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PRACTICAL IMPLEMENTATION OF THE INTERNATIONAL SOCIETY FOR ENGINEERING PEDAGOGY CURRICULUM IN RUSSIA

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Abstract

The new IGIP (International Society for Engineering Pedagogy) Curriculum was approved in 2020. It is intended for training of engineering disciplines teachers in higher education institutions. The authors present their point of view on implementing practice of the IGIP Curriculum in Russia. The article on this topic published in January 2021 includes the translation of this curriculum into Russian, and discusses various points of view on it. In the present paper, the authors consider in detail the content of the first two modules of the IGIP Curriculum in connection with the specifics of its implementation in Russia. The current situation in higher education systems in different countries is taken into account. The first module is devoted to the general problems of engineering education discussed in the world community. Its implementation aimed at the expanding general outlook of trainees and allows one to form his/her basic competencies. The second module represents the core of the IGIP Curriculum, since it sets out the didactics and the basic methods of teaching of engineering disciplines. In this regard, the module pays special attention to the modern educational technologies. This is especially true for the use of the information and communication technologies. The importance of such technologies significantly increased over the last year, when the transition to distance learning was forced. Therefore, the accumulated experience of teaching in the distance form is discussed.

Keywords: Distance learning, engineering teacher, IGIP Curriculum, information and communication learning technology

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1. Introduction

The new IGIP Curriculum consisting of seven modules (M1 - M7) has been approved by the International Society in Engineering Pedagogy in March 2020. President of IGIP Hano Hortsch presented the new text at the 49th IGIP conference, which took place in Tallinn from 23 to 25 September in 2020. He reported about the new aspects of the additional pedagogical training for engineers who are trained to become teachers at technical universities. Training of a teacher of technical disciplines according to this curriculum gives him/her an opportunity to apply for the title of International Engineering Educator (ING-PAED IGIP). In this paper, the authors set out their vision of teaching the first two modules of the curriculum. The first module is devoted to the importance of engineering education in the rapidly changing modern world, and to general approaches for solutions of the emerging challenges (in particular, the LLL doctrine). Among them there are problems of international accreditation of educational programs, and of the convergence of national higher education systems (in particular, European Higher Education Area creation). The result of the first module studying should be not only expansion of teachers' general outlook, but also the application of world experience in their activities. The second module represents the curriculum core, since it presents both the classical basics of engineering disciplines' didactics, and the use of modern educational technologies, such approaches PBL, CDIO techniques, gamification, etc. The importance of information and communication technologies' application in laboratory classes and practical work is emphasized in the conditions of total transition to distance learning.

2. Problem Statement

The first IGIP Curriculum for technical teachers' training was developed in 1972 by professor Adolf Melezinek (University of Klagenfurt, Austria), who was the founder of the International Society for Engineering Pedagogy (IGIP). He offered many innovations and fresh ideas that are effectively used in teachers' training (for example, didactics of laboratory classes). Over the years, IGIP Curriculum has been revised several times, taking into account changing environment and new pedagogical doctrines. The latest updated version of the Cuirriculum was reported in September 2020 and published in Russian in January 2021. The next step of the Curriculum implementation consists in the "filling" modules with updated content based on the modern pedagogical and philosophical concepts such as "Industry 4.0" and "Education 4.0".

3. Research Questions

The Curriculum for teachers' training consists of seven modules (M1 - M7), and each module is divided into blocks. The goals of each block mastering are formulated in terms of acquired competencies. The subject of this article is the initial information for teachers' training programs development taking into account the realities of the Russian higher education system (Federal State Educational Standards - FSES, etc.). In this article, we have focused on discussion of the first two modules.

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Module M1 "Interaction of national systems of higher and engineering education" describes the current trends in building the European Higher Education Area, as well as some international and national specifics of educational programs' accreditation. Future technical university teachers should have wide erudition in their professional areas of activity on global scale. They have to acquire the questions of curricula standardization and accreditation, to know doctrines that dominate in pedagogical literature, and to evaluate the role and the place of engineering education in modern society. The trainees should be familiar with the concepts of modern world instability, uncertainty and complexity and with possible responses from the educational environment to these challenges.

Module M2 "Didactics and teaching methods fundamentals of engineering disciplines - educational technologies" is divided into four blocks:

1. Educational and methodological support design.
2. Information and communication technologies in engineering education (didactics, methods of use and design).
3. Communication processes of interacting with students.
4. Control and assessment of education process and learning outcomes (development of control methods, taking into account students personal characteristics).

As a result of mastering this module, the trainees should be able to design teaching and learning processes for students of technical universities, as well as of improving the engineering qualifications for specific target groups using various tools of communication (ICT). It is necessary to master stages of the planning, execution, analysis and evaluation of above processes. Foregoing allows us to consider this module as a key one in the IGIP Curriculum.

4. Purpose of the Study

The purpose of this work is to prepare teaching materials that can be used to create a work program for the curriculum implementation in modern conditions. It is achieved not only by enumerating pedagogical paradigms, but also by their philosophical justification.

5. Research Methods

The comparison and collation analysis of articles on engineering education, published mainly over the past two years, has been carried out. Statistical data on the role of technical education in the modern world are considered. Published results of students' and teachers' opinions surveys on the effective use of the information and communication technologies in the situation of the new coronavirus infection were used. At the same time, attention is paid to the changes in teachers' opinion about e-learning, that they expressed before March 2020 and in pandemic midst.

6. Findings

Authors filled the blocks of modules M1 and M2 taking into account planned competencies achievement based on mastering the IGIP Curriculum content. First, in Module 1, it is proposed to

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discuss the interaction between higher education and engineering education national systems from the global unification point of view. Second, a growing role of engineering education in the modern world is outlined. Module M2 contents didactics and methods of teaching of engineering disciplines. Four blocks of the module relate to the educational and methodological support design, use of the information and communication technologies, as well as to the control and assessment of the learning process and learning outcomes. The authors proposed to familiarize trainees with a number of modern techniques used in the engineering education. The particular attention is paid to the distance technologies in theoretical and practical training (including laboratory classes), as well as in the knowledge control.

6.1. Module M1 discussion: interaction of higher and engineering education national systems

6.1.1. Globalization of educational problems

In the second half of the twentieth century, there was a rapid intra- and intercontinental transport development, an improvement in communications, which contributed to an increase in population mobility. In turn, attraction of foreign students has turned for many countries to a kind of educational services export that brings significant income. At the same time, there was an increase in global economic, environmental, demographic problems that could be solved by strengthening of the world community education as a whole. This, in particular, was one of the stated goals of the Bologna Process, which began in 1999, which is aimed at building the European Higher Education Area (EHEA). In essence, this means standardization of higher education planning and acquisition, assessment of its results, mutual recognition of degrees awarded, etc. to facilitate the labor cross-border movement.

Inclusion of the Russian Federation in the Bologna process led to the creation of the multi-level system of higher education in the country, and to the implementation of new higher education standards up to FSES 3 ++. Standardization process does not stand still all over the world. For example, ABET, the Council for Accreditation of Educational Programs in Engineering and Technology in the USA, is actively working in this direction (Chuchalin, 2021). Another example is the European Network for Accreditation for Engineering Education (ENAEE). It was founded in 2006 as an organization to promote engineering education quality in Europe and beyond. Its activities have become an essential part of the Bologna Process. In Russia, this is done by the National Accreditation Agency for Education (Rosakkredagentstvo), created under the Federal Service for Supervision in Education and Science.

The Bologna process was caused by the European community desire to standardize higher educational programs, but despite the regular meetings of education ministers, the goals announced has not yet been fully achieved due to the significant differences in national educational traditions. We consider such situation to be natural and connected with inertia immanently inherent in any educational system. This remark especially applies to the high school level of education on which higher education is based. Historical perspectives show that drastic changes in educational programs can hurt high schools.

Another question arises about a sufficient level of standardization. Many experts from different fields of knowledge point to volatility, uncertainty, complexity and ambiguity of the modern world, which in is characterized by abbreviation VUCA, formed from the first letters of the corresponding English words. An example is often cited as one aspect of this uncertainty: an applicant entering first year cannot

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be sure of demand for his bachelor's degree in four years. Naturally, disappearance of some professions and emergence of others are both international and national factors. It is no coincidence that when describing the new curriculum, IGIP President stressed importance of taking into account national conditions in its implementation. For example, in the most state universities in Russia, training takes place within framework of the Federal State Educational Standards (FSES). This fact must be taken into account when implementing IGIP Curriculum.

The work on improvement of engineering education in Europe continues. Let's look at two examples. Within the framework of the Erasmus+ program, an international project ENTER (EngineeriNg educaTors pEdagogical tRaining) is being developed for period 2018-2021 (Shageeva et al., 2020). Recognizing challenges of VUCA, the Education Council of the European Commission emphasized in the resolution of 22 May 2018 that “European universities can play leading role in creating European education area as a whole”. To this end, they have been offered university funding under the Digital Europe 2021-2028 program (with total budget of 10.2 billion Euros), which, among the other goals, should also support Industry 4.0 based on Education 4.0. Accordingly, the network of seven universities from seven European countries has been formed. This network is called Advanced Technology Higher Education Network Alliance (ATHENA). Polytechnic Institute of Porto (Instituto Politécnico do Porto, Portugal) is the head organization of this network.

One of the key provisions of the modern educational doctrine recognized in many countries consists is implementation of the "LLL paradigm" - lifelong learning. This includes increased attention to the postgraduate level of education, which is one of the continuous educational process components (along with pre-university). This requires constant improvement of postgraduate education system, which is implemented in Russia, as a rule, in Institutes for Advanced Studies, in Institutes of Continuing Professional Education and in other universities departments. At the same time, a special role is played by retraining under the "Technical University Teacher" program using the IGIP Curriculum in technical universities.

6.1.2. The role of technical education in society

It is indisputable that a future engineer cannot remain aloof from fundamental issues of socio-economic development. In order to characterize economic development driving forces in the late twentieth and early twenty-first centuries, the term: "high technology society" is used (Rakitov et al., 2009). At the same time, the authors criticize the term “knowledge-based society” often used by other social scientists, with which they try to emphasize that scientific knowledge is the main factor in modern society development. The reasoning is as follows: "every human society differs from other communities found in animal kingdom in that it uses knowledge which level is available in the corresponding historical period". In addition, the term "post-industrial society" is often used, which states the end of a certain era of economic development. This era does not start simultaneously in different countries. According to Novikov (2011), the use of the corresponding term "postindustrial education" is relevant. The term "high-tech society" is global, since today in almost all countries we observe not only the development of mobile communications, computers, the Internet, artificial intelligence, but also the fundamental changes in various industries and science. The term "fourth industrial revolution" is often used to describe this era.

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Since 2011, the terms "Industry 4.0" and "Education 4.0" are increasingly used instead of the terms "high-tech society" or "fourth industrial revolution".

Many authors believe that the engineering education is based on specific engineering disciplines. Often the set of these disciplines is characterized by the abbreviation STEM, formed from the English words "science, technology, engineering, mathematics" (Zamyatin & Chuchalin, 2021). Along with this abbreviation, the abbreviation STEAM is also applied. Added letter "A" is an abbreviation follows from the English word "art", which is appropriate to understand in this context as “humanities”. This means not only engineering entrepreneurship or management, but also a broader familiarization with the concept of "sustainable development".

Let us explain the last concept in more detail. It is generally accepted that in the capitalist society the demand for particular product determines economic development vector. However, nowadays more and more scientists speak out about the need for legislative regulation of "market element". "Sustainable development" includes, in particular, solution of the following mankind pressing problems: development of alternative economically viable energy sources with corresponding reduction in harmful emissions, ensuring availability of clean water; improvement of medicine engineering support. We have examples of how some of the tasks can be solved by engineers of various specializations. For each area of training you can find your "niche" in response to challenges of "sustainable development", so it is necessary to appropriately shape engineers’ mindset in their training. This idea is very clearly formulated in the following paper (Dreher et al., 2021): “Any engineering activity is characterized by dialectical contradictions: social contradictions between engineering problems and technical possibilities of their solution, as well as technological contradictions between natural laws and artificial engineering objects. ... this leads to an ethical dilemma for engineering work: as a rule, when something new is created, then social, moral and environmental problems arise. This explains the "two-facedness of Janus" in engineering profession: along with the initial intention to do good the negative consequences arise that must be mitigated through new technical solutions".

According to the Organization for Economic Cooperation and Development (OECD), a special role of the engineering education for national economies is characterized by the fact that in highly developed countries, engineers contribute 20% of innovative gross domestic product (GDP), although in terms of their number they make up less than 1% of the total workers. The importance of technological progress is emphasized on the website (https://oecdru.org/actual.html) when comparing different scenarios for development of the BRICS countries until 2060. “By 2060, BRICS countries have significant opportunities to improve governance and education. In scenario where both factors catch up with the OECD average by 2060, living standards are 30-50% higher than in baseline scenario”.

At present, the population which is constantly dealing with production or consumption of "high technology products" in their daily life and in their professional activities is growing year by year in the most countries. Thus, "at full height" there is a problem of saturating an increasing number of people with knowledge, skills and abilities, allowing them to be both developers, manufacturers and users. In this regard, Belotserkovsky (2011) calls spending on higher education as “the investing in the future". In turn, the book (Rakitov et al., 2009) defines the concept: “Intellectual resources contain information about the nature around us, about society and people, as well as knowledge about various technologies, skills and

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abilities" (Rakitov et al., 2009, p. 13). In fact, mastering intellectual resources is based on competencies formation. All of the above allows us to conclude about the important role of the higher technical education in the modern world.

6.2. Module M2 discussion: didactics and basic methods of teaching engineering disciplines - educational technologies

6.2.1. Educational activities for training and retraining of higher education teachers

Above, we have already substantiated a growing role of higher education teachers and, accordingly, need to improve their qualifications. Let us consider the prospects for development of this direction in our country according to the statistical data for 2019 (Gokhberg et al., 2020). A number of students in the Russian Federation (in bachelor's, specialty and master's degrees) amounted to 4068.3 thousand people and 28% of these (that is, approximately 1,140 thousand people) were trained in areas related to engineering, technology and technical sciences. Of the total number of teaching staff in universities, which is 227 thousand people, only about 800 people were trained in internship. At the same time, over 134 thousand people studied in a postgraduate school. Considering a wider period, it can be seen that the number of students in Russia during the last twenty years reached its minimum in 2019, and the maximum of this indicator was in the middle of this period and was 70% more.

Let us discuss statistical data presented above. The number of students enrolled in engineering is significant. Number of postgraduate and doctoral students, many of whom are preparing to take up scientific and pedagogical positions, is comparable to active teacher's number in higher education. At the same time, teachers number of improving their qualifications is disproportionately small. According to data for 2019 (Gokhberg et al., 2020), postgraduate students were trained in 599 research organizations, 567 educational institutions of higher education and 17 organizations of additional professional education. Data presented allow us to judge about two types of target audiences for the pedagogical training implementation for Russian teachers of higher education: postgraduate students and current teachers. The scale of tasks is characterized by the following data on students' number who completed training in additional professional programs in 2019: 5603.7 thousand people – for continuing education programs, 734.8 thousand people – for professional retraining programs.

6.2.2. Modern approaches to the educational and methodological support design

An extended discussion of problems associated with improving engineering education can be found in article (Galikhanov et al., 2021). This paper describes the five years of work carried out at series of conferences under the general name "Synergy". These conferences touched upon a wide range of issues, ranging from theoretical and methodological foundations of the modern educational process (Education 4.0), up to practical implementation of learning outcomes in Industry 4.0. According to professor of Tallinn University of Technology, T. Ruütman, in modern conditions a theoretical basis can be a combination of "behaviorism (practical training), cognitivism (knowledge transmission), social constructivism and humanism (responsibility, self-motivation, etc.). We find a similar point of view in the work (as cited in Tchoshanov, 2021), the main idea of which is a need to provide the theoretical basis for

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the distance learning that is relevant today. In addition, Tchoshanov (2021) points out that the ability to learn is of particular importance for the distance learning effectiveness, and the role of teacher is precisely to teach student to learn. He names three basic principles that must be followed in this process. They 1) are based on knowledge already acquired by students (traditional pedagogical approach); 2) link student's actual knowledge with fundamental understanding of facts (so-called "horizontal curriculum"); 3) involve students in activities related to study of cognitive processes and formation of self-assessment skills (from our point of view, the latter is decisive when using distance technologies). This is also written in two works (Donskikh, 2021; Lukashenko, 2021). Thus, when developing the conceptual theoretical foundations of the distance learning, the issues of relationship between teaching and learning should first of all be discussed. In addition to the general theoretical considerations on this topic, we find in (Galikhanov et al., 2021) – the brief descriptions of reports of representatives of technical universities from various cities of Russia. Reports are devoted to the possibilities of interaction with industrial partners and implementation, thanks to this, of such modern training technologies as PBL and its latest version CDIO. An adherent of widespread use of the last of these technologies is Chuchalin (2021).

6.2.3. Problems of information and communication technologies in education

It can be considered that the main vector that sets direction in teachers advanced training and retraining is the spread of new information and communication technologies in education over the past decades. Even before onset of the Covid-19 pandemic, scientists paid great attention to education quality in connection with digital transformation (Serditova & Belotserkovsky, 2020). In the context of fight against spread of the new coronavirus infection, which is being carried out in all countries, urgency of improving such technologies has immeasurably increased, allowing, among other things, to carry out remote learning (see above about the ATHENA project). Detailed description of practical experience gained as a result of the full transition to work in the remote format in April 2020 one can find in the works (Gafurov et al., 2020). In these works, authors also discusses in detail various options and possible consequences of the transition to online education in universities.

An important aspect of the engineering education is conduct of educational and industrial practices, as well as laboratory work. This issue has been discussed very actively at several recent IGIP conferences. For example, it explains difference between "virtual" laboratory and a "remote" laboratory. A virtual laboratory is a hardware and software complex that, in an interactive mode, allows a student to simulate certain real processes. For example, you can "control" investigated internal combustion engine by setting a change in certain "input" parameters of its operation and observe on display how rest of operating parameters change (in form of graphs, tables, etc.). This means that such measurements of characteristics were carried out in a real experiment, and then their results were entered into computer model. Remote laboratory allows you to remotely conduct a real experiment, transmitting remote control actions to laboratory installation and receiving results of some measurements as the feedback. There are two significant differences in this case. Firstly, remote laboratory can be considered as center for collective use, and secondly, it allows not only educational laboratory work, but also research. Unfortunately, not all types of practice and laboratory work required for many engineering specialties can be implemented as a virtual or remote one.

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The communication between teacher and student, as well as among students themselves, is developing in completely new way in distant learning. This, in particular, is actively expressed by the interviewed students (Aleshkovsky et al., 2020) and teachers (Lobova & Ponkina, 2021). Teachers survey who conducted distance classes (for example, seminars) requiring dialogue with students, while fighting spread of the new coronavirus infection, made it possible to clearly formulate a common opinion: new pedagogical techniques are needed to enhance student participation. One of these techniques is considered by many to be the “gamification” of educational process (Tsiatsos, 2019). Based on observations of modern youth ("generation z") who are fond of computer games, we can assume the success of this approach to learning. The second argument “for” is a well-known technique in pedagogical theory and practice, “introduction of an adversarial aspect into teaching”. Do not think that only giving a loud name to a certain method will make it effective. It is necessary to analyze the relevance of its application in context of discipline being studied and students existing group. To do this, some universities are following path of providing distance learning services using their own electronic information and educational environments (EIEE).

6.2.4. Concepts for advanced training of higher education teachers in the context of transition to distance and mixed learning

One of philosophical approaches to understanding transition from offline learning to online learning is considered using the term “digital twins” (Vikhman & Romm, 2021). Authors believe that “We are talking about onset of an era of total networkization, digitalization and integration of three interconnected and interdependent worlds: 1) the world of real objects, processes and interactions; 2) the world of social relations, meanings and people, and, finally, 3) the world of virtual digital data, technologies and content”. The philosophical position formed in this way looks quite convincing in this terminology.

Let us talk about the pedagogical aspects of the problem. As a part of innovative activities for implementation of the IGIP Curriculum, it seems important to develop adaptive, practice-oriented and flexible educational programs for advanced training, retraining and continuous professional development of universities’ teachers, ensuring their readiness to implement modern models of educational process, including, in format of online courses. It should be borne in mind that the distance education is both a field of opportunities and a source of risks - individual, institutional, systemic (Donskikh, 2021).

As a result of training in these advanced training programs, future teachers should fully get acquainted with modern information products, educational online technologies, understand not only their place in educational process, but also the possibilities and boundaries of their application in the particular educational situation. As in the traditional offline learning, use of distance technologies should contribute to formation of the following personal qualities in students, which are the basis of their competencies: conceptual qualities (ability to explore, learn about the world around them, based on the existing knowledge base), creative (innovative) such as flexibility of mind, awareness of contradictions. Organizational qualities come to fore in distance learning (purposefulness - ability to understand the goals of educational activity and ability to formulate them; ability not only to set a goal, but also to organize its

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achievement), reflective thinking. An effective process of the distance learning (essentially independent) is impossible without self-analysis and self-assessment of student (Lukashenko, 2021).

Special place in the distance learning is occupied by the problem of assessing achievement degree of planned competencies by students. Experience gained in a number of universities for period from March 2020 to March 2021 shows low efficiency of control of examiners' answers independence with existing technology development. Apparently, one of the solutions is rating assessment of knowledge accumulation in learning process. This type of assessment corresponds to the modern pedagogical paradigm about need to assess not so much the final competencies of a student, but rather to assess degree of growth of his/her competencies, starting with "entrance" control. Of course, the "case technology" can be used, that is, issuance of a complex task (project or case) with subsequent assessment of independence and quality of its implementation during subsequent defense.

7. Conclusion

Authors (Rakitov et al., 2009) discuss properties of the concept of "intellectual resources of mankind" introduced by them. We will name only two of them. One is preservation and renewal due to ability to transmit continuously developing knowledge from person to person, and the second is ability to accumulate (preserve and remember). The "general", intellectual resources of mankind are realized through "private" - intellectual resources of the individual. This philosophical message has a lot to do with learning and is taking on a new dimension in the era of spread information and communication technologies (ICT). First, the mediation degree in knowledge transfer from person to person changes. Second, not only ways of storing knowledge (information) are changing, but also search for information and its accessibility. These considerations substantiate, in our opinion, widespread use of ICT in the modern educational process.

The above philosophical concept fully applies to the engineering education and, in particular, to preparation of graduate engineers to teach technical disciplines based on the IGIP Curriculum. In process of discussing content of the first two modules of this teaching plan, we outlined methodological basis of corresponding pedagogical process, taking into account modern society needs, new educational technologies and realities of the current moment.

Study of module M1, in addition to the general developmental function, involves supply of trainees with initial information about the attitude towards engineering education in the world, about the main trends in standardization of the global educational space, about accreditation principles of educational programs in Russia and in the world.

The second module takes the main place in the IGIP Curriculum. Following the proposed division of each module into blocks, we discussed in detail educational and methodological support design using the information and communication technologies in engineering education (including laboratory work didactics, which was laid down in the first IGIP Curriculum version by the founder of IGIP, Professor A. Melecinek). Based on the results of students and teachers' surveys about total distance learning experience during pandemic, we made certain recommendations for modernizing communication processes both between teacher and student and in the students' environment. Certain experience of remote control of the learning process and learning outcomes has been accumulated, which requires further discussion and improvement.

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