Pododimenko I.I. [1]

Qualification levels of specialists in computer sciences training in the conditions of IT education development: the experience of Japan

[1] *Pododimenko Inna Ivanivna, post-graduate student*
Khmelnytskyi National University, Khmelnytskyi, Ukraine

Abstract. The most urgent problem of competitive specialists training in higher educational establishments in the conditions of socio-economical dynamics of the transformation of Ukraine and the integration of our country into the world society has been considered. Especially the comparative analysis of professional training of specialists in computer sciences in Japan where extremely precipitous economic and technological changes influence on the continuous modification and the upgrading of curricula and teaching techniques has been conducted. The attention is focused on the features of the organization of IT specialists training at different qualification levels at the most prestigious universities of Japan. The characteristics of the peculiarities of Bachelor's, Master's and Doctor's academic programs which are suggested at Japanese universities have been presented. The innovative achievement of the universities of Japan is the organization of study on the basis of the individually-oriented curriculum at the direct participation of the academic advisor. The effectiveness of the model of training of specialists in computer sciences in the higher education system of Japan testifies the presence of positive approaches and ideas and is the basis for the implementation of this model into the practice of native higher education establishments. The importance and necessity of the implementation of positive foreign experience into the training of professionals for professional activity in the IT industry in Ukraine has been emphasized. The prospects for further research of training practice of specialists in this field of knowledge have been outlined.

Keywords: *qualification levels, training programs, credit points, Bachelor's degree, Master's degree, Doctor's degree.*

Introduction. The integration of Ukraine into European and world educational space and the permanent upgrading of quality of specialists training are those organically interrelated priorities that come forward as key in the understanding of modern strategy of the development of higher education in Ukraine taking into account the basic principles of the Bologna Process. In this aspect the question of qualification and specialization of specialists of all industries on the whole and industry of information communication technologies in particular acquires the important value as the phenomenon caused by technological factors that determine the structure of the labour market and assist to personal and professional development of students. Among the factors that negatively influence on the development of Ukrainian industry of information technologies the deficiency of personnel occupies a key place. The maintenance of professional training of graduates of IT profile direction causes serious complaining from the leaders of native IT business [3].

The urgency and necessity of solving this problem is traced at the level of legislative and normative documents of government and the Ministry of Education of Ukraine. In particular it is envisaged "to implement at higher educational establishments the specialists training in new specialties in the field of information communication technologies in accordance with the necessities of the market" by the Law of Ukraine "On fundamental principles of the development of information society in Ukraine in 2007-2015" [1]. It should be especially noted that the realization of assigned task must be based on the results of study of the latest versions of the international classification systems concerning education, the structure of the information technologies market, the IT career options and also the academic and professional qualification framework structures.

And in the Letter of the Ministry of Education of Ukraine "Concerning the improvement of the training quality of specialists for IT industry" (the Letter of the Ministry of Education and Science, Youth and Sport of Ukraine from 16.02.2012 No 1/9-119) [2] the necessity is marked to revise the maintenance of normative disciplines that are taught during the training of specialists in the marked field of knowledge in accordance with the current development achievements of information technologies. In addition the Ministry also recommends take appropriate measures concerning the improvement of the level of students' practical training with the involvement of employers into its organization due to the implementation of different forms of students' internship in IT companies and the development and implementation of the adapta-

tion on the field programs for graduates of higher educational establishments.

The aim of the study. To investigate the academic qualification levels of specialists in computer sciences professional training at the universities of Japan, in particular the ways of obtaining the higher education, the maintenance of the Bachelor's and Master's training programs and the duration of study.

Theoretical framework and research methods. Many researchers contributed to the problem of the training of engineers in the information communication technologies industry in Ukraine and abroad. The problem of the training of future professionals in the field of computing is investigated in the dissertations of A. Gudzhiy (the teaching of programming at higher education), H. Kozlakova (the continuous training of specialists in computer systems), T. Morozova (the theoretical-methodological fundamentals of higher information technology education), Z. Seidametova (the methodical system of continuous training of specialists in information technologies), S. Semerikov (the basics of fundamentalization of computing courses teaching), et al. The proved by scientists technologies and methodologies of training of modern specialists in computer sciences have general character and are successfully used in the practice of ICT engineers training.

The study of foreign experience acquires great importance for the training of highly skilled, competitive specialists in the conditions of globalization and integration processes. The problems of the professional training of specialists abroad are investigated in the researches of Ukrainian scientists in comparative professional pedagogics such as N. Bidiuk, T. Desiatov, V. Kovalenko, T. Koshmanova, K. Korsak, N. Patsevko, L. Pukhovska, A. Sbruieva, N. Sobchak, B. Shunevych, et al.

The research works of V. Bykov, B. Vulfson, O. Karelina, I. Kozubovska, V. Kukharenko, N. Nychkalo, P. Stefanenko, N. Syrotenko, et al are dedicated to the aspects of lifelong education and distance education. In particular, in the opinion of N. Nychkalo, current tendencies in development of continuous professional education stipulated the requirements of permanent flexibility in the development and updating of curricula and programs that assists the providing of access to study at different levels of education, creation such conditions to every person that he/she would have the opportunity to begin to study, cut it short in the case of necessity and then continue it again at any stage [4].

The scientific pedagogical researches on the problem of development of Japanese pedagogical theory and practice with the aim of creative implementation of progressive ideas at the native educational practice were conducted by Yu. Boiarchuk, A. Dzhurynskyi, V. Elmanov, V. Kudin, I. Ladanov (the modern state of the education system), O. Myhailychenko, Ya. Neimatov, O. Ozerska (the professional training of English language teachers at higher educational establishments), N. Paziura (the theory and practice of intercompany training of specialists), V. Pronnikov, N. Repetiuk (the formation of education in modern Japan), T. Sverdlova (the theoretical fundamentals of the process of education humanization), L. Tsarova (the aesthetic culture of personality in modern school education).

Results. In the conditions of Eurointegration processes the achievements of Japan are of especial perspective for the transformation of the native system of higher education. On the modern stage of development of society, like the European, the Japanese system of higher education, not taking into regard its centuries-old history, was confronted with the necessity of reformation to answer the constantly growing public requirements to the universities and colleges for providing the stable development of the society. Having regard to the dynamism of globalization processes the extreme reforms were conducted by the government of Japan that substantially influence on the activity of the system of higher education, for example: the incorporation of national universities; the implementation of the system of accreditation and certification, the evaluation of quality of higher education and its internationalization. The tendencies concerning the quality increasing of higher education of Japan are traced at the level of legislative, conceptual documents of the government, department of education, management of education.

Also it should be noted that the system of higher education of Japan is recognized as the example of the variety of mass higher education in the highly industrialized country and is presented by higher educational establishments of different type and category that differ by their functions, tasks, academic standards, prestige, status and sources of funding. And among the 200 best universities of the world in the training of specialists in computer sciences and information systems according to the rating of "QS World University Rankings by of Subject 2013 – Computer Science & Information Systems" 8 Japanese universities were noted: the University of Tokyo, Kyoto University, Osaka University, Tokyo Institute of Technology, Kyushu University, Waseda University, Keio University and Tohoku University [13].

As shown in Figure 1, the training of future personnel for IT industry at the universities of Japan is three-stage: Bachelor's degree – Master's degree – Doctor's degree. In addition, in the country for a long time the discussions concerning the increase of amount of qualifications, the experiments with the short-term training programs are conducted.

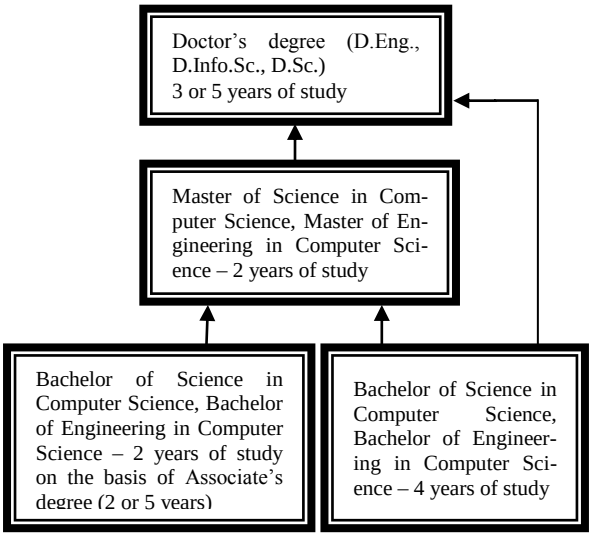

Figure 1. Qualification levels of specialists in computer sciences professional training

The baccalaureate programs (Bachelor's degree or Gakushi) are the basis of university training. The basic university undergraduate program consists of 4 years of full-time study and gives the opportunity to obtain a degree of Bachelor of Computer Sciences (Bachelor of Science in Computer Science, Bachelor of Engineering in Computer Science). Thus, at Waseda University it is possible to obtain a degree of Bachelor of Science in Computer Science after the successful fulfillment of four years of full-time studies and acquiring of 136 credit points [8] and 132 credit points at Osaka University [7].

Students study such courses: elective required "Circuit Theory", "Logic Circuits", "Fundamentals of Programming", "Algorithms and Data Structures", "Computer Systems", "Signal Processing", "Information Network Systems", "Operating Systems", "Information Security", elective "Electrodynamics", "Electronic Circuits", "Communication Systems", "Software Engineering", "Information Theory", "Transmission Theory", "Wireless Communication", "Multimedia Systems", "Mobile Communications", "Network Engineering", "Image Processing", conduct computer science and engineering laboratory, 4 research projects, do internship and prepare graduation thesis [8].

Besides this the training of high competitive ICT engineers takes place with the help of great number of elective courses which is the distinguishing feature of Waseda University among other universities of Japan and allows to conduct comprehensive training and research in innovative information technologies such as hardware (system VLSI design, super high performance computer architecture), software (programming language, compilers, OS, software engineering, algorithm, artificial intelligence), networks (internet, digital broadcasting, satellite communication, multimedia, mobile, security, GRID, ubiquitous networks), computer network applications (humanoid, information retrieval, computer music, bioinformatics), etc [6].

The Major in Computer Science is pursued in research groups in information communications, information science, and information engineering at the graduate school of science and engineering with the aim of producing specialists who support the future IT revolution in the fields of technology, research and education and promoting basic and advanced research contributing to Japan's IT industries.

Also, at Waseda University the graduate school curriculum is organized with consistent links to the undergraduate curriculum. This enables to cultivate IT experts with planning qualities and contributes to the stimulation of research minds in undergraduate and graduate students.

Students aiming to obtain a degree of Bachelor of Engineering in Computer Science and therefore taking the curriculum of the Department of Computer Science at Tokyo Institute of Technology [5] learn specialized knowledge across a wide range of fields, from information theory (the mathematical systemization of methods for expressing and conveying information) to software, hardware, integrated circuits, signal processing, communication systems, the Internet, multimedia, artificial intelligence and more. The objective of the education provided by the department is not to make students learn computer programming so that they can be mere users. Rather faculty seeks to develop people with a deep understanding of the principles of the information technology embedded in all social systems nowadays. Working as world-leading, cutting-edge researchers and engineers, such people will be able to develop new computer and communication systems and pioneer applications in multimedia, artificial intelligence and other fields.

Students study the following courses: "Fourier and Laplace Transforms", "Probability Theory and Statistics", "Basic Integrated Circuits", "Switching Circuit Theory", "Foundations of Computing", "Programming", "Mathematical Logic", "Automata and Formal Languages", "Computer Logic Design", "Algebraic System and Coding Theory", "Discrete Structures and Algorithms", "Computer Architecture", "Operating Systems", "Communication Theory", "Numerical Analysis", "Foundations of Electrical Circuits", "Foundations of Artificial Intelligence", "Compiler Construction", "Foundations of Functional Analysis", "Integrated Circuit Design", "Linear Circuit Theory", "Digital Communications", "Signal Processing", "Pattern Recognition", "Computational Biomedical Knowledge", "Mathematical Programming", "Linear Electronic Circuits", "Communication Networks", "An Introduction to Databases", "Computer Networks".

It should be noted that to promote undergraduate/graduate integrated education, at the universities of Japan it have been made possible for students who will continue on to the graduate school to take graduate-level lecture courses for preemptory credit while they are in the fourth year of the undergraduate course (3+2 Program (Dual Bachelor's Master's Degree Program). It creates a way to complete a master's degree in five years from the time of initial enrollment in the college.

In the conditions of higher education decentralization every university of Japan that conducts the professional training of Bachelors of Computer Sciences independently sets the curricula content requirements, the amount and the sequence of passing of educational courses for training of competitive specialist in accordance with the labour market requirements.

The concept of curriculum in Japan substantially differs from the native understanding. The innovative achievement of the universities of Japan is the study organization on the basis of the individually-oriented curriculum composed every term from with the coordination of the department and ratification in the dean's office. Such approach allows the student to elect educational courses, leaning on taking into account own individual interests, inclinations and capabilities. In addition, the success with forming and becoming of future competitive specialist in a great deal depends upon the correctly built educational process with the direct participation of academic advisor that bears the direct responsibility for students' training to their future profession. According to [14], the academic advisor is a faculty member who consults a student on scientific questions and choosing their major, helps student to compose an individual curriculum during the registration process and who is also student's seminar instructor. The applying of the personality oriented pedagogical techniques (dialogue, the choice modeling approaches, the free exchange of ideas, the success advancing) by the academic advisor assists the realization by future specialists the necessity of permanent self-

education and self-development, comprehensive determination of the level of own possibilities, vital aims and reference-points [12].

It should be mentioned that on the basis of an Associate's degree the graduates of junior colleges (2 years of study) and technical colleges (5 years of study) have the opportunity to obtain a Bachelor's degree by acquiring minimum 62 credit points during study on the two-year academic program approved by the National Institution for Academic Degrees and University Evaluation (NIAD-UE).

The highest postgraduate degrees of university training in Japan are a Master's degree or Shushi and a Doctor's degree. It is possible to take a Master's degree after two years of successful full-time studies that also implicates deep scientific and professional specialization. In addition, a holder of Master's degree has a right to conduct teaching activity on the position of a teacher assistant. The Master's degree programs are divided into coursework, research and professional ones, related to implementation of certain projects.

For example, the Division of Computer Science at Hokkaido University [11] offers educational and research programs geared toward creating engineers and researchers who will support a knowledge-based society and become active in the international arena. Through systematic teaching of the fundamentals and applications of the two relevant pillars of knowledge – software science and mathematical science – potential engineers and researchers are trained to properly handle the vast amount of diverse information available in the digital network era. The major research fields are Knowledge media, Knowledge base, Knowledge discovery, Algorithm theory, Fundamentals of information science, Data science, Prediction and recognition theory, Human-machine intelligent system. The major curriculum is the following: "Advanced Software Engineering", "Advanced Computer Architecture", "Knowledge Base", "Knowledge Discovery", "Information Knowledge Networks", "Theory and Practice of Algorithms", "Introductory Functional Analysis for Mathematical Science", "Advanced Pattern Information Processing", "Advanced Theory of Programs", "Advanced Probability and Data Analysis", "Foundations of Informatics", "Advanced Computational Mathematics", "Large-scale Discrete Computation". To obtain a degree of Master of Engineering in Computer Science after two years of successful full-time studies students need to obtain 30 credit points, pass the qualification examinations and defense the graduation thesis.

The Graduate School of Informatics at Kyoto University provides graduate programs of study leading to the Master's and Doctoral degrees [9]. To receive the Master's Degree (Master of Engineering in Intelligence Science and Technology), every student is required to take at least 30 credits, to submit a thesis in the fields of specialization, and to pass an examination on the thesis. To cultivate a wide scope, the student may take subjects offered not only by his or her major department but also by other departments. A Doctoral degree (Doctor of Engineering in Intelligence Science and Technology) requires original research of high grade in an academic field. To receive the Doctoral Degree, student is required to take at least six credits of subjects offered in this school and to pass an examination on the thesis submitted.

Master students enter the Graduate School in April, while doctoral students can start their activities in April or October. In general the Master's degree requires two academic years of study and the Doctoral degree three years. Common Subjects for Master's Program: "Perspective in Informatics". Required Subjects for Master's Program: "Advanced Study in Intelligence Science and Technology". Elective Subjects for Master's Program: "Introduction to Bioscience", "Introduction to Cognitive Science", "Introduction to Information Science", "Introduction to Bioinformatics", "Seminar on Biological Information Processing ", "Seminar on Cognitive Science", "Foundation of Software Science Pattern Recognition, Adv.", "Artificial Intelligence, Adv.", "Foundations of Intelligent Systems", "Multimedia Communication", "Speech Processing, Adv.", "Language Information Processing, Adv.", "Computer Vision Visual Interaction", "Advanced Research in Intelligence Science and Technology". Elective Subjects for Doctoral Program: "Advanced Seminar on Intelligence Science and Technology", "Advanced Seminar on Biological and Cognitive Processing", "Advanced Seminar on Foundation of Software Science", "Advanced Seminar on Intelligence Media", "Advanced Seminar on Application of Multimedia", "Advanced Seminar on Gene Informatics".

The highest degree that can be obtained at the universities of Japan is a Doctor's degree or Hakushi, envisages three years of study on the basis of Master's degree and obtaining of 50 credit points or five years of study on the basis of Bachelor's degree, passing qualification examination and defense of dissertation on the basis of the individually conducted research work. For example, at the Tokyo Institute of Technology the degree of Doctor of Science in Mathematical and Computing Sciences can be obtained [10].

Conclusions. The current results suggest that higher education in Japan concerning the specialists in computer sciences training is multistage, accessible and variable. The experience of Japan is useful for the implementation into the practice training of IT specialists in Ukraine form the positions of variety of programs that answers both the demands of employers and personal requirements of students; the implementation of the individually-oriented curriculum; the smooth transfer from one stage of study to another. The multidimensionalness of the problem of highly skilled competitive specialists in computer sciences training is acknowledged at the state level in Ukraine and in the world. Therefore the perspective for subsequent scientific research is considered in the improvement of professional training of Bachelors of Computer Sciences in the native system of higher education by the implementation of progressive ideas of the experience of Japan.

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Пододименко И.И. Квалификационные уровни подготовки специалистов по компьютерным наукам в условиях развития ИТ-образования: опыт Японии

Аннотация. Рассмотрена чрезвычайно актуальная проблема профессиональной подготовки конкурентоспособных специалистов в учреждениях высшего образования в условиях социально-экономичной динамики трансформации Украины и вход нашего государства в мировое сообщество. В особенности сделано сравнительный обзор профессиональной подготовки специалистов по компьютерным наукам в Японии, где чрезвычайно стремительные экономические и технологические изменения способствуют постоянной модификации и усовершенствованию программ и методов обучения. Внимание акцентируется на особенностях организации подготовки ИТ-специалистов на разных квалификационных уровнях в самых престижных университетах Японии. Представлено характеристику особенностей бакалаврских, магистерских и докторских образовательных программ, которые предлагаются в японских университетах. Инновационным достижением университетов Японии есть организация обучения на основе индивидуально-ориентированного учебного плана при непосредственном участии научного консультанта. Эффективность модели подготовки специалистов по компьютерным наукам в системе высшего университетского образования Японии доказывает присутствие позитивных подходов и идей и есть основанием для использования данной модели в отечественной практике высшей школы. Подчеркнуто важность и необходимость использования позитивного зарубежного опыта в подготовке кадров для профессиональной деятельности в ИТ-сфере на территории Украины. Выделены перспективы для дальнейших исследований практики подготовки специалистов данной области знаний.

***Ключевые слова**: квалификационные уровни, программы подготовки, зачетные единицы, бакалавр, магистр, доктор.*