Technology education in Bosnia-Herzegovina: how does it measure up?

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***Abstract* — In this paper program content of ICT programs in Bosnia-Herzegovina is being compared to international standards for such programs, in order to gain insight into the currency and completeness of these programs. Standard program content for Information Technology, Computer Science, and Computer Engineering created by the Association for Computing Machinery (ACM) has been selected to compare these programs with.**

***Key words* — ICT, technology, education, curriculum, standard, ACM**

I. Introduction

As part of a long-term study of the adoption and impact of information and computer technologies (ICT) in Bosnia-Herzegovina, we examined the subjects contained in the ICT-related programs in several major universities in Bosnia-Herzegovina. By examining the program content of ICT programs in Bosnia-Herzegovina and comparing it to international standards for such programs, we can gain some insight into the currency and completeness of these programs. In this paper we compare the contents of these programs with the standard program content for Information Technology, Computer Science, and Computer Engineering created by the Association for Computing Machinery (ACM).

II. Association for Computing Machinery Curricula Recommendations

Since the 1960s, ACM has worked in partnership with leading professional, academic and scientific computing societies to develop curriculum recommendations that reflect the current state-of-the art of information and computer technologies. Curricular models were developed to be as current as possible but also durable. It was also necessary to create new curricular models to reflect the subfields that developed in response to market needs.

The curricula recommendations represent the core body of knowledge determined to be essential elements of an undergraduate program in ICT. For this analysis, only the concepts/classes identified as core were used. Electives were not considered. The contents of the Information Technology, Computer Science, and Computer Engineering curricula recommendations are summarized in Table 1. All three of these were included to illustrate their similarities and differences and to allow for the broadest comparison with programs in Bosnia. It is important to note that the authors of these curricula recommendations intend these to be guidelines only, and not normative criteria for program quality comparisons.

Table 1: Core Classes in ACM Curricula Recommendations

Information Technology	Computer Science	Computer Engineering
IT Fundamentals	Discrete Structures	Computer Science I
Programming Fundamentals	Programming Fundamentals	Computer Science II
Computing Platforms	Operating Systems	Computer Organization
IT Systems	Algorithms and Complexity	Algorithm Design
Web Systems	Net-Centric Computing	Digital Logic
Networking	Programming Languages	Circuits and Systems
Human Computer Interaction	Human Computer Interaction	Computer Networks
Information Assurance & Security	Information Management/Databases	Computer Ethics

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INFORMATION TECHNOLOGY	COMPUTER SCIENCE	COMPUTER ENGINEERING
Databases	Software Engineering	Embedded Systems I
Professional Ethics	Intelligent Systems	Computer Architecture
System Administration and Maintenance	Architecture and Organizations	Digital Signal Processing
Integrative Programming	Social and Professional Issues	Capstone Project
System Integration and Architecture	Technical Writing	
Social and Professional Issues	Design Project	
Technical and Professional Communications		
IT Capstone (Project)		

III. ICT PROGRAMS IN BOSNIA-HERZEGOVINA

We examined programs from two private universities and three public universities. These were the Faculty of Information Technology at Slobomir P University, Faculty of Information Technology at Apeiron University, Faculty of Information Technology at University of Mostar, Faculty of Electrical Engineering (department for Computer Science and Informatics) at University of Banja Luka, Faculty of Electrical Engineering (department for Computer Science and Informatics) at University of Sarajevo.

The ICT contents of these programs are summarized in Table 2. For the sake of brevity, and to make comparisons to the ACM recommendations more straightforward, only courses directly related to ICT are included. Courses in mathematics, statistics, sciences, management and foreign languages and other non-ICT areas are not included. Please see the university websites for complete details of the programs.

FACULTY OF INFORMATION TECHNOLOGY, SLOBOMIR P	FACULTY OF INFORMATION TECHNOLOGY, APEIRON	FACULTY OF INFORMATION TECHNOLOGY, MOSTAR	FACULTY OF ELECTRICAL ENGINEERING, BANJA LUKA	FACULTY OF ELECTRICAL ENGINEERING, SARAJEVO
Introduction to computer technology	Architecture of computer systems and networks	Introduction to programming	Introduction to electrotechnics 1	Introduction to electrotechnics
Introduction to informatics	Business applications	Introduction to information technology	Introduction to computer technology 1	Introduction to computer science
Introduction to electrotechnics	Theory of systems with automatic control	Programming 1	Introduction to electrotechnics 2	Electrical circuits 1
Introduction to programming	System software (Operating systems)	Algorithms and data structures	Introduction to programming	Programming techniques
Programming languages	Programming principles	Introduction to operating systems	Introduction to computer technology 2	Electrotechnical elements and assembly
Introduction to electronics and digital techniques	Algorithms and data structures	Architecture of computer systems	Programming languages 1	Operating systems
Algorithms and data structures	Databases	Programming 2	Algorithms and data structures	Algorithms and data structures
Computer architecture	Administration and management of networks	Computer networks	Introduction to electronics and digital techniques	Program solutions development
Databases	Computer graphics and design	Introduction to databases	Programming languages 2	Logical design
Introduction to telecommunication	Web programming and design	Server operating systems	Operating systems 1	Computer architectures
Internet technologies	Protection of computer- and business systems	Communication technology	Theoretical introduction to computer science	Object-oriented analysis and design
Management information systems	Technological management	Object-oriented analysis and design	Software engineering	Introduction to databases
Computer networks	Projecting of information systems	Reporting	Operating systems 2	Introduction to information systems
Operating systems	Business intelligence	Database Management Systems	Computer architecture	Introduction to operational research

FACULTY OF INFORMATION TECHNOLOGY, SLOBOMIR P	FACULTY OF INFORMATION TECHNOLOGY, APEIRON	FACULTY OF INFORMATION TECHNOLOGY, MOSTAR	FACULTY OF ELECTRICAL ENGINEERING, BANJA LUKA	FACULTY OF ELECTRICAL ENGINEERING, SARAJEVO
Software engineering	Management of business information systems	Management and information systems	Computer networks	Computer graphics
Microprocessor systems	Higher programming languages and RAD tools	Projecting of information systems	Digital systems processing	Information systems
New software technologies	e-Business	Software engineering	Theory of information	Introduction to computer networks
Protection of information and information systems	Internet marketing	Computer graphics	Human-computer interaction	Software engineering
Multimedia systems	Expert systems	Web technology	Information systems	Web technologies
e-Business	Cyber law	Human-computer interaction	Microprocessor systems	Artificial intelligence
Diploma thesis		e-Business principles	Multimedia systems	Final project (thesis)
		Security / protection of IS	Internet programming	
		Project (individual work)	Computer graphics	
		Business information systems	Real time control and embedded systems	
		Software development principles 1	Data acquisition	
		Web applications development	Construction of compilers and interpreters	
		Software development principles 2	Artificial intelligence and computer simulation	
		Data Mining	Robotics	
		Parallel and distributed systems	Object-oriented projecting and programming	
			Projecting of information systems in internet surrounding	
			Cryptography and computer protection	
			Computer systems projecting	
			Computer-integrated production	
			Microprocessor systems 2	
			Diploma thesis	

IV. Comparison of Programs and ACM Recommended Curricula

Although the Bosnian programs have different titles and are in different faculties (IT versus Engineering), there is some similarity in the contents of all of the programs, and some differences that are not entirely related to the title of the program. All of the programs cover programming, operating systems, web or internet systems, databases, networks, computer architecture, and computing algorithms. Nearly all address computer security and software engineering. All of these topics are also included in the ACM recommended curricula.

The subject areas included in the ACM recommended curricula that are not addressed in the Bosnian programs are those dealing with social and professional issues, technical and professional communications, and ethics. Nor are the subjects of system maintenance, computer platforms and integration (integrative programming) specifically identified as modules in any of the Bosnian programs. Human-computer interaction is included explicitly as a module in only two of the Bosnian programs.

There are topics included in some of the Bosnian programs that are not identified as core elements of an ICT program by ACM. The most popular of these include electrotechnics (in one of the IT programs and two of the Computer Engineering programs), computer graphics and electronic-business (in four of the Bosnian programs), and artificial intelligence and object-oriented analysis and design (three Bosnian programs). Data mining, business intelligence, cyber law, microprocessor systems, and multi-media systems are included in one or two of the Bosnian programs.

V. Conclusions

The relevance of any of these programs depends, of course, on whether or not the programs are providing graduates with the skills and knowledge they need to obtain employment and to achieve continued success in their careers. It appears that all of the programs examined cover the basics: programming, operating systems, algorithms, architecture, databases, networks, and web-based systems. Perhaps there is less relevance for topics such as social and professional issues and technical communications in Bosnia because fewer graduates will become consultants. And the focus on integrating across multiple platforms may be of less importance in a region where there are few large corporations with multi-platform environments and a need for cross-platform systems.

The analysis done here cannot be used to determine the quality of these programs. That would require an examination of the content of each module, the method by which it is taught and the availability of appropriate technology and materials. A true assessment of students' learning is beyond the scope of this small paper, but it is hoped that this comparison will spark discussion of the appropriate program content and amount of focus on the various subjects in order to provide Bosnian students with the knowledge and skills they need to be successful and to contribute to the growth of the region as well as to ultimately compete in the global economy.

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