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Integrating mobile technologies in a smart classroom to improve the quality of the educational process: Synergy of technological and pedagogical tools

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Abstract

The article describes the possibilities of mobile learning to implement the innovative educational concept of Smart Classroom. To increase the effectiveness of international partnerships and to develop opportunities for creating innovative projects in relevant socio-economic areas, an online forum "Engineering of educational courses in the medical and pharmaceutical industry" was held. Proficonf videoconferencing system made it possible to organize five online meetings on digital technologies in the training of modern pharmaceutical personnel within the concept of "Smart Classroom". The study results show that under digital transformation of the educational paradigm, it is advisable to consider a curriculum development strategy in the university ("Smart Campus"). Based on the study results, one can conclude that implementing the concept of "Smart Classroom" allows one to improve teaching methods and interaction between students at all stages of international educational relations.

Keywords: digital technology, mobile learning, Smart Classroom, Smart Environment, Smart Technology, student interaction.

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1. Introduction

Smart Learning Environments (SLE) involve the conscious and strategic use of technology in the learning environment to impact students' learning experience positively. In such an environment, learning scenarios are identified, student characteristics are determined, and appropriate learning resources and convenient interactive tools are provided to help learners achieve educational goals. A smart learning environment is a ubiquitous, context-sensitive, personalized intelligent system capable of providing a high level of motivation, engagement, and intellectual feedback (Agbo et al., 2021).

The global technological revolution has manifested itself in the transition from desktop computers to the widespread use of mobile technologies and has opened up opportunities for implementing innovative teaching methods both in the classroom and beyond. With the development of new mobile technologies, the variety of their functions, and popularity, smartphones have become an integral piece of human life regardless of age, gender, or economic status (Jabali et al., 2019). Smartphones provide teachers and students with the opportunity to collect, evaluate and process knowledge and information in and outside the classroom, as well as facilitate learning, collaboration, and communication in real-time, make it easy to adapt the learning process to individual needs and different levels of students (Twum, 2017). Technology-driven learning processes promote individual learning while meeting specific requirements, adapting and personalizing it; thereby, students get more involved in educational activities. Multi-sensory access to real-world phenomena makes education an inspiring and exciting experience. An interactive learning system that supports the learning process allows users (subjects of the educational process) to simultaneously perform various educational tasks and exercises in real-time (Savov et al., 2019).

Mobile learning has become popular in the university environment due to creating and supporting creative, collaborative, and interactive learning experiences. The unique capabilities of mobile devices, including connectivity, portability, high-performance computing, GPS, and cameras, have tremendous potential to enrich the teaching and learning experience. Mobile learning also impacts the quality of training by integrating work and student experience into the learning process (Al-Hunaiyyan et al., 2017).

Mobile devices are the preferred choice of media, and their massive use has led to a new generation of software for use in educational contexts (Kuatbekov et al., 2021; Papadakis & Kalogiannakis, 2020). Smart mobile devices and their accompanying apps have changed the lifestyle and social interactions of modern society. During the last decade, the number of mobile educational applications with the proposed parameters, such as usability, efficiency, control, and safety, has dramatically increased (Papadakis et al., 2020). In parallel with the widespread use of mobile educational applications in the learning process among developers of educational products and recipients of educational services, there is a growing demand for reliable, fast, and easy-to-use tools for assessing the actual educational value of these applications (Papadakis, 2020a).

1.1. Conceptual research basis

In an innovative learning environment paradigm, smart classrooms act as a physical space enriched with digital, adaptive, and environment-aware devices (Cebrián et al., 2020). Functional parameters of smart classrooms are technologies, learning environment, and processes (Palau & Mogas, 2019) (Fig. 1). The concept of Smart Classroom is implemented through the synergy of technologies, learning environment parameters, and processes carried out within educational activities. Smart Classroom technological solutions include digital and mobile devices, sensors, recognition systems, learning

management systems, specialized software, artificial intelligence, augmented and virtual reality, cloud computing, big data, and learning analytics. A smart learning environment is based on a dynamic lighting system and air quality control parameters, an acoustic system, architecture, and the functional design of the classroom. Smart classroom learning is supported by effective interaction with educational content, in which educational activities are produced both by the participants in training and the educational platform and technological tools.

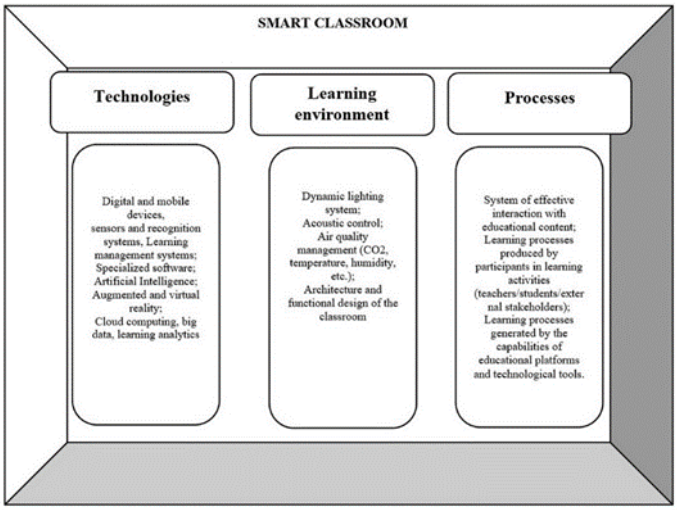

Figure 1. Smart Classroom concept

* Own development based on Cebrián et al. (2020), Palau and Mogas (2019).

The development of mobile technologies such as laptops, tablets, and smartphones has made them more accessible, and educational software has become more user-friendly and familiar, which ensures increased participation in learning through the application of different approaches (Andrews et al., 2011). The widespread use of technology, continuous information updates, the need for people to access information everywhere, and the personalization of education have led to the emergence of distance learning, e-learning, and mobile learning. Wireless technologies and mobile devices play an essential role in popularizing these concepts. As mobile technologies have become widespread, they have become instrumental to teachers and students who can receive numerous educational benefits (Zengin et al., 2018).

Mobile learning can be defined as the ability of students to access information regardless of time and space through mobile devices and manage their learning processes based on their characteristics and needs (Talan, 2020). Students switch from passive learning to active, intellectual, and emotional participation in educational problems through mobile learning. Mobile learning positively affects learning outcomes and students' attitudes to the learning process (Talib et al., 2019). Many universities have introduced cloud computing in their educational process to support their central learning systems or learning management systems (LMS) (Moravčík et al., 2017). Essential aspects of cloud computing, such as cloud data security, customizable service level agreements (CSLA), and cloud services, play an essential role in forming a more reliable and practical mobile learning system (Ahmad et al., 2020).

AI-assisted learning is gaining popularity; it affects several areas of e-learning, offering students intuitive algorithms and automated e-learning content delivery through state-of-the-art LMS

platforms. Adaptive learning technologies will create a completely personalized environment with content modeled and developed based on the student's individual needs (Muniasamy & Alasiry, 2020).Virtual (VR) and augmented reality (AR) technologies that open new opportunities for developing students' professional competencies are increasingly often used in higher education. While VR takes the learner to the virtual world, AR overlays computer-generated virtual objects such as images, video, text, or animation in the real-world environment, creating an expanded or augmented reality.

VR and AR provide learning flexibility as these technologies can be used in both face-to-face and distance learning. AR technology can be implemented at minimal cost as most students have mobile devices. AR web platforms are easy to master and implement; they can help educators quickly introduce learners to the world of augmented and virtual reality (Schneider et al., 2020). Creating an engaging learning environment that is user-friendly and meets various learning needs of university students is a challenging task. However, improvements in simulation technologies such as augmented reality (AR) and virtual reality (VR) provide some solutions to the issue (Salem et al., 2020).

The continuous integration of digital and intelligent technologies and interactive gamification tools into educational interactions is a widely visible phenomenon in modern educational practices. Gamification in the learning process helps increase the level of motivation and engagement among students, has a noticeable effect on academic achievement, and increases interest in social, educational interactions. The introduction of gamification into education ensures the effectiveness and efficiency of learning (Kalogiannakis et al., 2021).

Technology should be adapted to pedagogical aspects and meet educational needs rather than an innovative solution that does not relate to them. Adjustment of external conditions such as lighting, acoustics, and air quality control is also an internal part of the basic definition of a smart classroom, as these factors directly impact students in terms of their comfort and, as a result, the learning process (Cebrián et al., 2020). Some research has been focused on using the smart classroom as a tool to measure teaching quality. For example, sensors were used to measure noise, CO2, temperature, humidity, lecturers' voices, and movements in smart classrooms. The data were evaluated with the help of various classification algorithms. The result showed that CO2, temperature, humidity, and noise levels are the mjar environmental factors affecting the quality of teaching (Uzelac et al., 2018).

Given the tremendous success of smart mobile devices and related mobile applications in educational contexts, there is a need to include computer science in every curriculum with the belief that today's generation of students should be able to develop their digital knowledge and skills to be the creators of technology-driven innovations and not simply consumers of technology (Papadakis, 2020b).

1.2. Relevant Research

Mobile learning components are intrinsic parts of a smart campus, which systematically integrates mobile functionality with the teaching and learning environment. A smart campus is a concept of an educational institution that uses technologies such as information systems, the Internet of Things (IoT), and context-sensitive computing to support learning, teaching, and administrative activities. Smart classrooms are an essential basis of a smart campus. In smart classrooms, the learning environment has been modernized in various ways with the help of the latest technology. The smart classroom concept was developed as a solution to improve the skills of future generations with the use of modern digital technologies (Mailewa et al., 2020). The format of the interactive learning

environment enables “smart learning” that is based on personalization and learning opportunities anytime, anywhere (Petchamé et al., 2021).

Thus, the concept of a smart classroom is based on the use of information and communication technologies to create an innovative teaching and learning environment (Huang et al., 2019). The unprecedented speed of information transfer due to digital solutions expands new educational opportunities for managing study groups. Therefore, technology-based learning offers innovative tools for collaboration, learning, and assessment (Makahinda, 2018).

Smart classrooms facilitate the creation of virtual campus learning environments based on different levels of interactivity to improve learning practices and implement an active learning model. Students are organized into small groups in such an environment to solve a specific problem or develop a group project. Smart classroom components create an interactive and engaging learning environment that enriches teaching methods, develops students' skills, improves their academic performance, and allows them to participate in the learning process further. The components of a smart class are an interactive whiteboard, class, and media management center; mobile devices; audio/video components; highly efficient software; a Learning Management System (LMS); available connection (Al-Hunaiyyan et al., 2017). Smart classrooms powered by dynamic learning data analysis and Cloud + End applications are characterized by essential features and innovative value in technology and learning applications. Group communication and knowledge sharing are easily implemented through smart mobile learning tools and application support platforms (Li, 2020).

The visual aspect of a smart classroom can bring a dynamic perspective to education that provides a clear insight into the subject of study by increasing student interest and engagement. A smart classroom helps teachers make learning more interesting, engaging, easy to understand, effective, and flexible (Phoong et al., 2019). An intelligent learning environment provides appropriate support (such as guidance, feedback, tips, or tools) in the right places and at the right time based on students' individual needs as determined by analyzing their learning behavior and performance. The goal of smart learning is to improve the quality of learning and student outcomes throughout the learning process (Hui et al., 2021).

Technology solutions for smart classrooms foster effective interaction between educators and students, using important channels to collect information about the student's status getting from mobile terminals. Intelligent technology helps teachers provide students with effective feedback. In addition, students have more opportunities to manage technology, especially during creative learning experiences (for example, finding resources, collaborating in groups, collaborating on assignments, conducting experiments in a virtual laboratory), which helps them gain specific learning experiences through direct participation (Zhan et al., 2021).

The purpose of this study is to explore the potential of mobile learning and Smart Classroom technology aimed at improving the level and quality of distance education. The main objectives of this technology are to increase the effectiveness of international partnerships and to create collaborative projects in areas of social and economic life.

The research aims to study mobile learning capabilities as a tool to implement the innovative educational concept of Smart Classroom. The following research objectives have been set:

- to reveal the conceptual basis of the smart learning environment (SLE) and to determine the functional parameters of the Smart Classroom concept;

- to theoretically substantiate Smart Classroom components: technologies, learning environment, processes;
- to organize an online discussion forum devoted to Engineering educational courses in the medical and pharmaceutical industry with the support of the Proficonf service;
- to survey graduate and undergraduate students at Moscow City University, Sechenov First Moscow State Medical University (Russia) and Gumilyov Eurasian National University (Kazakhstan) at the end of the discussion and determine the consumer demand of modern students concerning the Smart Classroom concept implementation in the learning process;
- to assess the dominance of technological solutions in the student community, conditions of the physical learning environment, and educational processes within the framework of the Smart Classroom concept;
- to outline the trajectory of the Smart Classroom concept in the context of digital transformation of the educational paradigm.

The article consists of the following sections: Introduction, Methods and Materials (Conceptual Framework of the Study, Study Design, Study Limitation), Results and Discussions, Conclusions, and References.

2. Methods and materials

2.1. Research design

In order to facilitate the high-quality exchange of knowledge and the development of international partnerships of students in terms of the creation of joint innovation projects in topical areas of the social and economic life of society, in January 2021, an online discussion forum Engineering of educational courses in the medical and pharmaceutical industry was held with the support of the Proficonf service (n.d.); it was attended by 200 graduate and undergraduate students of Moscow City University, Sechenov First Moscow State Medical University (Russia) and Gumilyov Eurasian National University (Kazakhstan) (Table 1). The discussion forum was related to developing innovative strategies for developing pharmaceutical personnel by introducing advanced technological tools and digital education models within the framework of the Smart Classroom concept. The Proficonf video conferencing system made it possible to organize five online meetings. During these meetings, each forum participant had an opportunity to present their innovative development, share views, describe personal experience of the interaction with digital education tools, take part in an open discussion and become a participant in the generation of relevant joint solutions to support educational processes in the field of pharmacy. The following topics shaped the online discussion:

1. The problem of the use of information and telecommunication technologies in pharmacist education.

2. Modern trends in the architecture of the digital education space.

3. Smart Classroom concept: strengths and weaknesses.

4. Mobile learning as a tool to implement the "smart class" environment.

5. Promotion of international cooperation in the medical and pharmaceutical industry through modern digital opportunities.

The students and teachers of the Center for Master's Programs of Sechenov First Moscow State Medical University initiated the online discussion forum. The forum was held in an open mode, and preliminary registration was required. Students participating in the online discussion forum specialized in Digital Space Architect, Virtual and Augmented Reality in Education, Information and Telecommunication Technologies in Education, Development of Digital Education Systems, Healthcare Management, Computer modeling in pharmacology, Visual and data mining in the analysis of medical and sociological information, Informatics, Smart City Technologies. Six teachers acted as moderators of the online discussion.

2.2. Sample

Table 1. Respondent group

Number of students	Training program	Institute/Faculty	University
24	Digital Space Architect	Digital Education Institute	Moscow City University
27	Virtual and Augmented Reality in Education		
21	Information and Telecommunication Technologies in Education		
32	Development of Digital Education Systems		
26	Healthcare Management	Organizations and Economics of Pharmacy Department	First Moscow State Medical University
25	Computer modeling in pharmacology		
14	Visual and data mining in the analysis of medical and sociological information		
17	Informatics	Faculty of Information Technologies	Gumilyov Eurasian National University
14	Smart City Technologies	Faculty of Information Technologies	
Total: 200 people			

At the end of the discussion forum, the students were asked to participate in an online survey to identify the consumer demand of modern students concerning the implementation of the Smart Classroom concept in higher education (Table 2). Students assessed the elements of the concept by priority within the framework of their ideas about the quality of the educational process, which was categorized into "Smart Technology," "Smart Environment," "Smart Learning Process." The priority ranking scale included three levels: low priority, medium priority, a high priority. The study participants gave their consent to their data processing and the publication of the survey results.

Table 2. Forum participants' questionnaire

Question: In your opinion, which of the elements of the Smart Classroom concept maximally support your understanding of Smart Learning? Rate the priority of each element on a 100-point scale

	Elements of the Smart Classroom concept	Priority (0-100 points)		
		Low (0-50)	Medium (50-80)	High (80-100)
1	Implementation of educational activities based on an online			

	educational platform
2	Use of digital and mobile devices in the educational process
3	Introduction of specialized software into the curriculum within the scope of vocational training
4	Learning in virtual labs that allow students to conduct complex experiments
5	Use of sensors to measure biological data and cognitive processes in students in the learning process
6	Use of digital tools for collaborative project management
7	Introduction of machine learning based on artificial intelligence
8	Use of mobile augmented and virtual reality applications in the practical activities of students.
9	Acoustics are adapted for premises where it is necessary to combine silence, debate, discussion, brainstorming, and presentations.
10	Smart oxygen level management system to conduct seminars and lectures
11	Energy consumption of efficient premises
12	High performance of the natural lighting system combined with artificial
13	Smart lighting adapted to different spaces and tasks.
14	Flexible furniture adapted to different types of student tasks and capable of working with mobile devices
15	Temperature control to ensure proper conditions for training
16	The space colors are adapted to the needs of students and the type of activity.
17	Up-to-date educational content that allows learners to develop applied professional competencies
18	Implementation of innovative pedagogical methods combined with the capabilities of technological tools
19	Students' cognitive processes monitoring in the learning process and creation of individual learning strategies and tactics
20	System of effective interaction of students of the study group aimed at achieving educational goals
21	A system of flexible and timely feedback and interactive communication of students with the course curators
22	Active training of students as part of the development of joint projects with the representatives of business, government, and the public
23	Opportunities for social learning, practical knowledge sharing, and generation of educational content on online social platforms
24	International cooperation of students forms the basis of the training course using mobile information resources and cloud services.
25	Efficient support for students' motivation in the implementation of educational activities

2.3. Tools and data collection process

The study was conducted through a survey among students who participated in online meetings aimed at promoting international cooperation in the medical and pharmaceutical industry through modern digital opportunities. The students filled out a special form that contained questions related to the implementation of educational activities, interaction opportunities, digital devices, and so on (see Table 2). The form with the questions was sent to the students' emails. Then they had to fill it out and send it to the researchers' email. The results of the survey were analyzed using SOFA software, which made it possible to systematize test results and create different types of graphs, without the help of simulation tables.

2.4. Ethical Issues

In order to participate in the experiment, all respondents signed an agreement to use the results of the survey in the study. All personal information obtained during the experiment is not to be disclosed.

2.5. Research limitations

The study is limited to the representation of the subjective attitude of students to the introduction of innovative approaches to educational activities that the concept of Smart Classroom is based on. In this regard, the assessment results are superficial. They reflect only consumer needs and expectations of modern students, which should be considered when designing a strategy for developing a smart learning environment ("smart campus") in the digital transformation of the educational paradigm.

3. Results and discussion

The study results made it possible to identify the dominant components of the Smart Classroom concept following the opinion of the educational product consumers – students (Table 3).

Table 3. Dominant components of the smart learning environment

No.	Components	Priority		
		Low priority	Medium priority	High priority
	Smart Technology			
1	Implementation of educational activities based on an online educational platform			✓
2	Use of digital and mobile devices in the educational process			✓
3	Introduction of specialized software into the curriculum within the scope of vocational training			✓
4	Learning in virtual labs that allow students to conduct complex experiments			✓
5	Use of sensors to measure biological data and cognitive processes in students in the learning process			✓
6	Use of digital tools for collaborative project management			✓
7	Introduction of machine learning based on artificial intelligence			✓
8	Use of mobile augmented and virtual reality applications in the practical activities of students.			✓
	Smart Environment			
1	Acoustics are adapted for premises where it is necessary to combine silence, debate, discussion, brainstorming, and		✓	

	presentations.		
2	Smart oxygen level management system to conduct seminars and lectures	✓	
3	Energy consumption of efficient premises	✓	
4	High performance of the natural lighting system combined with artificial	✓	
5	Smart lighting adapted to different spaces and tasks.	✓	
6	Flexible furniture adapted to different types of student tasks and capable of working with mobile devices		✓
7	Temperature control to ensure proper conditions for training	✓	
8	The space colors are adapted to the needs of students and the type of activity.	✓	
	Smart Learning Process		
1	Up-to-date educational content that allows learners to develop applied professional competencies		✓
2	Implementation of innovative pedagogical methods combined with the capabilities of technological tools		✓
3	Students' cognitive processes monitoring in the learning process and creation of individual learning strategies and tactics		✓
4	System of effective interaction of students of the study group aimed at achieving educational goals		✓
5	A system of flexible and timely feedback and interactive communication of students with the course curators		✓
6	Active training of students as part of the development of joint projects with the representatives of business, government, and the public		✓
7	Opportunities for social learning, practical knowledge sharing, and generation of educational content on online social platforms		✓
8	International cooperation of students forms the basis of the training course using mobile information resources and cloud services.		✓
9	Efficient support for students' motivation in the implementation of educational activities	✓	

According to most students, the smart learning environment consists of digital technologies introduced into the educational process and makes it possible to implement the Smart Classroom concept both in face-to-face and distance learning. Online learning platforms, mobile applications, virtual laboratories, virtual and augmented reality technologies, and specialized software open up new opportunities for the development of smart campuses with the dominant principles of flexibility, interactivity, mobility, openness, and comfort (Figure 2).

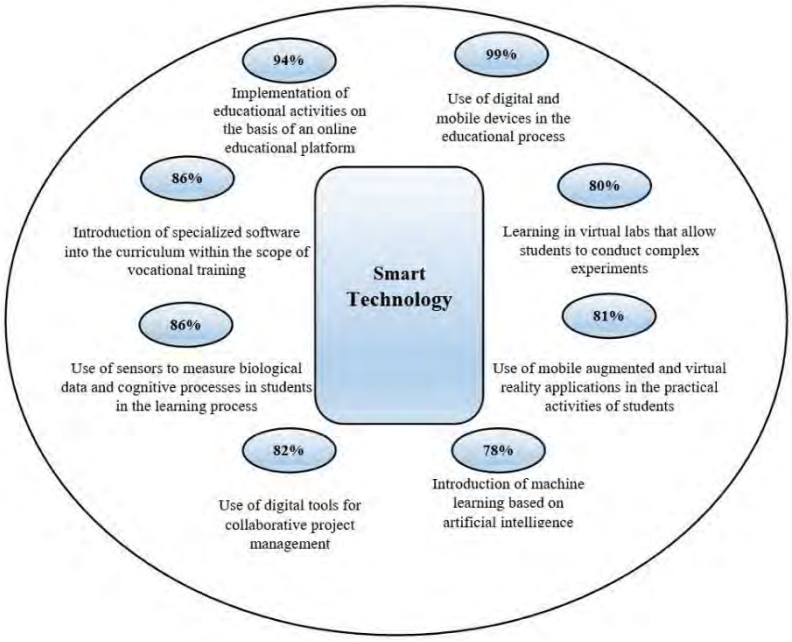

Figure 2. Assessment of the dominance of technological solutions in the Smart Technology category

*Own development

The smart classroom performs holistic functions thanks to modern digital technologies (interactive panels, tablets, phones, computers). Specially developed applications are installed on them. All participants in the process are united by a common platform, where the learning process and interaction between teachers and students are optimized. In other words, it is possible to describe the "Smart Class" as a system consisting of a single hardware-software complex.

The questionnaire results revealed a minor impact of innovative solutions in ensuring the comfort of the physical learning environment on the students' perception of the quality of the training course within the framework of the Smart Classroom paradigm. This indicates that the educational processes are rapidly advancing into the virtual world, and the student's expectations for educational activities are moving away from the physical dimension, which is losing its relevance (Figure 3). In addition, in the current development of socio-cultural and economic life, electronic interactions are increasingly prevalent, and creative and intellectual work is rapidly coming to the fore.

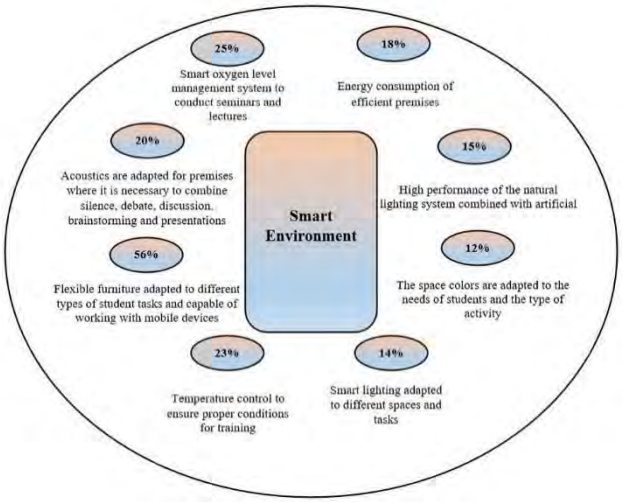

Figure 3. Assessment of the dominance of the physical learning environment conditions in the Smart Environment category

*Own development

Educational processes carried out within the framework of an innovative learning environment make it possible to create a high-quality development of professional competencies. According to most students, it is the practical learning activity in the virtual learning environment that strengthens the Smart Classroom concept and leads to individual and group educational goals (Figure 4).

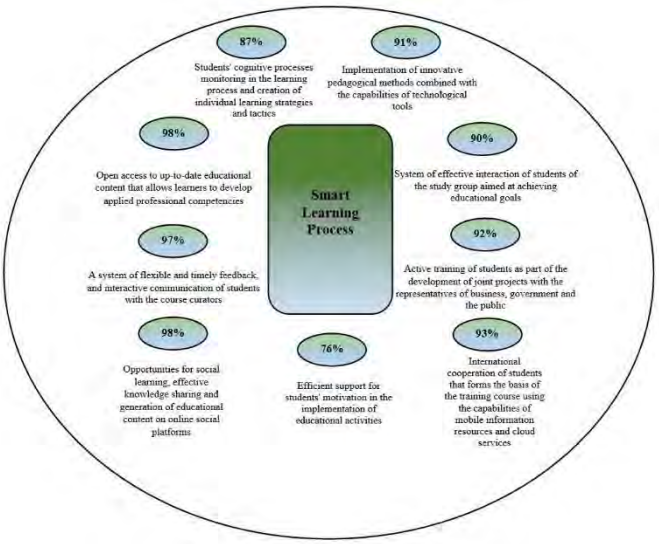

Figure 4. Assessment of the dominance of the ongoing educational processes in the Smart Learning Process category

*Own development

The global digital transformation of the socio-economic life of society has entailed qualitative changes in educational strategies. Distance mobile learning implemented through online learning platforms and services is a trend in the education system. Popular Learning Management Systems

(LMS) include Coursera, edX, Udemy, SkillShare, Kadenze, DataCamp, Canvas Network, ivercity, EduOpen, OpenLearn. As a new form of learning and a carrier of modern teaching methods, the intelligent learning environment opens new opportunities for education and teaching and realizes the sharing of learning resources (Hu, 2021) through the integration of computers, software, mobile applications, assistive devices, and audiovisual aids (Chiemeka & Ola, 2021).

A smart learning environment promotes mobile applications in educational activities that support the concept of Smart Classroom. For example, Smart Classroom, an interactive learning app developed by Hong Kong Telecommunications (HKT) Limited, allows learners to respond to teacher-assigned tasks anytime and anywhere through a wireless network. Students can record and share their innovative ideas on the platform and comment on them in real-time. The Learn Smart Classroom (Knowledge Platform Pte Ltd) mobile app offers a wide range of features, including customized training programs based on a built-in artificial intelligence technology; digital lesson plans for teachers and students; programs to increase student engagement and retain student focus; group chat to interact with students.

Smartphone applications are becoming more popular and widespread, playing an essential role in supporting education and medical training in particular (Jabali et al., 2019). In pharmaceutical personnel training, specialized mobile applications, which make educational practice more efficient and high-quality, are widely used. Mobile apps are used as a self-study tool during training courses. Popular mobile applications that optimize the effectiveness of educational practices include Pharmacology Exam & Board Prep, Pharmacology Exam & Board Prep, Case Files Pharmacology, Drugs Dictionary - Best Drugs & Medical Dictionary, Pocket Pharmacist, Nursing Drug Handbook, Learn Drug, Medical Dictionary, The BNF, Micromedex Free Drug Reference, SIGN Guidelines, Medscape, MD Calc, Patient Access, RightBreathe, etc. The use of smartphones for educational purposes is a more accessible resource than textbooks, and medical applications for smartphones are a helpful reference when looking for specific information about medicines (Pawluk & Eissa, 2018).

Healthcare professionals need up-to-date clinical information and support for point-of-care decision-making. Smartphones provide access to traditional medical textbooks, community guidelines, drug guides, and institution-specific therapy standards. Smartphones provide doctors with numerous benefits, including quick access to medical reference materials, research applications, and patient information. Although smartphones can improve both learning and ongoing patient care, it is recommended that the target application of digital technologies is outlined and their benefits in medical education are leveraged (Chaudhary et al., 2019).

Digital learning methods have a number of features that make learning quite effective. The functions of recording a video lesson, interacting with different teachers and students from different cities and countries, forming an interactive learning, visual examples, 3D models to help learning can be highlighted. An important factor is learning in a comfortable environment where there is no emotional pressure or the need to get up early for classes. Digital learning allows one to create a comfortable atmosphere for each student, class schedule and learning process that will help to make the process more effective and increase the competence of students in the process of self-organization.

Mobile learning offers excellent opportunities for enhancing collective learning by providing greater flexibility and personalization of learning while making it more student-centered. However, this type of learning is still being underestimated or not used effectively in curricula (Zidoun et al., 2019). The digital age seems ready for mobile learning both psychologically and in terms of knowledge and skills.

Educational institutions must structure their learning environment, training programs, and teaching and learning processes so that the educational practice meets the needs of the new generation, changing learning styles, and innovative technological solutions. The improvement of the compatibility of the learning environment and learning materials with mobile technologies, the introduction of mobile learning definitions in the curriculum, and the use of advanced technologies to update those definitions will be necessary steps to improve the effectiveness of mobile learning (Talan, 2020).

Educational institutions have already started to actively implement technologies in teaching mainly to ensure communication between teachers and students and unify processes and exchange data (Ryabov et al., 2019). Digital technologies facilitate new educational practices and contribute to more realistic and relevant training through participation outside the physical learning space. With the help of innovative technological tools, it is possible to achieve increased interest in the educational course, improved interaction with learning materials, more effective assimilation, and perception of knowledge. In this regard, virtual reality and augmented reality (triggered by digital games and simulations) can play a significant role. Technology equipment can be effectively used to present, visualize, and use learning materials and learn through games and check the acquisition of knowledge and skills (Savov et al., 2019).

In developing the process of digital learning, which has occurred at an accelerated pace because of the current world situation, it is necessary to develop a system that will provide enough opportunities to learn information, to know and understand the basics of the subject, and to apply the information obtained. Developing the right psycho-pedagogical system of teacher-student interaction should be a priority in the development of a digital learning scheme. There is a problem with the formation of an effective digital learning program and therefore it is important to consider the perspectives of this kind of education. Computer-based learning has many paths to follow, which will coincide with improvements in the quality and availability of technology. Just as phones became more prevalent, so now augmented reality technology will spread and make learning more effective by combining the advantages of classical and digital learning.

There is great potential to improve learning and teaching at universities worldwide using various pedagogical tools and methods that support personalized and adaptive learning (Ryabov et al., 2020). A smart learning environment considers the context of the modern world and places students in scenarios simulating real professional activities (Vesin et al., 2018). Learning is a project-based activity that can be seen as the intellectual center of the teaching and learning cycle supported by processes and tools. A learning situation (also known as a pedagogical situation) is a set of conditions and circumstances that can help a person accumulate knowledge. The design of a pedagogical situation involves expressing the need in a disciplinary context and setting goals and objectives that students must achieve (Oubahssi et al., 2018).

Smart classroom design requires a dramatic rethinking of classroom activities, the system of interaction between the teacher and students, and the role of physical space in the educational process. To ensure that these measures are appropriately interpreted and implemented and, most importantly, that they consider the real needs of modern students, the teacher must be involved in the creation of a smart learning environment in the context of a separate training course (Tissenbaum & Slotta, 2019) as the role and position of the teacher increase student motivation and involvement, as well as the efficiency of educational processes. Thanks to developing a smart learning environment, a pedagogical approach based on collaborative learning is being implemented. The fusion of

interactive multimedia, ubiquitous computing, and portable devices will undoubtedly lead to a more efficient and active learning process (Bdiwi et al., 2019).

Compared to classical teaching methods, which require the full presence of the teacher and the student in the classroom, during instruction, the Smart Classroom allows one to share knowledge at any time from any location. This is especially positive during a pandemic. In contrast to the possibility of interacting with students and teachers from different cities and countries, the problem of sufficient technical support is evident in online learning. There are poor quality of the Internet, inability to connect to the program, poor technical support or poor knowledge of how to work with new technologies, etc. All of this can have an impact on the ability to interact through Smart Classroom. While digital interaction provides many opportunities for communication, it also reduces it. It becomes more difficult for students to communicate with each other and develop social skills when communication only takes place via text message or webcam.

Digital tools can facilitate a more reliable and faster interaction between the participants in education when coherently integrated to support effective learning. The introduction of a smart learning system can improve student's ability to achieve a set of required competencies. A smart learning environment provides the most effective communication, interaction, support, and learning (Dron, 2018).

Broadly, smart classrooms help teachers and learners move beyond the traditional way of teaching and learning. Therefore, educators should be aware of the smart classroom learning environment, systematically change their teaching styles and develop appropriate teaching and learning content. Otherwise, there will be difficulties in adapting to the new culture of educational technologies (Kugamoorthy, 2019). Effective implementation of smart classrooms also depends on the pedagogical skills and digital competencies of teachers. Thus, teacher training programs aimed at the correct use of the smart classroom capabilities and the development of digital competencies in teachers are critical to implementing the Smart Classroom concept (Cebrián et al., 2020). Educational tools' technology, pedagogy, and usability should be appropriately distributed (Mahesh et al., 2016).

In implementing mobile applications into educational practice, special attention should be paid to their design and content so that the many benefits of smart mobile devices are translated into productive learning. In this context, researchers, educators, mobile developers, and designers must ensure that learning applications have a solid theoretical foundation and high-quality standards to promote 21st-century skills development (Kalogiannakis & Papadakis, 2017; Papadakis, 2021) effectively.

4. Conclusion

The study has identified the dominant components of the Smart Classroom concept to generate a high-quality educational offer for the modern digital generation of students. Graduate and undergraduate students at Moscow City University, Sechenov First Moscow State Medical University (Russia) and Gumilyov Eurasian National University (Kazakhstan) took part in the online survey. They assessed the Smart Classroom elements by priority within the framework of their personal ideas about the quality of the educational process.

According to the survey participants, the structure of the concept of Smart Classroom is shaped by the use of digital and mobile devices in the educational process (99%); implementation of educational activities based on an online educational platform (94%); use of sensors to measure biological data and cognitive processes in students in the learning process (86%); introduction of specialized software

into the curriculum within the scope of vocational training (86%); use of digital tools for collaborative project management (82%) and mobile applications of augmented and virtual reality in the practical activities of students (81%); introduction of machine learning based on artificial intelligence (78%).

Students' practical activities during the training course allow implementing the concept of Smart Classroom, ensuring a synergy of technological and pedagogical tools. According to the students, educational processes within the smart learning environment involve open access to up-to-date educational content that allows learners to develop applied professional competencies (98%); implementation of innovative pedagogical methods combined with the capabilities of technological tools (91%);students' cognitive processes in the learning process and creation of individual learning strategies and tactics (87%); system of effective interaction of students of the study group aimed at achieving educational goals (90%); a system of flexible and timely feedback, and interactive communication of students with the curators of the course (97%); active training of students as part of the development of joint projects with the representatives of business, government and the public (92%); social learning, adequate knowledge sharing and learning content generation on online social platforms (98%); international cooperation of students embedded in the concept of the training course using the capabilities of mobile information resources and cloud services (93%); efficient support for students' motivation in the implementation of educational activities.

As the current conditions of socio-cultural and economic life have a severe impact on the development of electronic interactions, which bring creative and intellectual work to the fore, a modern student does not find the comfort of the physical learning environment to be an essential component of a high-quality educational process. Only 28% of students confirmed the importance of a smart learning environment in the structure of the Smart Classroom concept.

The study results indicate that a smart educational activity is rapidly moving towards mobility, openness, accessibility, flexibility, and contact while going beyond the classroom. Mobile learning in the field of the pharmaceutical industry is a priority for modern students. In addition, online educational platforms and services provide all opportunities necessary for introducing the Smart Classroom concept into teaching practice with minimal investment in the university infrastructure development.

The study results allow outlining the directions for implementing the "Smart Classroom" concept both at the stages of modernization of teaching methods and forming international educational relationships.

The proposed method for assessing consumer demand of modern students concerning the implementation of the concept of "Smart Classroom" in the practice of university education can be helpful for developers of educational courses at the stages of the conceptual design of the structure of "smart learning," which determines the practical value of the article for the scientific community.

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