Integration of IT Education in Ukraine into the European Educational Space

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Abstract. A systematic approach to determining the requirements of the IT industry for the Master's degree of Information Systems, a systematic analysis of the European framework of ICT competencies and the MSIS2016 international standard competencies for the development of a competency paradigm of IT education and methods for processing statistical information to analysis the results of the employer's survey were applied. The scientific novelty is the methodology of development of an educational program for Master's in Information Systems based on systematization of the IT industry requirements regarding competencies of graduates and statistical analysis of the results of the employer's survey. Approbation of the research results within the framework of Erasmus+ MASTIS project of the European Union program during pilot implementation of the educational program of Master in Information Systems at six Ukrainian universities gave positive results.

Keywords: competence, competency, Information Systems, Information Technologies, IT education, IT industry, educational program.

1 Introduction

Information Technology (IT) forms the basis of any developed economy. Information and Communication Technologies are identified as a priority direction of economic development for the period up to 2020 in accordance with the Law of Ukraine on "Priority directions of science and technology development". IT is one of the most dynamic and successful industries in Ukraine and is a major source of competitive advantage for business entities in the digital economy era. Information systems (IS), upon their implementation, are instrumental in improvement of the management structure, facilitating prompt reacting to changing market conditions and development of marketing strategies. Qualified professionals are the main IT resource. Their insufficient quantity and quality are one of the main constraints on the development of this sector of the economy.

The market demand for Information Systems and Technology specialists is growing every day; their role in improvement of the efficiency of Ukrainian economy

is on the rise. IT industry requirements for information system specialists are formulated in the form of competencies. These competencies are a set of requirements regarding possession of a large range of modern information technology, skills of modelling, programming and support of information systems, understanding the subject area, the ability to analyze and optimize automated business processes and the tasks of organizational management, methods and technologies of project management and to undertake management decisions.

Educational paradigm, which is based on the principle of higher educational institutions graduates' competency formation of, that is the ability to meet the industry requirements in the context of knowledge, skills, experience, personal qualities, is defined as a competency paradigm.

Many IT companies have research and development centers whose task is to achieve competitive advantages by developing innovative technologies and creating new information services. IT graduates with a Master's degree should have the appropriate skills to work at such centers. The current level of masters' training in higher educational institutions, given the crisis state of science sector development in Ukraine (0.41 percent of GDP planned for 2019 [1]) does not meet these requirements. Current masters do not know how to formulate goals and objectives of scientific research, identify critical errors, have no experience in conducting research and developing research results, and do not have the ability of a researcher and an architect [2]. Therefore, the implementation of the competency paradigm of education in higher education institutions is an actual methodological problem of organizing the educational process with the provision to provide high-quality training of specialists for the IT industry in accordance with the requirements of the labor market.

Many scientific papers of native and foreign researchers are devoted to the analysis of the status and improvement of the quality of the education for the Bachelor`s and Master`s degrees in IT specialties. In particular, V. Andrushchenko, V. Viktorov [3], S. Nikolaienko [4], O. Yesina [5], Y. Yakymenko [6], E. Hanushek, L. Wößmann [7], C. Hordiichuk [8] suggest different views and methods of searching the ways to improve the quality of the educational process. The common point for many authors is the idea of the necessity to harmonize educational programs with the real needs of the labor market [9], the interaction of higher education institutions, IT enterprises and authorities, such as the triple helix model [10], the formation of a new model of a project and entrepreneurial university [11], in particular for IT education.

Features of the competency paradigm are considered in the works of A. Andreev [12], G. Ponomarenko [13], O. Ovcharuk [14], S. Lisova [15], N. Bibik [16], and others. The authors consider the essence of the formation of key competencies, the conditions for the implementation of the competency approach. Thus, the competency paradigm involves the implementation of educational programs that allow the period of adaptation of university graduates to the requirements of the industry and the time graduates need to join employer's production process to be as short as possible. The university model, based on the triple helix principle, will turn it into a project and entrepreneurial educational institution, in which the students' designs, practical work, and the educational process will be combined into one business process within the university.

2   Discussion

2.1   Rationale for Changing the Educational Paradigm

Education reconstitutes and improves the intellectual, mental and economic potential of the society. Reforming the education system to increase the quantity and improve the quality of training technical specialties graduates, in particular in the field of IT, is one of the first steps to stimulate the growth of the innovative component of the state and to unlock Ukraine's intellectual potential. The system of IT education should play a catalyst role in the development of the entire education system, just as information technology plays a leading role in the development of science, technology, and society as a whole.

The major problems of higher education, including IT education, are:

- weak staffing of the educational process with qualified teachers and inadequate remuneration for their labor;
- obsolete material and technical base of departments that carry out training in IT specialties;
- unsatisfactory training of students and schoolchildren in the field of information technology, physical and mathematical disciplines;
- outdated curricula and discipline programs;
- exodus of talented students and schoolchildren to foreign universities;
- flight of qualified specialists to work at foreign IT companies;
- low motivation of students because of the hard dictate of disciplines to be studied that is imposed by the university administration and the lack of possibility to implement personal educational learning trajectories.

The "Information Technologies of Ukraine" Association has determined that an experienced teacher brings much more profit to IT companies if he is in his place – that is, in a university – because he provides an average of 20-30 qualified young professionals to leading IT companies [17]. For their part, IT companies are trying to encourage teachers' quality work by stimulating them for professional growth and effective use of their own professional knowledge.

Ways to solve the problems above are:

- to arrange the exchange of experience between qualified teachers and IT staff;
- to modify work plans and programs considering the current needs of IT companies;
- to bring experienced teachers back from IT companies to higher education institutions while retaining the level of material incentives;
- to improve the teachers' qualifications via distance courses, internships in IT companies, etc.;
- to provide additional training on modern information technologies for students and pupils;
- to attract post-graduate students and masters to teaching work;
- to encourage university professors to work with students and schoolchildren.

Thus, harmonization of the requirements of the IT industry and IT education, the implementation of a competency educational paradigm with the introduction of personal educational learning trajectories in accordance with the desires, capabilities and abilities of students is the basis for defining the strategy of IT education development.

2.2 International Projects for Capacity Building in Higher Education of Ukraine

Ukraine solves several tasks within the framework of the international projects of the Erasmus + program of Capacity Building in Higher Education, funded by the European Union (EU), in particular:

- modernization, introduction of innovations and accessibility of Higher Education;
- improving the quality of Higher Education and its relevance to the needs of the world and national labor markets and society;
- promotion of cooperation between the EU and partner countries;
- development of a common educational space within the framework of EU initiatives, interpersonal contacts and intercultural awareness and mutual understanding.

One of such Erasmus+ projects that initiates the training of Masters in Information Systems (IS) in Ukraine is the MASTIS project "Establishing Modern Master-Level Studies in Information Systems" [18]. The content of the masters' training in this project corresponds to modern European standards for Information Systems, requirements of the Ukraine IT industry, international competences of the IS specialists under the European e-Competence Framework (e-CF). The orientation of masters' studies in Information Systems on European value propositions will ensure student mobility in the context of the Erasmus+ program of the European Union.

Competence-based approach and assessment of learning outcomes in accordance with the "Tuning Educational Structures in Europe" project, laid the foundation for the development of an IS training program for MASTIS [19]. According to the Tuning methodology, the learning outcomes are statements of what a learner is expected to know, understand and/or be able to demonstrate after completion of learning. Learning outcomes are formulated in terms of competencies. Competency is a dynamic combination of knowledge, hard and soft skills, ways of thinking, professional, ideological and civic qualities, moral and ethical values, which determines a person's ability to successfully carry out professional and further educational activities and is the result of learning at a certain level of higher education [20]. The development of competencies is the goal of educational programs. The main difference between learning outcomes and competencies is that the former is formulated by teachers both at the curriculum level and for a separate discipline, while the learners acquire the competencies [21].

The IT industry has specific requirements for the level of graduates' competencies, which take form of the list of competencies. By definition [22], competency is a quality of the person, which manifests in the specific ability and readiness to

effectively perform a certain action in a particular subject area, which involves specific knowledge, hard, soft skills, ways of thinking and a sense of responsibility for their actions.

According to the notions above, the competency is an integrative embodiment of the competences.

2.3 European e-Competence Framework and its Relation to the Professional Standard of IS Specialist

Requirements to IT professions in the form of competences are defined in the European e-Competence Framework (e-CF). The e-CF provides a reference to 40 competences regarding the Information and Communication Technology (ICT), using a common language for competencies, skills, knowledge and proficiency levels that can be understood across Europe. The e-CF is a component of the European Union's strategy for e-skills in the 21st century supported by the European Commission and the Council of Ministers. The Framework supports key policy objectives of the Digital Skills and Jobs Coalition and benefits the ever growing user community from the EU and across the world.

The European e-Competence Framework has four dimensions. These dimensions reflect different levels of business and human resource planning requirements in addition to job / work proficiency guidelines and are specified as follows [23]:

1. Five e-Competence areas, derived from the ICT business processes PLAN, BUILD, RUN, ENABLE and MANAGE.
2. A set of reference e-Competences for each area, with a generic description for each competence. Forty competences identified in total provide the European generic reference definitions of the e-CF 3.0.
3. Proficiency levels of each e-Competence provide European reference level specifications on e-Competence levels from e-1 to e-5, which are related to the EQF levels 3 to 8.
4. Samples of knowledge and skills relate to e-Competences in dimension 2. They are provided to add value and context and are not intended to be exhaustive.

The e-CF Profession List contains 30 profiles (Fig.1).Among the 30 e-CF IT-profiles seven professions can be highlighted that are included in the MASTIS project in terms of defining the knowledge and skills required to carry out professional tasks by Information System specialists. These are the following: [24]:

- Business Analyst, who analyzes Information Systems for improving business performance, identifies areas where information system changes are needed to support business plans and monitors the impact in terms of change management, contributes to the general functional requirements of the business organization in the area of ICT solutions;
- Business Information Manager, who proposes, plans, and manages functional and technical evolutions of the Information System within the relevant business

domain, manages and implements updates to existing applications and maintenance activities guided by the needs, costs, and plans agreed with internal users;

- Enterprise Architect, who designs and maintains the Enterprise Architecture, balances technological opportunities with business process requirements. Links the business mission, strategy, and processes to the IT strategy;
- Systems Analyst, who analyzes requirements and specifies software and systems, ensures the technical design and contributes to implementation of new software and/or enhancements;
- Project Manager, who manages projects to achieve optimal performance conforming to original specifications, defines, implements, and manages projects from conception to final delivery, responsible for achieving optimal results; conforming to standards for quality, safety; and sustainability and complying with defined scope, performance, costs, and schedule;
- System Architect, whose main tasks are to develop the IS and software architectures;
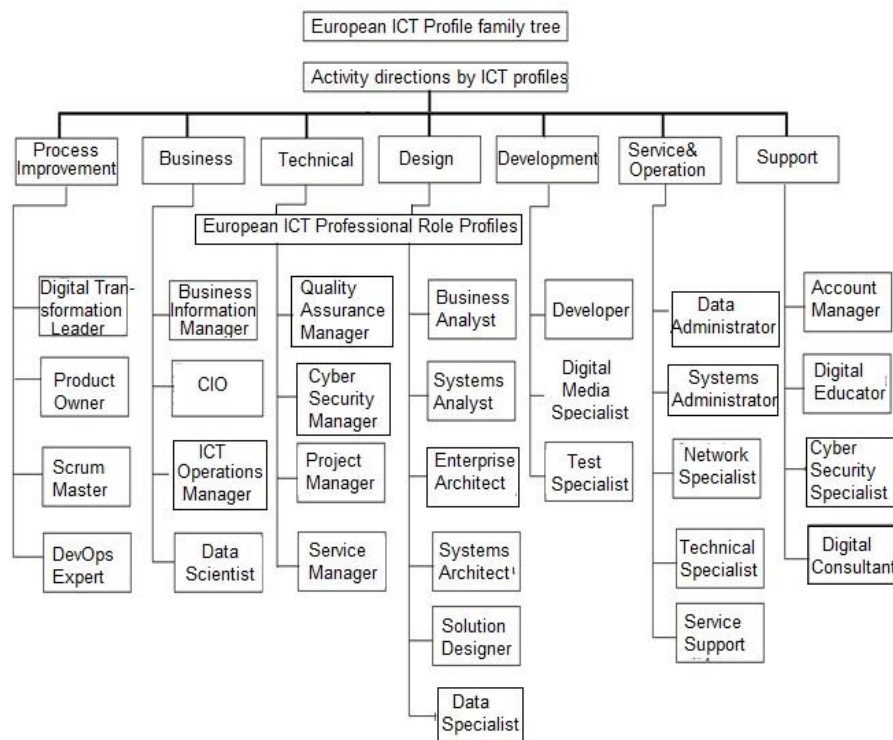- Cyber Security Manager, who manages security policy of the Information System.

Fig. 1. List of ICT Profiles in accordance with the European e-Competence Framework.

Knowledge and skills are identified for each profession in accordance with e-CF. For example, one of the competencies for the Business Analyst profile is defined as "IS

and Business Strategy Alignment" at the stage of the Planning. Knowledge and skills that are associated with this competence and are recommended by e-CF are given in Table 1.

Table 1. An example of knowledge and skills for competence "IS and Business Strategy alignment" from e-CF

#	Knowledge	Skills
1	Business strategy concepts	Analyse future developments in business process and technology application
		Understand the legal & regulatory landscape in order to factor into business requirements
2	Trends and implications of ICT internal or external developments for typical organisations	Contribute to the development of the business strategy
3	The potential and opportunities of relevant business models	Review and analyse effects of implementations
4	The business aims and organisational objectives	Determine requirements for processes related to ICT services identify and analyse long term user / customer needs
5	The issues and implications of sourcing models	Analyse feasibility in terms of costs and benefits
6	The new emerging technologies (e.g. Distributed systems, virtualisation, mobility, data sets)	Understand the impact of new technologies on business (e.g. open / big data, dematerialization opportunities and strategies)
		Understand the business benefits of new technologies and how this can add value and provide competitive advantage
7	Architectural frameworks	Understand the enterprise architecture
8	Security	Contribute to the development of ICT strategy and policy, including ICT security and quality

The improve cooperation of IT education with employers is one of the tasks of e-CF. IT education needs to coordinate educational content with the requirements of the IT industry, and therefore e-CF is a perfect tool to support such cooperation.

Professional Standards in IT industry contribute to coherence of graduates' qualifications with employers' requirements. Professional standards provide the education sector with necessary data regarding graduates' professional activity area, objects of this activity, its kinds and tasks, necessary competencies for future professionals. Professional IT standards can be applied to: the development of educational standards based on professional standards; the development of educational programs with regard to IT industry requirements; education quality evaluation in accordance with the employers' requirements; prompt update of educational standards based on changes in professional standards [25].

The compliance of the professional standard of the IS specialist with the e-CF is presented in Table 2.

Table 2. Correspondence between functional areas of Information Systems Specialist Professional Standard and e-CF descriptors for master in IS.

#	Functional Area of Professional Standard	ICT Competence Descriptor according to the e-CF	ICT Competence according to the e-CF
1	The Pre-contractual Work	A. Plan E. Manage	A3. Development of business plans E1. Development of forecasts
2	Management of Requirements	A. Plan	A2. Management of the service level
4	Human Resources	D. Enable	D3. Organization of studies D9. Staff training
5	Modelling of the Customers' Business Processes	A. Plan	A1. Reconciliation of IS and business strategy
6	Communications Management	D. Enable E. Manage	D10. Information and knowledge management E4. Relationship Management
7	Procurement Management	D. Enable	D4. Ensuring of the procurement process
8	Management of contractual relations	D. Enable	D8. Contract Management
9	Development Process	A. Plan B. Build	A5. Designing architecture A6. Applications' development B2. Systems' integration B3. Testing
10	Quality Assurance	D. Enable E. Manage	D2. Development of IS Quality Assurance Strategy E6. IS Quality Management
12	Deployment/ Implementation of IS	A. Plan B. Build	A7. Introduction of technologies B1. Design and Development B4. Solutions' Deployment
13	Management of Changes	E. Manage	E5. Improvement of processes E7. Management of Changes
14	Document Management	B. Build	B5. Development of the documentation
15	Security Management	D. Enable E. Manage	D1. Development of Information security strategy E3. Risk Management E8. Information security management

The Erasmus+ MASTIS project "Establishing Modern Master-level Studies in Information Systems" (No 561592-EPP-1-2015-1-FR-EPPKA2-CBHE-JP), the requirements of parties involved and the Professional Standard of IS specialist

became the basis for the development of Master's Degree Programs in the field of IS in Ukraine.

2.4 Competency Model for Master's Degree Programs in IS

The methodological basis for defining the contents of the Master's curriculum for the MASTIS project was the Curricula Recommendations from the Association for Computing Machinery (ACM) and the Association for Information Systems (AIS). ACM along with leading professional and scientific computing societies has endeavored to tailor curriculum recommendations to the rapidly changing landscape of computer technology. AIS serves society through the advancement of knowledge and the promotion of excellence in the practice and study of Information Systems. The Curricula Recommendations are based on a hierarchy of competency areas, competency categories, and sample competencies for IS. A set of competencies in the areas of Information Systems form the competency model presented in the document "MSIS 2016: Global Competency Model for Graduate Degree Programs in Information Systems" (Fig.2). MSIS 2016, the European e-Competence Framework and the Professional Standard of IS specialist formed the basis of the curricula for the Master's program in IS.
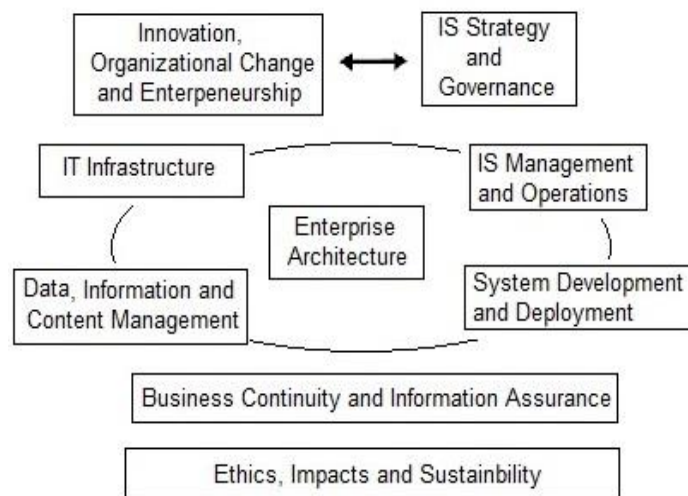

Fig. 2. Competency Model for Master's program in IS [24].

The normative part of the Master's program in IS with the MASTIS project was developed based on the survey of IT company managers in different regions of Ukraine to determine the requirements of the IT industry for the content of masters training. The competencies that IS masters have to gain during their training for successful employment in the IT industry are identified as a result of this survey. The key competencies defined by the MSIS2016 areas and summarized results of the

survey of employers regarding the specification of the requirements to the IS masters' qualifications are given in Table 2. The evaluation is carried out on a 5-point scale.

Table 3. Key competencies and generalized survey results of employers in Ukraine.

Competency areas and categories	Results of assessment of the competency importance
1. Business Continuity and Information Assurance	
Managing system recovery	3,33
Assuring safety throughout systems lifecycle	4,17
2. Systems Development and Deployment	
Selecting between systems development approaches	4,33
Designing systems	5
3. Data, Information and Content Management	
Selecting appropriate data management technologies based on the needs of the domain	4,67
Creating a scalable infrastructure for large amounts of data using parallel and distributed technologies	4,83
4. Ethics, Impacts and Sustainability	
Maintaining an ethical culture	2,67
Maintaining compliance with legislation, regulations, and standards	3
5. Enterprise Architecture	
Participating in building and maintaining an EA	3
Communicating and deploying an EA	3,17
6. IS Strategy and Governance	
Conducting IS strategic analysis	3,5
Engaging in IS strategic planning	3,67
7. Innovation, Organizational Change and Entrepreneurship	
Innovating by exploiting an emerging method or technology	4,5
Application of creative problem solving to technology-related issues	4,17
8. IS Management and Operations	
Managing IS/IT projects and programs	3
To apply widely used Project Management tools and techniques	4
9. IT Infrastructure	
Designing infrastructure solutions using external service provider(s) (cloud computing)	4,17
Infrastructure risk management	4,5

System analysis of the employers' requirements to Master in Information Systems, the structure of competency areas and competency categories, model of the educational program are shown in detail in [24] [26].

The analysis of the employer's survey results (Table 3) was used to determine the content of the educational curriculum for masters in IS in the form of a list of the following academic disciplines [18]:

- Innovations and Entrepreneurship;
- Information System Strategy;
- Data Bases and Data Warehousing;
- Information System Development and Deployment;
- Enterprise Architecture Management;
- Information System Security;
- Information Technology Infrastructure;
- Management of Information System Projects.

The list of disciplines corresponds to the areas and competency categories defined in MSIS 2016 and the list of IT professions according to e-CF. Methodological complexes for each discipline have been developed. They are based on the European format and include:

- List of competencies;
- List of Programme learning Outcomes;
- Correlation matrix of Competencies and Programme learning Outcomes;
- Correlation matrix of Programme Learning Outcomes and Courses;
- Course Descriptors;
- List of Course Learning Outcomes;
- Correlation matrix of Programme Learning Outcomes and Course Learning Outcomes;
- Themes, Theoretical component, Practical component, Learning Objectives;
- Recommended or required reading.

The content of each discipline is a unique experience of combining intelligence and creative forces of teachers, scientists, practitioners and employers from Ukraine and the European Union countries. As a result of the creative partnership teaching programs for disciplines have been developed. They integrate the requirements of the IT labor market, scientific research and practical results in the field of IS, modern teaching methods, revitalization students' activity, and the students' wishes for more pragmatic courses.

The developed methodical complexes have been reviewed at the universities – partners of the MASTIS project, at IT companies - associated project members, and at universities of Ukraine. During the 2017-2018 academic year, a pilot test was conducted for the academic disciplines of the project. Based on the results of pilot reading of disciplines, directions for further work on improving the content of disciplines, teaching methods, teaching materials, in particular, for distance learning are determined.

3   Conclusions

The experience of developed countries shows that in the modern world, science and education are becoming main structural factors of the modern economy. An important task is the development of IT education as a driving factor for the entire educational system.

One of the major challenges, which higher IT education faces, is the need to reduce the gap between theoretical knowledge and practical skills and to make the educational process flexible and adequate to ever-changing needs.

Thanks to the MASTIS project supported by the European Union's Erasmus+ program, Ukraine has received the European level-Master's degree program in Information Systems, which is harmonized with the requirements of the IT industry in Ukraine and the European requirements for IT professions.

The prospect of further research lies in finding ways and developing models for effective adaptation of students of IT specialties to the business processes of IT companies within the competency education paradigm.

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