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THE CONCEPT OF DESIGNING A «SMART CLASSROOM» OF AN EDUCATIONAL INSTITUTION

Abstract

The creation of a smart classroom is one of the priorities of the digital transformation of higher education, which allows for an increase in the efficiency of the educational process creates comfortable conditions for learning using the latest technologies, and is carried out in several stages. Concept development is one of the first and most important steps in creating a smart classroom. It defines the main directions and goals of creation, the structure and content components of a smart classroom, and the requirements for its functionality to create the most efficient and convenient space. The purpose of this study was to develop a concept for designing a smart classroom for the training of future informatics teachers and ICT specialists for education, the further implementation of which will not only optimize resource management but also create more effective, comfortable, and modern conditions for learning. The research methodology included analysing literature on the creation and implementation of smart classrooms in the educational process, as well as surveying its potential users to determine the functionality requirements. Based on the analysis of literature and the survey results among informatics students and future ICT education specialists, the functionality for the «smart classroom» was constructed, and its key structural components for implementation were identified and substantiated. The developed concept defines the technological basis for creating a functional smart classroom that meets modern requirements.

Keywords: smart classroom, equipment management automation, control sensors, system integration, Likert scale, sensor equipment.

Introduction. The creation of a smart classroom is one of the priorities for the modernization of the educational process in universities in modern conditions of rapid development of intelligent technologies. The Smart Classroom, based on the Internet of Things concept, represents a high-tech learning space where all technical systems and devices work in coordination with minimal or no human intervention, ensuring maximum comfort and effectiveness of the educational process (Yağanoğlu et al., 2024).

Such classrooms contribute to the development of innovative approaches to learning and education, providing new opportunities for interactive learning, the use of virtual and augmented reality, video classes, and other innovative educational formats (Ma et al.,

2024). A comfortable, stimulating, intelligent atmosphere in the classroom, created by smart equipment integrated into a single network, meets the needs of modern students who are accustomed to digital devices and online resources. Smart classrooms provide the opportunity to use these technologies in the educational process, increasing their engagement, efficiency, and quality of learning to the requirements of the digital age (Hu et al., 2022; Lu et al., 2021).

Automation of routine tasks in a classroom with the help of «smart» technologies helps to optimize the educational process and allows teachers to focus on the creative aspects of learning and improve the quality of the educational process (Pospelova et al., 2024). Creating smart classrooms to improve the learning environment by modern technological challenges, makes the university more modern, and contributes to increasing its attractiveness and competitiveness.

Due to their relevance, a lot of research has been devoted to the creation and implementation of a smart classroom in higher education institutions. In the work of Grigoriev et al., (2013), the principles of the organization and functioning of the smart classroom are formulated, in the study of Kostarev et al., (2020). Kostarev et al., (2020) present the concept of creating and physically implementing a smart classroom. In the work of Shen et al., (2014) the possibility of using short-range wireless communication technology to automate attendance management, determine the location of students, provide real-time feedback, and increase their motivation to study informatics. Among other works, important technical characteristics of various types of smart classrooms are considered, which are usually equipped with interactive whiteboards and touchscreens, wireless displays and shared screens, cameras and recording and broadcasting equipment supporting synchronous and asynchronous video transmission, setting up the Internet of Things to control the microclimate in classrooms (Saini & Goel 2019; Radosavljevic et al., 2022). In the work of Suo et al., (2008) a synchronous distance learning system open smart classroom is proposed to solve the problems of remote software management, downloading files, and adding new remote classes (including mobile devices) to synchronous live courses.

A lot of research has been devoted to the impact of smart classrooms on student academic performance and effectiveness in higher education (Yang & Huang 2015; Phoong et al., 2019; Radosavljevic et al., 2022; Asalkhanov & Petrova 2021). All these works formed the basis of our research.

Technically, the smart classroom is very similar to the smart home and includes the same modules for microclimate, lighting, security, switching on and off equipment, and others. Such modules have already been technically implemented in a smart home, and the idea of solving them can also be applied when creating a smart classroom. The difference between a smart classroom is that it is an educational room equipped with computer technology and specialized equipment, and the necessary educational effect will be achieved if a comfortable intellectual learning environment is created (Barinov, 2023). Learning in such an educational environment equipped with various IoT technologies combined into a single network prepares future informatics teachers and specialists in the field of ICT application in education to work in a high-tech world and prepare the younger generation for this.

At the moment, there are very few analogue of its creation and application in the educational process, they mainly solve narrow tasks related to the development of the IT infrastructure of the classroom based on IoT. The purpose of this study was to develop a concept for designing a smart classroom, the further implementation of which will not only optimize resource management but also create more effective, comfortable, and modern-day learning conditions.

Materials and methods. The research was conducted in three stages: theoretical, experimental, and analytical. The choice of research methods at each stage was determined by the goals and objectives of the study. The study and analysis of the literature on the topic under consideration, the practice of creating

and introducing a smart classroom into the educational process at the first stage allowed us to conclude the need to create a smart classroom and introduce it into the system of training future informatics teachers and ICT specialists for education, which will provide them with the necessary knowledge and skills for successful work in a modern school in the rapidly changing world of information technology.

The survey of students and teachers of informatics, future specialists in the field of ICT for education at the second stage of the study allowed us to determine the requirements for its functionality to create the most efficient and convenient space.

The survey was attended by students of 1-4 courses of the specialties Informatics, Informatics and Robotics, Information Systems in Education and teachers of the Department of Informatics and Informatization of Education of the Abai Kazakh National Pedagogical University and teachers of several schools in Almaty.

Statistical methods were used to process, analyse, and interpret the survey results at the final stage. The analysis of the results of the conducted research made it possible to determine the conceptual scheme of the «smart classroom» system, its necessary hardware and software components, and intelligent control schemes for various classroom systems.

Results and discussion. The preparation of future informatics teachers and ICT education specialists requires constant adaptation to the rapidly changing technological landscape. Traditional classrooms, equipped only with an interactive whiteboard, no longer fully meet the needs of the modern educational process. Given the rapid development of technologies, it is advisable to train them in a smart classroom equipped with innovative IoT-based equipment that meets modern technological challenges. Such a classroom will enable students to acquire the modern knowledge and skills necessary for successful work in the rapidly changing world of information technology.

A smart classroom is not just a learning space equipped with smart equipment. It is an integrated system in which all elements, from the interactive whiteboard to the ventilation system, are interconnected and centrally controlled. Its creation includes several stages:

– analysis of needs and definition of functional requirements for a smart classroom based on the specifics of academic disciplines and user needs;

– designing a concept describing the specific goals of creating a «smart classroom», its intended functionality, and the technologies, equipment, and software necessary for its implementation;

– installation and configuration of hardware and software;

– training teachers and technical staff to use smart hardware and new software;

– step-by-step implementation of the smart classroom in the educational process, monitoring the operation of the system, and making necessary adjustments.

The foundational stage in the process of its creation is the development of a concept for designing a smart classroom. This is the foundation on which the entire smart classroom system is built. To determine the need to create a smart classroom for the training of future specialists in the field of IoT, its potential advantages over traditional classrooms, and the requirements for its functionality, the present research studied and analysed the work of scientists and the results of implemented practices in this field (Asalkhanov & Petrova 2021; Palau & Mogas 2019; García-Tudela et al., 2023; Phoong et al., 2019; Dai et al., 2023), and a survey was conducted among 216 respondents (students of the specialty Informatics, Informatics and robotics and Information systems in education, as well as teaching staff of pedagogical universities in Almaty).

To determine the priority functions of the smart classroom for potential users and, accordingly, the requirements for the functionality of the smart classroom, they were asked 10 questions (table 1) covering key aspects of the functionality of the smart classroom using the Likert scale to assess the degree of agreement or disagreement of respondents with various statements. This will optimize the functionality of the system during creation and make it more convenient and efficient.

Table 1. *Questions on the definition of key aspects of the functionality of the «smart classroom» and the results of the survey on them*

		no	I don't know	yes
1	A smart classroom should be flexible and easily adaptable to different work formats	30 (14%)	7 (3%)	179 (83%)
2	The presence of automatic lighting and temperature control systems in the classroom improves comfort and increases productivity	4 (2%)	22 (10%)	190 (88%)
3	The presence of interactive elements (for example, touch panels, touch tables, interactive scoreboards) will make lessons more interesting and effective	10 (4.5%)	12 (5.5%)	194 (90%)
4	The presence of voice control systems significantly increases the efficiency of the educational process	2 (1%)	15 (7%)	199 (92%)
5	The integration of the smart classroom system with the university's learning platform will optimize the learning process.	-	54 (25%)	162 (75%)
6	Integrating a classroom management system with popular video conferencing platforms is a must for a smart classroom	22 (10%)	43 (20%)	151 (70%)
7	The function of recording lectures and automatically saving them to the cloud storage will be useful for students	17 (8%)	130 (60%)	69 (32%)
8	Do you consider it necessary to implement wireless presentation in a smart classroom to simplify the reporting process?	26 (12%)	17 (8%)	173 (80%)
9	The availability of automatic attendance control systems is a prerequisite for a smart classroom	22 (10%)	17 (8%)	177 (82%)
10	A smart classroom should automatically connect to a personal calendar and adjust classroom settings according to planned events.	4 (2%)	52 (24%)	160 (74%)

In this questionnaire, the Likert scale 3 was used (1-no, 2-I don't know, 3 – yes). Teachers and students evaluated it according to their real ideas. The school was then tested to verify its validity and reliability. The results showed that Cronbach's alpha (α) is 0.9047 and the square root of α, which was used to determine validity, is 0.951. Smits et al., (2018), indicate that the reliability and validity values are excellent, as indicated in the work of Heale & Twycross (2015) and even indicate a very high internal consistency of the data.

The survey results provided a more complete understanding of the needs and expectations of various user groups and highlighted the main requirements for its functionality:

– combining, various technical devices (with sensors of illumination, temperature, motion, and others) used in the smart home, computers, interactive panels, audio and video systems, touch tables, and other equipment of the classroom into a single system for ease of management;

– integration of the above-mentioned technical devices and equipment of the classroom with other information systems of the university and popular educational platforms (LMS, Microsoft Teams, and others) to optimize the educational process;

– integration of interactive equipment (interactive panels, surveys, tests, and other classroom tools) into a single system to involve students in the learning process and ensure active interaction of subjects of the educational process with each other;

– automation of routine processes specific to the classroom: automatic monitoring of student attendance, automatic task verification, and automatic control of technical equipment (just like in a smart home);

– personalization of learning: adaptation of educational materials and teaching methods to the individual needs of each student;

– automation of recording and storing lectures to view them again and create a knowledge base;

– automation of the processes of collecting and analysing data on attendance, class effectiveness, and student preferences to optimize the learning process;

– user-friendliness: a simple and intuitive interface for managing all audience systems.

The listed requirements are general and can be adapted to the specific conditions and needs of the university and, if necessary, supplemented. Taking into account these requirements and based on the analysis of research in this field (García-Tudela et al., 2023; Li et al., 2015; Palau & Mogas 2019; Dai et al., 2023), the structural components of the smart classroom have been identified, which can be divided into several categories. They are presented differently by different authors (Li et al., 2015; Palau & Mogas 2019; Dai et al., 2023). In this article, as well as in the work (Dai et al., 2023), 3 structural components are considered: the physical environment, resource space, and social space.

The physical environment is an important component of a smart classroom. It covers all the physical objects of the learning environment that can affect learning and the organization of the learning process, including infrastructure, educational equipment, and systems, as well as sensory equipment, which is the basic support for the entire classroom. The infrastructure of the classroom mainly includes the spatial layout of the physical environment: dynamically combined tables and chairs, controlled lighting, blinds, air conditioning fresh air supply, and others.

Educational equipment and control systems are used primarily for the presentation of educational content, communication and collaboration, and knowledge transfer and include intelligent display equipment, an intelligent terminal, augmented reality (AR)/virtual reality (VR) equipment, audio and video equipment, network equipment, recording and broadcast equipment, and a centralized Internet of Things management system. Sensor equipment is the main channel for receiving data in a «smart classroom», including a high-definition (HD) camera, face recognition cameras, temperature and humidity sensors, illumination, motion, a microphone, a universal card reader, and others. It recognizes, identifies, and collects the necessary data in the classroom using various sensors. The collected data includes information about the surrounding state in the classroom, data about the learning process, and information about personality recognition, among other things.

The physical environment of the «smart classroom» for effective IoT training includes the following devices and control systems:

– interactive panel for presentations of educational material and results of educational and scientific research in 3D format and collaboration;

− the teacher's desktop, equipped with a computer, a video conferencing system for managing the presentation and activities of students, and remote interaction with them, an electronic attendance log, a system for viewing and managing the content of students;

− high-quality video cameras and audio systems to ensure a clear display of three-dimensional visual aids and sound;

− wireless networks for Internet access and data exchange;

− computers for students, integrated into a single network, connected to the teacher's computer and an interactive panel;

− smart interactive scoreboard;

− touch tables for organizing student collaboration;

− 3D printer for prototyping devices and models;

− demonstration prototypes (smart traffic light, smart greenhouse, smart home, robotics kits, and others) used in the training of future IoT specialists for education;

− microclimate control system, including air conditioning, temperature, humidity, carbon dioxide concentration sensors, a subsystem of window opening drives for automatic maintenance of indoor air quality;

− the control system for natural (curtains) and artificial lighting (lamps) to automatically maintain the lighting level recommended by sanitary standards in the auditorium;

− the automation system of equipment management implies the installation of «smart» sockets that will allow remotely, at a certain time or according to a given scenario, to turn on (turn off) equipment, for example, when a teacher enters the classroom, it is possible to use voice control;

− automation system for opening and closing window blinds;

− equipment technical condition monitoring system;

− SMS notification system for critical situations;

− the student face recognition system at the entrance to the classroom to provide automated monitoring of class attendance;

− the classroom access control system. The smart classroom security system involves the installation of a video surveillance system (IP camera with built-in motion sensor) with the storage of observation data in a cloud service, door and window opening sensors, and vibration sensors for expensive machinery and equipment.

− voice control systems for equipment and information retrieval without using a keyboard and mouse;

− systems for automatic task verification, and chatbots for answering questions.

To manage all the components of the system and their interaction with each other and the user, it is necessary to connect the devices to a single node, the server. For these purposes, you can use a microcomputer (for example, Odroid or Raspberry Pi) and special open-source software (for example, Home Assistant or Yandex Smart Home). To control the system of classroom elements in manual mode, it is possible to install a smart tablet with the development of click scenarios. Such an integrated smart classroom management system will allow centralized control through the touch panel interface of the entire complex of smart classroom equipment, even by an unprepared user.

Currently, in all educational institutions, many classrooms are standardly equipped with interactive panels that are controlled from the teacher's computer. Thanks to them, it becomes possible.

– demonstration of educational material to illustrate the studied concepts and practical situations;

– the use of various digital educational resources and presentations, the ability to supplement and save existing records; at the same time, there is no need to stand near the blackboard to make any notes or corrections, since he controls the blackboard from a computer.

Students' computers, touch desks, 3D printers, and other devices can also be connected to the specified interactive panel system, the teacher's computer. This integration of technical means into a single network is one of the components of a smart classroom. In such a learning environment, the learning material is available not only on the teacher's computer screen and is demonstrated on a smart board, but is also shown in parallel on each student's computer. The teacher can transfer control to any of the students both on the blackboard and on the computer screens of the teacher and all students, he will be able to demonstrate his solution from the spot, which will allow the teacher to assess the correctness of the execution, and the group to see a solution to the problem, ask questions (Kostarev et al., 2020).

The creation of such a learning environment, where the teacher's computer, interactive panel, students' computers, and other technical learning tools work as a single whole, centrally controlled, will allow for the implementation of a student-centred, activity-based approach to learning, optimize the learning process, increase its efficiency and interactivity. To create such an environment, in addition to physically connecting technical training tools to a single network using cables or Wi-Fi.

− routing configuration is required to ensure communication between devices;

− the necessary software is installed for the devices to interact with each other and with the interactive panel. The ability to display the smart panel screen on students' computers is being configured;

− data synchronization between devices is configured;

− device management software is being installed. The possibility of remote control of all network devices is implemented;

− a reliable server or cloud solution is being identified that will centralize network management. It will store all settings, software, educational materials, student and teacher data;

– scripts are created to automate various tasks, for example, turning on/off devices, and launching applications.

Of course, equipping a «smart classroom» and the competent organization of management of all its systems plays a key role in creating an intellectual learning environment and improving the effectiveness of the educational process. The elements included in the physical space can support the representation of various resources necessary for the organization of the educational process and provide a place for their storage and management. As a medium of communication, the physical environment also provides support for the social space of the smart classroom. Therefore, the physical environment is one of the important components of a smart classroom that should be taken into account when designing it.

An equally important component of a smart classroom is the resource space. Resources, physical and informational, are the main elements of the introduction of intelligent learning in a smart classroom. In this case, it is possible to use various LMS and educational platforms (Microsoft Teams) with the integration of cloud services. They provide various learning management services, such as user management, and digital educational content, provide rich information resources for organizing intellectual learning activities, both in a smart classroom and beyond, allow online and offline connections, and organize mixed learning. Their use in the learning process allows teachers to instantly adjust learning strategies and display resource content according to the learning situation to fully reflect the student-centred learning concept.

Learning through the combination of a variety of physical and digital resources included in the resource space of a smart classroom is an important feature of the intellectual learning environment. The choice of specific software products included in the resource space of a smart classroom depends on the needs of the educational institution and the characteristics of the equipment. The most accessible of them are:

– cloud services such as Google Classroom, and Microsoft Teams provide tools for placing educational material and organizing both individual and collaborative work of students, as well as for instant organization of video conferences and classes not only offline but also in a mixed format and the implementation of the inverted classroom model;

– platforms for conducting online surveys, tests, and other interactive activities;

– learning management Systems (LMS) for the organization of the learning process;

– virtual laboratories (Tinkercad, and others);

– video conferencing software;

– open platforms such as OpenCast, and Canva, among others, for recording and storing lectures. Canva also provides a set of tools for creating artificial intelligence-based content and performing group projects.

Smart classroom software plays a key role in creating a comfortable, stimulating, innovative, and interactive learning environment. It allows you to combine various devices and systems (interactive panels, computers, sensors, and others) into a single whole, providing convenient management and optimization of the educational process, and allowing teachers and students to interact with educational material at a new level. By mining the collected data, the resource space can provide resources and data to groups of users of the social space. At the same time, it also acts as a link between social relationships, that is, by taking resources as a link to form a community of people with the same or similar learning needs and interests, to encourage team learning.

The social space of the «smart classroom», as its third important structural component, mainly includes the space of students, the teacher's space, and the administrative space and ensures their interaction through the resources and systems of the «smart classroom» communication in the format of questions and answers, monitoring of educational achievements of students, instant communication tools and more. Offline interaction refers to interaction in the classroom, including group discussion, supported by information technology integrated into a single system, and real-time feedback. Online interaction is mainly carried out through the support service platform. For example,

students can visit the course homepage to complete assignments and tests published by teachers, receive feedback on the work done, and communicate and interact on topics of interest in the course in the discussion area.

The smart classroom can be managed from a shared server or devices connected to it. Compliance with the principles of organization and functioning of the «smart classroom» formulated in the work (Grigoriev et al., 2013) (heterogeneity, object orientation, cross-platform, meaningful and methodological unification) minimizes almost all technical and technological problems of integration and unification of various engineering and informatization tools within the framework of the «smart classroom».

Conclusion. Smart classroom is not just a trend, but a necessary condition for modern education. It allows you to make the learning process more efficient, convenient, and interesting for both teachers and students and helps to increase the attractiveness of the university. The use of this innovation in IoT training for future informatics teachers and specialists in the field of information and communication technologies in education will improve the quality of their training in this field. The presented concept defines the technological basis for creating a functional smart classroom of an educational institution that meets modern requirements. It allows you to clearly define the necessary set of technologies and tools to equip the classroom with intelligent innovative systems. Due to the dynamic development of artificial intelligence and Internet of Things technologies, it is possible to expand the functionality of the smart classroom and subsequently modernize this concept taking into account new technologies.

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GRAMMARLY'S INFLUENCE ON ACADEMIC WRITING CONFIDENCE IN HIGH SCHOOL STUDENTS: A QUASI-EXPERIMENTAL STUDY

Abstract

This quasi-experimental study investigates the impact of Grammarly, an AI-powered writing assistant, on the confidence and self-efficacy of high school students in academic writing. Conducted with 48 students from a school of Physics and Mathematics, the research employed a non-randomized design with two groups: an Experimental Group using Grammarly Premium and a Control Group that did not receive technological support. Results indicated that Grammarly significantly reduced writing errors in the EG, compared to a lesser reduction in the CG. Additionally, the EG reported notable improvements in writing confidence and self-efficacy, with increases observed on validated scales. These findings suggest that Grammarly can substantially enhance both the quality of academic writing and students' self-perceptions as writers. The study highlights the potential of integrating digital tools in educational settings to foster better learning outcomes. Limitations include the study's short duration and non-randomized group assignment, pointing to the need for further research to explore long-term effects and broader educational impacts.

Keywords: Grammarly; academic writing; high school students; self-efficacy; confidence; educational technology; writing skills improvement.