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INFORMATION AND COMMUNICATION TECHNOLOGY: CASE FOR TERTIARY EDUCATION IN TERMS OF SMART ECONOMICS

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Abstract. *This research analyses information and communication technology as an effective tool and infrastructural basis for tertiary education development. The paper aimed to determine common roadmap of ICT implementation into national educational system taking into account variable factors of smart economics, global digitalisation and conditions of the international environment. Sufficient evidence of European countries' willingness to ICT transformation is illustrated. A subsidiary objective of this research involves the building of a logical model outlining correlation between tertiary education and level of ICT access by the example of some European member states and Ukraine. Statistical data were based on variable indicators describing ICT infrastructure, education effectiveness and economics. The methodology of statistical methods and GAP-analysis was applied. This allowed revealing complex recommendations for the transformation of education into a smart education. The research highlights key considerations and important trends in the development of European education under the digitalisation.*
Keywords: *information and communication technology, tertiary education, European education, ICT access, digital education, smart economy.*

Introduction

There are no doubts, humanity lives in an era of the Digital Millennium since "informatization" and "digitalization" directly relates to the way of doing business and even our lifestyle. The information flaw has grown rapidly for the past few

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years while our biological ability to recognize all this big data remains the same. In this context, modern communication requires technological solutions so long as they are capable to transmit the information despite the distance, data volume and another barriers.

This imperative is quite topical for education because educational process involves active communication, informational exchange, delivering of a new knowledge and its creation. Thus, modern information society and educational environment are simply unimageable without widespread application of information and communication technology (ICT).

At least several reasons for this process could be distinguished.

Firstly, while global knowledge is constantly being updated, the introduction of ICT into education significantly accelerates the transfer of accumulated knowledge not only from person to person, but also from generation to generation.

Secondly, advanced ICT improves the quality of educational process and contributes to successful social adaptation in terms of ongoing informational changes and industrial progress.

Thirdly, integration of ICT is the calling of a digital era. The necessity of digitalization is particularly relevant for the tertiary education because higher educational institutions co-exist within a competitive and innovative framework. Thus, they should keep pace with the time and create intellectual potential of the nation. This crucial mission is completely impossible without comprehensive informatization and cooperation in the field of knowledge transfer.

We have to admit an accurate statement given by Director-General of UNESCO Federico Mayor in early 2000. He pointed out that new information technologies should contribute to creating a better world in which everyone will benefit from the achievements of education, science, culture and communication (Daniel, 2001). These days information and communication are strategically vital for the development of various spheres of human activity, including education.

The primary aim of this research is to determine a common roadmap of ICT implementation into tertiary education taking into account variable factors of smart economics, global digitalization and conditions of the international environment. A subsidiary purpose involves the analysis of European countries' willingness to ICT transformation. From another hand, the study is intended to describe a logical model outlining correlation between tertiary education and level of ICT access by the example of some European member states and Ukraine.

Literature Review

Over the past decade the concept of digital education has gained considerable acclaim among the scientists and practitioners. Thus, information and

communication technology is analyzed in terms of its practical application in educational process.

Besides, the strategy of ICT integration meets the requirements of the Fourth Sustainable Development Goal, proclaimed by the lead United Nations Organization for education. In general, this Goal ensures inclusive and equitable education, promotes lifelong learning opportunities for all. In particular, it argues for the transformation of education and puts the idea of digital-based approach to the world educational system. In addition, UNESCO encourage countries' awareness about the role and opportunities of ICT in education. This vision was described in Incheon Declaration devoted to global education strategy to 2030 (UNESCO, 2017).

We have to admit a profound research of European professors (García-Peñalvo et al., 2017) that described ICT as a key element in educational and knowledge management processes. They pointed out the idea of the learning ecosystem that became very important because of the gap between advances in technology and current teaching methods.

Significant possibilities of ICT for education are illustrated in the paper (Orishev, 2020) claiming for irreversible change of education system under new technologies. Some scientists propose the concept of emerging technologies as a new reality for blended learning (Dziuban et al., 2018). Moreover, blended learning widely uses ICT and will forces technological adaptation in higher education in the next years (Becker et al., 2017)

In addition, authors agree in stating that ICT improves the quality of education since encourages the new forms of learning. For instance, the following new form were represented by the scientists (Raja & Nagasubramani, 2018): creative learning, integrative learning and evaluative learning.

No doubt, these tendencies open wide opportunities for ICT implementation into the tertiary education.

Methodology

In general, we accomplished a complex analysis of the problem based on the empirical method of scientific research. Statistic and econometric tools were applied for better describing trends, dynamics of criteria and coherences between them. Data collection implied statistical processing of information synthesised from the official open Internet resources such as Eurostat (2019) and other World-statistics given in the different analytical reports. We also used elements of deductive and inductive methods, logic approaches, methods of prospective and retrospective analysis in order to arrange analytic conclusions, to describe a logical model of tertiary education in the context of digitalization and ICT implementation.

Results of the research methodology will be outlined below.

Research Results
Global Outlook of ICT Performance and Education Development

Taking into account global digitalization, data explosion and comparatively simple access to innovation, present-day tertiary education could not operate effectively without information and communication technology, that significantly improves at least two main educational processes: transfer of knowledge and multilateral communication between all educational stakeholders and participants.

Broadly speaking information and communications technology (ICT) includes the special infrastructure and variable computing elements. In contrast to informational technology, ICT is generally used to describe a broader and more comprehensive understanding of a digital environment since its scope is more extensive (Tatnall, 2020). Moreover, it refers to all technological fields, namely telecommunications, media, programming, artificial intelligence, information systems, network-based systems, audiovisual techniques, monitoring etc.

Thus, ICT considerably improves, enrich and even transform educational process for the better. However, the main problem is how to provide an explanation of the role such technology could play and how ICT could be integrated into the tertiary institutions. While in theory the opportunities of ICT are quite understandable, in practice there are some problems with ICT's infrastructure, funding and overall development.

ICT market has grown considerably for the past decade. Furthermore, this market is very attractive for the investment and could be considered as one of the most long-standing digital market these days (Figure 1).

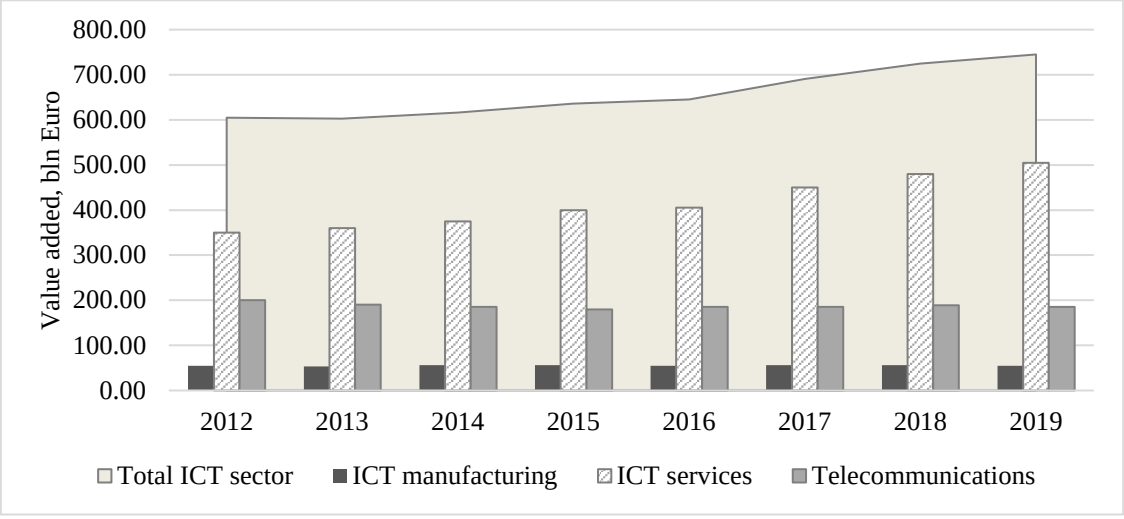


Figure 1 ***Global Value Added Made by ICT Sector***
(composed on the basis of European Commission, 2020)

For the last 7 years global value added by ICT sector has gone up to almost 500 bln Euro. The diagram illustrates total increase in the range of 20% (100 bln Euro). This significant growth results from the rapid development of ICT services (4,5 % in 2019). Eventually, value added of ICT services continue to rise in 2020 due to the sharp growth in demand for information technology under global lockdown. It is noteworthy, that the level of technological ICT production and telecommunication remains stable in comparison with ICT services.

To be more specific, ICT affords very significant opportunities for the development of tertiary education, namely automatisation of the learning process, application of digital technologies and virtual reality, access to the big data and the latest scientific information, global internet, distance learning and communication, smart equipment (tablets, interactive boards) etc.

On the other hand, implementation of all these benefits depends on country's readiness to the digital transformation in educational sphere. This relates to the following criteria: low level of university infrastructure and logistics, the general level of digitalization, index of innovation, research and development activities, as well as the general level of digital competencies of both students and lecturers.

These technical factors restrict the development of educational systems. Besides, the main barrier relates to reluctance of some universities to transform their old system in order with new digital standards and student's needs. In addition, ICT introduction may be inhibited due to pure economic performance. There are no doubts, educational ICT projects imply large funding. While ICT services are comparatively affordable for the universities, ITC infrastructure and special hardware could be very expensive.

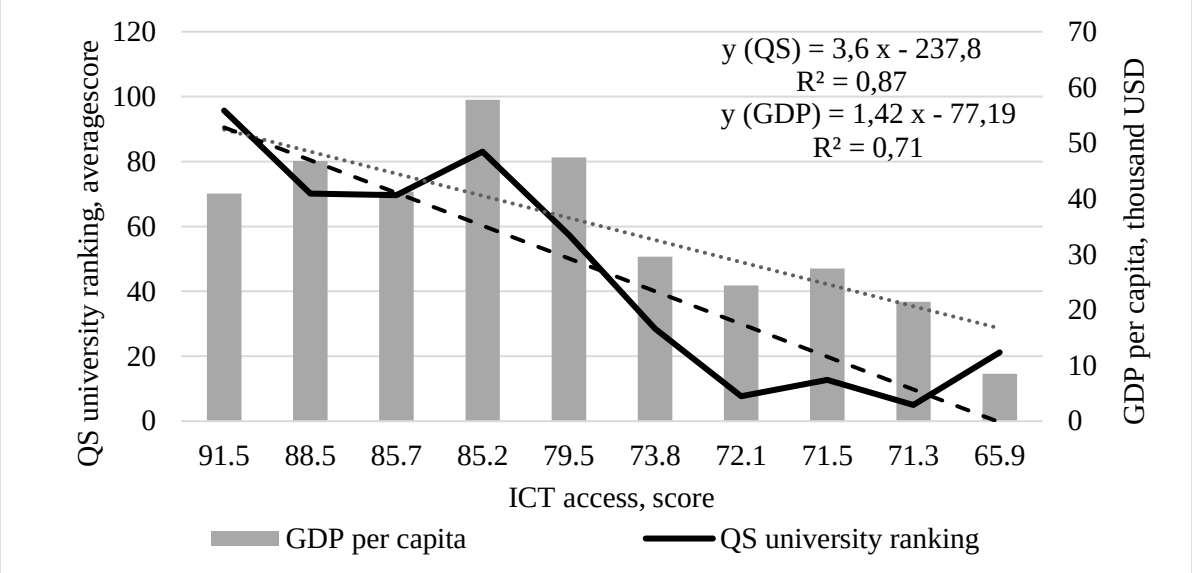


Figure 2 ***Linkages between ICT Access, University Ranking and GDP per Capita***
(authors' calculations based on Global innovation index report by Dutta et al., 2020)

The analysis confirms that the development of ICT impacts both the national economy and national education (Figure 2). This correlation was illustrated on the basis of compiled data from some European member states and Ukraine.

The obtained trend models allow delineating at least two correlations:

1) A high level of GDP per capita is followed by a sufficiently high access to ICT infrastructure. We may set a hypothesis that modern domestic production is grounded on the digital basis and mostly depends on information technologies, that proves the evidence of Industry 4.0.
2) Diagram illustrates the fact, that ICT access accelerates universities development. Thus, countries with highly developed tertiary education also have a good access to ICT services and hardware. This level could be evaluated by the average score of the TOP national universities given by QS World University ranking (Mussard & James 2018).

To be more specific, these conclusions could be drawn as follows. According to the research, the ICT score above 80 points could be considered as strong position for upper middle- and high-income countries (European Commission, 2020). At the same time, level of national universities in advanced economies is differentiated as: QS average score above 70 points (strong level, advanced university), 50-70 (good position), 20-50 (low middle, but satisfactory level). However, some universities in developing countries gets above 20 points and this score illustrates comparatively high development of national tertiary education. Thus, in order to ensure ICT access above 80 points, the level of GDP per capita should be above 30 thousand dollars. Indeed, such growth of GDP and ICT access will encourage the development of higher education. We can expect average growth of universities up to 50 points according to the QS assessment.

The outlined results led us to investigate the system "Information and communication technology ↔ tertiary education ↔ economics" in the context of European countries. The variable indicators were arranged due to this purpose (Table 1).

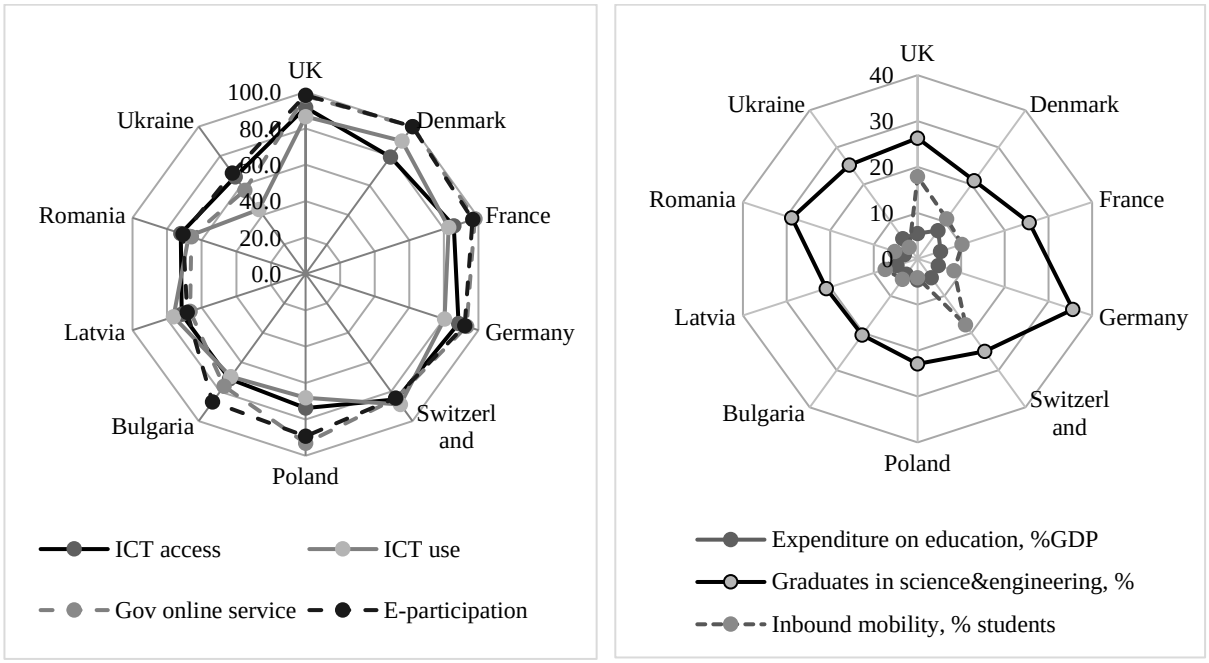
The table represents a wide range of technical, social and economics indicators relevant for European member states and Ukraine. The analysis allows establishing crucial and minor gaps in the level of ICT, education and general economic outcomes of the countries (Figure 3).

Despite strong common correlation between ICT and education (Figure 2), there are some essential differences identified during the gap-analysis. The first diagram (Figure 3a) illustrates comparatively strong position in all ICT indicators for high income economies (United Kingdom, Germany, France, Denmark and Switzerland). Romania, Latvia, Bulgaria and Poland show a delay compared to leading countries. However, the level of government online services and e-participation increases steadily in Poland and Bulgaria.

The biggest negative gaps were established for the level of ICT use and government online services in Ukraine. We have to admit, that Ukraine is the one country in Europe classified as lower middle-income economy. On the contrary to Ukraine's underdevelopment in ICT sphere, its education illustrates very promising perspective (Figure 3b).

Table 1 ***The System of Indicators for ICT and Tertiary Education***
(authors' arrangement based on Global innovation index report by Dutta et al., 2020)

Indicator	United Kingdom	Denmark	France	Germany	Switzerland	Poland	Bulgaria	Latvia	Romania	Ukraine
Income level	*high*	*high*	*high*	*high*	*high*	*high*	*Upper middle*	*high*	*Upper middle*	*Lower middle*
ICT place in world ranking / score	1/ 93,6	3/ 92,4	6/ 90,8	15/ 88,5	21/ 85,8	30/ 81,1	44/ 76,2	55/ 70,8	60/ 69,1	82/ 58,8
Tertiary education place in world ranking / score	15/ 51,3	26/ 45,3	24/ 45,4	6/ 56,1	18/ 49,4	51/ 37,9	54/ 37,4	30/ 44,5	43/ 39,8	32/ 43,9
Population, mn	67,5	5,8	65,1	83,5	8,6	37,9	7	1,9	19,4	44
GDP per capita, thou. USD	40,88	47,4	41,23	46,76	57,79	29,59	21,472	27,42	24,4	8,53
Tertiary education indicators										
Expenditure on education, %GDP	5,5	7,6	5,3	4,8	5,1	4,6	4,1	4,7	3	5,4
Graduates in science&engineering, %	26,3	21	25,6	35,6	24,9	22,9	20,5	20,9	28,8	25,3
Inbound mobility, %	17,9	10,8	10,2	8,4	17,8	4,1	5,5	7,4	5,2	3,1
QS university ranking, averagescore	95,7	57,4	69,6	70,1	83	28,5	5	12,7	7,7	21,2
PISA reading, math	503,5	501,1	493,7	500,4	498,2	512,8	426,7	487,4	427,8	462,7
Digital skills among population, 1-7 (best)	4,94	5,42	4,49	5,07	5	4,27	4,65	4,79	4,49	4,45
ICT indicators										
ICT access, score	91,5	79,5	85,7	88,5	85,2	73,8	71,3	71,5	72,1	65,9
ICT use, score	86,5	90,3	82,8	80,3	88,8	68,1	69,9	76,3	67,4	43,7
Gov online service, score	97,9	100	97,9	93,1	84,7	93,1	76,4	66,7	66	56,9
E-participation	98,3	100	96,6	92,1	84,3	89,3	87,1	68,5	70,8	68,5



a) ICT indicators (score) *b) Educational indicators (%)*

Figure 3 ***European ICT Infrastructure via Education Performance***
(authors' calculations based on European Commission, 2020)

The research led to the conclusion, that countries with the highest expenditure on education are the most developed in ICT services. One can observe an increasing tendency for the significant growth of graduates in science and engineering in the countries with the best ICT scores. Moreover, this could be interpreted as a condition for the competitiveness of modern tertiary education.

International ICT's Roadmap for Tertiary Education in Terms of Smart Economics

The concept of interaction between ICT sector and higher education should be considered as cyclical. Initially, ICT provides numerous tools for the educational process. Tertiary education, in turn, contributes to the creation of a new knowledge and innovation. Eventually, such innovation becomes a driver of the Industry 4.0, that gradually accelerates scientific researches, technological development and ICT design. In addition, it is impossible to consider this complex process without the economy and dynamic market relations.

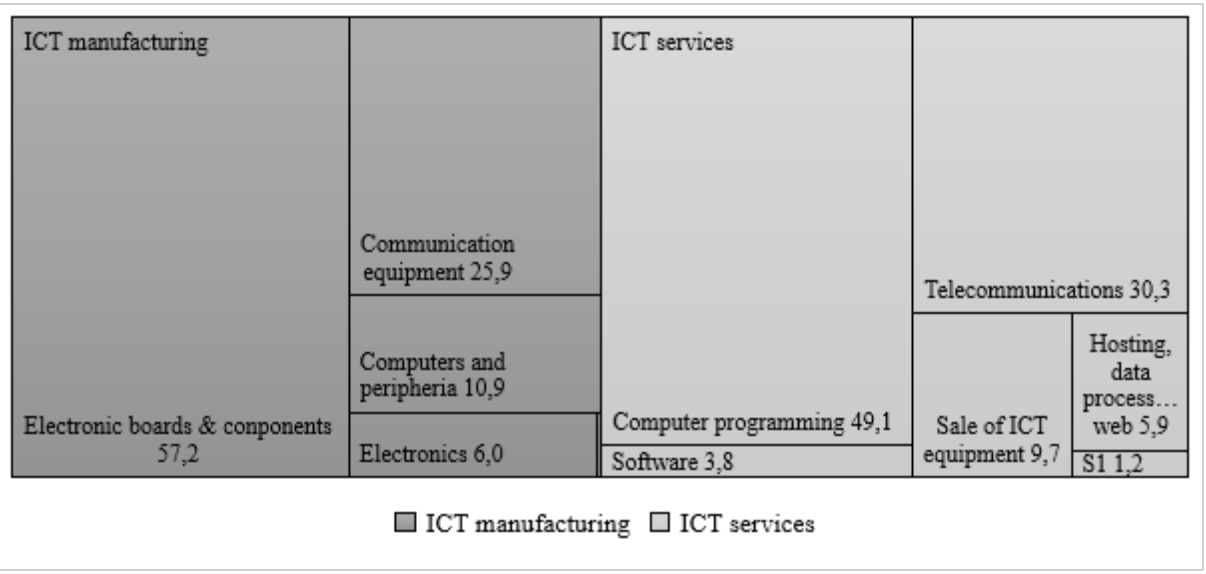
It is noteworthy, that global digitalization describes modern world from the perspective of "smart", namely smart industry, smart home, smart city etc. SMART economy is measured as Specific, Measurable, Achievable, Realistic and Timed (Elgazzar, 2017). Smart economy involves high-tech innovation,

digitalization, intellectual potential, effective production, free market, social and ecological responsibility (Izmaylov et al., 2018).

Thinking this way, the development of information and communication technologies reflects the new paradigm of smart education. Tertiary Smart education is based on ICT and provides open access to educational process, automatization and support, distance learning, individual approach to student's study, transparent form of a control, personal accounts for students and lecturers (Berdnikova et al., 2019).

The world ICT market is represented by 2 profound sectors: ICT manufacturing (hardware production) and ICT services. This fact should be taken into account in elaborating the national strategy of education development based on ICT introduction.

The hierarchical structure of these ICT sectors is the following (Figure 4).



Where S1 – computer maintenance and repairing

Figure 4 ***Structure of ICT Manufacturing and Services in Terms of its Value Added, %*** *(authors' calculations based on Eurostat, 2019)*

The model reveals that manufacture of electronic components and boards is dominated field of ICT production. It provides 57.2 % of the total ICT value added. Communication equipment relates to the next largest share (25.9%), while production of consumer electronics, magnetic and optical media provides only 6% and 0.1% consequently.

As illustrated above (Figure 1), ICT services represent the lion's share of global ICT value added and actually drive the market. Computer programming, consultancy and related activities cover about the half of all ICT services

(49.1 %). Telecommunication is also very promising kind of ICT services accounted for 30 % of the total value added.

In practice, ICT allows effective presenting of educational information with color, graphics, sound, video that reflect real situation or simulate some processes.

ICT services and manufacturing can address different needs and goals of tertiary education. Besides, the integration of ICT into educational process contributes to the establishment of the innovative forms in tertiary education, such as virtual universities, open and distance education etc. That is the most spectacular opportunity of ICT implementation.

Accordingly, the following scheme illustrates the common roadmap of ICT integration into tertiary education (Figure 5).

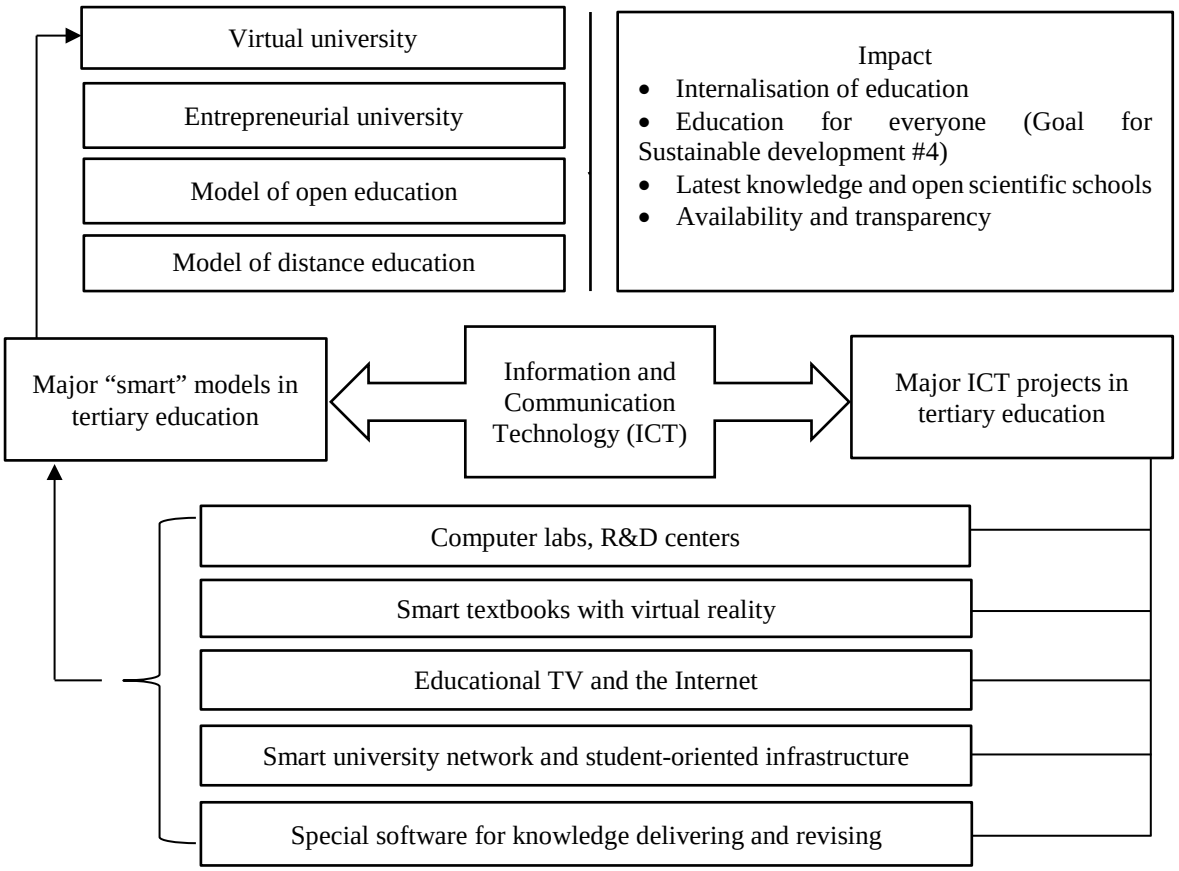


Figure 5 ***Common ICT Roadmap Focused on Tertiary Education*** *(authors' scheme)*

The implementation of this roadmap involves the following steps and reformations.

1. The reform of the educational infrastructure that should be designed on the digital basis. It is necessary to develop and to implement fundamentally new pedagogical ICT that will ensure a high level of basic digital literacy among the population. Such infrastructure ensures

equal access to tertiary education and includes a wider range of digital services, such as lifelong learning, distance learning and dual education.

2. Funding the universities in the fields of applied research and digital entrepreneurship. Tertiary education requires effective scientific R&D centers and digital business models.
3. Training centers and additional education in the field of digital economics. According to McKinsey Global Institute, up to 50% of all work activities will be automated by 2036, which will lead to a significant layoff of labor, reducing the number of jobs that require secondary skills (Illanes et al., 2018). Thus, the university mission is overcome the lack of needable skills.
4. Improvement of the knowledge monitoring system. ICT allows changing the approach to the control of educational activities. This provides flexibility and transparency in the management of the educational process.
5. Partnership between universities, government and business. This interaction involves the development of analytical platforms and IT applications for data exchange.

As a result, ICT introduction requires the increase of students and lecturers awareness about the importance of innovation, digital approaches to education, common risks and prospects.

Conclusions

Global digitalization forces all areas of human being, including primary and tertiary education. In these conditions Information and Communication technology becomes an essential tool for the educational management and knowledge transfer, since. In addition, ICT serves multilateral communication between all educational stakeholders and participants.

ICT provides very significant opportunities for the development of tertiary education, namely automatization of the learning process, application of digital technologies and virtual reality, access to the big data and the latest scientific information, global internet, distance learning, smart equipment (tablets, interactive boards) etc. On the other hand, the implementation of ICT benefits depends on country’s readiness to the digital transformation.

The analysis confirms that the development of ICT impacts both the national economy and national tertiary education. A high level of GDP per capita is followed by a sufficiently high access to ICT infrastructure. This proves the hypothesis that modern domestic production is grounded on the digital basis and mostly depends on Industry 4.0. Research results confirmed, that ICT access

accelerates universities development. Thus, countries with highly developed tertiary education also have a good access to ICT services and hardware.

The analysis illustrates comparatively strong position in all ICT indicators for high income economies (United Kingdom, Germany, France, Denmark and Switzerland). Romania, Latvia, Bulgaria and Poland show a little delay. The biggest negative gaps were established for the level of ICT use and government online services in Ukraine.

Countries with the highest expenditure on education are the most developed in ICT services. There is a significant growth of graduates in science and engineering in the countries with the best ICT scores.

The roadmap of ICT integration implies the launching of ICT projects into tertiary education, such as computer labs and R&D, smart university infrastructure, educational Internet, smart books etc. This allows forcing the new educational ICT-based models, namely virtual and entrepreneurial university, open, distance and blended learning. The implementation of this roadmap involves some complex steps and reformations, given in the paper.

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References

Becker, S.A., Cummins, M., Davis, A., Freeman, A., Hall, C.G., & Ananthanarayanan, V. (2017). *NMC horizon report: 2017 higher education edition*, 1-60. The New Media Consortium.

Berdnikova, L. F., Sherstobitova, A.A., Schnaider, O.V., Mikhalenok, N.O., & Medvedeva, O.E. (2019). Smart university: assessment models for resources and economic potential. *Smart Education and e-Learning 2019*, 583-593. Springer, Singapore.

Daniel, J.S. (2001). *Using ICT for quality teaching, learning and effective management*. UNESCO Asia and Pacific Regional Bureau for Education.

Dutta, S., Lanvin, B., & Wunsch-Vincent, S. (2020). *Global Innovation Index 2017*. Cornell University.

Dziuban, C., Graham, C. R., Moskal, P. D., Norberg, A., & Sicilia, N. (2018). Blended learning: the new normal and emerging technologies. *International journal of educational technology in Higher education*, *15*(1), 1-16.

Elgazzar, R.F. (2017). Smart cities, sustainable cities, or both. *Critical Review and Synthesis of Success and Failure Factors. In Proceedings of the 6th International Conference on Smart Cities and Green ICT Systems, Porto, Portugal*, 22-24.

European Commission. (2020). The EU ICT Sector and its R&D Performance. *Digital Economy and Society Index 2020*. EC publishing.

Eurostat. (2019). ICT sector - value added, employment and R&D. *Eurostat data base*. Retrivered from https://ec.europa.eu/eurostat/statistics-explained/index.php/ICT_sector_-_value_added,_employment_and_R%26D

García-Peñalvo, F.J., Hernández-García, Á., Conde, M.Á., Fidalgo-Blanco, Á., Sein-Echaluce, M.L., Alier-Forment, M., ... & Iglesias-Pradas, S. (2017). Enhancing education for the knowledge society era with learning ecosystems. *Solutions for Knowledge Management and Technological Ecosystems*, 1-24. IGI Global.

Illanes, P., Lund, S., Mourshed, M., Rutherford, S., & Tyreman, M. (2018). *Retraining and reskilling workers in the age of automation.* McKinsey Global Institute.

Izmaylov, Y., Yegorova, I., Maksymova, I., & Znotina, D. (2018). Digital economy as an instrument of globalization. *Scientific Journal of Polonia University*, *27*(2), 52-60.

Mussard, M., & James, A.P. (2018). Engineering the global university rankings: gold standards, limitations and implications. *IEEE library*, *6*, 6765-6776.

Orishev, J. (2020). The use of information and communication technologies in the educational process. *JSPI, 1*(1). Retrieved from https://science.i-edu.uz/index.php/archive_jspi/article/view/188

Raja, R., & Nagasubramani, P. C. (2018). Impact of modern technology in education. *Journal of Applied and Advanced Research*, *3*(1), 33-35.

Tatnall, A. (2020). In A Tatnall (Ed.), *Encyclopedia of Education and Information Technologies*. Springer.

UNESCO. (2017). Education 2030, Incheon Declaration and Framework for Action. *World Education Forum 2017, 1* (1).

UNESCO. (2020). *Global education monitoring report 2020: inclusion and education: all means all.* Paris: UNESCO. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000373718