Formation of the Electronic Informational and Educational Environment in the Prospects of the University 4.0

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Abstract: The aim of the study is justified by the need to create modern personnel competencies for the digital economy and create a new model of modern universities. Strengthening the role of the university, as one of the main producers of knowledge and competencies for the information society, dictates the need for it to implement both the functions of education and research, as well as the functions of transfer, commercialization of technology, and a provider of knowledge about the future. The purpose of the study is to analyse the role of electronic forms of learning and the functioning of the electronic educational system in the prospects for the establishment of University 4.0, and also to identify what the electronic information and educational environment in a new generation of higher education should be like. The methodological basis of the work is the analytical and systemic approaches to the study of the object of study using the methods of logical and causal analysis, expert assessments and systematization of data. The article discusses the specific experience of the development and implementation of e-learning in Peter the Great St. Petersburg Polytechnic University (SPbPU). The authors analyse the effectiveness of the interaction of participants in the educational process within the framework of the electronic information educational environment, changes in the personnel policy, issues of staff development, the creation of a developed ICT infrastructure and the prospects for promoting large-scale modernization of the university. Based on the analysis of the experience of development and implementation at electronic information educational environment in SPbPU, the article highlights the advantages and disadvantages of using digital technologies in the educational activities of the university considering the challenges of its modernization. The authors concluded that the electronic educational environment is effective both in the educational process of the university and in increasing the competitiveness of the university in the modern digital market, in fulfilling the functions of transfer, commercialization of technologies and a provider of knowledge about the future.

Keywords: digital technologies, e-learning, University 4.0, university education.

Introduction

In discussions of recent years about the future of higher professional education and what a university should be like in modern Russia, University 4.0 model is increasingly mentioned. The ideas about this model took shape in the context of the discussion of those prospects that Henry Itskowitz so colourfully describes, considering the university as the core of the knowledge society, the most important channel for technology transfer, which plays a huge role in the formation of the modern knowledge economy (Etzkowitz, 2008). Previously, the apology for the modernization of higher education has varied for a long time and the well-known postulates of already tested strategies in the USA, countries of Western Europe and Asia. The trends of the world university environment that were set at the end of the last century were tirelessly repeated: the development of the market component, the race for high positions in world university rankings, the increasing mobility of students and distance education, the expansion of the penetration of the higher education system into society (life-long learning) (Clark, 2003). It is noteworthy that over the past decade, the list of inalienable components of a modern university has firmly included the problem of university informatization and the development of distance education.

In works as domestic (Patarakin, Shustov, 2004; Zhigadlo, Odinokaya, 2017; Glukhov, Vasetskaya, 2017; Almazova, Barinova, Ipatov, 2018; Kalmykova et al., 2018; Rubtsova, 2019; Rudskoy et al., 2019) and Western authors (Rosenberg, Foshay, 2002; Masie, 2003; McKeown et al., 2008; Katane, Katans, Vāvere, 2012; Roskosa, Stukalina, 2018; Nemejc, Smekalova, Kriz, 2019) the problems of introducing e-learning are considered in sufficient detail. There are much fewer works devoted to the electronic information and educational environment (EIEE) and its role in the functioning of the university; this topic itself has been problematized much later, but in recent years it has become more and more popular (Gleason, 2018). Updating the new university model 4.0. with the transition to its

implementation in the leading universities of the country, it requires the addition of the previous conclusions on digital technologies for training and analysis of the electronic information and educational environment in a new context.

It's about the supplement, because the ideas of the university 4.0., although they claim an original approach in developing a strategy for its modernization, nevertheless are built based on the previous model of the university 3.0., acting as a kind of add-on. The amendments to the previous model are caused by the desire to transform Russian universities in the direction of considering the trends of the knowledge economy and the unfolding 4th industrial revolution (industry 4.0) (Fries, 2019). Despite the hypothetical nature of many of the components of the new industry, they all agree on the growing digitalization of the economy, which directly affects modernization projects of higher professional education with the tasks of accelerating restructuring and reorienting the training of specialists. Moreover, in the context of measuring the knowledge economy (the mass introduction of cyber-physical systems in production, the automation of most production processes, the endowment of devices with artificial intelligence and total digitalization) in the life of a modern university, the EIEE is of particular importance, being as adequate as possible to the new digital format of key areas of society.

In the scientific literature, the very concept of "information educational environment of the university" appeared relatively recently, but has already managed to "acquire" a variety of interpretations. Mostly in the interpretations of this concept, they focus on the educational activities of the university, which is also confirmed by regulatory documents (Ob obrazovanii…, 2012). In the Federal Law on the Education of the Russian Federation, the components of the electronic information and educational environment indicate electronic, information, educational resources, a combination of information and telecommunication technologies, appropriate technological tools that provide the opportunity for the full development of educational programs, regardless of the location of the student (Ob obrazovanii…, 2012).

However, today, universities are actively using information technologies and services that form its unified information infrastructure, covering all components of the university. And it is justifiable to adhere to a broader interpretation of EIEE, including also those information technology tools, application programs and software products based on which the educational process is carried out, but also the research, administrative and financial and economic activities of the educational institution. For example, today the SPbPU EIEE includes the following services: educational portals and video hosting portal; Learning Content Management Systems and Learning Content Management Systems based on online learning platforms Moodle and openEdX; a system for organizing video conferencing; SPbPU basic services (corporate e-mail, IS "Repository of curricula", distributed distance learning system, video conferencing system); Resources of the Information Library Complex (electronic catalogue, electronic library, databases).

University 4.0 is spoken of as a global, open, dynamically developing centre for the creation and commercialization of intellectual property, which not only executes orders for research and development, but also actively creates technologies and technology companies. At the same time, the university model 4.0. far from a detailed study, it acts more like a guideline, a kind of concept of the desired transformation of advanced institutions in the field of higher professional education. At the level of common phrases, the key components of the University 4.0 model remain, as well as the restructuring programs of universities. Coordination with the realities of higher education in Russia is built, at best, on particular examples - of the country's leading universities and, above all, specific projects and ongoing state programs.

And earlier, the ideas of turning the university into a client-oriented organization that produces educational services were directly related to state policy regarding higher professional education (changing the system of allocating budget places, financing principles, performance evaluation systems, etc.). University Model 4.0. is also a well-founded concept that meets not so much the realities of the domestic economy as government programs and initiatives (the Digital Economy program and the National Technology Initiative was adopted earlier). Nevertheless, despite all the assurances, it should be recognized that in Russia there is both the 4th industrial revolution and the associated university model 4.0. are mostly hypothetical in nature, only partially touching the realities of individual advanced universities. Inevitably, the logic of analysing the role of digitalization of a modern university in achieving the horizons of model 4.0 will also be appropriate. But the forecasting will be noticeably more thorough in the case of approaching the realities, namely, the analysis of the EIEE in a university focused on model 4.0.

In discussions about the new model of the university, the leading universities of the country are often mentioned, and SPbPU occupies a special position among them. Among the key protégés of the new university model, the figure of the professor, vice-rector for promising projects of SPbPU A. Borovkov, who also serves as the leader and co-leader of the TechNet working group of the National Technological Initiative and a member of the working group of the Economic Council under the President of the Russian Federation in the field of Digital Economy. In his speeches, he repeatedly dwelt on questions about the new model of higher education, quite naturally stating that SPbPU is one of the few universities that operate in the "University 4.0" paradigm. However, in support of his findings and forecasts, A. Borovkov refers to certain areas of research and development and structural units of the university, namely, the Institute for Advanced Production Technologies, the Centre for Computer Engineering (CompMechLab), and the "Factory of the Future" created in 2015. While the implementation of the claimed model 4.0 requires a comprehensive modernization of the university and, especially, those areas of its functioning that are directly associated with the digital format of the economy (Rudskoy et al., 2019).

The aim of the study is to analyse the role of electronic forms of learning and the functioning of the electronic educational system in the prospects for the establishment of University 4.0, and also to identify what the electronic information and educational environment in a new generation of higher education should be like.

Methodology

The object of the research is the electronic information and educational system analysed in the framework of the formation and implementation of the concept of University 4.0. and modernization of higher education in accordance with the challenges of the digital economy. A direct example of this environment in these conditions was the development of electronic information and educational environment in SPbPU, which is one of the key universities in Russia, functioning in accordance with the paradigm of the University 4.0. The authors of the article analysed the key components of the electronic environment of SPbPU and more than 70 online courses placed on such platforms as the national platform "open education". Lectorium, Coursera, Stepik and internal platforms of SPbPU. The study traces the main stages of development and implementation of key components of the electronic information and educational environment in SPbPU.

The methodological basis for studying the electronic information and educational environment of the University and the courses developed in it were analytical and systematic approaches using methods of logical and causal analysis, expert assessments and systematization of data, as well as methods of pedagogical diagnostics.

Results and Discussion

University Model 4.0 was updated in 2016, at the same time the development of the EIEE of SPbPU intensified, and this coincidence is not accidental. The new educational policy of the university stated the need for the widespread introduction of educational teaching technologies, increasing the effectiveness of the teacher through the active use of electronic information educational environment for interaction with students.

In accordance with the new model, the university is seen not only as an active integrator of the scientific environment and a link between science and the economy, but also as a leader in the development of high-tech industries. And here it is important to note that the design and improvement of the EIEE of a university is an important indicator of its manufacturability, i.e. use in the educational process the latest achievements of information and telecommunication technologies. Improving the EIEE turns out to be the university's innovative activity, which is not only directly related to modern technical and technological solutions, but also acts as an element of the digital economy.

A. Borovkov describes a future university, starting from his previous model 3.0, which combines scientific, educational and entrepreneurial activity with the formation of an innovation ecosystem. The "University 4.0" model assumes the next step and focuses on solving the most complex problems-challenges of modern high-tech industry, which for several reasons the industry itself cannot solve. As for education, it is not only

built on the results of advanced scientific research, but is being transformed from a training system into a market development trend. Obviously, the solution of the stated tasks will require a qualitative reorganization of not only research, but also educational activities with a common system of training specialists in new areas of knowledge and professions that meet the needs of the business community.

And let University 4.0 remain a project, a kind of university of the future, and its image is quite flexible. However, this is not an image of the future we desire, as some write, it is an image drawn by the needs of the present. According to the assurances of A. Borovkov "the global digital transformation is no longer an abstract trend, but a reality that determines the development of companies and global markets". To a certain extent, this new reality has an obvious effect on the development of higher education.

Perhaps the main requirement for the system of higher professional education, which is put forward by the 4th industrial revolution, is flexibility, and in the broad sense of the word. Due to technological uncertainty, setting strict education standards is becoming less and less feasible. Reasoning A. Borovkov is not unfounded when he says that it is pointless to continue for 5 years to train engineers who will not be needed by the market. During this time, in the current conditions there are too many changes, first changes in high technology that the traditional educational system simply does not have time to master. It is necessary to change the very logic of interaction with the employer and not try to "guess" who will be in demand in the market in a few years, but to prepare graduates who will enter the market with such a "range" of competencies that will allow them to be in demand in various fields.

Electronic information and educational environment with a developed e-learning network ensures the implementation of continuous, open education with a wide field of variability in the context of the formation of a global environment of intercultural and interdisciplinary communication, the integration of the university, individual programs and directions in the international scientific community. At the fast pace of economic transformation and technology updates, it is just on EIEE and electronic forms of training that it is justifiable to pin hopes on the possibility of meeting the level of graduates with market demands. Indeed, EIEE allows you to create an extremely mobile and ramified system of additional training, retraining, advanced training, which is by no means limited to the resources of the university, but is interfaced with the global scientific and educational community, with prestigious universities, world-renowned scientists and leading experts in high-tech technologies, about which they say in the context of the 4th industrial revolution. And at SPbPU, much has already been done in this direction. SPbPU courses are presented at online learning platforms Coursera - open source, the National Portal "Open Education", Lecture Hall, Stepik (Figure 1).
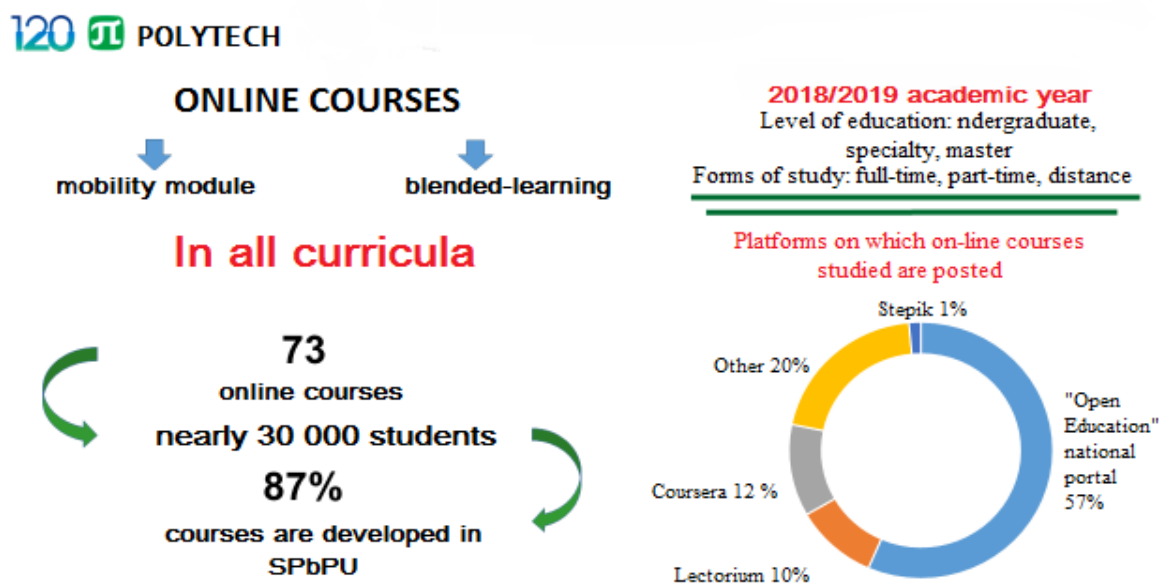

Figure 1. The representation of SPbPU courses at online learning platforms Coursera - open source, the National Portal "Open Education", Lecture Hall, Stepik.

Today, online courses in the form of blended learning or in the format of a "mobility module" are included in 100 % of the curriculum of students at SPbPU. The university's open education centre is developing joint courses not only with educational organizations, but also involving industrial partners. So, in 2019, the course "Introduction to the Kotlin Language", developed jointly with JetBrains, was developed and posted on the Coursera platform. JetBrains is a cutting-edge software vendor specializing in the creation of intelligent development tools, including IntelliJ IDEA - the leading Java IDE, and the Kotlin programming language.

The course "Technology of the Future of the Future" launched at the end of 2018 on the National Portal "Open Education" is very popular. The course is aimed at developing students' knowledge system in the field of new business models, business processes and technologies in high-tech industries. During the mastering of the course, students get an idea of advanced production technologies, production management tools, get acquainted with the basic concepts and tools used for digital transformation of the market, as well as with the key technological and market trends of the developing Digital Economy.

The electronic information and educational system turn out to be that element in the educational processes of training specialists that it is able to adapt as quickly as possible to changing socio-economic needs and challenges due to the variability, adaptability, efficiency, intensification, cost-effectiveness, variability, accessibility and mobility of EIEE.

- **The variability of education** in general is becoming one of the key parameters for training specialists at university 4.0. And this is not only a matter of plasticity of the electronic learning system, the possibilities of adjusting, supplementing existing educational programs, individual disciplines, for example, including entrepreneurial competencies in the list of knowledge and skills formed by students (including support for student activities). The variability of the educational process allows students (students, staff) to independently choose an educational trajectory, plan the time, place and duration of classes, which develops the ability to choose and find the most effective solutions within their own training, the skills to find the right information, use various sources of information to solve problems, i.e. those skills that are so necessary in the new economic realities. Undoubtedly, the EIEE and the developed e-learning system noticeably simplifies and accelerates the process of expanding the learner's range of competencies with the intensification of continuous self-development in a dynamically changing world.

- **Adaptability** should also be understood ambiguously. This is the adaptability of any educational technological resource of the educational information environment to the specifics of a particular subject. And, at the same time, adaptability must be considered from the standpoint of meeting external needs, in particular, the market, which involves the supply of such information and educational material that is necessary for the further adaptation of university students in real conditions of professional activity.

It should be noted that despite the fact that the blended learning format allows you to implement a certain flexibility of the educational process, to make it individualized and adaptive, all this is happening in a very "rigid and opaque" framework, as a result, the result is the same "unclaimed graduate" and 'unsatisfied employer". University 4.0 should allow overcoming this barrier, making the university open to external content, services, interaction, while maintaining its competitiveness and leadership position.

The task is to develop such an educational model, thanks to which the university will accompany a person throughout his life through a flexible system of modules, courses, programs "on demand" of the client and the market. And today steps are already being taken to implement this task at the University's EIEE. For example, in SPbPU, continuing education programs in the field of online training are being implemented, which allow employees of educational institutions to create content that is in demand on the foreign market.

- **Efficiency**. Speaking about the effectiveness of EIEE, one should start with the optimization and general reorganization of the university's functioning, which is one of the key requirements in the implementation of the University 4.0 model. Modern digital technologies can reduce the time it takes to search, transfer and work with environmental objects, simplify the processing of huge amounts of data, automate many routine processes, including in the field of the educational process (checking tasks, progress of students, etc.). They are expected from the fourth industrial revolution that it through digitalization, automation and robotization will free a person from solving many typical problems. EIEE quite rightly is expected to have a similar effect with thoughts about transferring the load to research work and developing innovative teaching technologies.

- **Intensification**. The development and development of the EIEE leads to the intensification of all levels of the scientific and educational process, as well as increasing the efficiency and effectiveness of managing the educational institution as a whole. Indeed, to create an effective EIEE, a comprehensive systematization and structuring of the entire educational system is required, restructuring of managerial parameters, selection of technologies and tools, determination of the composite and meaningful content of the information and educational space is necessary for competent personnel in technological support, its functioning and development, and resource support. Additional incentives for scientific and educational activities, determined by EIEE and e-learning, contribute to the development of innovativeness, ability and desire to create a new product as part of the educational process and to update the results of scientific research in new digital formats.

At the same time, EIEE facilitates the implementation of an independent external and internal assessment of the quality of implementation of EP and its individual elements, including from the professional community.

- **Profitability**. Economic efficiency is manifested by reducing the cost of maintaining the space of educational institutions, saving temporary, material resources (printing, reproduction of materials, etc.).

- **The variability of EIEE** is ensured by the universality of technological processes for the creation, storage and use of educational information resources. The system of such developments is easily modernized with the development of information technology, which facilitates the design of the information and educational environment of the university, adjusting it in accordance with current and future requirements of the educational services market.

- **The availability of EIEE** is associated with the wide and open use of information and educational resources of the environment with the provision of access to them from anywhere in the network and their transfer to other addresses. The latter refers to the ultimate mobility of the system.

- **Mobility of EIEE** and e-learning, implying independence from the geographical and temporal position of the student and educational institution, researcher and scientific institutions. The weakening of the barriers of space (distances, territories, borders) and time (time zones and work schedules) expand the boundaries of the scientific sphere of the university and allows not to limit the country's population in educational needs. The developed EIEE also means an increase in the coverage of the scientific and educational field - simultaneous use of many sources of scientific and educational information (electronic libraries, data banks, knowledge bases, scientific publications, etc.), a wide range of specialists and scientists, as well as a large number of students. On the agenda is the image of a virtual university, in which, at least, a significant proportion of the educational and scientific processes takes place in virtual settings. It should be noted that over the past few years, the virtual component of the Polytechnic has noticeably increased its scale.

In the conditions of the forthcoming 4th industrial revolution, a large amount of data, the speed of reaction to requests dictate the need to use information systems at almost every stage of the university's functioning. At the beginning of the current decade, individual researchers noted that the problem of the development of the information and educational environment is becoming central to the education system.
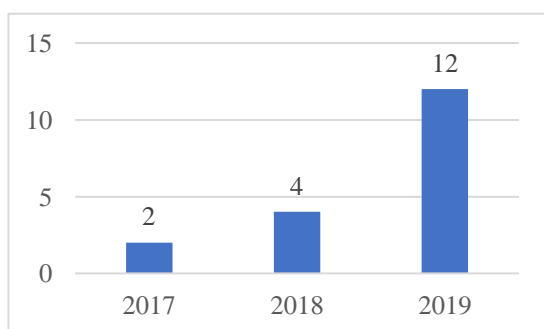

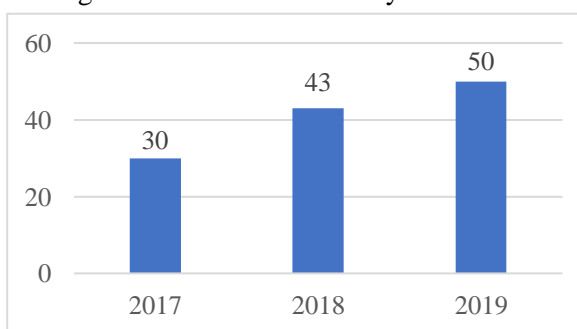Figure 2. Courses on the Coursera platform.

Figure 3. Courses on the "Open Education" national portal.

Currently, each educational institution creates its own information and educational environment, based on the information space of the whole society and the amount of invested funds. The interest in improving EIEE determines the competitiveness of the university not only in the Russian, but also in the international market for educational services. In the future, the indicated dependence will only increase and those universities that are lagging behind in the pace and quality of digitalization of education will be in a very vulnerable position.

The above graphs clearly show the growth of the number of SPbPU courses and their students on the basic international (Figure 2 and Figure 3) and national (Figure 4 and Figure 5) educational platforms.
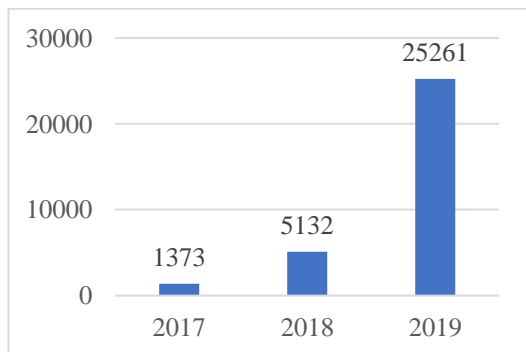
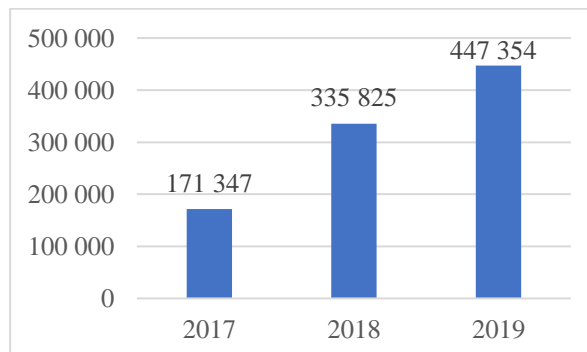Figure 4. Growth in the number of users on Coursera.

Figure 5. Students of the courses on the "Open Education" national portal.

In recent years, thanks to the active digitalization of education, SPbPU has taken one of the key positions in the Russian market of electronic educational services, achieving significant results in the commercialization of this area. At the Open Education Center, SPbPU, together with partners, were created and posted on the Open Education portal over 10 courses. Here are some of them: History of Fine Arts, St. Petersburg GBPOU "Petrovsky College"; Russian language and culture of speech, Federal state budgetary educational institution of higher professional education "NWIM RANEPA"; Fundamentals of oil and gas business, Federal state budgetary educational institution of higher professional education "MSTU"; Theory of state and law, Federal state budgetary educational institution of higher professional education "NWIM RANEPA"; Culturology, Federal state budgetary educational institution of higher professional education "NWIM RANEPA"; Technology for constructing an individual trajectory of a professional career, St. Petersburg State Public Educational Institution of Higher Professional Education, Petrovsky College; Bioethics, Federal State Budgetary Educational Institution of Higher Professional Education at the Ministry of Health of Russia. In total, more than 50 courses of the Polytechnic University are placed at the NPOE (National Platform of Open Education), the number of students exceeded 500,000 courses hosted on Coursera, while they have a smaller audience, but quickly gaining popularity, especially those that allow you to master real skills (Figure 6).
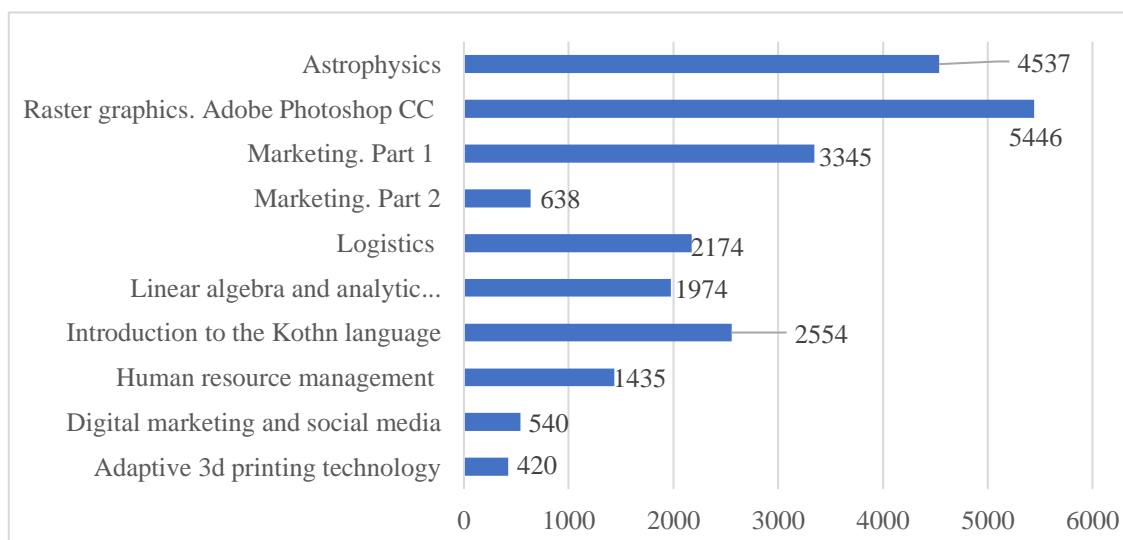
Figure 6. Students of SPbPU courses on Coursera platform.

The development of EIEE at SPbPU sets new guidelines for thinking in the design and development of the educational process, ensuring not only internal university needs, but also the fulfilment of external orders and the involvement of outside students and students. This ensures commercial efficiency and market demand, the formation of sustainable revenue streams with less dependence on budget financing. Advanced digital technologies, organizational and technical support for the development and implementation of an electronic training format in the educational process, an extensive EIEE give the Polytech every chance to intensify the transfer of knowledge and make it one of the main providers of knowledge about the future.

Conclusions

Further modernization of higher professional education, considering the trends in the knowledge economy and the challenges of the 4th industrial revolution, which determined the new University 4.0 model, is inextricably linked with the improvement of the EIEE of educational institutions. Indeed, today SPbPU is one of the few universities operating in the "University 4.0" paradigm, but some research programs and developments, any successes of individual structural units of the university remain only private examples. The implementation of the new model requires a comprehensive modernization of the university and all its key components with guidelines for building and developing a unified educational information space.

The EIEE of SPbPU should be the system that will provide the possibility of an operational response to the challenges of the 4th industrial revolution. The following areas of development are important here: training of new specialists that meet market expectations; formation of information conditions for the creation of advanced technologies and technology companies (in cooperation with the business community, industrial leaders - Russian and international), increasing the competitiveness of the university in the rapidly growing digital educational services market.

Being the most adequate to the new digital format of key areas of society, the university's EIEE is based on information and communication technologies, in particular, virtual and augmented reality technologies. The latter are today one of the priority areas of science and technology, gaining the character of decisive or, as they are often called, critical technologies. Critical are understood as those technologies that are cross-sectoral in nature, create significant prerequisites for the development of many technological areas or areas of research and development, and together make the main contribution to solving key problems of development and progress. Today, there is every reason to agree with the opinion that the critical role in education undoubtedly belongs to educational technologies that use the means of information and computing, telecommunication equipment and technologies, which together form the technical and technological infrastructure of the educational institution.

Currently, the presence and successful development of EIEE is one of the most important conditions for the functioning of a modern competitive university and movement towards the implementation of the University 4.0 model. And now SPbPU has achieved significant results in the development of the university's EIEE with the accompanying transformations of the administrative and economic structure, the training of managerial and teaching staff, teaching and research methods.

However, the need for a comprehensive modernization of higher professional education in the direction of implementing the University 4.0 model requires the further introduction of modern information and technical equipment in the main activities of the university: educational, pedagogical, research, organizational and managerial, expert. The prospect of digitalization has been voiced more than once - a unified space of the university's information and educational environment for further optimization and expansion of opportunities for the accelerated development of higher vocational education. Only such a comprehensive, effective innovation infrastructure ensures the competitiveness of the university today.

Further improvement of the EIEE is a necessary condition for the implementation of the University 4.0 model. The transformation of the format of scientific and educational activities is inevitable, and the role of digital technologies and e-learning in the training of new personnel will only increase. Therefore, the urgent tasks of the development of EIEE of SPbPU today are also the qualitative deepening of the integration of the university's information educational systems into the global network, the growth of EIEE components, increasing attention to the transfer of knowledge and technologies (the formation of a policy for working with intellectual property, supporting academic entrepreneurship, developing the university's innovative ecosystem, supporting activity on the creation of start-ups), the internationalization of the university (the

mobility of students and teachers, the formation of international partnerships and projects). A promising information system for educational and research activities should consider the main challenges of the 21st century and the most important human problems associated with them in the fourth industrial revolution.

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