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# Development of Educational Information Systems in Smart Cities with the Application of Artificial intelligence

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**Abstract:** The development of educational information systems in the context of the fourth industrial revolution and smart cities is transforming traditional approaches to education through the integration of artificial intelligence (AI), IoT and cloud computing. These advanced systems enable personalization of learning, automation of knowledge assessment and efficient management of resources, thus supporting the principles of Education 4.0. The focus is on adaptive technologies that meet the individual needs of students, improve the quality of teaching and increase user engagement. This paper analyzes the key technologies, methods and tools which are enabling the application of AI in education, identifying challenges such as privacy protection, ethical dilemmas, the digital divide and the integration of new technologies into existing educational practices. Special attention is given to the application of AI in the personalization of learning, the automation of knowledge assessment and the optimization of resource management in educational institutions. The results of the analysis highlight the significant potential of these systems for improving the educational experience, while proposing a strategic framework for their implementation in smart cities.

**Keywords:**artificial intelligence; educational information systems; IoT; personalization of learning; resource management; smart cities

## 1 INTRODUCTION

Information systems used in education obtain a new dimension by integrating artificial intelligence (AI). The application of AI in education brings numerous advantages, such as personalization of learning, adaptation of teaching content to the needs of students and more efficient management of resources [1, 2]. New information systems used in education completely transform traditional education and contribute to improving the quality of the teaching process and increasing student engagement [3, 4]. The large increase in virtual tutors, chat-bots and intelligent tutoring systems directly affects the role of educators [4]. In modern education systems, the main role of educators is to encourage creativity, critical thinking and problem-solving skills, while leaving routine tasks to AI assistants [4].

Educational information systems used in smart cities are based on the principles of Education 4.0. Education 4.0 represents an educational model that is in line with the fourth industrial revolution and is based on the use of digital technologies, artificial intelligence, IoT and other modern technological solutions [5, 6]. Key principles of Education 4.0 such as personalization of learning, data-driven learning and flexibility of educational processes are directly related to the goals of educational information systems in smart cities [7].

The goal of the paper is to provide insight into technologies, methods and tools that enable personalized learning, automated knowledge assessment and data-based decision-making. An analysis of the main challenges faced by these information systems, such as data privacy, ethics, the digital divide and the integration of new technologies into existing educational practices, will be carried out. Special attention is devoted to the analysis of perspectives for the development and improvement of educational systems in the Republic of Serbia.

## 2 EDUCATIONAL INFORMATION SYSTEMS

The information system is based on the infrastructure of information technologies that are used. The IT infrastructure of an organization, which is shown schematically in Figure 1, consists of hardware, software, databases, networks/telecommunication technologies and human resources [8].

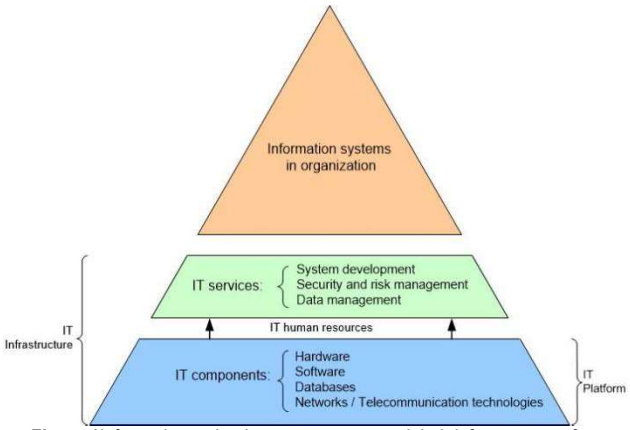


**Figure 1** Information technology components and their infrastructure of an organization [8]

Information systems used in education belong to the category of specific information systems intended to support educational processes [9]. These information systems play an important role in the process of digitization and improvement of educational processes and enable more efficient management and learning [10]. There are different models and categories of these educational information systems, which indicates their great complexity.

There are educational information systems that can function independently and focus on specific tasks (for example, school library management) [11]. On the other hand, there are educational systems that integrate with other systems, combining their functionalities (for example, when combining

curriculum management, administration and communication with students).

According to the type of support provided to users, educational information systems are divided into learning support systems, collaborative systems and assessment systems. Learning systems are designed to provide direct support to educational processes and include various tutorials, exercises and multimedia content [12]. Collaborative systems enable the collaboration of students and teachers (tools that enable the implementation of forums, video conferences and document sharing such as Microsoft Teams and Zoom) [13]. Assessment systems are designed to enable the creation, implementation and analysis of tests and student evaluation (examples of tools: Kahoot and Google Forms) [14].

According to the type of data processed by educational information systems, they are divided into systems for data analysis and systems for recording and reporting. Data analysis systems include tools for monitoring and analyzing the results achieved by students, as well as monitoring and analyzing their behavior in the learning process and predicting their results. Typical examples of systems for recording are systems for tracking student attendance and performance.

Looking at the technological basis of educational information systems, systems with artificial intelligence (AI-powered system) and systems with augmented and virtual reality have a leading position [15]. These systems enable personalized learning and interactive and simulation lessons. The integration of new technologies contributes to the modernization of the learning process and the management of educational institutions.

## 3 THE CONCEPT OF EDUCATIONAL INFORMATION SYSTEMS IN SMART CITIES

Educational information systems in smart cities integrate IoT devices, cloud computing and artificial intelligence with the aim of creating dynamic and adaptive learning platforms [16]. These platforms enable interactive teaching in smart classrooms, distance learning and more efficient management of resources such as teaching materials, lecturer's time and classroom capacity. Figure 2 shows a graphic representation of the ecosystem of educational information systems.

The application of IoT technology enables the collection of data on student behavior in real time [17]. Sensors in smart classrooms monitor student attendance, focus and activity. For example, smart classrooms use motion, sound and light sensors to identify the level of student engagement during class. All this information can be used by teachers in real time and used to adjust the dynamics of the lesson. The integration of cloud computing into the educational information system enables the storage of a large amount of data, as well as their analysis in real time [18].

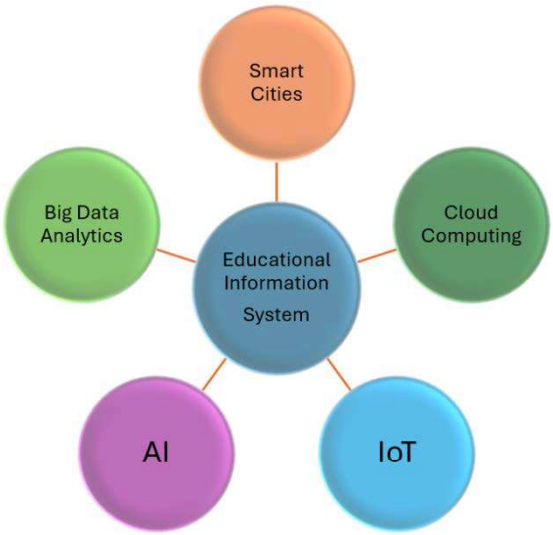


**Figure 2**Ecosystem of educational information systems

### 3.1 Application of AI in the personalization of learning

The key principle of Education 4.0 is the personalization of learning, which is very successfully realized by implementing AI in the educational process [19]. AI systems enable the analysis of huge amounts of data, identify patterns and adapt to individual learning styles [4]. The main goal is to adapt the teaching content to each student based on his knowledge, interests and skills. In this way, students are allowed to learn at their own pace, with personalized resources, recommendations for further work and automatic information about their progress available to them. Figure 3 shows a graphic representation of the benefits of AI in personalized learning.

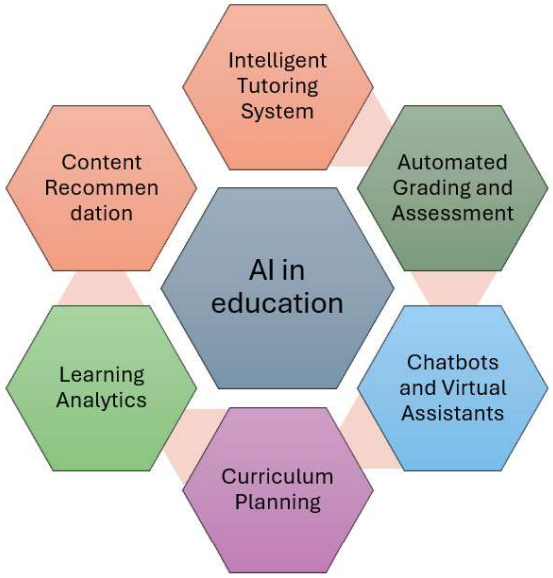


**Figure 3** Benefits of AI in personalized learning

The key techniques used in personalizing learning are:adaptive learning systems, recommendation systems andintelligent mentors.

AI algorithms are used to analyze student progress and adjust the difficulty of tasks and the type of content in accordance with the results of the analysis [20, 21]. AI algorithms track various student performance metrics, such as accuracy, response time, and error patterns, and using this

data, the system generates new tasks that are tailored to each student's needs [22]. Research has shown that maintaining an appropriate level of challenge, often referred to as the "zone of proximal development," is critical to effective learning [22]. Special AI algorithms have great potential to enrich the learning experience of students with special needs [23].

AI uses appropriate algorithms to suggest additional content to students that can help them better understand the material. These can be additional lessons, video materials or various quizzes to determine the material. This approach uses the behavioural patterns of other students to provide optimal recommendations.

AI systems provide personalized guidance to students during the learning process and behave similarly to human mentors [21]. Intelligent tutors have the ability to provide real-time explanation to students and answer questions using natural language processing.

Figure 4 shows a graphic comparison of traditional and AI-personalized learning approaches based on data from [22].

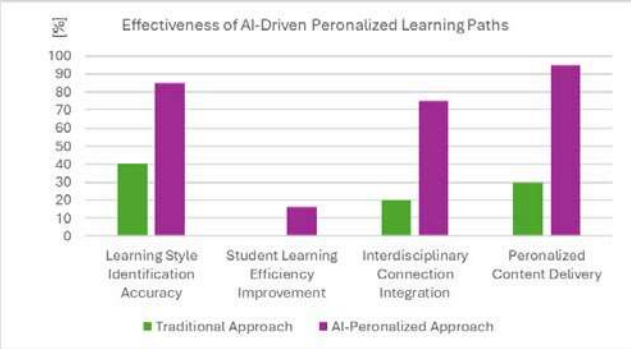


**Figure 4** Comparison of Traditional vs AI-Personalized Learning Approaches [22]

### 3.2 Automation of knowledge assessment with the help of AI

The integration of AI technology into the educational information system can enable the automation of the process of assessing students' knowledge [21]. In this way, the teacher's workload is reduced and the accuracy of the assessment is increased.

Methods of automation of knowledge assessment are:automatic recognition of answers, analysis of student behaviour and automatic task generation.

The main goal is that AI can analyze and evaluate students' open answers, which is achieved by using methods of natural language processing and machine learning [24].AI can recognize when a student is not focused on the task, when is having difficulty working in class or what learning style suits him best. This can be achieved through the use of sensors and IoT devices in the classroom.Based on the assessed level of knowledge and interest of the student, AI can generate test questions or a customized quiz.

In addition to automating knowledge assessment, AI algorithms have high accuracy in predicting student dropouts. These data are of great importance for the creation of a special curriculum for such students, which would contribute to increasing interest in the learning material and increasing student motivation. Figure 5 shows a comparison of traditional and AI estimation methods based on data from [22].

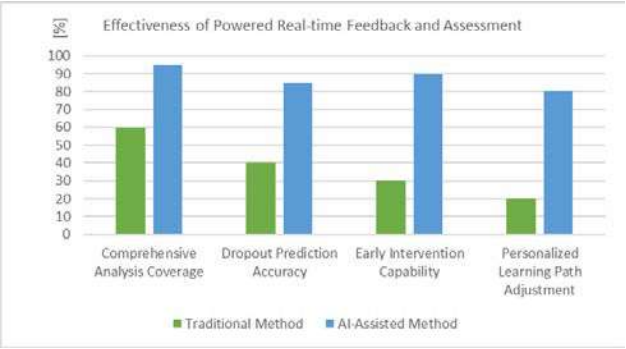


**Figure 5** Comparison of Traditional vs AI-Assisted Assessment Methods [22]

### 3.3 Application of AI in resource management

Efficient management of all resources is crucial in the concept of smart cities. AI algorithms help optimize the following areas:

• optimization of classroom use – the use of AI predictive models enables the optimization of classroom use schedules based on the needs of students and teachers;

• management of teaching resources - AI algorithms can be used to automatically assign tasks to teachers and optimize workload [21];

• management of financial resources - AI algorithms can be used to analyze the costs of educational materials and, in accordance with the results of the analysis, suggest a more rational use of the budget [21].

## 4 CHALLENGES IN THE APPLICATION OF MODERN EDUCATIONAL INFORMATION SYSTEMS

The implementation of educational information systems entails various challenges that can be of a technical, social, economic and organizational nature. Addressing these challenges is critical to the successful integration of technology into the education sector.

One of the main problems is the existence of a digital divide between different socio-economic groups. Unequal access to information and communication technologies represents a major challenge for achieving equality in education [25]. The application of new technologies can lead to an additional increase in inequality. Also, rural and poorly developed areas do not have developed infrastructure, which is a complicating factor for the implementation of modern education systems. To solve this, significant investments in digital infrastructure are necessary.

Given that educational information systems collect, process and store huge amounts of data about students, teachers and educational processes, there are risks related to data security and privacy. The integrity of the system can be threatened by various hacker attacks, information leaks or unauthorized access to information. It is necessary to carry out the following actions:

- collect only data that is necessary for educational purposes;
- clearly inform students and parents about data collection practices and obtaining appropriate consent;
- implement the necessary cyber security measures to protect against data breaches and unauthorized access;
- establish clear guidelines on the data retention period;

- carefully monitor all third parties who may have access to student data [22, 26].

Addressing these issues requires a collaborative effort between educational institutions, technology developers, policy makers, and privacy advocates to develop an appropriate framework to protect the privacy of students who take advantage of AI in education.

The implementation of smart education systems requires large financial investments in infrastructure construction, equipment acquisition, staff training and system maintenance. The high costs of implementation and maintenance represent a long-term challenge to the sustainability of these systems.

Effective implementation of educational information systems depends on the digital literacy of all users of the system. If the users of the system do not have enough knowledge to use new technologies, then there will be a weaker integration of the system. Resistance to change is also common, especially among teachers and administration, which can slow down the implementation process [27]. This is why training and ongoing support for all system users is extremely important. Additionally, collaboration between educators, AI developers, and educational researchers contributes to AI tools being designed according to the needs and limitations of smart classrooms [22].

Modern educational information systems are characterized by high technological complexity. As a result, cross-platform and device issues, system crashes, network speed limitations, and hardware and software compatibility issues can occur. Insufficiently developed IoT infrastructure can limit the capabilities of these systems.

The use of AI in educational systems raises many ethical questions. There are many prejudices about the use of certain algorithms, the problem of transparency in decision-making and the question of whether automation can replace people in the educational process [28]. For this reason, it is necessary to define appropriate regulations and ethical guidelines.

The integration of smart educational systems implies intensive use of electronic devices, which increases the amount of electronic waste and energy consumption. Therefore, it is necessary to consider the use of sustainable solutions, such as the use of recycled materials and energy-efficient technologies, when planning these systems.

## 5 EDUCATIONAL INFORMATION SYSTEMS IN REPUBLIC OF SERBIA

The development of educational information systems in the Republic of Serbia is gaining importance through national digitization strategies, among which is the Strategy for the Development of Education and Training in the Republic of Serbia until 2030 (hereinafter: Strategy). This document recognizes digitization as a priority area in the modernization of education, with the aim of increasing the availability, quality and efficiency of educational services.

In recent years, significant steps have been taken towards the implementation of educational information systems in the Republic of Serbia. The most significant projects are the introduction of an electronic diary and a digital classroom. However, there are also numerous limitations and challenges such as the lack of adequate IT equipment and internet connection in schools in rural areas, large variations in the level of digital competences of teachers, the need to improve data protection in accordance with privacy regulations and limited resources for the development and maintenance of modern information systems.

According to Strategy, priorities in the development of educational information systems in Serbia include infrastructure improvement, digital transformation of the teaching process (development of platforms for online learning and personalization of educational content), professional development of teaching staff and integration of artificial intelligence [29].

Serbia has the potential to develop integrated educational information systems that connect schools, local communities and wider social sectors. The key steps towards achieving this goal are the creation of a national education portal, encouraging innovation through public-private partnerships and digital inclusion programs for schools in less developed areas.

## CONCLUSIONS

The application of artificial intelligence in educational information systems within smart cities is revolutionizing education by ensuring that every student receives a personalized learning experience tailored to their needs, interests, learning style, and pace. Integrating AI into the educational process facilitates automated grading and more efficient resource management. While challenges persist, the potential of AI in education is immense, particularly in creating data-driven smart cities powered by intelligent systems. Future research should focus on developing ethical guidelines, increasing technology accessibility, and enhancing educators' capacity to work with AI tools.

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