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ON ISSUE OF IT–SPECIALISTS' TRAINING IN CLASSICAL UNIVERSITIES

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Стаття присвячена проблемам навчання IT-фахівців в українських університетах. Розглядається значення різних областей знань, указуються здібності та навички, які вимагаються від сучасного IT-фахівця. Запропоновано приклад учбового плану, який охоплює достатнє математичне навчання, містить ядро CC2001 в сфері інформатики, а також забезпечує всі необхідні навички.

The paper is devoted to the problems of IT-specialists training in Ukrainian universities. It discusses the weights of different knowledge areas in its body of knowledge stemming from the stated in the paper abilities and skills required from modern IT-specialist. The example of curriculum which includes sufficient fundamental mathematical training, covers the core of CC2001 in computer science field and thus provides for all required skills is offered.

Most modern technical systems include a software component as its substantial part. Moreover there is a strong tendency of this software component weight growth comparing with other components of the system which leads to the stable demand for highly qualified IT-specialists. Thus, the universities face the problem of such demand satisfaction. The generalized scheme of the creation /maintenance process for a system with a software component is shown in fig. 1.

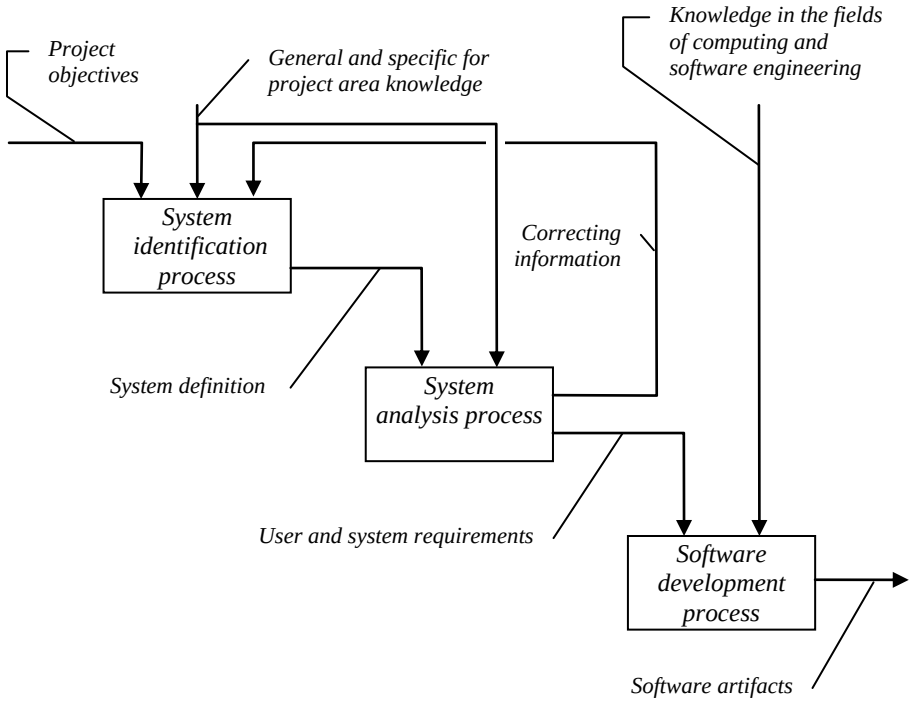

Fig. 1. System design process

It illustrates the necessity to have in the project team the professionals of all the specialties trained in Ukraine within the "Cybernetics" area, namely, "Applied mathematics", "System analysis" and "Computing". The approximate weights of professionals from each specialty within the whole process of the creation /maintenance of a system with a software component is shown in fig. 2.

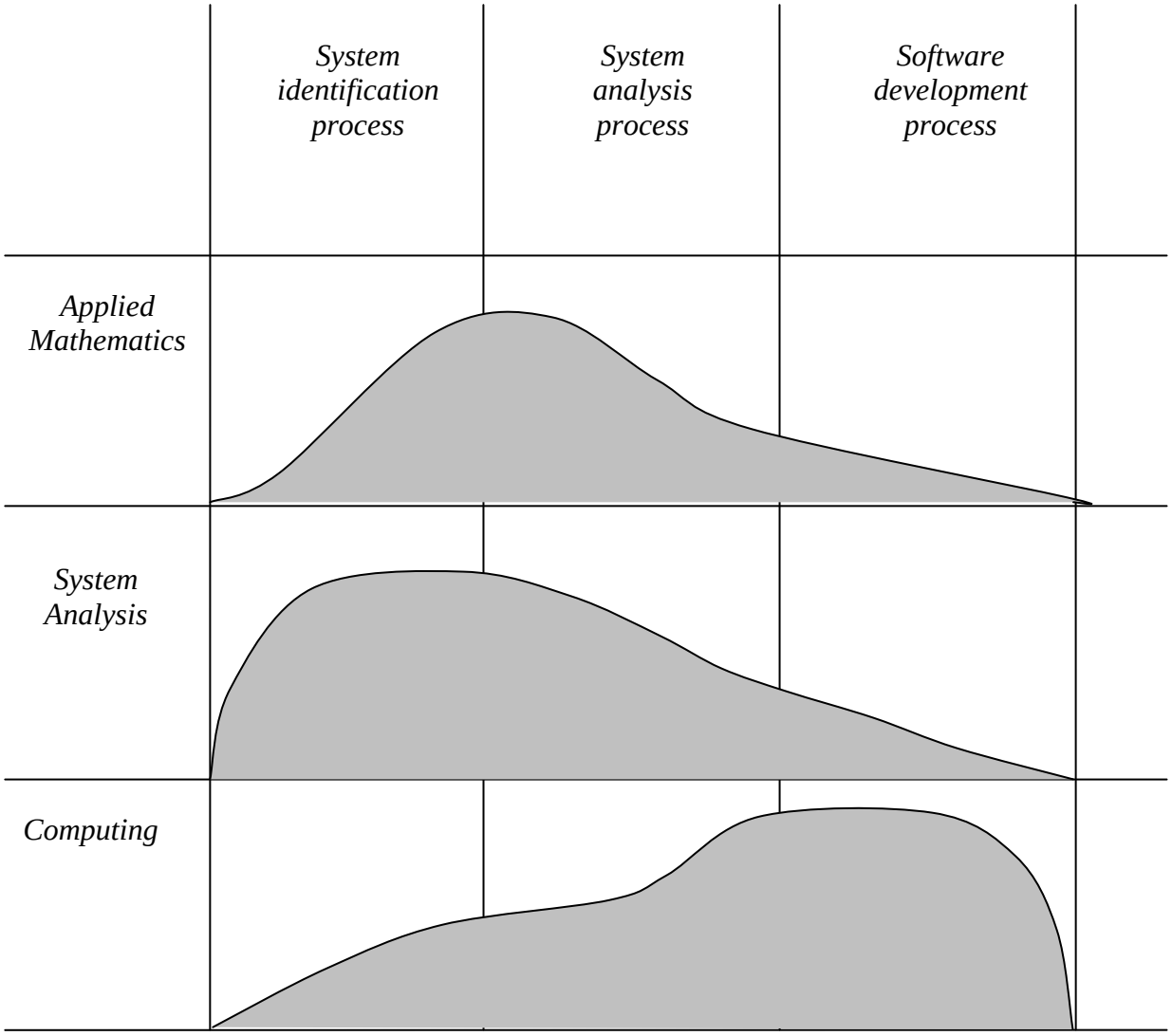

Fig.2 Participation of professionals in the process of system creation /maintenance

Analysis of competence requirements for modern IT-specialists results in the scheme of general knowledge areas shown in fig.3. The classification of knowledge bodies for the mentioned above specialties within the "Cybernetics" area is mostly defined by the weight of each component in fig.3 as it is shown in fig. 4.

As to "Applied mathematics" and "System analysis" their bodies of knowledge are well described and tested in practice and by quite long experience. The area of training IT-specialists majoring in "Computing" in classical universities is rather young one so we concentrate our efforts on its body of knowledge analysis and development.

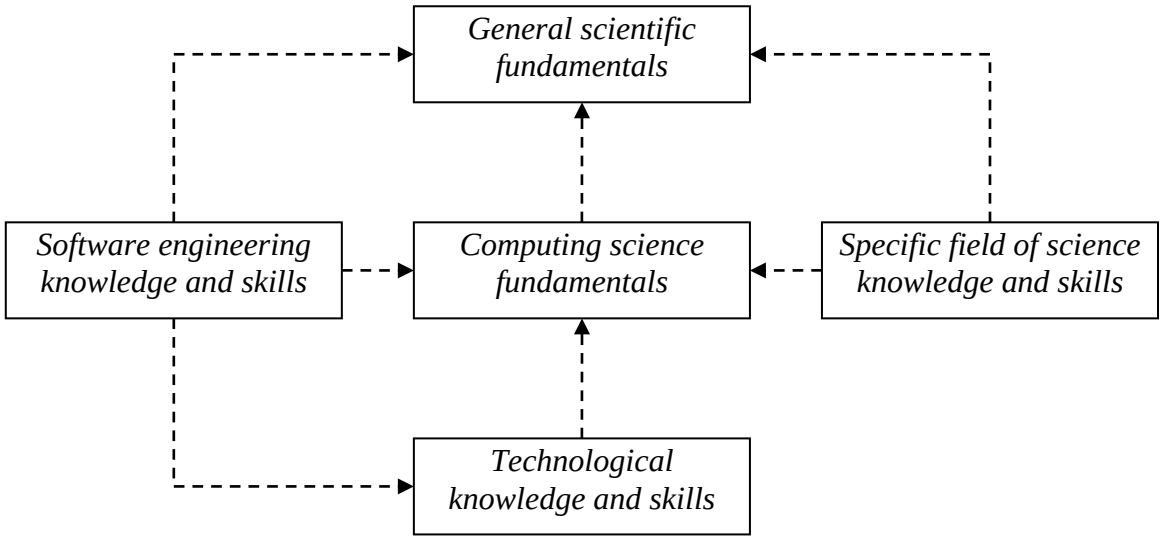

Fig. 3. IT body of knowledge structure

Stemming from the diagrams shown above we formulate the following aims of the IT-specialists' training:

- Provide the students with the knowledge and skills to equip them for a career in computer science.
- Develop analytical and critical powers of the student in relation to computer science.
- Develop the students' competence in applying skills to the practice of computer science according to the present requirements of enterprises.
- Provide the student with the ability to cope with and benefit from rapid change in the computing field.
- Develop problem-based learning skills and transferable skills to prepare the student for graduate study and research work.
- Provide the student with opportunities to develop the skills required to both autonomous practice and team-working.
- Enhance the development of students' interpersonal skills.

These aims define the competence requirements to the graduates of universities. Conventionally we divide required abilities and skills into four groups.

A *Knowledge and understanding of:*

A1 Fundamentals of mathematical sciences (Calculus, Algebra, Geometry, Differential equations, Probability Theory and Mathematical statistics) and Physics to represent formally, model and analyze natural, social, economical and ecological processes to be computerized.

A2 Fundamental concepts, principles and theories of Discrete Mathematics and Mathematical Logic to understand basics of computer science.

A3 System analysis and modeling techniques related to computer science and software applications.

A4 Essential facts and theorems of Algorithm Theory and Algorithm Complexity.

A5 Programming paradigms, their fields of application and corresponding programming languages.

A6 Organization of computer system, its architecture and operating system functions, basics of computer networking, principles and architectures of distributed systems, network programming and web-programming in particular.

A8 Principles and techniques of information management, human – computer interaction and fundamentals of artificial intelligence.
A9 Essential facts, concepts and theories related to software engineering.
A10 Social, professional and ethical responsibilities of computer science professional.

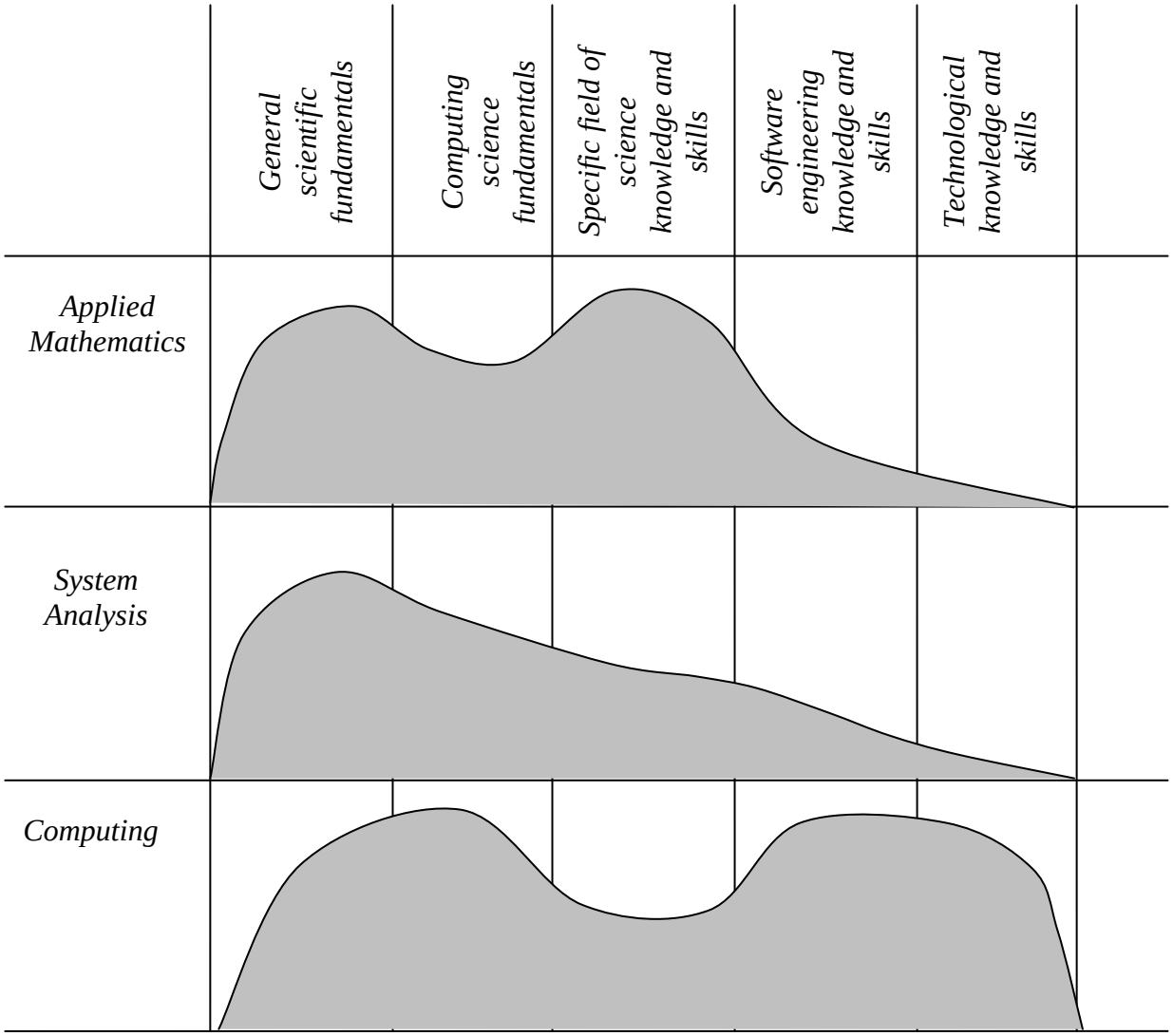

Fig.4 IT body of knowledge in "Cybernetics" specialties

B *Intellectual (thinking) skills – able to:*
B1 Formulate, analyze and solve problems related to computer science and software development and/or software application in particular.
B2 Be creative in the solution of problems including modeling and design.
B3 Integrate and evaluate information and data from a variety of sources.
B4 Identify and analyze criteria and specifications appropriate to specific problems and planning strategies for their solution.
B5 Design a computer-based system, component or module to meet specified requirements.
B6 Analyze the extent to which a computer-based system meets the criteria defined for its current use and future development.
B7 Evaluate designs, processes and products and make improvements.
B8 Take a holistic approach in solving problems and designing computer-based systems, applying professional judgments to balance risks, costs, benefits, safety, reliability, aesthetics and environmental impact.

B9 Plan and conduct research.

C *Practical skills – able to:*

C1 Deploy appropriate theory, practices, and tools for the specification, design, implementation, and evaluation of computer-based system.

C2 Specify, design and implement computer-based systems.

C3 Evaluate systems in terms of general quality attributes and possible tradeoffs within a given problem.

C4 Apply the principles of effective information management, information organization and information retrieval skills to information of various kinds, including text, images, sound and video.

C5 Apply the principles of human-computer interaction to the evaluation and construction of the wide range of materials including user interfaces, web pages and multimedia systems.

C6 Identify and analyze risks and safety aspects that may be involved in the operation of computing equipment within a given context.

C7 Deploy effectively tools used for the construction and documentation of software, with particular emphasis on understanding the whole process involved in using computers to solve practical problems.

C8 Operate computing equipment and software systems effectively.

C9 Recognize and be guided by the social, professional, and ethical issues in the computer technology.

D *Transferable skills – able to:*

D1 Make succinct presentations to a range of audiences about technical problems and their solution.

D2 Communicate effectively (in writing, verbally and through diagrams and drawings) also using more than one language.

D3 Work effectively as a member of a development team.

D4 Evaluate psychological characteristics of a person to reach understanding and agreement within a team, create auspicious conditions for team members' interrelations in the process of joint development.

D5 Understand and explain the quantitative dimensions of a problem.

D6 Gain experience, transfer techniques and solutions from one project to another.

D7 Organize self learning and development including time management and organizational skills.

D8 Keep abreast of current developments in the discipline to continue one's own professional development.

D9 Learn independently in familiar and unfamiliar situations with open-mindedness and in the spirit of critical enquiry.

The computer science body of knowledge is well represented and grounded in CC2001 and following versions (up to the report CC2005). It is quite enough to satisfy requirements to practical skills but it is certainly insufficient to develop required intellectual skills and analytical thinking abilities. We have a strong opinion that to develop such skills the fundamental mathematical subjects should be taught during the whole educational program but mainly during the first years. We consider the following subjects to be necessary (the minimal number of lecture hours is given in brackets):

Calculus (108), Discrete mathematics (72), Mathematical logic (36), Algebra (72), Geometry (36), Differential equations (36), Probability and statistics (72), Stochastic processes (36), Mathematical physics equations (36), Numerical methods (72), System analysis (36), Mathematical modeling (36), Operations research (36), Methods of optimization (36).

The activities on balanced curriculum development are held in Kharkiv National University and Kherson State University in frame of the Tempus Joint European project JEP-27237-2006 "Computing Curricula for Ukrainian Universities".

The represented below curriculum for undergraduate students majoring in "Computing" combines fundamental mathematics with computing subjects, which completely cover the CC2001 core areas.

	1 semester	2 semester
1 year	Calculus 1 Discrete mathematics 1 Algebra and Geometry 1 Programming Fundamentals 1 Architecture and Organization Human sciences 1	Calculus 2 Discrete mathematics 2 Algebra and Geometry 2 Data Structures and Algorithms Programming Fundamentals 2 Mathematical logic and Algorithm theory 1 Human sciences 2
2 year	Calculus 3 Differential Equations Programming Fundamentals 3 System programming and Operating systems 1 Mathematical logic and Algorithm theory 2 Human sciences 3	Probability and statistics 1 System programming and Operating systems 2 Object-oriented programming Databases and Information systems 1 Information theory and coding Basics of Computer graphics Human sciences 4 Coursework Mathematics electives
3 year	Databases and Information systems 2 Computer networks Probability and statistics 2 Mathematical physics equations Human-computer interaction Human sciences 5 CS elective Mathematics electives	Software design Net-centric computing 1 Numerical methods 1 System theory and mathematical modeling 1 Methods of optimization and Operations research 1 Stochastic processes CS electives Mathematics electives Human sciences 6 Undergraduate research project
4 year	Software engineering Numerical methods 2 System theory and mathematical modeling 2 Methods of optimization and Operations research 2 Knowledge bases and Intelligent Systems CS electives Mathematics electives Human sciences 7 Undergraduate research project	Theory of programming Software management Intelligent Systems Data analysis CS electives Mathematics electives Human sciences 8 Capstone project

It also provides for all abilities and skills mentioned above as shown in the following table.

	A										B								
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9
Calculus	X		X								X	X	X	X				X	X
Algebra and Geometry	X		X								X	X	X	X				X	X
Discrete mathematics	X	X	X								X	X	X	X				X	X
Differential equations	X		X								X	X	X	X				X	X
Probability and Statistics	X		X								X	X	X	X				X	X
Numerical Analysis	X		X								X	X	X	X				X	X
System theory and mathematical modeling	X		X								X	X	X	X				X	X
Mathematics electives	X		X								X	X	X	X				X	X
Math. Logic and Algorithm theory	X		X								X	X	X	X				X	X
Programming					X						X	X	X	X	X	X	X	X	X
Data Structures and Algorithms				X							X	X	X	X	X	X	X	X	X
Methods of optimization and operations research				X							X	X	X	X	X	X	X	X	X
Object-oriented Programming					X						X	X	X	X	X	X	X	X	X
Computer Organization						X					X	X	X	X	X	X	X	X	X
System Programming						X					X	X	X	X	X	X	X	X	X
Operating Systems						X					X	X	X	X	X	X	X	X	X
Human-Computer Interaction								X			X	X	X	X	X	X	X	X	X
Databases and Information Systems							X	X			X	X	X	X	X	X	X	X	X
Computer Networks							X	X			X	X	X	X	X	X	X	X	X
Intelligent systems								X			X	X	X	X	X	X	X	X	X
Software Engineering									X		X	X	X	X	X	X	X	X	X
Coursework											X	X	X	X	X	X	X	X	X
CS electives				X							X	X	X	X	X	X	X	X	X
Undergraduate project											X	X	X	X	X	X	X	X	X
Capstone project											X	X	X	X	X	X	X	X	X
Human Sciences										X									

	C									D								
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
Calculus																		
Algebra and Geometry	X																	
Discrete mathematics														X				
Differential equations																		
Probability and Statistics																		
Numerical Analysis														X				
System theory and mathematical modeling														X				
Mathematics electives														X			X	X
Math. Logic and Algorithm theory																		
Programming	X	X					X							X				
Data Structures and Algorithms	X	X												X				
Methods of optimization and operations research	X	X												X				
Object-oriented Programming	X	X					X											
Computer Organization	X	X				X		X						X				
System Programming	X	X				X		X						X				
Operating Systems	X	X				X		X						X				
Human-Computer Interaction	X	X			X	X	X	X										
Databases and Information Systems	X	X		X		X	X	X						X				
Computer Networks	X	X				X	X	X										
Intelligent systems	X	X					X	X						X				
Software Engineering	X	X	X			X	X							X	X	X		X
Coursework							X		X	X	X				X	X		X
CS electives	X	X	X	X	X	X	X	X	X								X	X
Undergraduate project									X	X	X	X	X		X	X		X
Capstone project									X	X	X	X	X		X	X		X
Human Sciences									X	X	X	X	X					X