Informatics Concepts in Secondary School Education: What Should We Teach?

Prof. dr. Valentina Dagienė valentina.dagiene@mii.vu.lt

Vilnius University, Lithuania

Two parts of my talk

- What should we teach?
 - Focus on Informatics (Computer Science) concepts, topics
- **How** should we teach?
 - Attractive tasks motivation to learn
 Informatics: BEBRAS contest

Informatics in Lithuanian schools

- The name: Informatics (1986-2002), then Information Technologies, IT (since 2002)
- Compulsory subject for grades 5-10 (lower secondary school)
 - approximately 1 hour per week (35 hours per year) for grades 5 and 6; 7 or 8; 9 and 10
- Optional modules for grades 11 and 12 (programming, data base, desktop publishing) for upper secondary school

Terminology (by UNESCO)

Informatics (Computing Science)

The science dealing with the **design**, **realisation**, **evaluation**, **use and maintenance of information processing systems**; including hardware, software, organizational and human aspects, and the industrial, commercial, governmental and political implications.

Informatics Technology

The technological applications (artefacts) of informatics in society.

Information and Communication Technology (ICT)

The combination of informatics technology with other, related technologies, specifically communication technology.

In UNESCO documents these definitions have been collapsed into one, all encompassing, definition of Information and Communication Technology (**ICT**). This implies that **ICT will be used, applied and integrated in activities of working and learning on the basis of conceptual understanding and methods of informatics**.

Pref x	Levels	
Digital, Media Computer, E (Electronic) IT, ICT, Informatics	Skills, Literacy, Fitness Fluency, Knowledge, Qualif cation Competence, Pedagogy Education	
Digital E-	Skills Literacy	
ICT Media	Fluency Fitness Education	
Computer IT	Knowledge	
Informatics	Qualif cation Competence	
	Pedagogy	

International curriculum development

- ACM K-12 curriculum (1999), revised March 2011
- CSTA (CS Teacher Association, USA) K-12
 Computer Science Standards
- Computer Science as a Core Discipline
 - CS is Intellectually Important
 - Leads to Multiple Career Paths
 - Teaches Problem Solving
 - Supports Links to Other Sciences
 - Can Engage All Students
- Other
 - Information technology fluency
 - Scales: concepts, capabilities, and skills

- Computer Science, on the other hand, spans a wide range of computing endeavors, *from theoretical foundations to* robotics, computer vision, intelligent systems, and bioinformatics.
- The work of computer scientists is concentrated in three areas:
 - designing and implementing software,
 - developing effective ways to solve computing problems, and
 - devising new ways to use computers.

CSTA K-12 CS Standards



Strands in the Computer Science Standards



CSTA K-12 Computer Science Standards

Computer science is the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society

10 concepts:

- Computer organization
- Information systems
- Networks
- Digital representation of information
- Information organization
- Modelling and abstraction
- Algorithmic thinking and programming
- Universality
- Limitations of information technology
- Societal impact of information technology.

International curriculum development

- UNESCO/IFIP (2002)
- The German Society for Informatics GI:
 - grades 5 to 10
 - content area and process area
 - The content part covers 5 basic concepts:
 - information and data
 - algorithms
 - languages and automata
 - informatics systems
 - informatics, man and society

Mathematics (NCTM)	Informatics (German Group)		
Content Standards			
Number and Operations Information and Data			
Algebra	Algorithms		
Geometry	Languages and FiniteAutomata		
Measurement	Informatics Systems		
Data Analysis and Probability	Informatics, Humans and Society		
Process Standards			
Problem Solving	Modelling and Implementing		
Reasoning and Proof	Reasoning and Evaluating		
Communication	Structuring and Networking		
Connections	Communicating and Cooperating		
Representation	Representing and Interpreting		

Classification Scheme for Austria's Lower Secondary Level (K8 – 14 years) Framework of Reference for Digital Competences - Competence Matrix for Basic Informatics Education

			Basic Competencies Level I	Extended Competencies Level II	Special Competencies Level III	
E (0	1.	Information Technology, Human and Society				
Media Reflexio Related Topics	1.1.	Benefits and Risks	Basic reflection on using the	Founded risk assessment. Solid knowledge in related topics. Knowledge of vocational, social	Foundational and coherent knowledge. Evaluation of using	
	1.2.	Privacy, Law and Responsibility	computer and its impacts. Basic Knowledge of vocational,			
	1.3.	Historical and vocational aspects	social and historical facts.	and historical contexts.	digital media.	
	2.	Informatics Systems				
Media Knowledge	2.1.	Hardware		Detailed IT-knowlegde, fluent rote skills and basic knowledge of relationships in the context of informatics	Extended knowledge of technical terms. Understanding of concepts and simple models.	
	2.2.	Software, Operating System and Filemanagement	Basic IT-knowlegde and practical skills on the level			
	2.3.	Networks	or operating systems.	systems.	Evaluation of informatics systems. Advisory skills.	
ıf	3.	Software Applications				
and tion o	3.1.	Documentation, Publication und Presentation	Basic knowledge and skills	Experienced use of application software. Solving of standard tasks in school and everyday live throug selection of	Extended tool competence. Conceptual understanding of application software. Problem solving competence and	
Product Med	3.2.	Calculation and Visualization	in the context of education and leisure time.			
	3.3.	Information, Communication und Cooperation		appropriate application software.	dynamic capabilities.	
PE	4. Informatics Concepts					
ing	4.1.	Representation of Information	Basic knowledge	21.1. AV (V. 10. 12	Foundational knowledge and basic understanding. Abstract thinking.	
Principle Computa Thinki	4.2.	Data, Relations and Structures	of informatics terminology and elementary connections.	Basic conceptual understanding of human-machine communication.		
	4.3.	Algorithms, Programming and Automatization	Execution and description of simple instructions.	tasks and their implementation.	Creative solutions for algorithmic problems.	

2			Competence Levels		evels
			Basic	Extended	Special
ទ	1.	Information Technology,	Huma	n and So	ciety
- E .	1.1.	Impact of IT in Society			
exi T T	1.2.	Responsibility in Using IT			
Me	1.3.	Privacy and Data Security			
Rela	1.4.	Developments and			
R		Vocational Perspectives			
	2.	Informatics Systems			
e	2.1.	Technical Components		Ĩ	
Aec		and their Use			
wie N	2.2.	Design and Use of Personal			
gita		Information Systems			
i ×	2.3.	Data Exchange in Networks			
	2.4.	Human-Machine Interface			
-	3.	Software Applications			
a	3.1.	Documentation, Publication			
edi		und Presentation			
M	3.2.	Calculation and			
I P		Visualization			
Dig	3.3.	Search, Selection and	~		
of		Organisation of Information			
5	3.4.	Communication and			
		Cooperation			
	4.	Informatics Concepts			
ald	4.1.	Representation of	20		
at ion		Information			
les tat ikir	4.2.	Structuring of Data			
hi bi ci	4.3.	Automatization of	~		
- E E		Instructions			
E O	4.4.	Coordination and			
		Controlling of Processes			

What concepts should Informatics include in secondary schools?

- The answer is problematic due to several reasons:
 - Informatics, information technology is a new and rapidly evolving science.
 - The variety of different practical applications of informatics overruns the core theoretical and scientific concepts.
 - No common framework, what should be introduced in school from the theory of informatics, and whether it should be introduced at all.

Few "commonly agreed" concepts of informatics for secondary schools

- Algorithms and programming
 - Decomposed into data, variable, cycle, procedure, object, class, etc.
- Structures and patterns
- Information
- Automata and graph theory elements

Finding answer...



Key informatics concepts for schools



The process of integration of informatics concepts in general education



International "Bebras" tasks creative workshop, Lithuania, May 2011



International Contest on Informatics and Computer Fluency BEBRAS (Lithuanian word for beaver)

Task oriented contest for school pupils aged 10 to 19

Goals

- to motivate pupils to solve problems using informatics methods
- to stimulate pupils' interest in informatics and information technology
- to encourage pupils to think deeper while using computers and information technolgies
- to **inseminate** concepts of informatics

Influence of Bebras Contest

- On **teaching informatics** (computing)
 - Introduces concepts to pupils
 - Encourages exploring
 - Gives examples of good tasks
 - Stimulates learning some topics of Informatics
- On developing curriculum
 - Sets an international standardization
 - Helps to agree on concepts
- On teacher training
 - Challenges teachers to deal with new concepts
 - Improves deeper understanding of informatics

International Bebras History

Invented 2004 by Valentina Dagiene Lithuania	Country	Participants 2008	Participants 2009	Participants 2010	First Contest
	Lithuania	6616	10358	13 889	2004
	Estonia	4039	3482	3 956	2005
	Netherlands	5120	8326	10 231	2005
Candidates:	Poland	8725	10344	9 962	2005
Belgium	Latvia	700	828	1 072	2005
Cyprus Hungary Israel	Germany	53602	82779	117 950	2006
	Austria	3910	6302	8 425	2007
	Slovakia	9317	13942	22 139	2008
Romania	Czech Rep.	4069	10351	14 867	2008
Russia Slovenia Spain	Ukraine	1429	13114	25 971	2008
	Italy	-	310	1 325	2009
	Finland	-	-	1 472	2010
	Switzerland	-	-	3 470	2010

Participation in Bebras 2010

Overall number: 234729



Austria

Czech Republic

Estonia

- Finland
- Germany
- Italy
- Latvia
- 🗖 Lithuania
- The Netherlands
- Poland
- Slovakia
- Switzerland
- Ukraine

Bebras Contest

Participants

all secondary school pupils age 10 to 19 different tasks for 4 age groups:

- BENJAMIN 10-12 years (grade 5-6)
- KADETS 13-14 years (grade 7-8)
- JUNIOR 15-16 years (grade 9-10)
- SENIOR 17-19 years (grade 11-13)

Tasks

pupils have to solve 18-24 tasks within 45 to 60 minutes interactive tasks and multiple-choice tasks approx. 3 min. per task easy, medium and hard tasks

usually performed during regular school lectures

Contest Technology

- Web-based system that needs online connection during contest
- About 8 different systems in use

Concepts of Informatics

are related to "Fundamental Ideas of Computer Science" that are applicable in different areas of computer science may be taught on every intellectual level will be relevant in the long run have meaning in everyday life

Concepts are independent from specific informatics systems Concepts can be applied in new situations in the future Concepts are valuable in the long run

Concepts consist of aspects

- Algorithmic thinking
- Symbolic representation
- Patterns, Structrurs
- Parallelism, Synchronization
- Iteration, Recursion

etc.

Concepts Learned in Bebras Contest

- Each stated Bebras task involves an aspect of an informatics concept
- Learning by doing
- Learning by exploring
- Not learning theory of a concept
- Not even the names of the concepts are mentioned
- Even advanced concepts possible
- A proper task story can ease a task essentially

Beaver Den

In the Beaver Den there are some tracks. Because Beavers don't go backwards there are some parallel tracks to give way. Look at the figure. In the each cell can be only one beaver. In which situation a total traffic jam is **unavoidable**?



Friends

- We know that:
- Michael's friends are John, Peter and Tom
- John's friends are Michael and Anne
- Anne's friend is John
- Peter's friends are Michael and Tom
- Tom's friends are Michael and Peter

We represent people as points and we draw a line between two people if we know that they are friends with each other. Which of the given figures can be obtained this way?

a.
$$b.$$
 $b.$ $c.$ $d.$ $d.$ $d.$

Graph for Waiters

Given is a graph for properly setting a table.

Beaver Bob has a job in a restaurant. He has to set the tables. The given graph defines in what way things may be put on each other.

An arrow A ---> B means that a thing of type B may be put on a thing of type A. A thing of type B must not be put on a thing of type A, if there is no arrow from A to B. Which of the following tables is set correctly according to this



Constructive Beaver

Beaver has developed a very simple modeling language. It consists only of two kinds of objects and two possible operations.



Which operation sequences would generate this thing?



The operation add(A, B) means: Put A and B side by side and glue B to the right side of A. The operation turn(A) means: turn A clockwise around 90 degrees.

4	В	С
A = add(cylinder, cylinder)	A = add(cylinder, cylinder)	A = add(cube, cube)
B = turn(A)	B = add(A, cube)	B = add(A, cylinder)
C = turn(B)	C = turn(B)	C = turn(B)
D = add(C, cube)	D = add(C, A)	D = add(C, cylinder)

- D
- A = add(cube, cylinder)
- B = add(A, cylinder)
- C = turn(B)
- $D = add(C, cylinder)^2$
- E = add(D, cylinder)

Task Categories

INF Information comprehension

Representation (symbolic, numerical, visual) Coding, encryption

ALG Algorithmic thinking

Including programming aspects

USE Using computer systems

e.g. search engines, email, spread sheets, etc. General principles, but no specific systems

STRUC Structures, patterns and arrangements

Combinatorics

Discrete structures (graphs, etc.)

PUZ Puzzles

Logical puzzles

Games (mastermind, minesweeper, etc.)

SOC ICT and Society

Social, ethical, cultural, international, legal issues

Criteria for good Tasks

Good tasks	Explanation	
are related to informatics, ICT, or computer literacy	see task categories	
allow learning experiences	learning gives satisfaction and is never boring	
can be solved in 3 minutes	average time	
do not require specific knowledge	not to check memorized knowledge	
have a difficulty level (3 levels)	1/3 easysolvable for all1/3 mediumthinking required1/3 hardfor the best	
are adequate for the age of contestants	Benjamin: grade 5 to 8 Junior: grade 9 to 10 Senior: grade 11 to 13 ₃₄	

Criteria for good tasks

are independent from any curriculum	The Bebras tasks are oriented on the usual ability of pupils of the addressed age groups
are independent from specific IT systems	All system specific terms must be explained within a task
have easy understandable problem statements	easy understandable wording and presentation of the problem and never misleading
are presentable at a single screen page	no scrolling necessary
are solvable at a computer without other hardware, additional software or paper and pencil	due to time restrictions and prevention of cheating
are politically correct	no gender, racial or religious stereotypes ³⁵

Example of a Task Development

 Idea: Given is a binary tree with values. How many exchanges of values is necessary to achieve a *heap data structure*?



First formulation of the task

The picture shows a binary tree with values in the nodes. A binary tree is called a "Heap" if each parent node has a value greater than or equal to both child nodes. The given binary tree is not a "Heap". Give the minimum number of value exchanges (of any two nodes) that produces a "Heap".



Answers: A) 2 B) 3 C) 4 D) 5

Final formulation of the *Group Photo* task

To make a group photo of 7 beavers it is necessary that the smaller beavers stand in front and the larger beavers in back. Unfortunately the beavers stand in a wrong order. In the graphics below those beavers are connected by a line where the back beaver should be larger than the front beaver. The only operation to rearrange beavers you can do is exchanging any two beavers of the group.

What is the minimum number of exchangeoperations, that after all, the beavers are ready for taking picture?

Please perform a minimum number of exchangeoperations by clicking on pairs of beavers.



Workshops are held in spring:

- 2005 in Balsiai, Pasvalys, Lithuania
- 2006 in Balsiai, Pasvalys, Lithuania
- 2007 in Balsiai, Pasvalys, Lithuania
- 2008 in Torun, Poland
- 2009 in Balsiai, Pasvalys, Lithuania
- 2010 in Dagstuhl, Germany, May 19-22
 - **2011** in Druskininkai, Lithuania, May 10-15

http://www.bebras.org



A pavement (Junior-Medium), Lowest Girls/Boys rate (0,83)

Peter took a photo of a pavement in front of his house and then created a graph which describes the paving (see pictures).





A point on the graph represents a tile. A line joining two points represents any two tiles bordering.

Later Peter was walking in the town and was photographing pavements. When he returned home he realized that all pavements (except of one) were suitable to fit his graph. Can you recognize which of them was not?





Stack of plates (Benjamin - Medium) - easiest task (68,74%) Least unanswered (1,95%)

In the restaurant of the Beaver school, there are two different kinds of plates: the high green ones for the small b and the flat brown ones for the big beavers.

One day, due to building activities, there is only room for one stack of plates.

The beaver kids are queuing for their lunch, and the kitchen beavers need to put the plates on the stack in the right order to make the stack match the queue. Example:



In one of the following pairs of plate stacks and beaver queues, there is a mismatch between queue and stack. In which one?





Easier for girls

OX (Senior - Medium)

Here is a line of text, containing only underscores and one single X. The cursor (denoted by |) is placed at the very beginning of the line.

Attention, the system is in the overwrite mode. That means, whenever you type a character you replace the character after the cursor and then the cursor moves to the right. Imagine you follow these instructions:

While the cursor is not at an X write an O
While the cursor is not at the beginning of the line write an X and move the cursor two places to the left
How will the above line of text look afterwards?

Х

Water supply (Benjamin - Medium)

Beaver has constructed a pipeline system to water his apple tree. In which case the apple tree gets water?

The expressions contain variables A, B, C, D, which may be true or false. A variable has the value true, if the corresponding gate is open, and false, if it is closed.

A = false, B = true, C = false, D = false A = true, B = true, C = false, D = false A = true, B = false, C = false, D = true A = false, B = false, C = false, D = true

Sorting game (Cadet - Hard)

On the break at the Beaver School pupils play sorting game with playing cards. In the game the cards must be ordered to the ascending order by switching the adjacent cards. Only numbers count, not the suits of the cards. If the numbers of the cards are in the right order you are not allowed to switch those cards.

How many moves does the game take with cards with the cards on the picture?

d) 7

a) 4 b) 5 c) 6

Twiddling (Junior - Medium) - hardest (28,13%)

Each of these two pieces of tube is made of 8 equal segments. These pieces are placed one above the other (they can be turned) so that they coincide partially.

What is the largest possible number of segments of their common part?

the same in the same same same

Beaver in his canoe (Senior - Medium)

eaver paddles in his canoe on a river. The river has a number of little lakes. Beaver likes all lakes of the river and has thought of an algorithm to make sure that he reaches every lake.

e knows that at each lake there is a maximum of two vers that he hasn't yet seen. If beaver arrives at a lake e decides which river to take with the following rules:

- If there are two rivers he has not yet seen, he takes the river on his left hand side
- If there is one river which beaver has not yet seen, beaver takes this river
- If he has seen all the rivers from a little lake, he paddles his canoe one lake back towards the previous lake

eaver stops his day of canoeing if he has seen verything and has come back to the start point. the picture you can see the river and the little lakes here beaver paddles his canoe. In each little lake beaver ses a different animal. Beaver writes down the animal name hen he sees an animal for the first time. which order will beaver write down the animals?

fish, frog, crocodile, turtle, stork, snake, otter, duck fish, crocodile, snake, stork, duck, otter, frog, turtle **fish, frog, turtle, crocodile, stork, otter, duck, snake** fish, frog, turtle

Running (Cadet - Hard)

Beaver likes running. Every morning when he wakes up he runs a few blocks. Below you see exactly how beaver runs:

Activity Running

perform activity Run_block perform activity Run_block perform activity Run_block Activity Run_block perform activity Run_street perform activity Run_street perform activity Run_street perform activity Run_street Activity Run_street Run 100 steps

Turn left

Beaver executes the activity Running. How many steps has beaver run?

Beetle path (Benjamin – medium, C / J / S - easy)

A robotic beetle is moving around this playing field according to these rules:

- The beetle starts on a randomly chosen cell.
 In one step the beetle looks at the arrows shown at the cell where it is staying and moves to the direction of the arrows so many cells as indicated by the number of arrows (one cell if there is one arrow, two cells if there are two arrows, and three calls if there are three arrows).
- During executing one step the beetle ignores the arrows in cells that it passes trough.
- The beetle repeats its steps until it either gets outside the playing field or it reaches a cell that has no arrows (column E).

A1, A2

A2, A3, A4

A2, A4

A1, A4

Thank you

Prisijungimas Vartotojo vindas:

Slantafodis:

Petsituriotti