

# COMPARATIVE REVIEW OF ELEMENTARY INFORMATICS EDUCATION IN PRIMARY SCHOOLS OF THE REPUBLIC OF SERBIA, FYR OF MACEDONIA AND SLOVENIA

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## **Abstract**

*The author of this paper presents the current situation with elementary informatics education in primary schools of the Republic of Serbia, FYR of Macedonia and Slovenia. The autor has also made some recommendations for contents and status of informatics courses in primary schools. In this paper, status of informatics courses in the mentioned countries, relevant literature and actual standards are analysed to draw conclusions regarding the current state of affairs and future challenges. The primary school informatics curriculum in the Republic of Serbia has been presented in detail. This curriculum has then been compared to the primary school informatics curriculum of the FYR of Macedonia and Slovenia and then also with the ACM K-12 CS curriculum proposal.*

**Keywords:** *curriculum, elementary school, informatics.*

## **Introduction**

Technology is advancing every day. Computers have become an integral part of people's daily lives in school, at home and at work. "Computational thinking" is a skill that children must learn if they want to be ready and able to participate effectively in this digital world. The new national curriculum for computing has been developed to equip young people in England. Through the new programme for computing, they will learn how computers and computer systems work. They will know how to build programs, develop their ideas using technology and generate a range of content. But what does this mean for primary schools? How should school leaders be prepared for the new curriculum and how should teachers develop the additional skills they will need? (Berry, 2013)

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ACM K-12 CS Model Curriculum (ACM K-12 computer science curriculum) describes concept of learning computer science in school (elementary and secondary). According to Frost et al. (2009) curriculum model describes covered topics needed to be implemented in the teaching content of elementary and secondary schools. Every course or special module can be one or two – semester and it includes four levels. There are two compulsory courses, (one for elementary and one for secondary school), while the two others are optional for the students with ability and desire to study computer science more thoroughly. Curriculum is equally intended for students who want to keep studying, and for those who do not have ambitions for continuing education. Motive for making this kind of curriculum is, in the words of the author, insufficient knowledge of computing, and lack of computer literacy within the student community on one side, and large existence of computer science in all aspects of life, on the other side. Also, there was a demand for unique standards in the domain of computer science in schools and that was the reason for implementing this kind model. Proposal also includes questions of computer science education and teacher’s competences required for realization of high-quality curriculum in that domain (*Rastovac and Mandić, 2016*).

### **Curriculum Model K-12**

The version of K-12 curriculum from 2011, which is being analyzed here, is a product of ACM collaboration with many professional organizations (IEEE, SIGCSE, ASCD, ISTE, NASSA, and NEA). Suggestions received from these institutions are implemented in the final proposal.

Model of K-12 computer science curriculum (table 1) consists of three studying levels, whereby each one corresponds with specific age of students. They are: K-8, first level, intended for specific students’s age, which in our system corresponds to students in elementary school (primarily for upper grades). This level is called “Computer Science and Me”.

Second level – “Computer Science and Community” is aimed at junior high school students (in the use of computational thinking as a problem-solving tool).

Third level – “Applying Concepts and Creating Real-World Solutions.”, has three sublevels. First level of “Computer Science in the Modern World” (3.A.) is aimed at students of the 9th or 10th grade and is compulsory for all the students in secondary schools. This level is the prerequisite one for

the next two levels: 3.B and 3.C. The level “Computer Science Concepts and Practices” (3.B.) is recommended for senior students of secondary school. “Topics in computer science” (3.C.)

**Table 1** *Primary school computer science topics by ACM model K12 CS curriculum (Frost et al., 2009)*

<b>Parts of a Computer</b>	<b>Standard Software</b>
<ul style="list-style-type: none"> <li>• Input and output components</li> <li>• Roles of PC components</li> <li>• Starting up and shutting down a PC</li> <li>• Keyboard and mouse</li> <li>• Parts of a computer</li> <li>• Evaluating features</li> <li>• Volatile and non-volatile memory</li> <li>• Roles of components in electronic Devices</li> <li>• Units of measurement</li> <li>• Cables and ports</li> <li>• History of computers</li> </ul>	<ul style="list-style-type: none"> <li>• Choosing and using software</li> <li>• Word processors and text editors, presentation creators, spreadsheets, web browsers, email clients, etc.</li> <li>• test taking software; and classroom, homework, and assessment management systems</li> <li>• Similarities and differences in the common user interface</li> <li>• Multiple software applications can be used to complete the same task</li> <li>• Critical thinking about software applications</li> </ul>
<b>Operating Systems</b>	<b>Networks</b>
<ul style="list-style-type: none"> <li>• Desktop icons and software applications</li> <li>• File name extensions</li> <li>• Distinguishing proprietary and nonproprietary file types</li> <li>• Understanding files and directories (folders)</li> <li>• Selecting an appropriate place to save a file, manipulating windows, navigating between running applications, etc.</li> <li>• OS utilities</li> <li>• advanced OS user interface elements and features</li> <li>• Comparing operating systems</li> <li>• Multi-tasking</li> <li>• Role of the OS</li> <li>• Using the clipboard</li> </ul>	<ul style="list-style-type: none"> <li>• Working with local and remote resources</li> <li>• Protocols</li> <li>• Hostnames</li> <li>• Network topologies</li> <li>• Client-server architecture</li> <li>• Error correction</li> <li>• Data communication over networks (LAN; WAN)</li> </ul>

<p style="text-align: center;"><b>The World Wide Web and Communicating over Networks</b></p>	<p style="text-align: center;"><b>Representing Information Digitally</b></p>
<ul style="list-style-type: none"> <li>• Accessing the WWW and using a web site</li> <li>• main parts of a URL</li> <li>• Editing a web page template that includes HTML tags</li> <li>• Search techniques</li> <li>• Top level domains</li> <li>• Creating a web site that conforms to standards (Create a basic web page using HTML and CSS that conforms to standards.)</li> <li>• Social networks</li> </ul>	<ul style="list-style-type: none"> <li>• Digitizing information</li> <li>• Coding information</li> <li>• Understanding binary values</li> <li>• ASCII and Unicode</li> <li>• Range of values in a byte</li> <li>• Challenges of modeling information digitally</li> <li>• Hexadecimal</li> <li>• Data compression</li> <li>• Digital data representation</li> </ul>
<p style="text-align: center;"><b>Problem Solving and Algorithms</b></p>	<p style="text-align: center;"><b>Computer Programming</b></p>
<ul style="list-style-type: none"> <li>• Understanding the word “algorithm”</li> <li>• Describing an algorithm</li> <li>• Understanding instructions with AND or OR</li> <li>• Combinatorics</li> <li>• Write an algorithm to solve an assigned problem using a specified set of commands.</li> <li>• Algorithm efficiency</li> <li>• Relationship between Boolean Algebra and circuits</li> <li>• Simulations</li> <li>• Parallel processing</li> </ul>	<ul style="list-style-type: none"> <li>• Knowing about a variety of programming languages</li> <li>• Familiarity with a computer programming language</li> <li>• Computer programming (Code and test a program to solve a stated problem, using variables and at least one decision or loop)</li> <li>• Converting an algorithm to a computer program</li> <li>• Planning, writing, and testing computer programs</li> </ul>
<p style="text-align: center;"><b>Privacy and Security</b></p>	<p style="text-align: center;"><b>Evaluating and Using Information from Networked Sources</b></p>
<ul style="list-style-type: none"> <li>• Choosing good passwords</li> <li>• Internet safety</li> <li>• Computer security</li> <li>• Digital theft</li> <li>• Backing up files</li> <li>• Safe web surfing</li> <li>• Determining the appropriateness of email</li> <li>• Dangers of revealing personal information</li> <li>• Making friends on the Internet</li> <li>• How viruses are spread</li> <li>• Types of malicious software</li> </ul>	<ul style="list-style-type: none"> <li>• Using a search engine</li> <li>• Accuracy of Internet information</li> <li>• Search engine performance</li> <li>• Evaluating relevancy of web sources</li> <li>• Using relevant information</li> <li>• Copyright</li> </ul>

Human Computer Interaction	Computers in Society
<ul style="list-style-type: none"> <li>• Software application differences</li> <li>• Evaluating software ease of use</li> <li>• Selecting a good user interface</li> <li>• Interface evaluation</li> <li>• (Create) User-centered design</li> <li>• User differences</li> <li>• Accessibility (ease of use of the interface for certain users, such as physically challenged or elderly users)</li> </ul>	<ul style="list-style-type: none"> <li>• Computers at work</li> <li>• Ethical and unethical behaviors</li> <li>• Reading an acceptable use policy</li> <li>• Future changes</li> <li>• History of computer science</li> <li>• the contributions of two or more computer scientists.</li> <li>• Social impacts of computerization</li> <li>• Computing careers</li> </ul>

Looking at the structure itself of proposed K-12 curriculum, we notice that it is in the larger part coinciding with current form of educating computer science in Serbia. Respectively, similar to concept in which informatics and computing are optional subjects in elementary school, and after that, depending of the type of school, there is at least one compulsory subject of informatics and computing. Noticable advantage of K-12 curriculum, looking at the structure of levels, is one compulsory course (at least) on the elementary level, which is a flaw of educational system in Serbia (although it is studied to some extent through the courses of Technical and Informatics education) (*Rastovac and Mandić, 2016*).

### **Informatical contents of courses “Technical and Informatics education” and “Informatics and Computing” in Republic of Serbia**

In Serbian elementary schools, informatical contents are represented in grades 1- 4 in the optional subject “From toy to computer”, while in the grades 5-8 of elementary schools there two subjects dealing with that topic: Informatics and Computing as an optional subject and compulsory subject Technical and Informatics education. The program of “From toy to computer” is conducted by teachers who feel competent enough to deal with this subject (*Petrović and Mandić, 2012*). Informatics and Computing is in the same group of optional courses as following: Keepers of Nature; Domestic education; Everyday life in the past; Drawing, painting, sculpting; Choir and Orchestra; Mother tongue with elements of national culture and Chess. School is obligated to, by its own choice and financial – organizational – personnel abilities, offer four subjects, from which the students (and parents) choose one for specific school year, according to student’s preferences and that repeats for every following year (*Nastavni planovi i programi za osnovne škole, 2014*).

Information technology are presented in teaching course “Technical and Information Education” within its section called “Information

Technology”. Table 2 shows the specific content of that section from the fifth to the eighth grade.

**Table 2** *Contents of Technical and Informatics Education course (Rastovac and Mandić, 2016)*

fifth grade	sixth grade
Introduction to Informatics and Computing. The use of computers. A computer system (basic parts, additional equipment and software). Connecting and turning on your computer. Using the computer’s operating system, working environment. Word processor. Software for technical drawing .	Software for simple drawings. Working with CD player and flash memory. Saving the drawings. Working with the printer. Using Internet .
seventh grade	eighth grade
Drawing using a computer and making presentations. Interface. Managing models using a computer. Working with interface based technology.	Practical application of computers. Computer networks. Using Web’s access to the global computer network (www), e-mail. Controlling your surroundings with PC. Using computers and interface technology to control various models. Applying previous mastery of word-processing, database, spreadsheets and graphics to prepare presentations in different areas. Creating technical documentation in electrical engineering using the software.

In addition to the content presented in Table 2, in a course “Technical and Information Education” there are two more areas for the eighth grade students that contain the information content: Digital Electronics and From idea to implementation–modules. Digital electronics in its plan includes: Fundamentals of analogue and digital technologies; Basic electronic components; the architecture of a computers: motherboard, processor, memory, interface, and modem. Electronic devices in the household; Telecommunications and audiovisual media: mobile phones, GPS systems, internet and cable television;

From idea to implementation – modules in its plan includes: The practical creation of electrical circuits – experiments- study of construction materials and simulation using computer software according to the preferences of students; Practical examples of control by computer; Modeling of electrical machinery and equipment, automation systems and robots;

Information technology course content of Informatics and Computing for the fifth grade includes three areas: Operating system, Text editing

and Introduction to multimedia. The content of the mentioned areas is presented in Table 3 (Rastovac and Mandić, 2016).

**Table 3** *Content of Informatics and Computing course for the fifth grade (Rastovac and Mandić, 2016)*

Operating system	Course introduction. Graphical user interface of operating system. Starting the programs. Using the program for managing files and directories. Adjusting the working environment. The installation of the programs. Installation of additional devices. Working with the keyboard and mouse.
Text editing	Layout of the main window. Entering and editing text. Working with documents. Formatting the page, adjusting the margins. Formatting characters. Formatting paragraphs. Printing. Working with images. Drawing in a word processing software.
Introduction to multimedia	Introduction to multimedia. Programs to work with multimedia. Application of multimedia in teaching. Using CDs and DVDs with audio and video content (books, encyclopedias, atlases)

Information technology course content of Informatics and Computing for the sixth grade includes five areas: Text editing, Internet, Graphics, Animation and Elective modules (Programming or Interactive graphic). The content of the mentioned areas is presented in table 4.

**Table 4** *Content of Informatics and Computing course for the sixth grade (Rastovac and Mandić, 2016)*

Text editing	Working with tables (creating tables, text formatting, editing text in a table, moving across the table, inserting rows and columns, deleting rows and columns, merging and dividing cells, width and height of rows and columns). Borders and shading to the table. Combining tables with text and images. Inserting headers and footers, page numbers, date, and time. Page break. Background. Setting the paper size and margins. Print Preview. Printing.	
Internet	The concept of global and local area networks. Connecting to the Internet. Working with basic Internet services. Search the Internet. Download text and images from the Internet. Online behavior and personal data protection. Internet Security.	
Graphics	Sources of digital images (drawing, screenshots, scanning, photographing, downloading images from the Internet). Image processing. Types of digital images. Conversion between formats. Preparing images for printing, display graphics and for publishing on Internet pages.	
Animation	Basics of animation. Creating simple animations.	
Elective modules	Programming	Introduction to Programming. Data types and declaration of variables. Elementary commands of programming language. A demonstration of the programming language capabilities.
	Interactive graphic	Teaching students to work with the programs for graphical editing and their use for mastering the curriculum of other subjects (mathematics, physics, technical education and IT education).

Information technology course content of Informatics and Computing for the sixth grade also includes five areas: Internet, Sound Editing, Video editing, Creating presentations and elective modules (Programming, Drawing and graphic design). The content of the mentioned areas is presented in table 5.

**Tabla 5** *Content of Informatics and Computing course for the seventh grade (Rastovac and Mandić, 2016)*

Internet	The concept of electronic communication and recommendations for safe on-line behavior . E-mail. The discussions and comments on the Internet, instant messaging, blogs, forums, video-conferencing, e-learning and distance learning. The digital library.	
Sound Editing	Audio formats. The conversion between different formats. Recording and processing of voice and other sounds. Practical work on the sound recording and processing.	
Video editing	Snimanje video zapisa. Obrada video sekvenci. Primena vizuelnih efekata. Montaža video, zvučnih, grafičkih i tekstualnih materijala u celinu. Samostalna izrada filma. Formati i konverzija.	
Creating presentations	The concept and structure of the presentations. Working with slides. Designing and finished template. Working with text, images and objects. Setting effects. Linking slides within the presentation. Linking to external content and web pages. Create a presentation on your own. Recommendations for successful presentations.	
Elective modules	Programming	Arrays. Loops and other control structures. Subroutines, procedures and functions.
	Drawing and graphic design	Working with drawing tools. Working with colors and textures. Special effects. Print Preview. Customizing the display views, printing and publishing on the Internet. Practical work.

Information technology course content of Informatics and Computing for the eighth grade includes two areas: Spreadsheets and Elective modules (Programming and On-line presentations). The content of the mentioned areas is presented in table 6 (Rastovac and Mandić, 2016).

**Table 6** *Content of Informatics and Computing course for the eighth grade (Rastovac and Mandić, 2016)*

Spreadsheets	Workbook and worksheet. Data entry. Formatting cells. Working with formulas. Using built-in functions. Working with graphic objects. Creating a chart. Printing.	
Elective modules	Programming	Procedures for solving of problems. Solving of problems.
	On-line presentations	The basic elements of HTML. The color and background image. Working with text. Working with images. The hyperlink. Working with tables. Specialized software for creating web pages.

### **Informatics courses of Republic Serbia, FYR of Macedonia and Slovenia in regards to ACM K-12**

In this section, we are comparing Informatics teaching courses in the elementary schools in Republic of Serbia, FYR of Macedonia and Slovenia with ACM K-12 computer science curriculum. Contents of Informatics teaching courses in these countries are:

In FYR of Macodonia Working with computers and programming fundamentals (two classes per week in third grade), Technical education (one classes per week in fourth and sixth grade and two classes per week in seventh grade) and Informatics (two class per week in sixth grade and one classes per week in seventh grade) are compulsory subjects Work with computers (two classes per week in fourth and fifth grade) is optional subject.

Technical and tehnologies (one class per week in seventh and eighth grade, two class per week in sixth grade) is compulsory subjects and Computing (two classes per week in fourth, fifth and sixth grade) is optional subject in Slovenia.

Teaching plans and programs (described in detail) are taken from the websites of institutions: Republic of Serbia (*Nastavni planovi i programi za osnovne škole, 2014*) – FYR of Macedonia (*Ministerstvo za obrazovanie i nauka- Biro za razvoj na obrazovaniето, 2015*), Slovenia (*Ministrstvo za izobraževanje školstvo, znanost in šport, 2013*). In this paper there is only a detailed description of program content of the Republic of Serbia (tables 2 to 6). Comparison of teaching programs in regards to ACM K-12 computer science curriculum is done in the following way. In the table 7 informatics teaching plans and programs content from mentioned countries are compared

with contents of ACM K-12 curriculum and the result of comparison is expressed in the percentages shown. First column in the table 7 represents basic content of ACM K-12 curriculum, and each basic content of ACM K-12 has its own program content (table 1). For example: content of “Parts of a Computer” (table 1) which includes 11 elements is observed and then each element is taught in the programs of enlisted countries. Only if there is an explicit emphasis of elements in the enlisted countries, we consider that teaching content of those countries match with compared elements of ACM K-12 curriculum. In the second column of table 7 we have that the matching percentage is 72% for Serbia (ie. out of 11 elements in Serbia teaching programs there are 8) as seen in tables 2 to 6, also in the third column 91% for Macedonia of matching (ie. 10 out of 11 elements), while in the fourth column Slovenia have 81% of matching (ie. 9 out of 11 elements).

We can notice that contents of “Standard Software”, “Operating Systems”, “Computer Programming” and “Privacy and Security” (in the table 7) match completely with ACM K-12 curriculum. Thus, programs of enlisted countries have in its entirety a plan to study elements of software, operative system, programming and security which are included in ACM K-12 curriculum. However, contents of “Evaluating and Using Information from Networked Sources”, “Human Computer Interaction” and “Computers in Society” have smaller percentage of matching. The most likely cause lies in the category (compulsory or optional) and number of classes in a week related to subject Informatics in the mentioned countries.

**Table 7 Curriculum comparison in relation to the ACM K-12**

Structure ACM K-12	Serbia	Macedonia	Slovenia
Parts of a Computer	72%	91%	83%
Standard Software	100%	100%	100%
Operating Systems	100%	100%	100%
Networks	57%	71%	71%
The World Wide Web and Communicating over Networks	57%	86%	71%
Representing Information Digitally	78%	89%	57%
Problem Solving and Algorithms	33%	78%	78%
Computer Programming	100%	100%	100%
Privacy and Security	91%	100%	100%
Evaluating and Using Information from Networked Sources	50%	100%	100%
Human Computer Interaction	43%	57%	57%
Computers in Society	50%	50%	62%

Author of this paper consider that the emphasis should be put on basic understanding of algorithms, although K-12 curriculum states that, in the frame of algorithms on this level there is a need for introducing concepts of conditional loops (if, for and while). Introduction of complexed principles like if, for and while loops would be useful for students who have more preferences toward informatical – logical way of thinking. The teacher should illustrate several examples of loops and therefore enable for certain group of students to have a better vision of algorithm processes. It's author of this paper opinion that it is too early to introduce concepts of loops, conditional expressions already in elementary school (unlike K-12 proposal) for all students, although they should be introduced into compulsory subject on the next level (first grade of secondary school). The main reason is the various structure of the students, who have very diverse abilities of abstraction and informatical – logical reasoning and ambitions toward further education (*Rastovac and Mandić, 2016*).

### **Conclusion**

K-12 curriculum is considerable equivalent with the current curriculum for educating computer science in Republic of Serbia. Two curriculum of one compulsory and two optional courses which K-12 suggest are similar to Serbian concept of Informatics and Computing studies in the elementary schools in one optional subjects. In the secondary schools there is at least one compulsory subject of Computing and Informatics. Advantage of K-12 curriculum is at least one compulsory course on the elementary level, which is a weakness of educational system in Serbia (even if it is in some studied through Technical education). Author of this paper conclude that introduction of compulsory and special course of Informatics and Computing is necessary. That is one of the principles of K-12 curriculum, which should be adopted to avoid, already mentioned, potential issues that students have in secondary school when they begin to learning it without any previous knowledge of computing. Students have realized that some other optional subject take less time and effort or it's easier to achieve higher grade, so they do not choose this area. Moreover, it is arguable are students able, at that age, to make an independent decision concerning what is more useful for them in future professional career. Also, it is not confirmed whether they are able to comprehend the necessity of studying computing and informatics. Potential barrier for adopting K-8 level as compulsory course is technical equipment, availability of Internet and legal and safe software in elementary schools.

The K-12 proposals (learning tools for word processing, creating presentations and image editing) which are needed to be adopted in the future framework of compulsory course (now optional subjects in elementary school). The K-12 proposal for students between sixth and eighth grade does not mention compulsory learning of any programming language. That should be considered. Implementing one course (as optional course) and introducing programming languages suitable for understanding basic concepts of structure, data flow and developing “computer” way of thinking is what author of this paper proposes. We need to be careful when implementing a programming language in the domain of computer science, regarding that all students will not select some of the secondary schools that study computer science more extensive (some of them won’t even continue with their education). Which basic programming language is suitable for learning demands a special discussion (for example traditional Pascal, Visual basic). Certainly, for the start, some of visual tools should be used as they make learning easier. The authors of this paper consider that methods of learning the chosen programming language are just as important (*Rastovac and Mandić, 2016*).

The analysis indicated that it is necessary to improve the curriculum in order to be better mached with modern challenges in primary informatics education. Moreover, the analysis showed the importance of the studying of informatics contents in primary schools through compulsory courses.

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