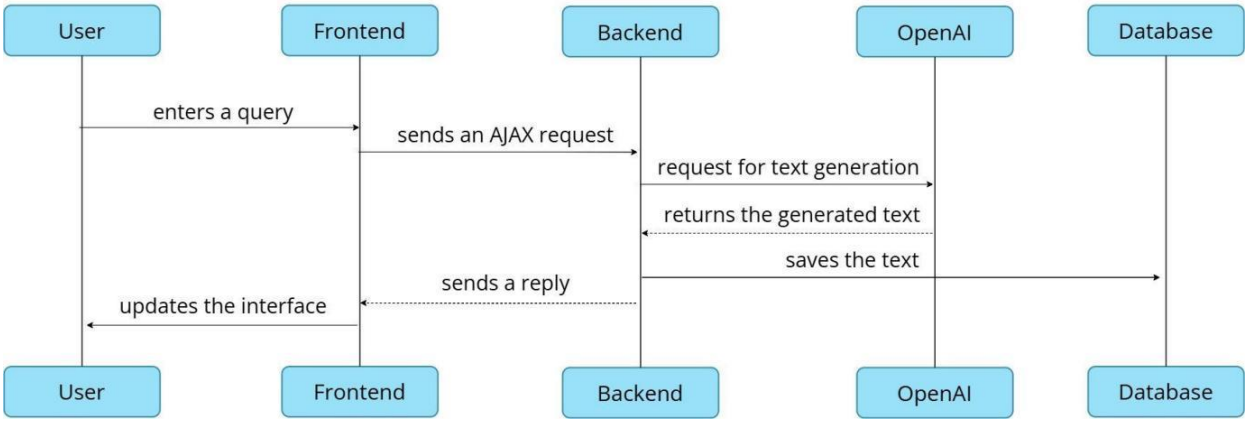

Figure 1 – Intelligent Information System Architecture

User Authentication and Authorization

The system employs a robust user authentication and authorization module to ensure secure access to the platform. Users are required to provide valid credentials, and their roles and permissions are strictly enforced to maintain the integrity of the system. For example, academic administrators can access tools for curriculum development and program evaluation, while instructors can utilize the system to design course materials and assessments aligned with the generated learning outcomes. Figure 2 shows the user access control mechanisms in the system.

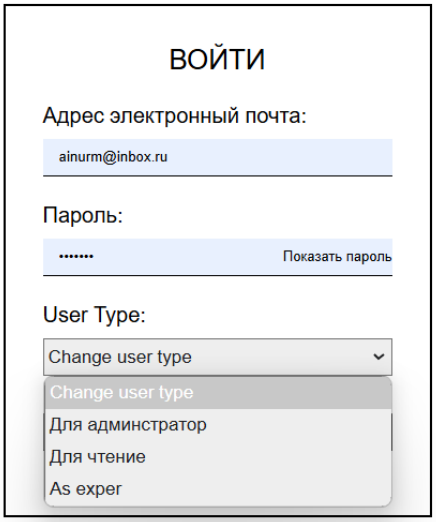

Figure 2 – Authentication and authorization system for user roles and permissions

Automated learning outcomes generation

The main functionality of the IIS is the automated generation of competencies and learning outcomes for educational programs based on professional standards and the Atlas of New Professions. The system analyzes the knowledge, skills, abilities, and job functions outlined in professional standards and uses this data to generate relevant competencies and expected learning outcomes. This ensures the adaptation of educational program content to the current labor market demands.

The practical application of the generation of learning outcomes is shown in Figure 3. The process of generating learning outcomes includes several stages:

1. The system loads knowledge, skills and abilities according to the selected standards.
2. Then the generation method is selected (NLP/Transformer/OpenAI)
3. Then, based on the selected method, the training result is generated.
4. Finally, the obtained learning outcomes are biased towards verbs from Bloom's taxonomy and presented to the user for the development of educational programs.
5.

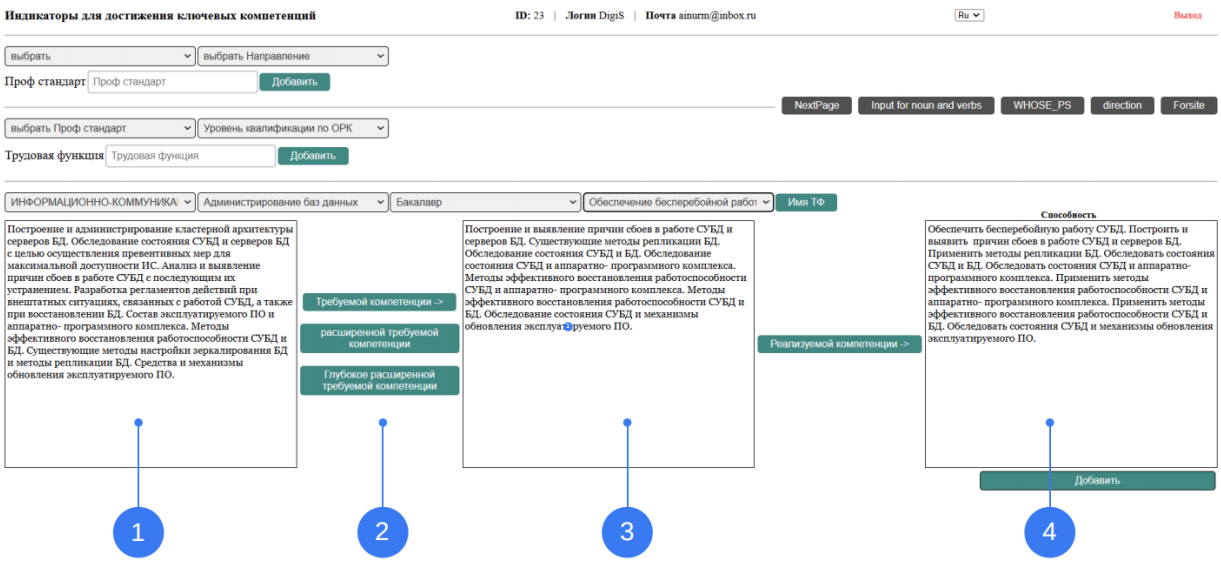

Figure 3 – Learning outcome generation process

Learning outcomes are generated by analyzing the knowledge, skills, and abilities defined in professional standards, and then translating them into measurable and observable statements. This ensures that the content of educational programs is closely aligned with the evolving requirements

of the labor market. This functionality is supported by various data analysis and verification tools, which minimize human errors and enhance the accuracy of educational material development.

Automated competency generation

The practical application of competence generation is shown in Figure 4. The competence generation process includes several stages:

1. The system loads all labor functions in accordance with the selected standards.
2. Then, the OpenAI methods generate competence in the selected direction
3. Finally, the obtained competencies are shifted towards verbs from Bloom's taxonomy and added to the database to form a competence map.

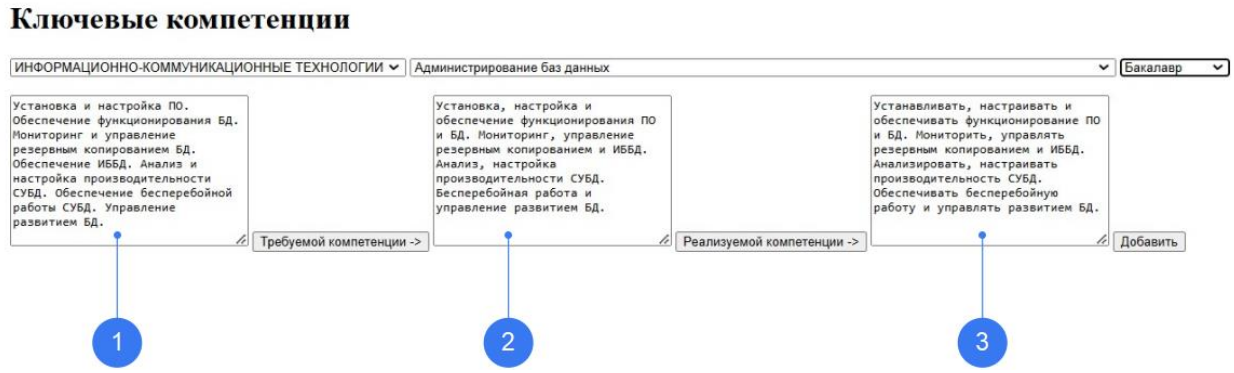

Figure 4 – Competencies generation process

Results and Discussion.

This paper presents an Intelligent Information System (IIS) designed to automate the formulation of competencies and learning outcomes for educational programs. The system integrates professional standards with data from the Atlas of New Professions, ensuring the alignment of educational content with the dynamically evolving labor market requirements and technological advancements.

Key functional capabilities of the system include user authentication, automated competency selection, learning outcome generation, and support for curriculum development. The system's data analysis and verification tools play a crucial role in minimizing human errors and improving the accuracy of educational material development. Additionally, the modular architecture and robust user access controls ensure secure and efficient management of competency-based education.

By streamlining the competency formulation process and integrating multiple data sources, the IIS addresses key challenges associated with educational program development. The automation of competency mapping not only enhances efficiency but also contributes to the adaptability of curricula in response to emerging professional standards and industry demands. The findings demonstrate that the proposed system significantly reduces manual workload, improves consistency in competency formulation, and provides a scalable solution for higher education institutions seeking to modernize their curriculum development processes.

Conclusion.

The developed Intelligent Information System (IIS) represents a significant advancement in educational technology. By leveraging automation and data analysis, the system ensures the effective adaptation of educational programs to the rapidly changing demands of the labor market. The integration of professional standards and labor market data minimizes the gap between the education system and real employer needs.

The key functionalities of the IIS include automated competency selection, learning outcome generation, and support for curriculum development. These tools not only streamline the course planning process but also enhance its relevance through a data-driven approach. Additionally, built-in data verification and analysis mechanisms ensure the accuracy and reliability of generated

educational elements, reducing the risk of errors and improving the overall quality of learning materials.

Despite the achieved results, further development of the IIS involves improving the interpretation of professional standards, enhancing the system's adaptability to diverse educational contexts, and integrating it with modern digital learning platforms. Future research may also focus on developing intelligent recommendations for personalized learning pathways, further enhancing adaptability and individualization in education.

Thus, the proposed system contributes to the digitalization and intellectualization of education, laying the foundation for the development of flexible and efficient educational programs that meet the challenges of the modern technological landscape.

ҚҰЗЫРЕТТЕРДІ ЖӘНЕ ОҚЫТУ НӘТИЖЕЛЕРІН БАСҚАРУДЫҢ ИНТЕЛЛЕКТУАЛДЫ ЖҮЙЕСІ: БІЛІМ БЕРУ БАҒДАРЛАМАЛАРЫН ЕҢБЕК НАРЫҒЫНА БЕЙІМДЕУ

Аңдатпа: *Мақалада кәсіби стандарттар негізінде құзыреттіліктер мен оқыту нәтижелерін қалыптастыруды автоматтандыруға арналған Интеллектуалды ақпараттық жүйе (ИАЖ) ұсынылған. ИАЖ-ның айрықша ерекшелігі-білім беру бағдарламаларын еңбек нарығының серпінді өзгеріп отыратын талаптарына және технологиялық өзгерістерге бейімдеуге мүмкіндік беретін жаңа кәсіптер Атласымен кәсіби стандарттарды интеграциялау болып табылады. Жүйенің негізгі функционалдығы, соның ішінде пайдаланушының аутентификациясы, білім беру бағдарламаларын жобалау үшін құзыреттілік пен оқу нәтижелерін қалыптастыру сипатталған. Жүйені енгізу AJAX технологияларын қолдана отырып, серверге асинхронды сұраныстарды жіберуді қолдайтын JavaScript-те интерактивті интерфейсті қамтиды. Құзыреттілік пен оқу нәтижелерін автоматты түрде қалыптастыру үшін OpenAI генеративті модельдері қолданылады. Ұсынылған жүйе құзыреттілікке негізделген оқу жоспарларын жобалаудан бастап кәсіптік бағдар жүйелерін құруға, еңбек нарығындағы өзгерістерді талдауға және болжауға, сондай-ақ білім беру бағдарламаларын жоғары технологиялық салалардың талаптарына бейімдеуге дейінгі әлеуетті қолданудың кең спектріне ие. Осылайша, әзірленген модель білім беруді цифрландыруға, оның сапасын арттыруға және білім беру стандарттарының білім экономикасының заманауи талаптарына сай болуын қамтамасыз етуге ықпал етеді.*

Түйін сөздер: *Құзыреттілікті басқару, Оқыту нәтижелері, Оқу бағдарламаларын әзірлеу, Интеллектуалды ақпараттық жүйе, Кәсіби стандарттар, Жаңа кәсіптер Атласы.*

ИНТЕЛЛЕКТУАЛЬНАЯ СИСТЕМА УПРАВЛЕНИЯ КОМПЕТЕНЦИЯМИ И РЕЗУЛЬТАТАМИ ОБУЧЕНИЯ: АДАПТАЦИЯ ОБРАЗОВАТЕЛЬНЫХ ПРОГРАММ К РЫНКУ ТРУДА

Аннотация: *В статье представлена интеллектуальная информационная система (ИИС), разработанная для автоматизации формирования компетенций и результатов обучения на основе профессиональных стандартов. Отличительной особенностью ИИС является интеграция профессиональных стандартов с Атласом новых профессий, что позволяет адаптировать образовательные программы к динамично изменяющимся требованиям рынка труда и технологическим трансформациям. Описаны ключевые функциональные возможности системы, включая аутентификацию пользователей, генерацию компетенций и результатов обучения для проектирования образовательных программ. Реализация системы включает интерактивный интерфейс на JavaScript с поддержкой асинхронной отправки запросов на сервер с использованием технологий AJAX.*

Для автоматической генерации компетенций и результатов обучения применяются генеративные модели OpenAI. Представленная система имеет широкий спектр потенциальных применений: от проектирования учебных планов, основанных на компетенциях, до создания систем карьерного ориентирования, анализа и прогнозирования изменений на рынке труда, а также адаптации образовательных программ к требованиям высокотехнологичных отраслей. Таким образом, разработанная модель способствует цифровизации образования, повышению его качества и обеспечению соответствия образовательных стандартов современным вызовам экономики знаний.

Ключевые слова: *Управление компетенциями, Результаты обучения, Разработка учебных программ, Интеллектуальная информационная система, Профессиональные стандарты, Атлас новых профессий.*

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