Teaching the Analysis of Information Technologies in Master Programs of IT-Area

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Abstract. The article presents the experience of teaching the discipline "Analysis of information technologies" in master program of IT-area. Analysis of IT is a relatively new and important discipline included in the curricula of master's curriculum in IT-area. Students must be able not only to master new technologies and platforms, but also to analyze the feasibility of their application, to develop corporate standards and functional profiles for information systems on the principles of open systems, to prepare the sets of tests to establish the conformance of the information systems to standards and profiles. In the South Ural State University, this discipline deals with the development of the information society, various indices estimating the level of readiness of society to effective function in the information environment: the networked readiness index, the e-government index, the ICT development index, and the knowledge economy index. The course includes a section on the study of e-competencies and qualifications. This deals with the European qualifications framework, their compliance with the Russian qualification framework, the European framework for e-Competence. A separate issue is the study of the Russian professional standards, defining 35 different sub-fields in the area of communication, information and communication technologies. The study of specific job functions permit the graduate to understand the requirements to him in the labor market clearly and to determine the point of the beginning of his career and its further development trajectory. Due to the proposed content, the course provides the teaching of normative methodological, consulting and consortium activities. The proposed syllabus provides the implementation of a number of professional competences of graduates related to management, consulting and taking part in the examination of both already existing and absolutely new information technologies. There are the results of questioning of students upon the completion of teaching. Analysis of students' responses showed a high level of awareness of their competences and capabilities, understanding and adequate assessment of their own position in the contemporary IT-area. This discipline is the important final stage of masters' preparation in the field of information technology.

Keywords: analysis of information technologies · e-competences · professional standards · federal state educational standard · labor market requirements

1   Introduction

The current state of development of information technologies shows that there are many different specialties in the labor market associated with the IT-area: programmers, database administrators, IT-analysts, specialists in information resources, software architects, web- and multimedia-developers and others. The Russian Federation has a wide list of professional standards, which systemize the requirements, obligations and competence for the various IT-professions (a complete list of professional standards is publicly available on the resource [1]). There is no doubt in the necessity of orientation of universities' educational programs on the requirements of IT-professions in the relevant professional standards [2]. At the same time, universities prepare bachelors and masters in specialties not clearly correlated to the names of professions and positions that they may hold in future. Thus, in the Russian Federation masters preparation programs in IT-area are determined by Federal State Educational Standards (FSES) as the following: Fundamental Informatics and Information Technologies [3]; Applied Mathematics and Informatics [4]; Mathematics and Computer Science [5]; Mathematical Software and Administration of Information Systems [6]; Informatics and Engineering [7]; Information Systems and Technologies [8]; Applied Informatics [9]; Software Engineering [10], Information Security [11]; Information Communication Technologies and Communication Systems [12]; Business Informatics [13]. As we see, they are far from usual names of IT-professions: administrator, programmer, etc.

Therefore, graduates of master's programs often have a problem of identity in the labor market. The course "Analysis of information technologies" is intended, in particular, to help solve this problem by the means of cataloging the fundamental and applied knowledge and skills acquired by students during the studying, to determine their own position in IT-sphere. This course is taught in a magistracy of the School of Electrical Engineering and Computer Science of the South Ural State University [14]. This goal is achieved through the study of scientific and methodical bases, the system of standards of information technologies and global development concepts to the IT-area.

2   Review of the Course Content

The course "Analysis of information technologies" was compulsory for master programs of specialty "Fundamental Informatics and information technologies" in Russia in 2011–2013, as well as strongly recommended since 2014. Still the master curriculums have very often this discipline. This is because at this discipline the students learn to work with such objects of professional activity as standards, profiles, open specifications and methodology of specification of information systems, documentation of systems, products and services; they study the methodology of determination of systems' and products' conformance to initial standards and profiles.

One of the leading textbooks for this discipline is the book by V.A. Sukhomlin "Introduction to analysis of information technologies" [15]. The main sections of this textbook are:

1. System of standards and concept of open systems;
2. Organizational structure of the system of IT-standardization;
3. Semantics, definition and principles of profiles' creation;
4. OSE-profiles;
5. Methodology and system of standards POSIX OSE;
6. Creation of profiles in POSIX standards;
7. Testing of conformance in POSIX-standards;
8. OSI-standards;
9. Reference model OSI;
10. Specifications of services and protocols;
11. Model of application level of OSI;
12. Testing of conformance in OSI-standards;
13. Global information infrastructure.

As can be seen, the focus of this textbook is made on the study of the system of standards of information technologies and methodology of profiling and testing the conformance of information systems to OSE and OSI profiles. According to the textbook, the course does not presuppose the extensive coverage of general trends of modern development in various IT-fields as well as the study of conformity of professional knowledge and skills received by graduates to the requirements of the real domestic and foreign labor market.

Another typical course program is proposed by Prof. A.V. Klyuev from the Nizhny Novgorod State University [16]. The main sections of this program are the following:

1. Term of an information technology;
2. Stages of IT development;
3. Problems of IT usage;
4. Basis of data transmission;
5. Channel capacity;
6. Methods of commutation;
7. TCP/IP protocol stack;
8. OSI model;
9. Satellite communications.

This program focuses in studying the technical aspects of computer networks in the framework of the reference model OSI. This situation is typical for many programs of the course "Analysis of information technologies" [17, 18]. They have a sufficiently detailed study of the reference model OSI, methods of specification of services and protocols, standards of names and addresses. However, there are a completely absent or briefly mentioned global trends of IT-development, as well as how a graduate can identify in the dynamic IT-sector of economics and what specific knowledge is required from him when working at varying positions in the Russian and foreign IT-companies.

Research on existing programs considering a course in various universities of Russia shows that "Analysis of information technologies" often refers to a somewhat narrower vision of information technology as a system, product or service subject to profiling and then testing of conformance to predetermined standards and profiles. At the same time, the preparation of normative methodical, consulting and consortium activities graduates is seldom addressed in the context of the discipline.

In accordance with FSES "Fundamental Informatics and Information Technologies", the consulting activity of masters involves the development of analytical reviews in the field of information technology, participation in departmental, sectoral or government expert groups for examination of projects, consulting services. The consortium activity supposes a participation in international projects to develop open specifications for new information technology implemented by international professional organizations and consortia based on the principle of consensus; a participation in professional online communities in specific areas of development of information technologies. The normative methodical activity of the student indicates his participation in the development of corporate technological policy in a corporate information infrastructure on the principles of open systems and a participation in the development of enterprise standards and profiles of functional standardization of applications, systems, and information infrastructure.

FSES "Software Engineering" does not imply either normative methodical, consortia or consulting activities for their graduates. Available activities for graduates of the "Software Engineering" are research activities, project activities and production activities. In a sense, consulting activities are available for graduates of this specialty due to such professional goals as: "participation in the development of operating systems" and "organization of industrial testing of the created software".

FSES "Informatics and Engineering" misses there types of professional activity of the graduates too. Listed in the FSES professional tasks of graduates only indirectly reflect the possibility of future work in the development of full specifications of the system and methods of testing its conformity, suggesting their participation only on the level of the implementer of specific tasks on creating, profiling and use of new information technologies.

In connection with the foregoing, we cannot speak about the possibility of work of graduates "Software Engineering" and "Informatics and Engineering" in international community on the design and standardization of new information technologies without any additional qualification in the relevant field.

These three areas were not chosen randomly for the comparison. They represent an example of the transition from the most general view on information technology ("Fundamental Informatics and Information Technologies") to a more practice-oriented activities within a particular section of IT-industry ("Software Engineering") and, ultimately, to the most techno-oriented, the most narrow and specific field of professional activity ("Informatics and Engineering"). Traditionally, the curricula of a specialty "Fundamental Informatics and Infor-

mation Technologies" has a wide range of disciplines, covering almost all of the modern sections of IT-sphere: parallel and distributed programming; Java; multimedia technology; web systems; corporate, including parallel, databases; modern technologies of software development; administering of supercomputer systems; neural networks and machine learning; program methods of information protection; markup languages; management systems for IT-projects and IT-companies, etc. "Software engineering" traditionally closely examines the methodology and technology of software development, software lifecycle including design, development, testing, implementation and support; and the analysis of these processes. The specialty "Informatics and Engineering" orients its graduates more on practice in the development of complex technological products based on modern information technology, supposes development of software and hardware systems and projects by students; that is, it is focused on the implementation of program-controlled objects in industrial production.

The decision of professional tasks for the consultation of new information technology development and the participation in regional and departmental bodies of standardization of information technology is imperative for graduates of all these areas holding the positions of the head of IT-department, the project manager and other positions involving management of IT-processes, not just implementation of a system. Hence, there is the usefulness of the course "Analysis of information technologies" in the curriculum for all master IT-specialties.

The absence in the typical content of the course "Analysis of information technologies" of didactic units required for the preparation of students to the normative-methodological, consulting and consortium activities, leads, primarily, to the fact that universities do not choose these activities in their educational programs (the selection of certain types of activities, to which a graduate will be ready, is proceeded by each university independently from the general FSES). As a consequence, the rejection of certain activities imposes restrictions on future places of employment of graduates and even indirectly affects their future careers. Indeed, to perform the duties of an expert of an international group on developing a standard for a new information technology will not be available for the graduate, as he do not have the appropriate skills. Both scientific and academic mobility of students is also more restricted in the absence of studying the considered activities.

To overcome the possible restrictions the School of Electrical Engineering and Computer Science of the South Ural state University has a course "Analysis of information technologies" involving the following topics:

1. Information society;
2. Scientific and methodical basis of IT;
3. The concept of open systems;
4. The concept of a global information infrastructure;
5. Multilevel model of standardization system;
6. Reference models of the main fields of IT;
7. Principles and methods of development of the information systems profiles;
8. Methodology of conformance testing;

9. European qualification framework;
10. European e-Competence framework;
11. Russian professional standards in IT-area;
12. Indexes of IT-development: network readiness index; index of e-government development; index of ICT development; index of the knowledge economy;
13. Information analytics;
14. Mental maps of IT-analysis.

The proposed program of the course covers both the aspects of methodological nature, and sections devoted to practical activities. For example, during practical lessons students:

1. closely study the international and national standards in the field of information technologies operating at the moment, and assess their use in specific examples of implementation of information products and services;
2. develop and estimate a model of their own information product in the context of open systems;
3. study the differences between implementations of a series of open systems standards in different countries;
4. study the international, regional and national organizations of standardization in the IT-area and evaluate their independence from governments and industrial corporations;
5. study the scope and organization of work of the profile committees of the international standardization organizations in the IT-area;
6. learn the criticism and formulate ways to the further development of various reference models of the main IT-fields;
7. create profiles for information system developed as a master's project; perform a partial test of the conformance of their product to the developed profile;
8. conduct a detailed comparative analysis of the educational qualifications framework in different countries;
9. closely study the European system of qualifications and formulate ways of its further development;
10. form their own e-Competence profiles;
11. conduct compliance between the typical IT-professions and their private profile;
12. work with projects providing vacancies of IT-companies, and conduct their compliance with the requirements of the e-Competence profile;
13. analyze their own work functions, which students performed during the internship or when they had a real experience in IT-companies, in the context of the Russian professional standards;
14. establish compliance between the IT-professions, requirements for education and practical experience and a list of possible positions for these professions;
15. predict the level of various indices characterizing the development and use of ICT in a public life and create their own recommendations for the improvement of the component indicators;
16. try to implement nontrivial logic of data processing;

17. justify the use of sophisticated algorithms of information analytics;
18. produce a processing big data with specific examples.

Thus, it is possible to assume the described course content necessary and relevant for all IT master degree programs in preparation to normative methodical, consulting and consortium activities.

3   Analysis of studying results

The course "Analysis of IT" realize the following competences of FSES [3]:

1. the ability to understand and to develop corporate standards and policies for the development of the corporate information technology infrastructure on the principles of open systems (professional competence No. 9);
2. the ability to prepare analytical reviews of the area of the applied mathematics and IT (professional competence No. 13);
3. the ability to perform the work as an expert in the organizational, sectoral or government expert groups on the examination of projects (professional competence No. 14);
4. the ability to work in international projects on the development of open specifications for new information technologies implemented by international professional organizations and consortia on the basis of consensus principle (professional competence No. 15);
5. the ability to participate in activities of professional network communities in specific areas (professional competence No. 16);
6. the ability to understand the corporate policy for increase of social responsibility of business to society, to participate in its development (No. 17).

The aim of the teacher is to have students attained a certain level of mastery of the listed competences. The mastery of each competence is carried out not in the only topic of the course but in different topics because in order to master the comprehensive ability to certain types of activities you need to build a consistent and logically coherent system of learning [19]. Fig. 1 reflects the implementation of these competences in various topics of the course.

Of course, students when learning are not interested in such sufficiently abstract things as competences, which they should have by the end of study. Besides, there is no clear conformity between the competences of the FSES and the curriculum in which they should and can be implemented. However, at the beginning of studying of any discipline, each student wants to understand why he needs this discipline, what specific knowledge and skills he will ultimately receive and how it can be applied in his future professional activities.

From the student's point of view, the course should give him the answers to the following questions:

1. At which IT-field shall I be the best?
2. What are my real professional skills?

	Information society	Scientific and methodical basis of IT	The concept of open systems	The concept of a global information infrastructure	Multilevel model of standardization system	Reference models of the main fields of IT	Principles of development of the information systems profiles	Methods of development of the information systems profiles	Methodology of conformance testing	European qualification framework	European e-Competence framework	Russian professional standards in IT-area	Indexes of IT-development	Information analytics	Mental maps of IT-analysis
No. 9		▨	▨				▨								
No. 13	▨									▨	▨		▨		▨
No. 14												▨		▨	▨
No. 15			▨	▨	▨	▨	▨	▨							
No. 16	▨				▨					▨	▨	▨			
No. 17	▨	▨	▨	▨				▨	▨			▨	▨	▨	▨

Fig. 1. Implementation of competences in various topics of the course "Analysis of IT"

3. Where shall I work?
4. How will employers evaluate me?
5. Do I satisfy their expectations and requirements?

They gradually answer for themselves on these questions during the lessons of the course "Analysis of information technologies".

At the end of the course the anonymous survey of students was carried out, which included the following questions:

1. Which topic of the course did you like best? Why?
2. Which topic of the course would you like to reduce? Why?
3. You've studied the requirements of professional standards and the European e-competence framework. How do you evaluate your own professional skills?

For the first two questions, a syllabus with a list of studied topics was given as variants of answers. Students could choose multiple answers. For each answer the students could write an explanation.

Answers to the last question were the following:

1. Enough for that position which I have now.
2. Enough for the wished position, which I shall try to get after the graduation
3. I discovered I don't match the requirements to the wished position in Russian company, I'll start from the lower position
4. I discovered I don't match the requirements to the wished position in international company
5. I'd like to continue scientific researches, I plan to enter a PhD program

The students of one academic group participated the survey, there were eight students. The survey was carried out after the final test of the course.

The results of the survey

For the first question about the additional study of some topics, students indicated the following answers:

1. Concept of open systems
2. European e-Competence framework

3. Profiling of information systems and testing their conformance to profiles
4. Global information infrastructure
5. Indexes of development of IT-area
6. Reference models of basic sections of IT-area

In the explanations students pointed to the usefulness of the chosen topics for their personal and professional development.

These responses indicate a high interest of students in key sections of the course which are most responsible for the formation of the required by FSES competences. Indeed, the topic "Concept of a global information infrastructure" implements, in particular, a competence No. 14. The topic "Concept of open systems" ensures students' attainment of the competences No. 9 and 15. According to the program of the course, the competence No. 13 is implemented in "Information society" and "Indexes of IT-development", which also entered the list of answers given by students in the survey.

Fig. 2 shows the topics of the course that were selected by students as the most useful and interesting.

	Information society	Scientific and methodical basis of IT	The concept of open systems	The concept of a global information infrastructure	Multilevel model of standardization system	Reference models of the main fields of IT	Principles of development of the information systems profiles	Methods of development of the information systems profiles	Methodology of conformance testing	European qualification framework	European e-Competence framework	Russian professional standards in IT-area	Indexes of IT-development	Information analytics	Mental maps of IT-analysis
No. 9			■				■								
No. 13										■			■		
No. 14						■									
No. 15			■			■	■						■		
No. 16										■					
No. 17			■										■		

Fig. 2. The most useful and interesting topics of the course "Analysis of IT" from the student's point of view

It can be concluded that most interested topics of the course cover all necessary competences. The teaching experience of the course with the suggested topics can be considered successful from the point of view of the task of achieving the selected competences.

In answers to the second question, the students, despite the anonymity of the survey, did not give meaningful answers. Mostly the responses were "No topic would be removed from the course", "I think all topics are important", "There was only one answer", "I would like to exclude the topic "Concept of open systems", as I have not attended classes where it was taught, and did not quite understand this topic in the self-study". It is advisable not to put this response as a relevant for selection, since the student acknowledged that an independent study of the said topic did not allow him fully realizing its extreme importance when considering the current state of development of the IT-sector.

Answers to the third question proved to be disappointing for supervisors of the master program: unfortunately, none of the eight students who participated the survey, gave the answer "I'd like to continue scientific researches, I plan to enter a PhD program". Fig. 3 shows that all the remaining responses were divided equally: two choices for each answer.
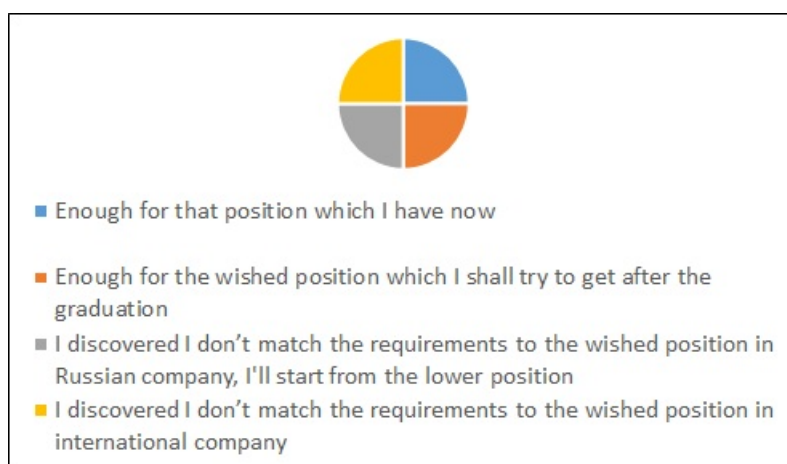

Fig. 3. Distribution of students' answers to the question "How do you evaluate your own skills?"

In the explanation to the selected answer, the students wrote: "I understand what I need to strive", "I have a clearer idea of what I can and what I can claim", "Now I have a picture of my achievements, I know in what area my skills are high priced and I hope to get a career in some international companies in accordance with the direction of my achievements", "Maybe someday I will want to do research and to attend the PhD program, but now I understand my place in the world of IT and first I want to get a practical experience".

These responses show a high level of awareness of their competences and capabilities, understanding and adequate assessment of own position in the modern world. Ultimately, we can conclude that the course "Analysis of information technologies" greatly contributed to the formation of a coherent picture of IT-area, led to the understanding of the further professional growth and motivated to professional mobility.

4   Conclusions

This article describes the experience of teaching the course "Analysis of information technologies" in the magistracy of the School of Electrical Engineering and Computer Science of the South Ural State University. The course exists in

the master curriculum "Fundamental informatics and information technologies" and provides studying of normative methodological, consulting and consortium activities. It is advisable to recommend the course "Analysis of information technologies" for other master programs in IT-area.

The analysis of the content of various programs of the same course in different universities showed that traditionally the general trends of modern development in various IT-fields are not supposed to be lighted, as well as the conformance of the professional knowledge and skills received by graduates and the requirements of the real domestic and foreign labor market. However, such content is reasonably in demand from students and potential employers. So, it is recommended to include to the course program the questions related to the concepts of open systems and the global information infrastructure, Russian and European qualification framework in IT-area, educational and professional requirements for typical professions in various IT-fields, general and specific labor functions of employees in various positions.

The proposed syllabus provides the implementation of a number of professional competences of graduates, without which it is inconceivable to perform the professional responsibilities to guide, advice and participate in examination of both already existing and absolutely new information technologies.

Listed in the article various types of practical exercises of the course allow fully recognizing its usefulness for the professional development of students and identifying the ways for their further development. "Analysis of information technologies" needs to turn from an abstract discipline to a relevant course that have a high potential for the final logical completion of the master program in IT-area.

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