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Technological innovations of educational. Innovations of smart university type

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ABSTRACT. A tecnologia é uma das direções importantes no desenvolvimento da sociedade do futuro, pois afeta o sistema de ensino superior como um todo, e está inserida no conceito de 'S.M.A.R.T', que se baseia em organizações educacionais do tipo Smart University. O objetivo do estudo apresentado no artigo foi analisar o uso das inovações tecnológicas em diversas áreas de atuação das organizações educacionais do tipo Universidade Inteligente, seu impacto no setor educacional como um todo. Neste artigo, o conceito de 'Universidade Inteligente' é analisado sob vários pontos de vista científicos. Além disso, é apresentada uma classificação das inovações tecnológicas utilizadas nas principais áreas de atuação das universidades em termos de análise de tecnologias de informação e comunicação e equipamentos/materiais tecnológicos. Foi realizada uma análise comparativa da utilização dos meios tecnológicos em termos de troca de informações, comunicação e apetrechamento dos sistemas de segurança das organizações educativas estudadas. Diferenças na inovação tecnológica usada pelas principais universidades do mundo: Escola Politécnica de Lausanne (EPFL) na Suíça, Instituto de Tecnologia de Massachusetts (MIT) nos EUA, Universidade de Aalborg (AAU) na Dinamarca, Universidade da Cidade de Hong Kong (CityU) na China , Central Queensland University (CQU) na Austrália e a Hamdan Bin Mohammed Smart University (HBMSU) nos Emirados Árabes Unidos. Dependendo da quantidade de recursos e capacidades de cada uma das universidades, bem como considerando a legislação dos países, das universidades estudadas que tentam introduzir o conceito de "Smart University" em suas atividades não conseguem utilizá-lo plenamente. Os materiais deste artigo podem ser usados para um estudo mais aprofundado do conceito de Smart University relacionado à introdução de inovações tecnológicas em organizações educacionais do mundo. Sua implementação atende às necessidades de alunos e funcionários em um mundo em rápida mudança. É claro que tal conceito é um dos fatores que afetam a saída gradual do contingente das principais universidades do mundo no mercado educacional global, por isso é importante a constante atualização dos serviços educacionais com as novas tecnologias.

Keywords: análise comparativa; mercado educacional global; Escola Politécnica; universidade inteligente; escoamento gradual; tecnologia da comunicação de informação (TIC); gestão inteligente.

Inovações tecnológicas da educação. Inovações do tipo universidade inteligente

RESUMO. Technology is one of the important directions in the development of the society of the future, as it affects the higher education system as a whole, and is embedded in the concept of 'S.M.A.R.T', which is based on educational organizations of Smart University type. The purpose of the study presented in the article was to analyze the use of technological innovations in various areas of activity of educational organizations of Smart University type, their impact on the education sector as a whole. In this article, the concept of 'Smart University' is analyzed from various scientific points of view. In addition, a classification of technological innovations used in the main areas of activity of universities is presented in terms of the analysis of information and communication technologies and technological equipment/materials. A comparative analysis of the use of technological means in terms of information exchange, communication and equipping the security systems of the studied educational organizations has been carried out. Differences in technological innovation used by the world's leading universities: Polytechnic School of Lausanne (EPFL) in Switzerland, Massachusetts Institute of Technology (MIT) in the USA, Aalborg University (AAU) in Denmark, City University of Hong Kong (CityU) in China, Central Queensland University (CQU) in Australia and the Hamdan Bin Mohammed Smart University (HBMSU) in the UAE are identified. Depending on the amount of resources and capabilities of each of the universities, as well as considering the legislation of the countries, the studied universities trying to introduce the concept of "Smart University" into their activities cannot fully use it. The materials of this article can be used for further study of the Smart University concept related to the introduction of technological innovations in

educational organizations of the world. Its implementation meets the needs of students and staff in a rapidly changing world. Of course, such a concept is one of the factors affecting the gradual outflow of the contingent from the world's leading universities in the global educational market, so the constant updating of educational services with new technologies is important.

Palavras-chave: comparative analysis; global educational market; Polytechnic School; smart university; gradual outflow; information communication technology (ICT); smart management.

Innovaciones tecnológicas de educación. Innovaciones tipo universidad inteligente

RESUMEN. La tecnología es una de las direcciones importantes en el desarrollo de la sociedad del futuro, ya que afecta al sistema de educación superior en su conjunto y está incrustada en el concepto de 'S.M.A.R.T', que se basa en organizaciones educativas de tipo Smart University. El objetivo del estudio presentado en el artículo fue analizar el uso de las innovaciones tecnológicas en diversas áreas de actividad de las organizaciones educativas de tipo Smart University, su impacto en el sector educativo en su conjunto. En este artículo se analiza el concepto de 'Universidad Inteligente' desde varios puntos de vista científicos. Además, se presenta una clasificación de las innovaciones tecnológicas utilizadas en las principales áreas de actividad de las universidades en cuanto al análisis de las tecnologías de la información y la comunicación y los equipos/materiales tecnológicos. Se ha realizado un análisis comparativo del uso de los medios tecnológicos en cuanto al intercambio de información, comunicación y equipamiento de los sistemas de seguridad de las organizaciones educativas estudiadas. Diferencias en la innovación tecnológica utilizada por las principales universidades del mundo: Escuela Politécnica de Lausana (EPFL) en Suiza, Instituto Tecnológico de Massachusetts (MIT) en EE. UU., Universidad de Aalborg (AAU) en Dinamarca, Universidad de la Ciudad de Hong Kong (CityU) en China , la Universidad Central de Queensland (CQU) en Australia y la Universidad Inteligente Hamdan Bin Mohammed (HBMSU) en los Emiratos Árabes Unidos. Dependiendo de la cantidad de recursos y capacidades de cada una de las universidades, además de considerar la legislación de los países, las universidades estudiadas que intentan introducir el concepto de "Universidad Inteligente" en sus actividades no pueden utilizarlo en su totalidad. Los materiales de este artículo se pueden utilizar para un estudio más profundo del concepto de Universidad Inteligente relacionado con la introducción de innovaciones tecnológicas en las organizaciones educativas del mundo. Su implementación satisface las necesidades de los estudiantes y el personal en un mundo que cambia rápidamente. Por supuesto, tal concepto es uno de los factores que afectan la salida gradual del contingente de las principales universidades del mundo en el mercado educativo global, por lo que es importante la actualización constante de los servicios educativos con nuevas tecnologías.

Palabras clave: análisis comparativo; mercado educativo mundial; Escuela Politécnica; universidad inteligente; salida gradual; tecnología de la información y las comunicaciones (TIC); gestión inteligente.

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Introduction

The relevance of the research topic is due to the fact that the use of information technology continues to grow in the world. For example, in 2019, 4.1 billion people used the Internet - this is 53.6% of the world's population, and in 2021 it became 63% (International Telecommunication Union [ITU], 2021, Retrieved from https://www.itu.int/en/Pages/default.aspx). Currently, information technology is one of the most important driving forces for the development of the future society. They are changing the world, society, and, in particular, higher education in general. The S.M.A.R.T concept is the basis of the Smart University concept, reflecting the use of technological innovations in educational organization.

Today, there are two transcripts of the abbreviation 'SMART'. The first version was proposed by the American George Doran in 1981 and is used in the field of management and marketing to achieve goals in various projects (Selvik, Bansal, & Abrahamsen, 2021). The second version, used in technology, was proposed by IBM in 1992 to describe the characteristics of computer hard drives.

The first definition of Smart University arose from the concept of Smart City, because any university can be both part of the infrastructure of the city, and the university itself can create its own small city ('college town' or 'university campus'). According to urbanists, Smart University is a concept of integrating technological innovations and the Internet aimed at improving the level of quality, comfort and efficiency of servicing the activities of educational organization (Nuzzaci, & Vecchia, 2012). According to the authors, it

is a frame of reference that indicates the presence of technological innovation and the Internet at the university, where students, teachers, staff, and even applicants feel comfortable when they are on its territory. Of course, a complete sense of comfort cannot be achieved, because everyone has a different attitude towards it, so you can only increase its level, which is the Smart City concept for urbanists. To increase the level of comfort in the university, other technological infrastructures of the city are also used, which provide access to transport, shops, banks, leisure, etc.

Educational organizations such as Smart University carry out pedagogical activities based on technology so that students have deep knowledge and can solve the problems of the future society, because technology is changing rapidly and cannot be separated from the development of society. It is noted that the concept of 'SMART' moves away from traditional teaching methods and moves to modern ones.

As a Russian definition of Smart University, it is noted that this is a university in which the combination of the use of technological innovations and the Internet by trained people leads to a new quality of processes and results of the educational, research, social, commercial and other activities of the university. It talks about the large-scale use of technological innovations and the Internet at the university (Kaptur, 2015). This definition emphasizes that a university of this type provides high-quality educational and extracurricular processes. It is important to note that the faculty and administrative staff at this university are already trained in the use of technology, so they are quicker to adopt the implementation of various types of technological innovations. Not only they, but also students are able to work with IT equipment and technologies.

All of the above definitions relate to technological innovations and their role in the activities of an educational organization. While studying the history of the creation of the definitions of the concept of Smart University, we can conclude that this concept arises only after the appearance of the concept of Smart City, that is, a little earlier than 2010. The structure of the "Smart" concept under consideration includes such concepts as 'smart education', 'smart scientific research', 'smart management', 'smart influence', 'smart student', 'smart teacher', 'smart campus' and 'smart audience' (Smart University Foundation, 2012, Retrieved from https://www.apollo.io/companies/Smart-University-Foundation--S-U-F/5da62cee3c928b0001305882?chart=count).

Material and methods

In order to analyze and practice the use of technological innovations in educational organizations of Smart university type, we define technological innovations in the following educational organizations of Smart University type (Table 1). The purpose of the study is to analyze the use of technological innovations in various areas of activity of educational organizations of Smart University type, their impact on the education sector as a whole. The tasks include analysis and experience in the use of technological innovations in various areas of the university. Thus, the methods are substantiated by theoretical and comparative analysis.

Table 1. Educational organizations of Smart University type compiled by the authors.

No.	University of Smart University type	Abbreviation	Country	Country ranking by innovation (2021)
1.	Swiss Federal Institute of Technology of Lausanne	EPFL	Switzerland	1
2.	Massachusetts Institute of Technology	MIT	USA	3
3.	Aalborg University	AAU	Denmark	9
4.	City University of Hong Kong	CityU	China	14
5.	University of Queensland	CQU	Australia	25
6.	Hamdan Bin Mohammed Smart University	HBMSU	UAE	33

The universities under consideration occupy high positions in the innovation rankings 'Great value colleges' and 'QS' in 2021. In addition, they are located in the leading countries of the world on the introduction of innovation according to the global innovation indices (Global Innovation Index [GII], 2021).

For the study of six universities, the abbreviation of the name has an important place in their activities. When the university begins to promote its abbreviated name, even then the process of digitalization of the university begins. In order to promote the name of its brand represented by the classification of technological innovations in the links of official websites of higher education institutions the abbreviated name is used: 'https://ww.epfl.ch/en', 'https://ww.en.aad'; 'https:/www.ed', 'httpa.w.w.w.h.h.t.h.h' 'https://wwww.cityu.edu.hk', and 'https://web.mit.edu' (Argenti & Druckenmiller, 2004).

Results

Let us consider in more detail the most important technological innovations in educational organizations such of 'Smart University' type, which are software of the document management system, which all the studied universities use in their activities: 'VPSI' (EPFL), 'EMC Documentum' (CityU) and CAPTIA (AAU). The software used in universities provides electronic document management in all departments and structures of the university. The graphic text code, barcodes and QR codes are affixed to the administrative documents of universities, for example, orders, announcements and memos. Encoding makes it possible to read information from paper media. With the help of code scanner devices, the detailed information of the document and its source are quickly recognized, sometimes the signature of the manual is not on paper documents. The code is generated by an online generator that produces numerous different graphics (Petrova, Romanello, Medlin, & Vannoy, 2016).

The use of such programs leads to the automation of control systems, reducing paper costs and speeding up the transfer of information. The software also allows to improve the efficiency of processes in the control system. For the operation of such special software, the Internet is used using a cable system and an IP address, depending on the distance between departments and the scale of the university itself, taking into account protection from external threats (Korzhuk, Popov, & Vorobeva, 2019).

For example, at the EPFL Polytechnic School in Switzerland, an access control system using the GASPAR software is used - this is an entrance by biometric identification of hands and synchronization of entry into the account of staff and students based on Tequilla Shibboleth systems. More than 150 IT specialists work at the AAU University and the EPFL Polytechnic School to ensure and support the management process. In addition, HBMSU University uses Interact Office software, which is provided by the Dutch company Philips. The program allows to manage the building as a whole and save up to 50% on electricity, that is, the lighting, heating, ventilation and air conditioning control systems are automated (Wahid, Ismail, Ghazali, & Aamir, 2019). The program can be operated via the staff's mobile phone and is controlled by motion detectors.

Let us consider the studied universities that have Internet resources for staff and faculty. There are two types of resources: website and mobile app. The website operates a staff portal that provides personal information and employee portfolios. European universities are expanding their information portals for other universities: 'IS-academia' (EPFL) is available for universities located in Lausanne; IRIS (AAU) is available to partner universities around the world. Most universities use the SharePoint mobile application created by Microsoft. AAU University uses Mindmanager for scheduling and network planning at work. The MIT Institute and CityU University in China use the 'Canvas' platform. For digital HR solutions, MIT Atlas allows employees to keep track of pay slips at all times. These applications are attractive for free-mode feedback optimization and allow management of administrative information for collaboration with a user-friendly interface (Shi & Bai, 2011). Therefore, for the digitalization process, an innovation service is available in the management structure of each of the studied universities.

In order to improve communication in their work, all universities use the Microsoft Outlook 365 application, which is designed for corporate e-mail, for staff, students and teachers. The standard package includes other applications such as office programs ('Word', 'PowerPoint', 'Excel'), 'SharePoint', 'Microsoft Teams', cloud storage ('One drive'), 'Project', Calendar, 'One Note', etc. This application is licensed and automatically activated using a personal account. Despite the fact that all the universities studied are licensed to use the Microsoft office 365 software package, they also have programs to provide video communications, for example, Cisco Webex, which is most in demand in EPFL in Switzerland, is used. AAU, CQU and CityU use Zoom for classes and conferences. HBMSU and the MIT Institute remain committed to using Microsoft Teams. All these information and communication technologies allow remote meetings or meetings to discuss work tasks (Amin & Sundari, 2020).

There is also high-tech equipment for a videoconferencing system that connects groups of people remotely by posting information on large screens, such as the CoViz system. Of course, universities can use other communication platforms such as Skype and True Conf, their choice of use depends on the meeting participants. In addition, higher education institutions use IP Office Phone and Digital Solutions (CQU) for office phones. An IP office phone is a type of phone with a modern design that works through local area network. That is, the connection is carried out without a wire, unlike an office phone.

The use of servers that store and protect large databases is among the technological innovations in the management system of educational organizations such of Smart University type. Servers ensure the

continuous functioning of the network system for connecting to office computers and other devices that belong to the university management system. All of the universities surveyed have servers that provide control and management of access to devices and ICT, including the website and applications. With the help of servers, the university automates the maintenance of the security system, observing codifications and network protocols. These universities have powerful server rooms, where there is equipment with software servers. Thus, several types of servers are used in the studied universities, including Microsoft Servers. Most of them store and manage their data on 'VMware' type servers - these are EPFL, AAU, CityU and MIT. The VMware-type server combines several servers on one machine using a virtualization system, so universities prefer such a server in order to reduce the number of machines used in server rooms. CQU and HBMSU universities use a 'Microsoft SQL' type server that is capable of compressing data online. In addition, the main EPFL server is a 'NAS' type server. For CityU University, Sun Solaris and Intel Windows servers are used. Of course, the server protects against external information threats and provides a data management tracking and monitoring system (Tariq & Agarwal, 2020).

The studied universities of 'Smart University' type actively use information and communication technologies (ICT) in their educational activities as well as in the university management system. Communication platforms are programs such as Outlook 365 for email; Microsoft Teams, Zoom, and Cisco Webex for video calling. But AAU University still uses the Adobe Connect platform, which is more feature-rich than others, such as the ability to conduct electronic tests. The use of video and information and communication technologies allows teachers to conduct distance learning (seminars, lectures) if necessary. The main advantage is that the platforms are interactive learning, taking into account the demonstration and animation of presentations on device screens. That is, it is possible to conduct a lecture with a large number of students in a remote format (Daniela, 2019). In addition, students can watch the recordings of lectures in case of missing classes. These apps are available on mobile devices of the participants' choice.

For the educational information system, EPFL, AAU, CQU and HBMSU use the 'Moodle' platform; others prefer 'Canvas'. These systems are publicly available both on the web and through applications. The Moodle platform was launched in 2002 with the aim of digitalizing the learning management system. It provides a flexible interface with the ability to customize layouts and page designs. These platforms have many online educational and communication tools that allow interaction between teachers, students and the university. Teachers post educational materials in accordance with the curricula using the above platforms. Their application improves the professional competence of teachers in the field of e-learning (Hu, Zhao, & Zhao, 2020).

In addition, there is a single network portal for students, which hosts educational materials and monitors the status of students at the university, including information about students and their progress. The portal also performs an information and communication function for electronic services that students need in the learning process.

CQU University and the MIT Institute use platforms with their own abbreviated name. The AAU University in Denmark provides two portals for higher education levels (undergraduate and graduate) for educational activities.

For the Polytechnic School EPFL, 'IS-Academy' is a single platform for all universities in the city of Lausanne (Switzerland). Access to the platforms is carried out using a single student account, synchronized with other systems. It should be noted that the universities of 'Smart University' type mainly use the following information and communication platforms in the educational process:

- international platforms ('Moodle' and 'Canvas');
- unified platforms ('IS-Academy');
- unified (own) platforms ('MyCQU', 'Smarter Information Systems' (HBMSU), 'AIMS' (CityU), 'MyMIT');
- platforms by levels of study (portal for bachelor's and master's degrees).

With the development of ICT, all studied higher educational institutions of 'Smart University' type use electronic libraries in the educational process as the main sources of literature storage. Digital libraries contain books, scientific articles, journals and other scientific publications. They allow students to speed up and simplify the search for scientific literature.

The EPFL Polytechnic School has over 100 million items in its electronic library. It cooperates with more than 470 Swiss libraries. The CQU University achieves 33 million electronic storage units. The smallest number of units is stored at the HBMSU University and is 108 thousand units. The reading rooms of these universities are equipped with special library platform computers supporting Dolphin Supernova and HIMS Braille Sense Plus software for visually impaired students.

For educational software, all studied universities use Microsoft office 365 office programs since they all have a license to use it, but, for example, the EPFL Polytechnic School prefers to use the LibreOffice program in the public domain. NVivo software is used by AAU and HBMSU Universities. The most demanded software in teaching in the field of engineering and computer science are 'Matlab & Simulink' and 'Mathematica' and 'Maple' (Table 2). These programs process digital data for programming, the scope of which is mainly related to applied sciences. The use of various software with constant updating of teaching methods is considered important for educational organizations such of Smart University type (Zahda & Natsheh, 2018).

Table 2. Basic educational software (licensed) in educational organizations such of Smart University type compiled by the authors.

University	EPFL	AAU	CQU	HBMSU	CityU	MIT
Software	Matlab& Simulink, Mathematica, Maple, ESRI GIS, LabVIEW, ANSYS	Matlab& Simulink, Maple, ESRI GIS, DMP SAS, SPSS, STATA, SURVEYXACT, Coulor Box, Latex	Matlab& Simulink, Adobe Creative Cloud, Adobe Reader	Matlab& Simulink	MathWorks TAH (Matlab&Simulink), SAS, SPSS + 88 Software	Matlab& Simulink, Mathematica, Maple, Athena Software, LabVIEW, SPSS, SAS, JMPWolfram|Alpha Pro, Project, Visio, think-cell

The use of educational software is regulated in accordance with the specialties in universities. For example, the LabVIEW program is used in EPFL and MIT technical universities. European universities provide training in the ESRI GIS program, designed for geographic information systems. In addition to the 'Matlab & Simulink' program, CityU University also uses 88 educational software from 'MathWorks TAH', including 'Robotics System Toolbox' and 'Fixed-Point Designer' (MathWorks TAH License, 2021, Retrieved from https://www.cityu.edu.hk/csc/deptweb/facilities/central-sw-tah.htm). The use of such software is required by computers with a high processor, for example, AAU University recommends that its students use a computer with a minimum of 16 GB of RAM (AAU IT Services, 2021, Retrieved from https://www.en.its.aau.dk/instructions/Recommendations+for+your+new+computer/).

For example, the EPFL Polytechnic School uses applications in mobile version. These applications are used to quickly test students' knowledge according to the result report. Mobile applications 'EPFL Survival' and 'Exercices Mecanique EPFL' are available on mobile devices for the convenience of students when conducting tests with an automated report of the results. In addition, all universities studied use the anti-plagiarism system to check the knowledge and uniqueness of students' scientific work. Most university professors check their written work through the 'iThenticate' system provided by the IT Company 'Turnitin', which was launched in 2004 and finds more than 70 billion scientific websites worldwide.

The AAU University prefers to use the 'Urkund' system, which finds more than 10 billion different sources of electronic literature on the web. This university from Denmark requires special cameras to be installed next to the screens of students' computers and downloading the Arcanic ITX Flex software for conducting control tests and exams in a remote format. The MIT Institute checks the uniqueness of students' scientific texts using the Safe Assign anti-plagiarism system.

Each student of the above universities has access to massive open online courses (hereinafter referred to as MOOCs), which are open access distance education, where various educational courses are provided in each specialty and new educational programs that contain short lecture forms are found. MOOCs are a kind of digital platform to support individual educational trajectories. They strengthen the position of the university as a center of global higher education. Students in educational institutions of Smart University type receive skills with opportunities to study additional courses from teachers around the world (Babaeva, 2019).

These unique courses aim to develop innovative and entrepreneurial skills. The MOOC platform allows students to stay relevant in a rapidly changing world (Dziuban, Graham, Moskal, Norberg, & Sicilia, 2018). The benefits associated with online learning are varied and enormous across all disciplines as lectures are delivered by faculty and experts from world or national leading universities, organizations including institutions such as the MIT Institute, Harvard University, and companies such as IBM, Microsoft, Google.

European universities EPFL and AAU offer their students to study courses on the Edx platform, which consists of 3 thousand courses. In addition, the EPFL High School recommends that its students listen to lectures on the Coursera platform with a choice of more than 3.8 thousand courses in various fields, provided to teachers from 200 universities and companies. The MIT Institute and HBMSU University use their own 'MIT OpenCourseWare' and 'Cloud Campus' platforms with a small number of courses, only 31 courses in Arabic.

Currently, CityU University of Hong Kong is expanding its learning across 3 platforms, which consist of 2 Chinese platforms: 'XuetangX', 'CNMOOC' (containing 750 courses) and one English 'FutureLearn', which was launched in 2013.

The educational platform 'TAFE' is one of the most popular MOOCs in Australia, which it was transformed into in 2016 and united 130 universities around the world (100 of which are from Australia).

Of course, Smart Universities use different platforms depending on the languages and courses. It should be noted that the launch of their own educational platform and the participation of their teachers in MOOCs will be an important stage in the development of universities of this type. In order to be able to provide all existing courses, CityU and EPFL universities use several platforms.

The presence of high-tech equipment is a feature of educational organizations of 'Smart University' type. The use of audiovisual and interactive equipment in conference rooms and classrooms promotes the participation and involvement of students in the learning process. Multimedia equipment facilitates communication between students and teachers in full-time education. Technological hardware integration supports pedagogical tools to speed up and enhance interactive courses.

Most of the conference halls and classrooms of the studied universities of 'Smart University' type are equipped with modern audiovisual technologies, including electronic boards, projectors, touch screens, cameras and microphones with the ability to connect to Wi-Fi or Bluetooth wireless network. Column boards are used in the halls of EPFL and MIT universities and are customized using information technology. The instructor's seat is provided with a device such as a work computer, 'LCD' and DVD player. In addition, the halls and auditoriums are structured with special modern design and quality materials to attract students and teachers. CityU University and EPFL Polytechnic School have a multifunctional study hall. That is, the stand, table and chairs are arranged according to a certain type of event with the help of technology. All of the universities studied have a dedicated multi-person video conference room equipped with an audiovisual system (Lorenzo, Gallon, Palau, & Morgas, 2021).

In research activities, technological tools are used that allow to accurately and safely determine underground, ground and space objects. The use of high-tech tools in research centers enhances the acquisition of research skills and helps to critically examine the problem under study.

For example, the EPFL Polytechnic School has more than 350 research centers, there are centers even outside the country. The MIT Institute in the USA has more than 60 centers. In the two above-mentioned universities for the study of the atomic nucleus and the operation of the electricity of the university itself, there is a nuclear reactor: MIT 'MITR-II' and EPFL 'CROCUS'. In addition, EPFL has a 'CARROUSEL' water tank for neutron research.

European universities also have renewable energy sources: solar (EPFL) and wind (AAU) for research in these areas. In this way, they are advancing towards the independent production of electricity and towards the preservation of the environment. All studied universities have the latest innovations in robotics, interactive touch devices, medical sensors, a 3D printer, as well as JEOL NEOARM electron microscopes and drones. In addition, the EPFL Polytechnic School has underwater drones and an astronomical telescope to observe marine and space species; in addition, it owns a '3D Mapping' drone to automate the mapping of objects as at the MIT Institute.

For example, the University of Hong Kong's CityU Science Center has '4D' printer that creates a 4-dimensional pottery format (Special 'ink'). Laser, milling and drilling machines are also used in the research centers of CQU and HBMSU Universities. Danish and American universities have different types of cameras for making videos. In addition, EPFL and CityU universities use voice, taking into account the use of various microphones. In addition, CityU uses over 40 technological research tools, including the Bruker In-Vivo Xtreme Live Animal Imaging System, D2 Phaser XRD Defractometer, LONZA 4D Nucleofector Cell Transfection and Optical Tweezer Control.

The EPFL Polytechnic School has a lot of high-tech equipment, more than 30 tools, including CNC CTX1250 turning and a welding and soldering station. At the same time, it applies material processing technology in scientific work, and CityU University uses nanowires in scientific research. The American Institute of MIT has more than 20 state-of-the-art research instruments available, including a rotary ball mill, differential scanning calorimeters, LECO microhardness testers, an ADE vibrating sample magnetometer, and a nanoindenter. Of course, the use of such tools in the research activities of educational organizations of 'Smart University' type attracts scientists to conduct research. On the territory of EPFL and MIT there is a technology park where robots and innovative devices of universities are presented.

Various software such as Rhino Ceros, SolidWorks for the 3D printer and Autodesk Navisworks 4D for the 4D printer are used to obtain scientific research results. In addition, the EPFL Polytechnic School uses software specialized in scientific research, such as: MIT, BSD, Apache 2.0, GPL, LGPL and AGPL.

CQU and AAU universities are actively using the Adobe Creative Cloud program as a graphic editor for students studying in the direction of architecture, design, as well as for those students who mount videos based on the results obtained. The software package includes such programs as 'Adobe Pro', 'Adobe Indesign' and 'Adobe Illustrator'. For example, CityU University provides access to the Galaxy server used for practical training of students in bioinformatics in virtual laboratory.

Both educational and research activities use information platforms aimed at storing biographical histories and information for researchers. The platform connects researchers with science managers at the university. The research manager controls the research process. The researcher uploads a report of his activities to the platform, including a report on spending on grants in a certain period. It can also be used to apply for research grants. Of course, the universities under study of 'Smart University' type have such platforms with different names and parameters. The Massachusetts Institute of Technology divides its platforms by levels of higher education: research portals for bachelors, for masters, and for graduate students.

In addition to the research portfolio, HBMSU has a quality management portal where experts and scientists around the world review and evaluate scientific results. The EPFL Polytechnic School uses the 'GrantDB' platform. The Danish University combines information platforms with a platform for scientific publications. An Australian university integrates information platforms with a library portal. Accordingly, EPFL, HBMSU, and MIT publish scientific articles by their students and faculty on scientific publishing platforms: EPLF Scientific publication, HBMSU Publishing House, and MIT Media Lab.

Financial management software is used in the commercial activities of educational organizations of 'Smart University' type. It specializes in issuing accounts linked to commercial banks that automate relationships between parties while limiting the possibility of third party interference. That is, the invoice is based on a graphic code for receipts: on 'QR' codes and barcodes that allow online payment of invoices and notices through banking applications. In addition to the bank card, the Swiss EPFL Higher School provides its students with the CAMIPRO card for the payment system within the campus of the university, both in shops and in cafes. In addition, this card is used to enter the Corps. This card is replenished with the money of a commercial bank through an electronic payment system. Also, the Australian CQU university recommends investing in the online bank 'BPAY' to pay for tuition, since there are advantages in using electronic money, among them there are fewer requirements and commissions in executing a transaction; there is no risk of fraud.

Information platforms are also used in the commercial activities of educational organizations of Smart University type, except for the AAU University (Table 3).

Table 3. Information commercial platforms of educational organizations of Smart University type compiled by the authors.

University	EPFL	CQU	HBMSU	CityU	MIT
Information platforms	Global Data, Google Form	e-Tender Queensland, Sponsor Portal	Partner Portal, Room Rental Portal	Portal United, We Soar	Partner Portal, Sponsor Portal

There are special platforms for admission to the university to ensure the registration of documents for applicants in a remote format. The applicant submits an application and downloads an invoice for educational services, including training and accommodation on the platform. That is, the platform performs the function of information exchange between the selection committee and the applicant. The use of information and communication technologies for applicants reduces the questions that arise from the commercial department of the university, because the applicant himself monitors the admission process and carries out the necessary procedure. In order to provide feedback when money is credited to the university's account, a notification is sent to the application or to the applicant's web page.

It is interesting that only the Danish university of all the studied ones has a mobile application 'AAU Start' for applicants. The rest of the universities use only the website to ensure the registration of applicants' documents. It should be noted that the Swiss higher education uses a single platform 'IS-Academy' with a separate section for applicants. The MIT Applicant Portal uses bloggers as chatbots or acting students to guide paperwork during application submissions. The platform for applicants at CQU University has 2 directions separately for Australian citizens and separately for foreign citizens.

In order to continuously track information in the educational and extracurricular activities of students, the studied educational organizations of 'Smart University' type have official mobile applications. Such applications unite all information and communication platforms of the university with a single entry system. In other words, the 3D geographic information system is added to the application of the university. For example, at HBMSU University, it automatically indicates the location and destination. Of course, such program is also available for applicants when looking for an audience or hall for booking.

All six of the surveyed universities name their applications, usually by a shortened name, in the interests of a simplified design and easier search in application service stores; for example, their apps are named as 'EPFL Campus', 'AAU Student', 'CQUniversity', 'Smart Campus HBMSU', 'CityU Mobile', and 'MIT Mobile'. Additionally, the application name uses words related to higher education along with the acronym to make it easier to find the application you need.

In addition, there are other specialized applications for extracurricular activities in the studied universities, except for HBMSU (Table 4).

Table 4. Additional applications of educational organizations of Smart University type compiled by the authors.

University	EPFL	AAU	CQU	CityU	MiT
Additional Applications	PocketCampus, EPFL Studio, EPFL Femmes de Science, EPFL Magazine, Sports UNIL-EPFL	Smart Elite AAU, AAU Connect, AAU BasketBall, AAU Map, AAU Guide	CQUniLife Students Bloggers	CityU CAP, CityU minerals, CityU Go Global, CityU Interviews, CityU information Day	MIT Orbit for advice, MIT Recreation

To provide digital services for informing participants in the educational process, universities of 'Smart University' type actively use various types of applications that are aimed at the organizational activities of the university. Such applications inspire students to learn more about and participate in the life of the university, as there are their own magazines that publish news of interest to students. They develop internal communication between students and give them the opportunity to feel like a part of the university. Social applications are actively used in 3 studied universities - these are universities such as CityU, AAU and EPFL. In addition, AAU and MIT have an information portal for finding student housing.

The presence of a wireless local area network on the territory of the university is considered significant in the development of the university, given the mobility of students and staff, as well as the high speed of information transfer. Wi-Fi coverage is available on all campuses of educational organizations such as 'Smart University'. It is available to both students, staff, and also to applicants outside the institution, despite the use of a virtual private network of the university. Western universities mainly use fourth-generation Wi-Fi '4G' on their territory. But some European countries, such as Switzerland, are already considering using the '5G' network. Asian universities 'CityU' and 'HBMSU' currently use fifth-generation coatings. Hong Kong university students have the opportunity to connect to the network of the city of Hong Kong with the help of 'Wi-Fi Hotspots' coverage. In addition, only in the above two universities, IP cameras are used in the surveillance system to monitor the safety of people on the territory of the university. Thus, in all six universities studied, there are PTZ cameras and night vision cameras to enhance control over the security of the territory. For example, at the MIT Institute, an identification system for entering academic and non-academic buildings is used using turnstiles and campus cards. Whereas at the HBMSU University, 3D camera (Face ID) is used to control the entrance without a turnstile. Also, the six studied educational organizations of 'Smart University' type have official pages on social networks for rapid dissemination and coverage of information / advertising around the world. The most used networks are Facebook, Twitter, Instagram, and Youtube with over 300 million users in 2020.

The five universities surveyed have an official page on the 'Linkedin' network, except for the University of Hong Kong, since it is blocked in the PRC. But CityU University actively uses 'WeChat', 'Flickr' and 'Weibo', which are the most popular in China. However, AAU, CQU and MIT also use it. Only HBMSU has a 'Snapchat' page.

The campuses of educational organizations of 'Smart University' type have multimedia and interactive equipment. In the halls and in the corridors there are touch interactive panels of kiosks in the navigation system on the territory of universities, which provide information search and online orders using technology. In addition, cameras, LED monitors, stage, sound, lighting and multimedia equipment of the assembly hall provide the opportunity to conduct live events, as well as broadcast announcements in dormitories through

the public address system. That is, university dormitories, including rooms, offer students modern design with technological equipment for a comfortable student life (Aion, Helmandollar, Wang, & Ng, 2012). As well as in dormitories, catering establishments in the studied universities use information technology on campus. So, for example, in the restaurant of the Polytechnic School EPFL, in order to automate the work of the courier, the order is delivered by unmanned vehicles 'ADORE'.

Thus, there are certain differences in the technological innovations used by universities, depending on the resources and abilities of each of the universities, as well as taking into account the legislation of the countries where they are located. The analysis of the practice of using technological innovations in the studied educational organizations of Smart University type allowed us to present a comparative analysis of self-assessment of universities from 0 to 10 on an assessment scale (Figure 1).

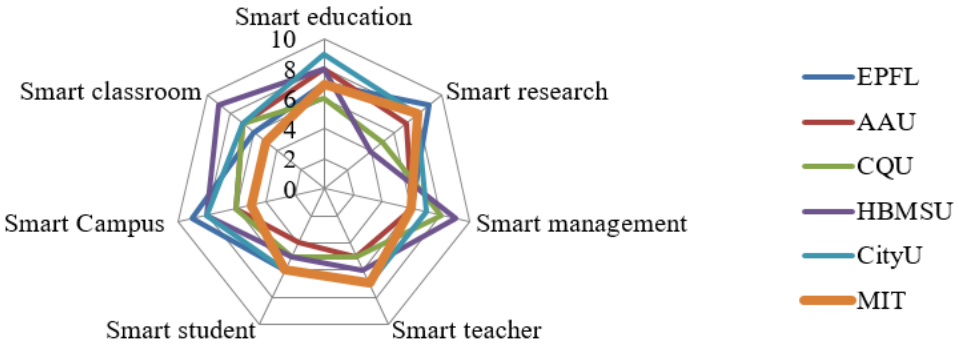

Figure 1. Diagram of self-assessment of educational organizations of 'Smart University' type.

The comparison presented here shows that HBMSU scores high for 'smart management' and 'smart audience' because it uses specific building management software and CQU university, which manages campuses located in 12 Australian cities.

EPFL, MIT, and CityU get the highest scores in the 'smart teacher', 'smart student', and 'smart research' categories, as their specialties and areas of study are more focused on technology. They also use a lot of technological equipment/research tools. In the field of 'smart education' universities such as CityU, HBMSU and AAU are leading. These universities use interactive devices as the main way of learning. In addition, EPFL, CityU and HBMSU campuses represent the best 'smart campuses'. As a result of the accrual of final points, it turns out that the University of Hong Kong ranks first in the self-examination of universities of 'Smart University' type, then the Swiss high school comes.

Discussion

An analysis of the experience of using information technologies and technological equipment in the studied universities in different regions of the world allows us to conclude that the university cannot fully share the concept of Smart University. It is observed that there is a problem in educational activities, which is referred to as the lack of a single technological educational standard. As a result of the study, both the existing differences in educational software and in the use of platforms for massive open online courses of universities were proved. Even between European universities (EPLF and AAU) and English-speaking universities (MIT and CQU) there is a big difference. Thus, the level of knowledge of students in the use of technology is not the same even in one direction. As a result, graduates may encounter many difficulties in finding a job. For this reason, the application of alternative teaching software throughout the country/region/world would be beneficial. But, at the same time, the implementation of this concept may affect the position of universities in the world educational rankings, and also meets the needs of students and employees in changing world. Of course, such a concept is one of the factors affecting the gradual outflow of the contingent from the world's leading universities in the global market.

Conclusion

Technological innovations play an important role in the concept of Smart University, being introduced into the main activities of universities. This concept reveals the presence of technologies and their

effectiveness from different points of view. The structure of the concept is determined by the technological and innovative features for the subjects, and can be expanded depending on the policy of the university. The concept of Smart University has special functions for the further prosperity of higher education and the general requirements of the labor market in the modern world. A new scientific aspect of universities will be the implementation of this concept for various purposes of educational organizations.

In the areas of activity, the use of technological innovations in educational organizations of Smart University type is due to the use of information and communication systems, multimedia and interactive equipment. At the same time, technological equipment and tools are used in the areas of research and social activities of universities. There are differences in technological innovations used by the 6 universities studied, depending on the resources and abilities of each of the universities, as well as taking into account the legislation of the countries in which the universities are located.

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