# Computer Science Competitions as Valuable Learning Experiences

## Computer Science and Engineering Education Research

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# Talk outline

- About Vilnius university and me
- Computer Science and Engineering Education Research
- Informatics Engineering Doctoral Studies in Lithuania
- Informatics  Competitions as object for research
- International Doctoral Consortium in Lithuania every winter (first week of December)

# Lithuania – **LIETUVA**


- Territory – 65 300 km²
- Population – 3 mln.
- Lithuanians – 84%
- Vilnius – 550 000
- Currency – Litas
- Borders: with Latvia, Belorussia, Poland, Russia and Baltic sea

# About Vilnius University

**Established 1579**

In 1579, King Stephen Bathory's charter transformed the Jesuit college, founded in 1570, into an establishment of higher education, Academia et Universitas Vilnensis Societatis Jesu

# Vilnius University has:

- 12 faculties and 7 institutes
- 4 research centres and 3 university hospitals
- a Library (the oldest one in Lithuania)
- an Astronomical Observatory and a Botanical Garden
- a Centre of Information Technology Development
- St. John's Church

- 14 890 undergraduate students
- 4 046 graduate and 785 MD's in residency
- 793 doctoral students
- International students 713
- **Totally: 21 596 students**
- **http://www.vu.lt**

# Department of Didactics of Mathematics and Informatics at **Faculty** of Mathematics and Informatics

- Educating teachers for 20 years
- Are Bachelor Studies and Master Studies
- Combination - Maths, Pedagogy and Informatics

http://www.mif.vu.lt/katedros/mmk/homea.html

# Department of Informatics Methodology at **Institute** of Mathematics and Informatics

- I am head of the department
- Have doctoral students who mainly focus on Informatics and ICT education research

http://ims.mii.lt/ims/en/

# About me

- involved in teaching Informatics since 1986
- wrote more than 60 textbooks in Informatics
- published more than 150 research papers and methodical works
- established national Informatics and later IT curricula at schools
- heading the group at the Ministry of Education on preparing strategy for Informatics and ICT at schools in 2015-2020
- established International Contest Bebras on Informatics and Computer Fluency
- Vice-chair of IFIP committee on education TC3
- Member of International Steering Committee of IOI
- Editor of the international journals

INFORMATICS IN EDUCATION: www.mii.lt/informatics_in_education

OLYMPIADS IN INFORMATIS: www.mii.lt/olympiads_in_informatics

# My research areas

- Logo-based programming and constructionism
- Teaching algorithms and programming
- Teacher (Informatics) training
- Technology based learning
- Learning sciences and computing
- Educational information and communication technologies
- Informatics (Computer Science) Didactics
- Education software design and localisation
- Informatics engineering education research methods
- Developing of Learning Environments
- Computational thinking

# My PhD students research areas

- Extended metadata model for learning resources
- Automatic testing of programming tasks' solutions
- Localization of software for deaf and dull of hearing students
- Developing learning activities scenarios
- Research on Web 2.0 technologies in education
- Adaptation of virtual learning environment for programming
- Computer-based model of constructive geometry proof
- Learning styles of university students in relation to programming teaching methods
- Developing and applications learning objects of computer mathematics in scientific computing education

# Computer Science Education Research

- Interdisciplinary field of science researching
- – How students learn computing concepts, processes and practices in Computer Science, Computer Engineering, Software Engineering
- – How can the learning process be supported in terms of tasks, learning resources, teaching/learning methods, environments, building motivation ...
- CSER is not a pure subfield of Education, nor CS but combines theories, methods and technologies from several fields:
  - Education and Social sciences,
  - Computer Science or other fields of Computing

# Main events in CSER

- ICER - International Computing Education Research workshop
- ITiCSE - Innovation and Technology in CSE, 2014 June 23-25 in Uppsala http://iticse2014.it.uu.se/
- SIGCSE – ACM Special Interest Group on CSE http://www.sigcse.org/
- Koli Calling - International Conference on Computing Education Research: http://cs.joensuu.fi/kolistelut/
- Doctoral Consortium www.sigcse.org/events/consortium
- DC in Lithuania, Druskininkai: http://ims.mii.lt/ims/renginiai/Consortium/consortium.htm

# Characterizing Research in CS education

- L. MALMI, J. SHEARD, SIMON, R. BEDNARIK, J. HELMINEN … A. TAHERKHANI, **CHARACTERIZING RESEARCH IN COMPUTING EDUCATION: A PRELIMINARY ANALYSIS OF THE LITERATURE. PROCEEDINGS OF THE SIXTH INTERNATIONAL WORKSHOP ON COMPUTING EDUCATION RESEARCH** (ICER '10). ACM, NEW YORK, NY, USA. 3-12.

- ICER had the highest percentage of research papers among computing education conferences
- ICER focuses on "A clear theoretical basis, drawing on existing literature in computing education or related disciplines" and "a strong empirical basis, drawing on relevant research methods"

- Research purpose
- Research framework
- Data source
- Analysis methods

# Research purpose

- **Descriptive** – description of a tool, technology or system. This may involve detailed explanation of features, functionality and rationale for development.
- **Evaluative** – assessment of a tool, method or situation, typically through a systematic process involving data gathering, analysis and reporting. This may involve hypothesis testing and may be exploratory or investigative in nature.
- **Formulative** – development and/or refinement of a theory, model, standard, or process, or proposition of a new concept.

# Research framework:

## Theories, Models, Instruments

- **Action research**
- **Case study**
- **Constructive research**
- **Delphi**
- **Ethnography**
- **Experimental research**
- **Grounded Theory**
- **Phenomenography**
- **Phenomenology**
- **Survey research**

# About each framework

- **Action research**: A self-reflective systematic inquiry undertaken by participants to improve practice. Typically conducted as an iterative cycle of planning, action, change, reflection.
- **Case study**: In-depth, descriptive examination conducted in situation, usually of a small number of cases/examples.
- **Constructive research**: Research that aims to demonstrate and/or evaluate the feasibility of a proposed idea (concept implementation; proof-of-concept research). Revolves around the development of, e.g., software, technology, a teaching approach, or an evaluation instrument.
- **Delphi**: Seeking consensus by showing a group of raters a summary of their ratings, with justifications, then iteratively inviting them to reconsider their ratings in the light of what the others have said.
- **Ethnography**: A branch of anthropology that deals with the scientific description of individual cultures.

# About each framework

- **Experimental Research**: Quantitative research based on manipulating some variables while varying and measuring others. This requires formation of control and experimental groups of participants with random assignment of participants or use of naturally formed groups.
- **Grounded Theory**: Qualitative, data-driven research in the tradition of Glaser and/or Strauss which aims to formulate theories or hypotheses based on data.
- **Phenomenography**: Investigation of the significant variations in the ways that people experience a phenomenon (2nd order perspective).
- **Phenomenology**: Investigation of the richness and essence of a phenomenon by studying one's own or others' experiences of it (1st order perspective).
- **Survey Research**: Quantitative research based on exploring the incidence, distribution and/or relationships of variables in non-experimental settings.

# Other well-known theories

- Bloom's taxonomy
- SOLO taxonomy
- Self-efficacy theory
- Cognitive apprenticeship theory
- Situated learning
- Cognitive load theory
- General systems theory
- Threshold concepts
- Schema theory

# Data source

- **Naturally occurring** data
- Data **collected specifically** for the needs of the research
- The researchers' **own reflections** and experiences of a phenomenon serve as data
- Data **collected about a software system**

# Analysis methods

- **Argumentation**: Conclusions are reached through arguments presented by the author(s)
- **Conceptual analysis**: Breaking down or analyzing concepts
- **Statistical analysis**
- **Qualitative analysis**
- Mathematical/logical **proof**

# Doctoral studies in Informatics and Informatics Engineering in Lithuania

- Informatics engineering (IE) is very dynamic and fast growing research area as well as practical engineering activity.
- IE is an application of engineering methods in the development of:
  - information systems (IS engineering);
  - software systems (SE);
  - robotic systems;
  - process management systems;
  - embeded systems;
  - computer-based communication systems;
  - etc.

# Informatics Engineering

- According to official science classification in Lithuania, informatics engineering (07T) belongs to technological sciences and covers the following areas:
  - image technologies (T111);
  - system engineering and computer-aided technologies (T120);
  - signal technologies (T121);
  - automation, robotics, and control engineering (T125);
  - telecommunication engineering (T180); and
  - telematics (T181).

# Informatics

- Informatics (09P), along with mathematics, physics, chemistry, biochemistry, geology, physical geography, palaeontology, and astronomy, belongs to physical sciences (P000) and covers the following areas:
  - mathematical logic, set theory, combinatory (P110);
  - computer science, numerical analysis, systems, control (P170);
  - informatics, system theory (P175);
  - artificial intelligence (P176);
  - mathematical and general theoretical physics, classical mechanics, quantum mechanics, relativisms, gravitations, statistical physics, thermodynamics (P190).

# Differences

- We have a slightly strange science classification:
  - both informatics and informatics engineering are ill-defined;
  - the border between informatics and informatics engineering is unclear and blurred;
  - informatics as an physical science includes informatics as a branch of this science,
- In practice, **informatics is considered as more theoretical research area and informatics engineering as more practice-oriented research**.

# Differences

- Often everything depends on a particular context and other circumstances.
  - For example, a doctoral student doing this same research can study in informatics or in informatics engineering programme depending on in which programme the funding exists.
  - Similar situation also is with publications, positions, etc.

# Doctoral study programs in Informatics Engineering

- There are two doctoral study programs in informatics engineering in Lithuania:
  - The program of  Vilnius University.
  - Join program of Kaunas University of Technology and Vilnius Gediminas Technical University.
  - Both programs started in 2010.
- At Vilnius University the studies are going in 3 places: at the Institute of Mathematics and Informatics, at the Faculty of Mathematics and Informatics, and at Kaunas Faculty of Humanities.

# Doctoral thesis defended in 2010-2012

| Dissertants | Thesis |
|---|---|
| | **Kaunas University of Technology (18)** |
| Rūta Petrauskienė | **METHODS AND TOOLS FOR APPLYING INFORMATION TECHNOLOGY TO IMPROVE THE QUALITY OF DISTANCE LEARNING** |
| Vita Špečkauskienė | DEVELOPENT AND ANALYSIS OF INFORMATIONAL CLINICAL DECISION SUPPORT METHOD |
| Gytenis Mikulėnas | THE CONSTRUCTION AND RESEARCH OF THE FRAMEWORK FOR A PARTIAL AGILE METHODS ADAPTATION |
| Kęstutis Jankauskas | SKELETON-BASED SURFACE GENERATION METHOD |
| Jonas Guzaitis | ADAPTIVE IMAGE ANALYSIS FOR AUTOMATED VISUAL QUALITY CONTROL |
| Edvinas Pakalnickas | COMPONENT SYSTEM MODEL BASED DESIGN OF INFORMATION SYSTEMS |
| Vidas Raudonis | DEVELOPMENT AND INVESTIGATION OF PORTABLE EYE TRACKING SYSTEM |

# Doctoral thesis defended in 2010-2012

| Dissertants | Thesis |
|---|---|
| **Kaunas University of Technology (18)** | |
| Andrius Raulynaitis | CONSTRUCTION AND ANALYSIS OF ASSYMETRIC CIPHERS, USING ALGORITHMIC HARD PROBLEMS IN MATRIX ALGEBRA |
| Martynas Patašius | AUTOMATED ANALYSIS OF EYE FUNDUS IMAGES |
| Gediminas Valiulis | EXTENDED SIMULATION MODELS FOR GRANULATION OF FERTILIZERS |
| Andrej Ušaniov | SOFTWARE INTERFACE AUTOMATED TESTING METHOD |
| Aurimas Laurikaitis | EXTRACTING CONCEPTUAL DATA SPECIFICATIONS FROM LEGACY INFORMATION SYSTEMS |
| Rokas Zakarevičius | RESPONSE AND REQUEST ZONE CONTROL FOR ROUTING IN WIRELESS AD HOC NETWORKS |
| Donatas Sandonavičius | COMPUTING GRID RESOURCE SELECTION METHOD |

# Doctoral thesis defended in 2010-2012

| Dissertants | Thesis |
|---|---|
| **Kaunas University of Technology (18)** | |
| Dominykas Barisas | AUTOMATED METHOD FOR SOFTWARE INTEGRATION TESTING BASED ON UML BEHAVIORAL MODELS |
| Mikas Binkis | OBJECT ORIENTED VISUAL SCRIPTING LANGUAGE RESEARCH AND DEVELOPMENT |
| Ernestas Vyšniauskas | HYBRID METHOD FOR TRANSFORMING OWL 2 ONTOLOGIES INTO RELATIONAL DATABASES |
| Kęstutis Jonelis | CONTROL ALGORITHMS AND SYSTEMS OF BIOTECHNOLOGICAL WASTE WATER TREATMENT PROCESSES |
| **Total:** | **18** |
| **E-learning:** | **1** |
| **Women:** | **2** |
| **Mans:** | **16** |

# Doctoral thesis defended in 2010-2012

| Dissertants | Thesis |
|---|---|
| **Vilnius Gediminas Technical University (10)** | |
| Justas Trinkūnas | RESEARCH ON CONCEPTUAL DATA MODELLING USING ONTOLOGY |
| Rūta Dubauskaitė | RESEARCH ON CONSISTENCY CHECKING OF DIFFERENT ASPECTS MODELS OF THE INFORMATION SYSTEM |
| Simona Ramanauskaitė | MODELLING AND RESEARCH OF DISTRIBUTED DENIAL OF SERVICE ATTACKS |
| Jurgita Lieponienė | **THE RESEARCH OF E-LEARNING RESULTS' ASSESSMENT TECHNOLOGIES** |
| Andrej Vlasenko | RESEARCH OF EMOTIONAL STATE STUDENTS DURING TEST USING BIOMETRIC TECHNOLOGY |
| Rūta Simanavičienė | THE SENSITIVITY ANALYSIS OF THE QUANTITATIVE MULTIPLE ATTRIBUTE DECISION MAKING METHODS |
| Darius Jurkevičius | RESEARCH ON USING FORMAL CONCEPTS FOR INFORMATION SYSTEMS DEVELOPMENT |

# Doctoral thesis defended in 2010-2012

| Dissertants | Thesis |
|---|---|
| **Vilnius Gediminas Technical University (10)** | |
| Aidas Šmaižys | A STUDY ON IMPLEMENTATION OF AUTOMATED DECISION PROCESS INTO THE INFORMATION SYSTEMS |
| Artūras Kriukovas | DIGITAL SIGNATURE TECHNOLOGIES FOR IMAGE INFORMATION ASSURANCE |
| Nikolaj Goranin | GENETIC ALGORITHM APPLICATION IN INFORMATION SECURITY SYSTEMS |
| **TOTAL:** | **10** |
| **E-learning:** | **1** |
| **Women:** | **4** |
| **Mans:** | **6** |

# Doctoral thesis defended in 2010-2012

| Dissertants | Thesis |
|---|---|
| **Institute of Mathematics and Informatics, Vilnius University** | |
| Povilas Treigys | DEVELOPMENT AND APPLICATION OF METHODS IN THE GRAPHICAL OPHTHALMOLOGICAL AND THERMOVISUAL DATA ANALYSIS |
| Rasa Lileikytė | QUALITY ESTIMATION OF SPEECH RECOGNITION FEATURES |
| Svetlana Kubilinskienė | **EXTENDED METADATA MODEL FOR DIGITAL LEARNING RESOURCES** |
| Ernestas Filatovas | SOLVING MULTIPLE CRITERIA OPTIMIZATION PROBLEMS IN AN INTERACTIVE WAY |
| Žilvinas Vaira | INVESTIGATION, IMPROVEMENT AND DEVELOPMENT OF ASPECT-ORIENTED DESIGN PATTERNS |
| Aleksandr Igumenov | ELECTRICAL ENERGY AWARE PARALLEL AND DISTRIBUTED COMPUTING |
| Saulius Preidys | **THE APPLICATION OF DATAMINING METHODS TO PERSONALISED LEARNING ENVIRONMENTS** |
| Bronius Skūpas (2013) | **A METHOD FOR SEMI-AUTOMATIC EVALUATION AND TESTING OF PROGRAMMING ASSIGNMENTS** |

# Doctoral thesis defended in 2010-2012

| Dissertants | Thesis |
|---|---|
| Institute of Mathematics and Informatics, Vilnius University | |
| TOTAL: | 7 |
| E-learning: | 2 |
| Women: | 2 |
| Mans: | 5 |
| In all institutions | |
| TOTAL: | 35 |
| E-learning: | 4 |
| Women: | 8 |
| Mans: | 27 |

# Study programs

| VU IMI | KUT | VGTU |
|---|---|---|
| **Mandatory courses (at least 2 must be choose)** | **Mandatory courses** | **Mandatory courses** |
| Mathematical methods in informatics engineering | IT methods | Theoretical methods of informatics engineering |
| **Research methods and methodology in informatics and informatics engineering** | Informatics theory | Optimisation methods and operation research in Internet environment |
| Parallel and distributed computing | | |
| Recognition theory | | |
| | | |
| | | |

# Study programs

| IMI | KUT | VGTU |
|---|---|---|
| **Optional courses** | **Optional courses** | **Optional courses** |
| Acoustic phonetics | Electronic design automation | Decision support models |
| Digital signal processing | Design automation methods | Engineering decisions making technologies |
| Recognition of speech signals | Hybrid control and optimisation systems | Conceptual modelling and knowledge representation |
| Digital image processing | Process modelling and identification | Application of AI methods in IS |
| Digital processing systems | Technology regulation and debugging systems | Face modelling and speech animation |
| Methods and applications of adaptive filters in systems | Software development technologies | Information security technologies |
| Optimization methods and applications | Information needs specification models | Advanced harming code discovering methods |
| Optimization theory and algorithms complexity | System analysis technologies | |

# Study programs

| IMI | KUT | VGTU |
|---|---|---|
| **Optional courses** | **Optional courses** | **Optional courses** |
| Multidimensional data visualization | Neural networks and neural computing | |
| Knowledge-based methods and systems in application of wireless technologies | Methodology of transformation of high level specifications | |
| Global optimization methods | DB and semantic models | |
| Stochastic programming | Information systems foundations | |
| Game theory: algorithms and applications | Program transformation models and processes | |
| Data analysis strategies in decision making | Formalisation and analysis of complex systems | |

# Study programs

| IMI | KUT | VGTU |
|---|---|---|
| **Optional courses** | **Optional courses** | |
| **Software localisation** | | |
| **Computer-based learning technologies** | | |
| Logical foundations of AI | | |
| Ontological foundations of IS | | |
| **Programming languages theory** | | |
| Generative and aspect-oriented programming | | |

# Doctoral studies in IE at Vilnius University

- Main requirements
  - **4 years, 20 credits**
  - **all results must be published**
  - **at least 2 papers should be published in reviewed journals**
  - all results should be presented at conferences (at least 1 international conference)
  - **thesis and extended summary** (about 30 pages) must be prepared (thesis and summary must be different languages – one in Lithuanian other in foreign language – English, French, Germany, Russian, etc.)

# Doctoral studies in IE at Vilnius University

- Current situation
  - 20 students (6 female, 14 male)
  - Research topics
    - Optimisation - 3
    - Recognition and signal processing – 2
    - Data mining and vizualisation – 4
    - Operation research – 2
    - Software engineering, information systems engineering, service engineering – 5
    - **Technology-based Leraning and CSE - 4**

# Research methods and methodologies in Informatics and Informatics engineering

- General research models (Wallace, Jenkins)
- Specific research models in informatics and informatics engineering
- Qualitative and quantitative research methodologies
- Analysis of phenomena in physical, social, and virtual realities: Observation, evaluation, conceptualization, descriptive and explaining theories

# Research methods and methodologies in Informatics and Informatics engineering

## Theoretical research methods

- Induction, deduction, abduction, analogical reasoning, scientific theory, modelling, mathematical methods, data analysis and date mining, comparative analysis, conceptual analysis, contextual analysis, application of theoretical research methods in informatics and IE

## Qualitative empirical research methods

- Hypothesis formulation and validation, grounded theory, case study, phenomenographic research, longitudinal research, ethnographic research

## Quantitative empirical research methods

- Controlled experiment, case study, field experiment, computing as research method, computer experiment, computational models, simulation and imitation as research methods, benchmarking, case study, application of experimental research methods in informatics and IE

# Research methods and methodologies in Informatics and Informatics engineering

## Constructive research

- Construction as scientific research method; developments of construction, their analysis, testing, and evaluation; prototyping; design research as constructive research; action research; constructivism vs. constructionism; constructive research in informatics engineering

## Problem solving

identification and definition of scientific problems; characteristics of difficult problems; problem analysis; problem solving strategies; problem solving methodologies; cooperative problem solving; how to use relevant old knowledge (past cases) to solve new problems; forming new concepts on the basis of experience and old concepts; problem solving in informatics and IE

# Competitions

- Competitions in Informatics have become **important events** for outstanding student developers to demonstrate their capabilities
- Just the idea of participating in a competition is often enough to increase students‘ **motivation**
- The competition structure creates an **environment that reflects real-world work context** better then course-related tasks
- Competitions are important **networking** events.

# Scope

- How have the contests in informatics organized?
- What kind of results has been achieved?
- What kinds of tasks are good for contests?
- How to design good tasks? What are the criteria for good tasks?
- How to evaluate the submissions – which are the relevant factors?
- What do we know about the participants, their background and the factors behind their success?
- What kind of effect the competitions have had on their future studies and careers?
- How could we develop computing education based on this information?

# Olympiads in Informatics

- Gifted and Talented
- Pupils gifted in Informatics?
- How we should recognize them?
- What age?
- Who can help them? Teachers? Parents?

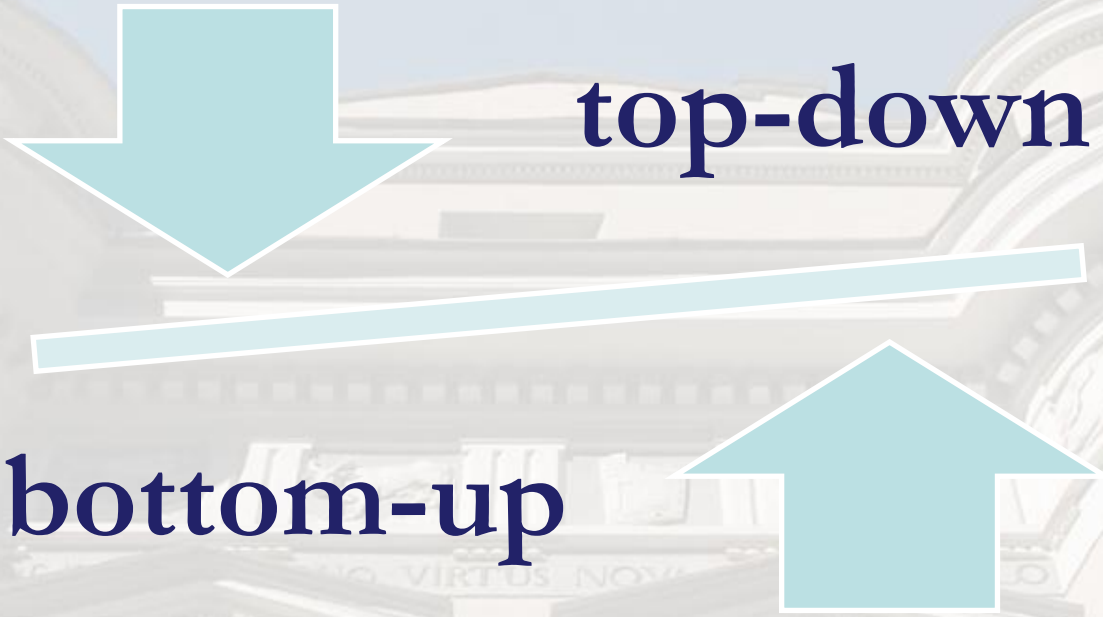
# Research on gifted children

- In one of the most extensive studies carried out, research found that out of 210 gifted children followed into later life, only 3% were found to fulfil their early promise.
- Prof. Joan Freeman, said that of 210 children in her study, 'maybe only half a dozen might have been what we might consider conventionally successful.‘
- http://www.digimaxhost.co.uk/~joan/tvclips.php
- http://www.dailymail.co.uk/news/article-1315414/Gifted-children-just-likely-fail-life.html

# Outcomes: students should be able

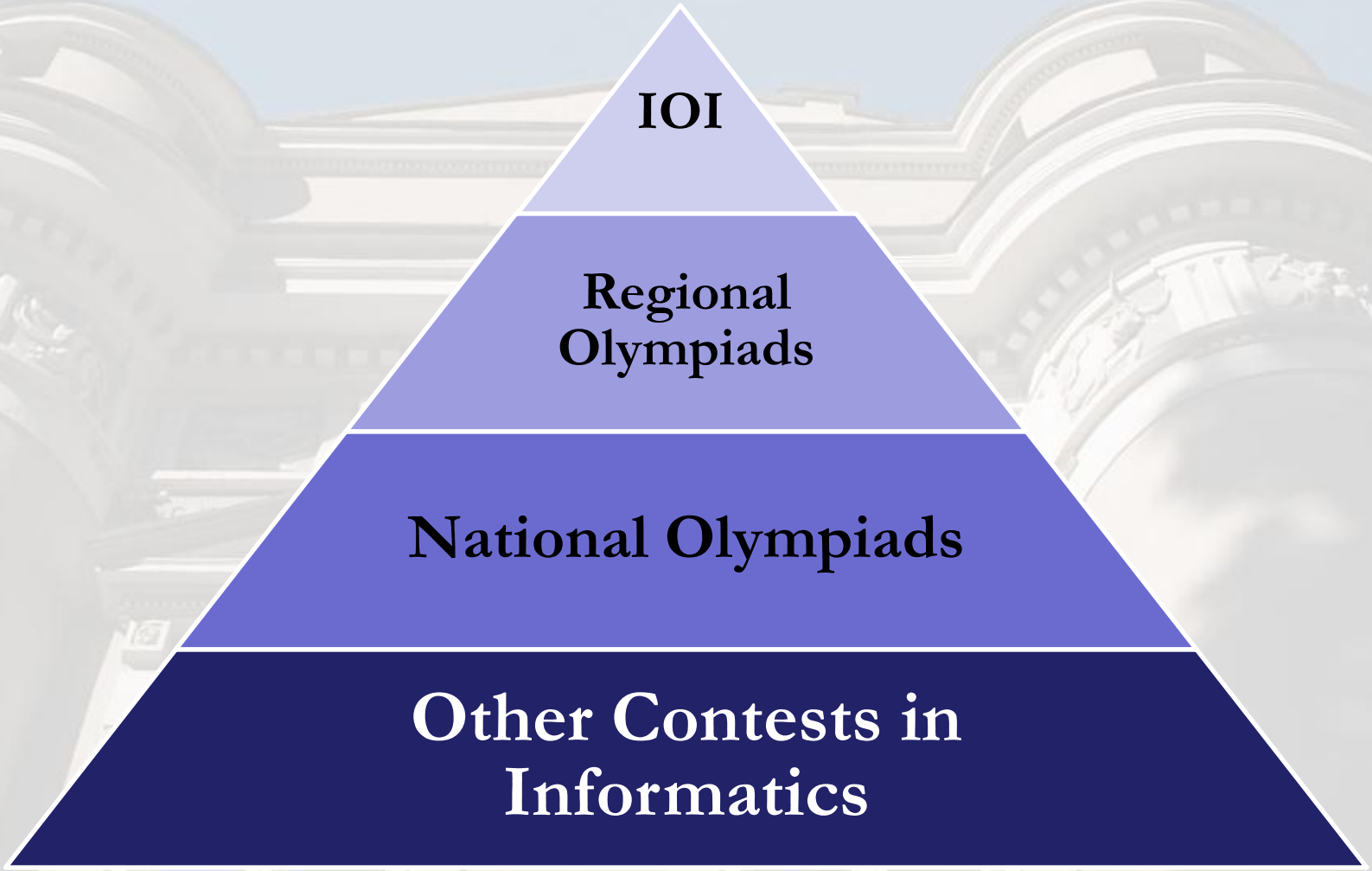
- to give an overview of the contests in informatics field, what kind of competitions can be
- to identify different types of tasks and their solutions, explain what kind solving methods they required and what kind abilities are possible to develop, when solving them
- to point out evaluation ways and testing systems
- to explain the basics of informatics concepts that students should know while participating in the contests
- to discuss the influence of the contests to students future studies
- to create tasks for the contests in informatics and evaluate them

# How to develop a contest?
## Two types of strategies




1) Top-down strategy is a challenge to find a suitable international contest, train students, and join it after intensive work
2) Bottom-up strategy stresses an opportunity to establish the original local contest

# Contests in Informatics



# International Olympiad in Informatics

IOI is annual international informatics competition for individual contestants from about 80 countries

IOI is managed by the General Assembly and International Committee

# Additional credits of the IOI

- Introduction to Informatics education in countries
- Influence on developing regional and national contests
- Social network for students and team leaders

# IOI Conference

- Established in 2007
- Two-half days conference during IOI
- Short and long presentations
- Journal


Richard Forster, UK

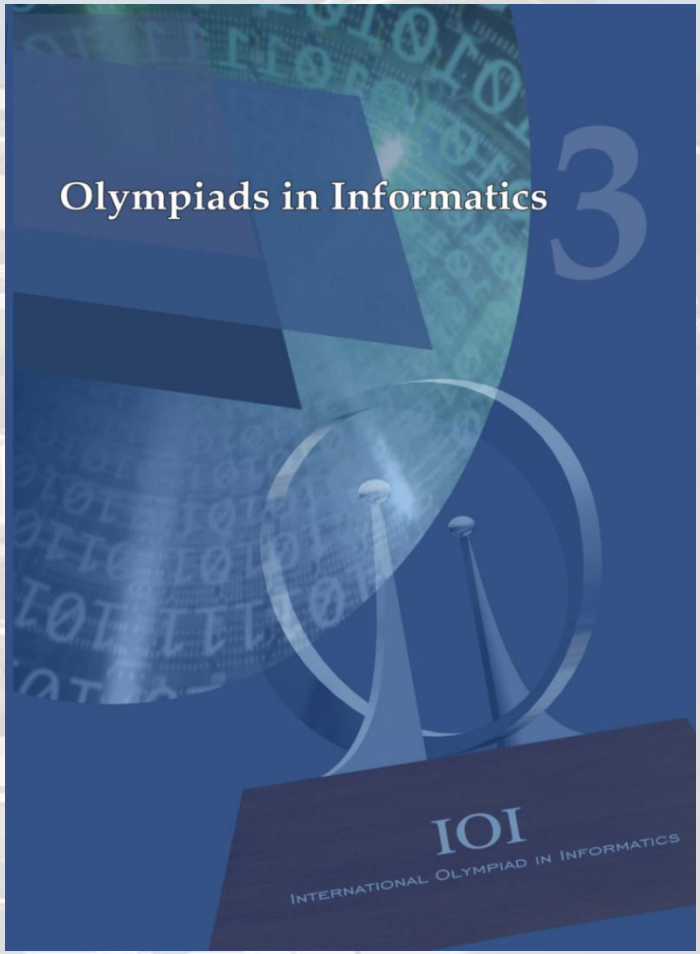
Valentina Dagienė, Lithuania

Troy Vasiga, Canada

# International IOI Journal

- 2007: 17 papers, 174 p.
- 2008: 16 papers, 207 p.
- 2009: 14 papers, 174 p.
- 2010: 15 papers, 170 p.
- 2011: 12+7 papers, 177 p.
- 2012: 10+10 papers, 231 p.
- 2013: 12+9 papers, 171 p.

http://www.mii.lt/olympiads_in_informatics



# Contests in Informatics

- Contests are a source of inspiration and innovation
- Test-and attractive-tasks-based contests may be the key to the potential of new knowledge and attractive way to bind up technology and education
- *Bebras* (Beaver) – International Contest on ***Informatics and Computer Fluency***
- The main principles of the *Bebras* contest are borrowed from the international mathematical contest *Kangaroo*

# 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

# Bebras Countries

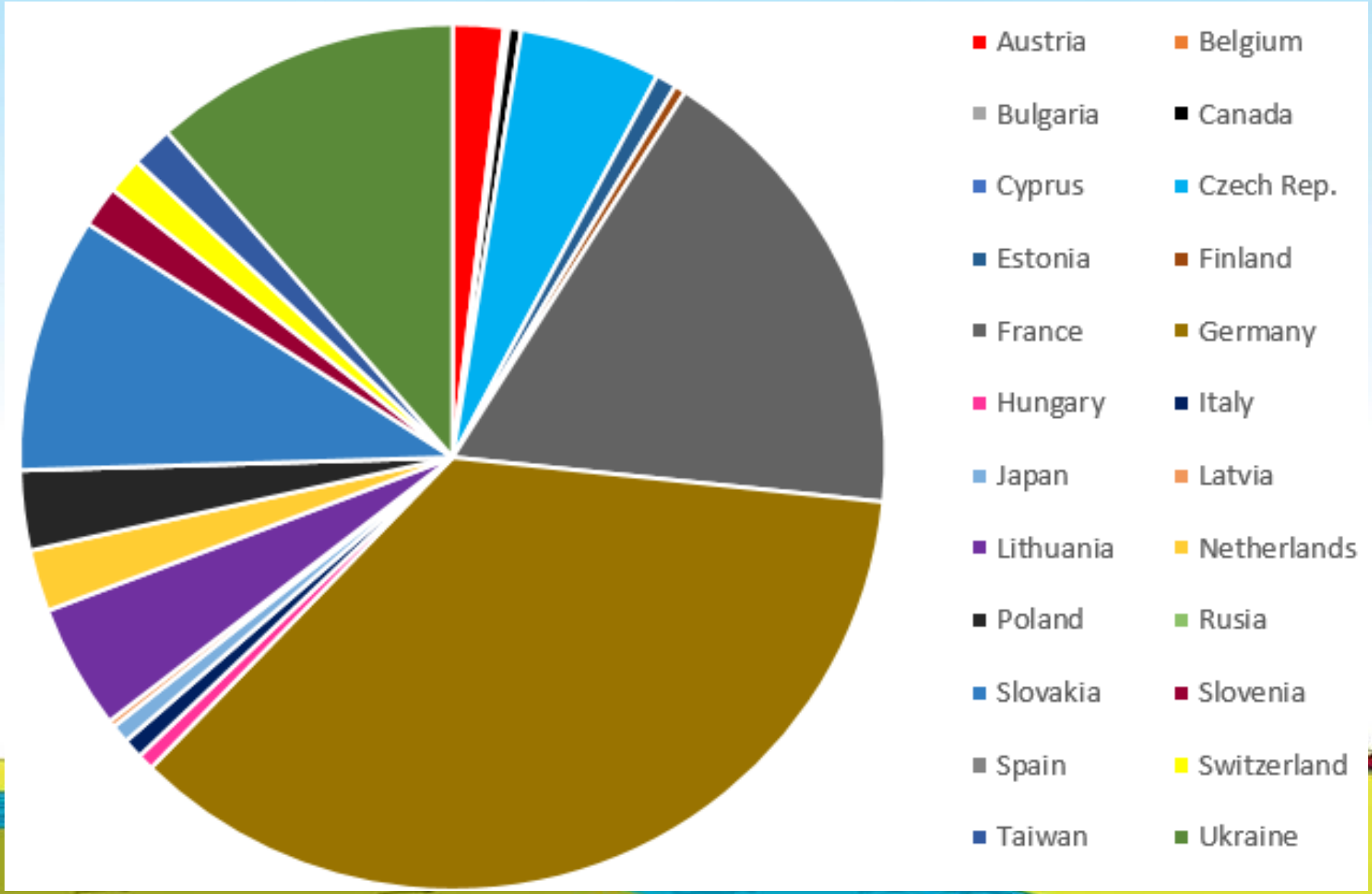
**24 countries**

**Trial**
Israel
Sweden

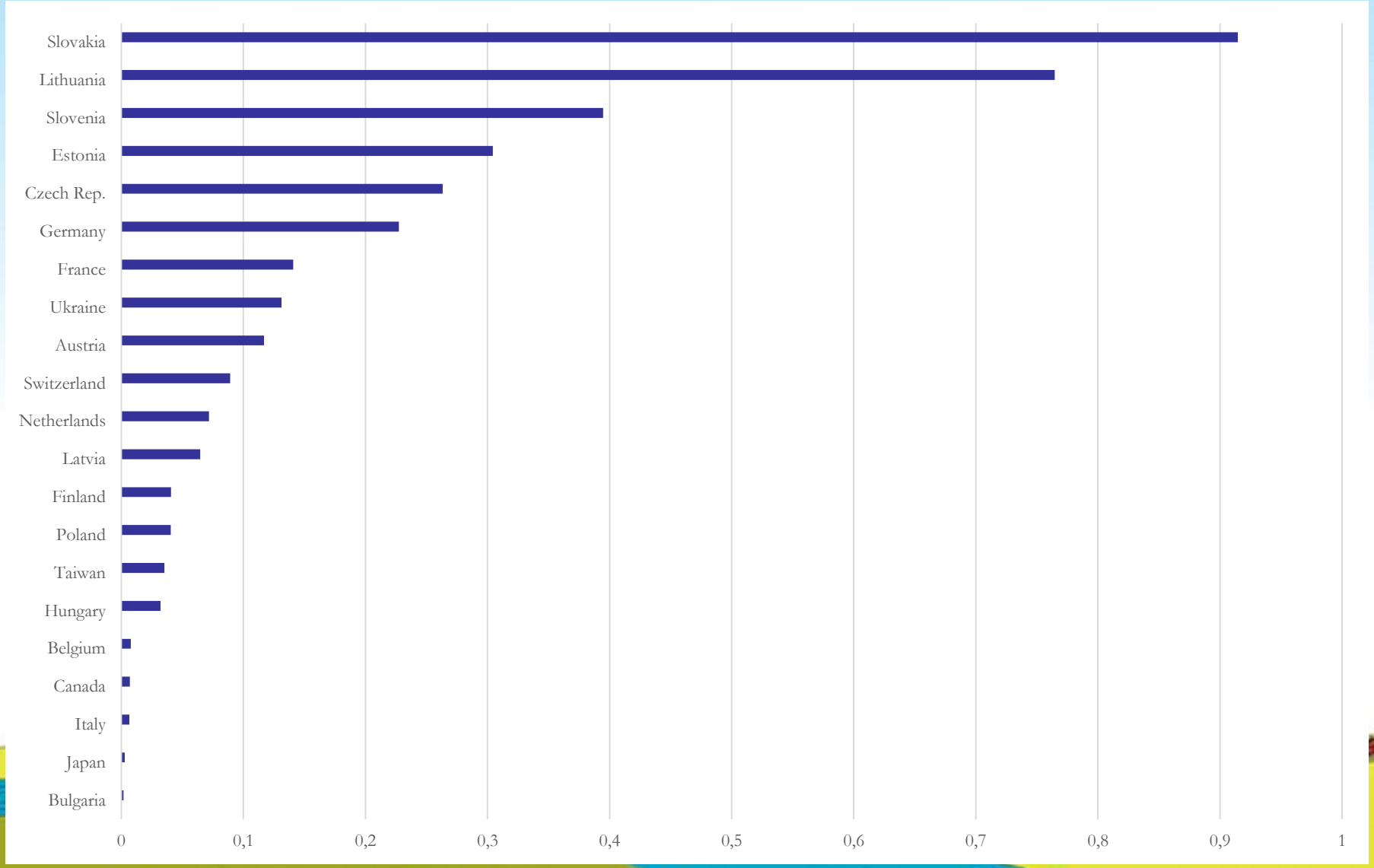
**New countries**
Ireland
UK
USA
S. Korea

| Country | Particip. 2010 | Particip. 2011 | Particip. 2012 | First Contest |
|---|---|---|---|---|
| Austria | 8 425 | 9 171 | 9877 | 2007 |
| Belgium | - | - | 848 | 2012 |
| Bulgaria | - | - | 137 | 2012 |
| Canada | - | 200 | 2400 | 2011 |
| Cyprus | - | - | ? | 2012 |
| Czech Rep. | 14 867 | 19 280 | 27650 | 2008 |
| Estonia | 3 956 | 4 807 | 4012 | 2005 |
| Finland | 1 472 | 2 045 | 2197 | 2010 |
| France | - | 46 346 | 92000 | 2011 |
| Germany | 117 950 | 155 419 | 186048 | 2006 |
| Hungary | - | 1 911 | 3200 | 2011 |
| Italy | 1 325 | 1 597 | 3885 | 2009 |
| Japan | - | 1 600 | 3600 | 2011 |
| Latvia | 1 072 | 893 | 1336 | 2005 |
| Lithuania | 13 889 | 19 277 | 24390 | 2004 |
| Netherlands | 10 231 | 11 252 | 12000 | 2005 |
| Poland | 9 962 | 11 945 | 15587 | 2005 |
| Russia | - | - | ? | 2012 |
| Slovakia | 22 139 | 36 382 | 49798 | 2008 |
| Slovenia | - | 3 454 | 8120 | 2011 |
| Spain | - | - | ? | 2011 |
| Switzerland | 3 470 | 4 475 | 7086 | 2010 |
| Taiwan | - | - | 8100 | 2012 |
| Ukraine | 25 971 | 42 176 | 59918 | 2008 |

# Absolute Participation 2012



# Relative Participation 2012



# Bebras Contest: The Challenge of Thinking

- To solve the tasks one has to **think**
- Already learned knowledge is not asked
- Pupils have to find solving strategies
- They have to find and understand structures
- They have to think about different cases
- They have to find arguments for or against given alternatives

# Developing Problem Solving Skills

- Solving Bebras tasks educates in „Computational Thinking“
- Computer science (CS) like thinking is done while solving a task
- Tasks are mostly on CS-related problem solving skills
- Each task involves a CS concept that needs specific thinking qualities

# Bebras Contest

**Participants**

all pupils age 8 to 19

different tasks for 5 age groups:

- PRIMARY 8-9 years (grade 3-4)
- 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 40 to 60 minutes

interactive tasks and multiple-choice tasks

2 - 3 minutes per task

easy, medium and hard tasks

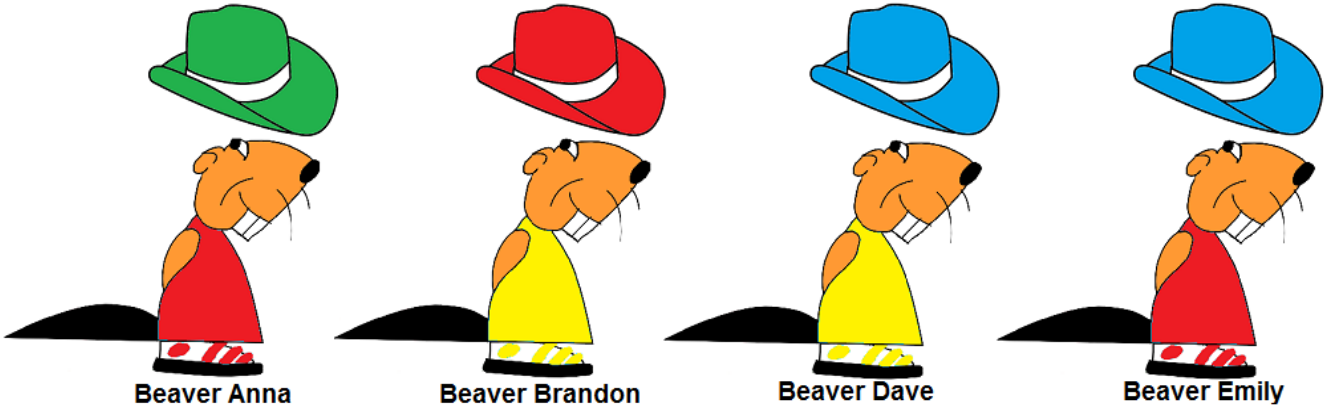
performed on PCs, usually during school lectures

## NL-12 Wrong hat (Cadet medium)

The beavers Anna, Brandon, Dave und Emily have in dressing style two rules:

- All four beavers have the hat with their preferred colour.
- None of the beavers prefer the same hat colour as the colour of the shirt

But at the moment all four beavers have the wrong hat colour:




**To which beaver belongs the green hat?**

A. Anna

B. Brandon

C. Dave

D. Emily

**It is informatics**
Logic deduction is the basis of computer science. Exclusion of impossible arrangements can lead to the desired solution.

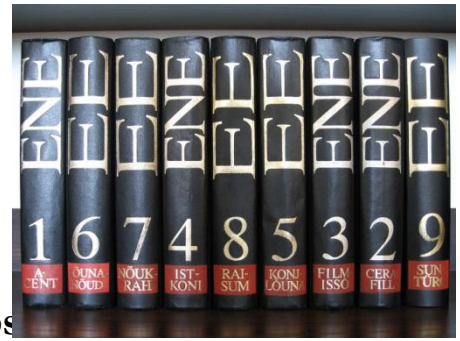
# EE-03 Bookshelf (Junior medium)

The librarian wants to order the volumes of an encyclopaedia with as few steps as possible.

For doing one step he takes a volume out of the shelf, shifts some of the remaining ones to left or right and puts the volume in his hand to the new free space.

The following example sorts 5 volumes using just one step:


Now he wants to order the following 9 volumes:



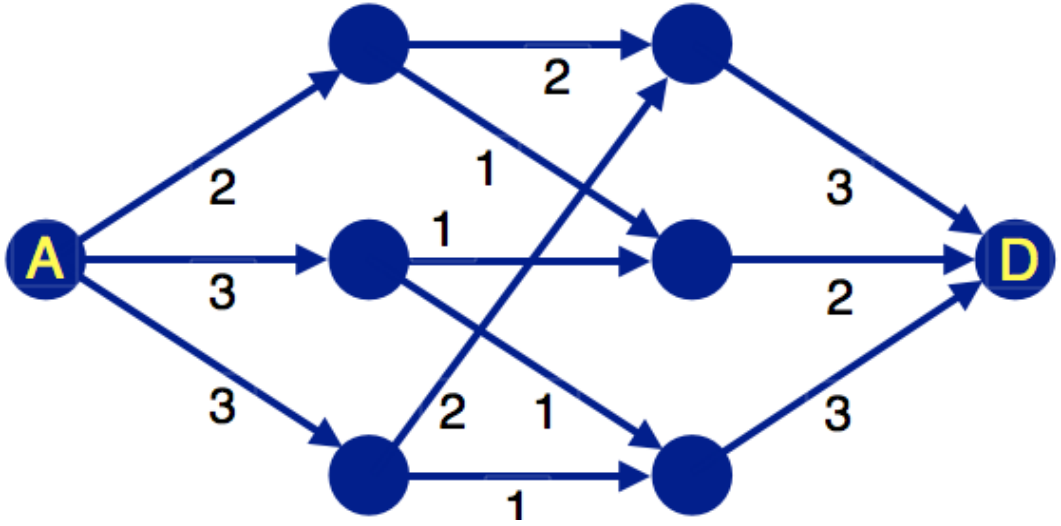

**What is the smallest number of steps**

**This is computational thinking**

A largest increasing subsequence remains untouched in the optimal solution . To find substructures that remain invariant is a key competence of computational thinking.

**CH-09 Beaver's log factory** (Senior hard)

The beavers have established a site (A) where they do all their log chopping. They want to transport them through a series of canals to the biggest dam ever built (D). Unfortunately the canals allow the transport only of a certain number of logs per minutes (the number at each arrow).



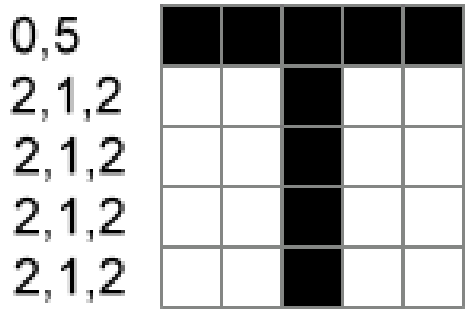

**How many logs can reach the dam (D) per minute?**

**This is informatics**

The "maximal flow" in a network with capacities is a typical optimization problem. It can be solved on a computer even for large networks with help of a systematical algorithm, that can efficiently calculate the exact solution.

## NL-08 Black and white images (BENJAMIN)

Images on a computer are divided up into a grid of small dots called pixels.
In a black and white image, each pixel is either black or white. The computer can represent black and white images with numbers, for example:




The first number always gives the number of white pixels, the next number giv
the number of black pixels and so on. So the first line consists of 0 white pixels
followed by 5 black pixels. The second line consists of 2 white pixels, 1 black
pixel and 2 white pixels.

**Which letter is represented by the following numbers?**

**0,1,3,1**
**0,1,3,1**
**0,5**
**0,1,3,1**
**0,1,3,1**

A) B B) U C) H D) E

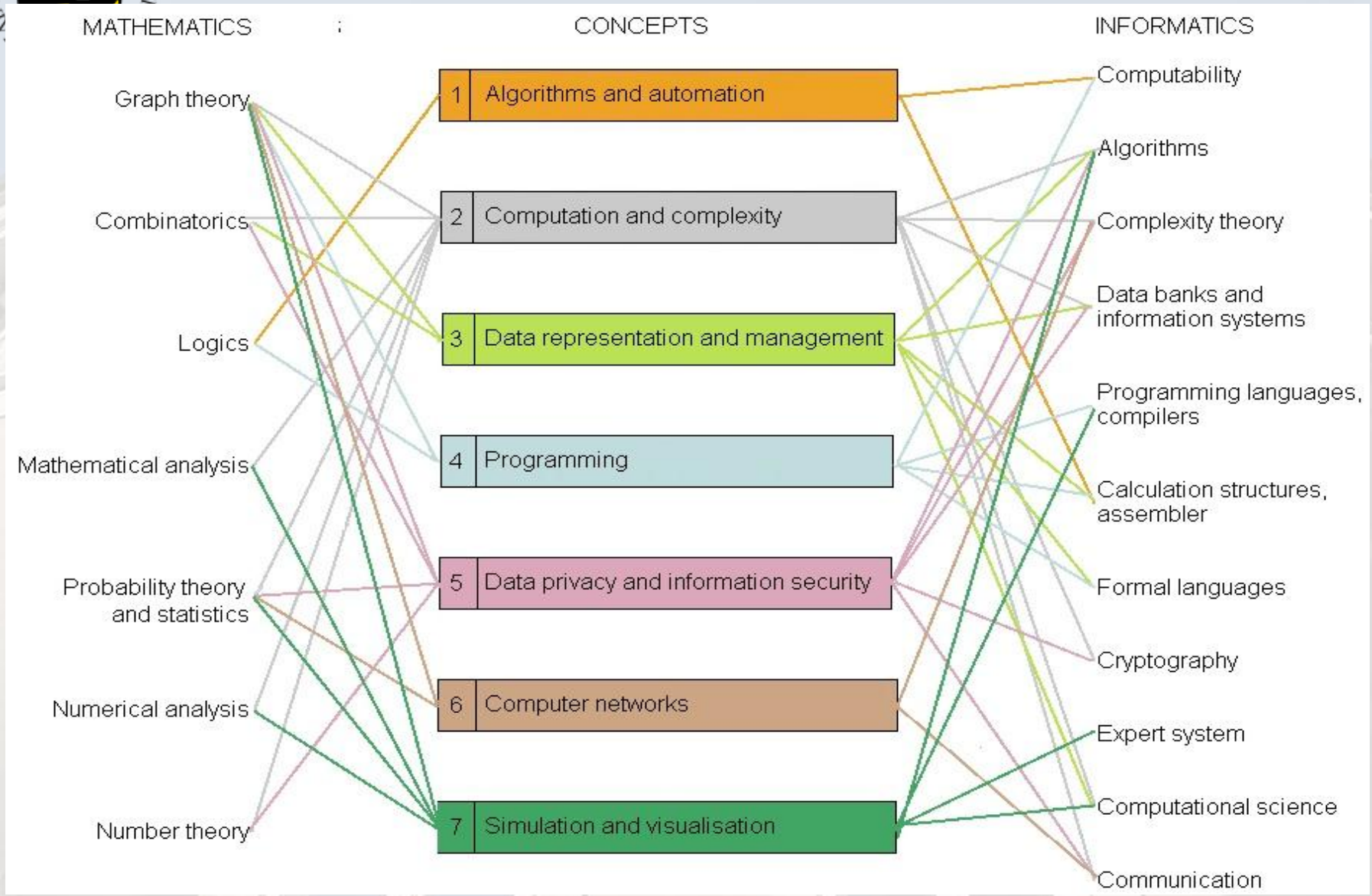
# Attractive tasks – keystone of contests

- Very important to choose interesting tasks, powerful, attractive, surprise...
- Powerful: what educational power they contains, whether they stimulate the motivation of learning
- Different types of tasks: starting from common questions of computer science application to specific integrated problems related to algorithms, computer history, programming languages, logics, discrete mathematics, etc.
- Important to choose the problems so that the participants could have as equal positions as possible irrespective of hardware or software

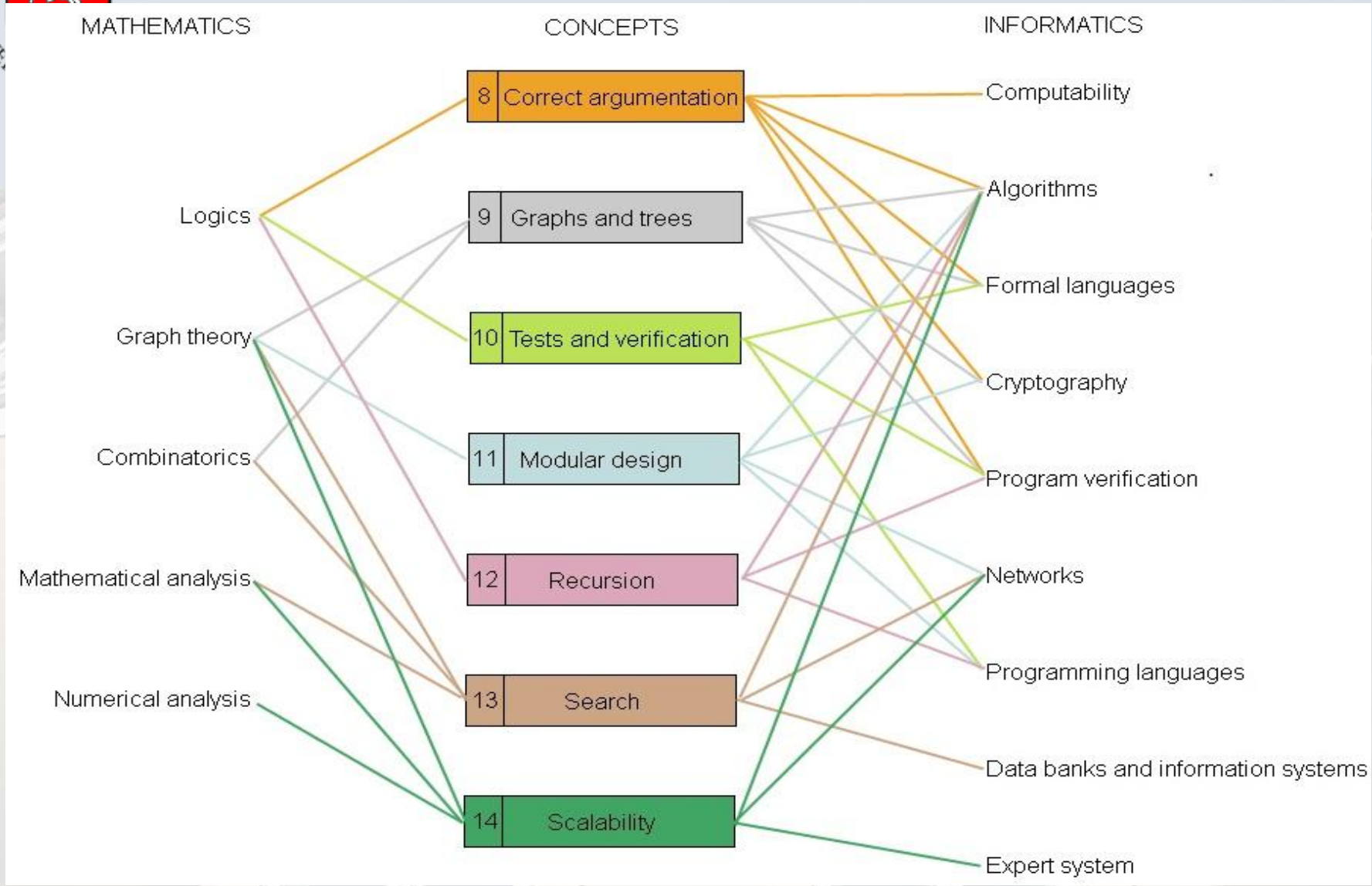
# BEBRAS Task Categories

- **INF - Information comprehension**
- representation (symbolic, numeric, visual)
- coding, encryption
- **ALG - Algorithmic thinking**
- including programming aspects
- **USE - Using computer systems**
- eg. search engines, email, spread sheet, etc.
- general principles, but no specific systems
- **STRUC - Structures, patterns and arrangements**
- combinatory
- discrete structures (graphs, etc)
- **PUZ - Puzzles**
- logic
- games (mastermind, minesweeper, etc.)
- **SOC - ICT and Society**
- social, ethical, cultural, international, legal issues

# Informatics concepts at school



# Informatics concepts at school



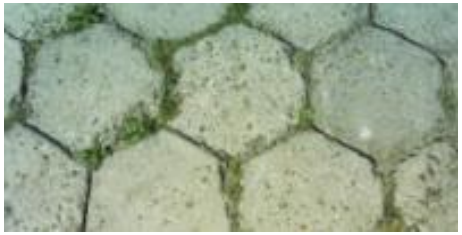

*Juraj Hromkovic*

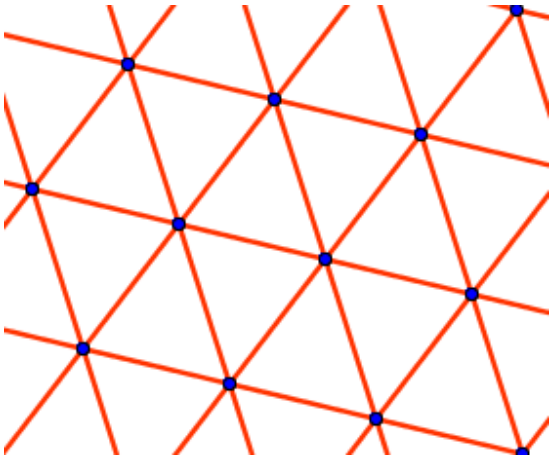
# Influence of *Bebras* Contest

- 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
- On **research**
  - Shows evidence
  - Helps to compare informatics education

# **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).

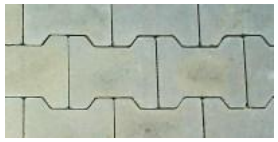


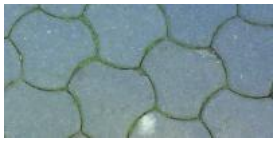


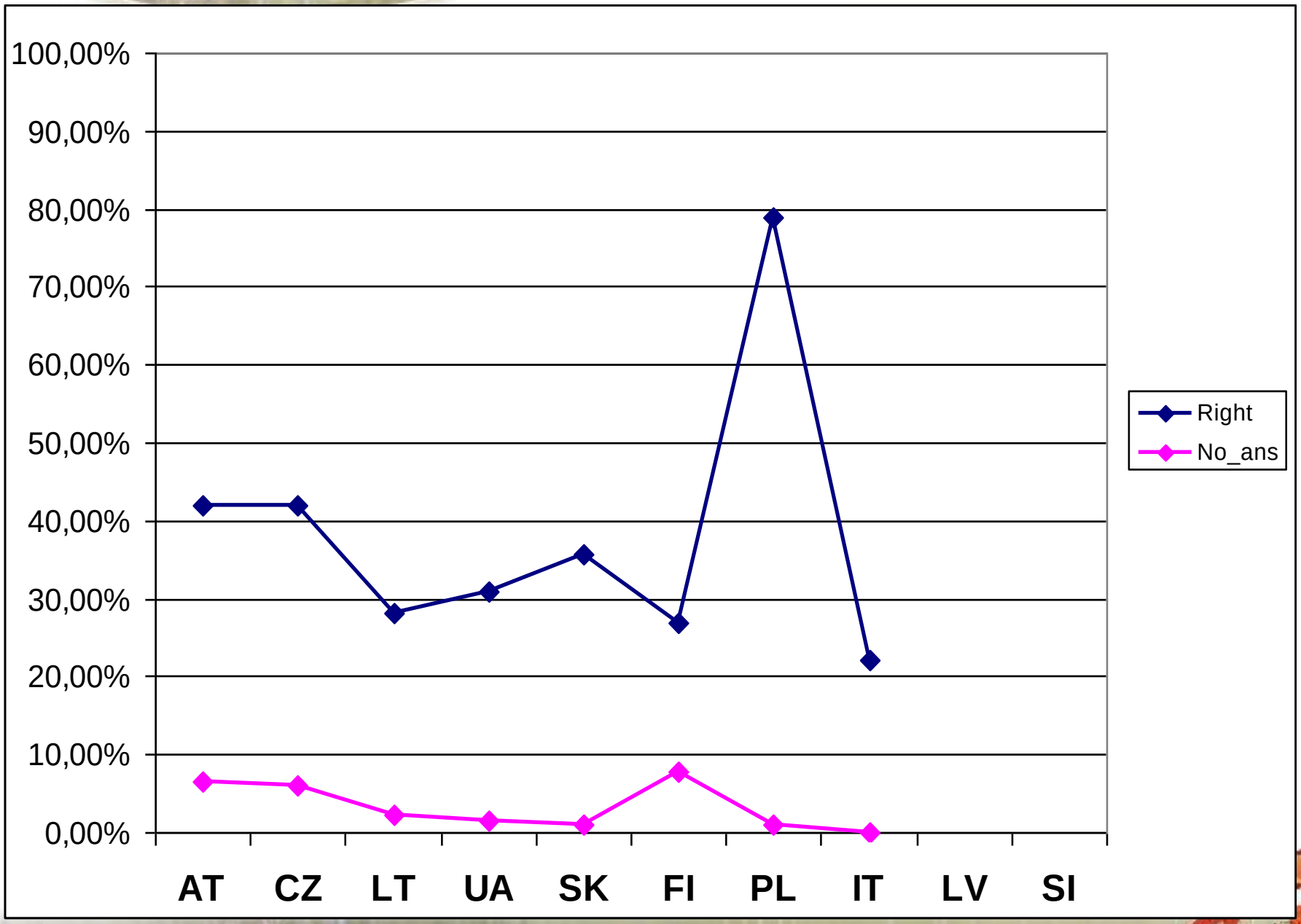
A point on the graph represents a tile. A line joining two points represents any two tiles bordering.
Later Peter was walking in the town and was photographing pavements. When he returned home he realized that all pavements (except of one) were suitable to fit his graph. Can you recognize which of them was not?

A 

B 

C 

D 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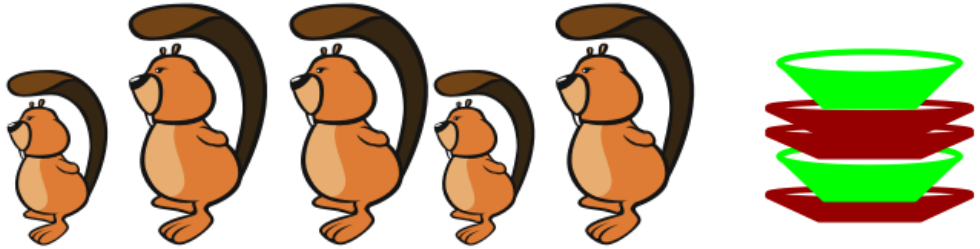
# **Stack of plates** (Benjamin - Medium) - easiest task (68,74%)

Least unanswered (1,95%)

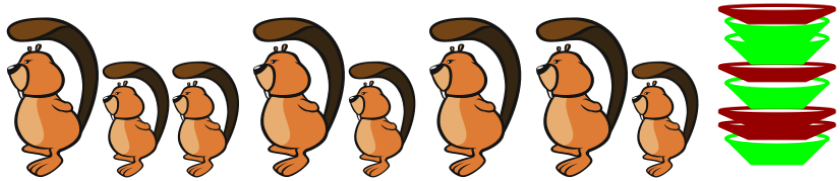
In the restaurant of the Beaver school, there are two different kinds of plates: the high green ones for the small be and the flat brown ones for the big beavers.
One day, due to building activities, there is only room for one stack of plates.

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:

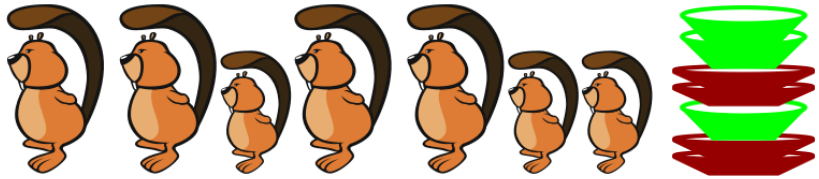


In one of the following pairs of plate stacks and beaver queues, there is a mismatch between queue and stack. In which one?

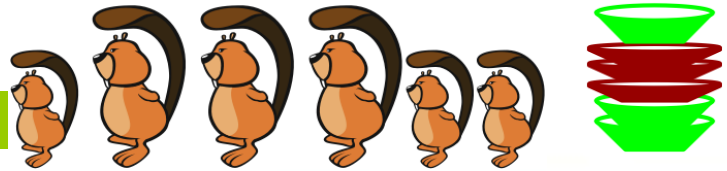
A.



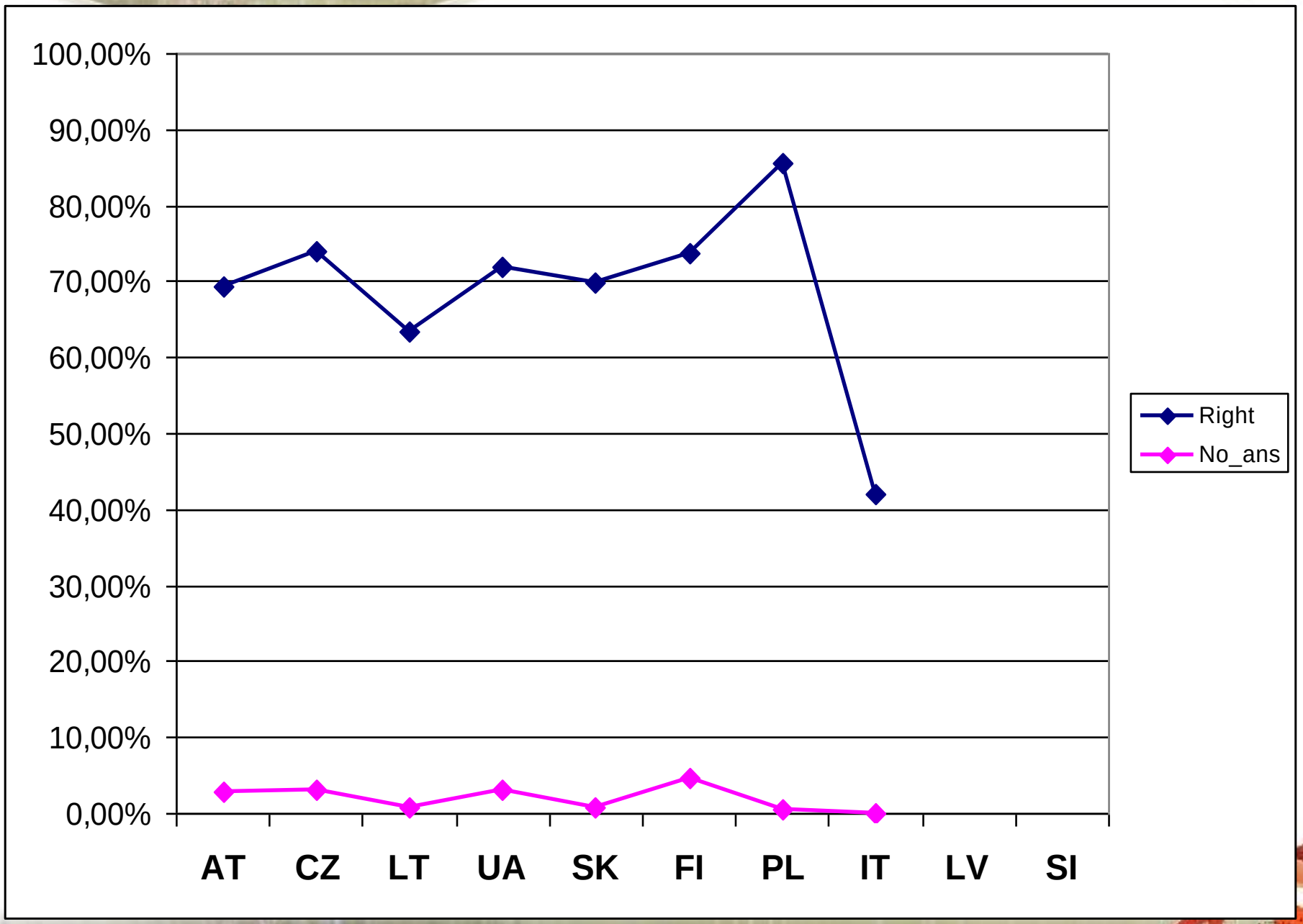
C.



**B.**



D.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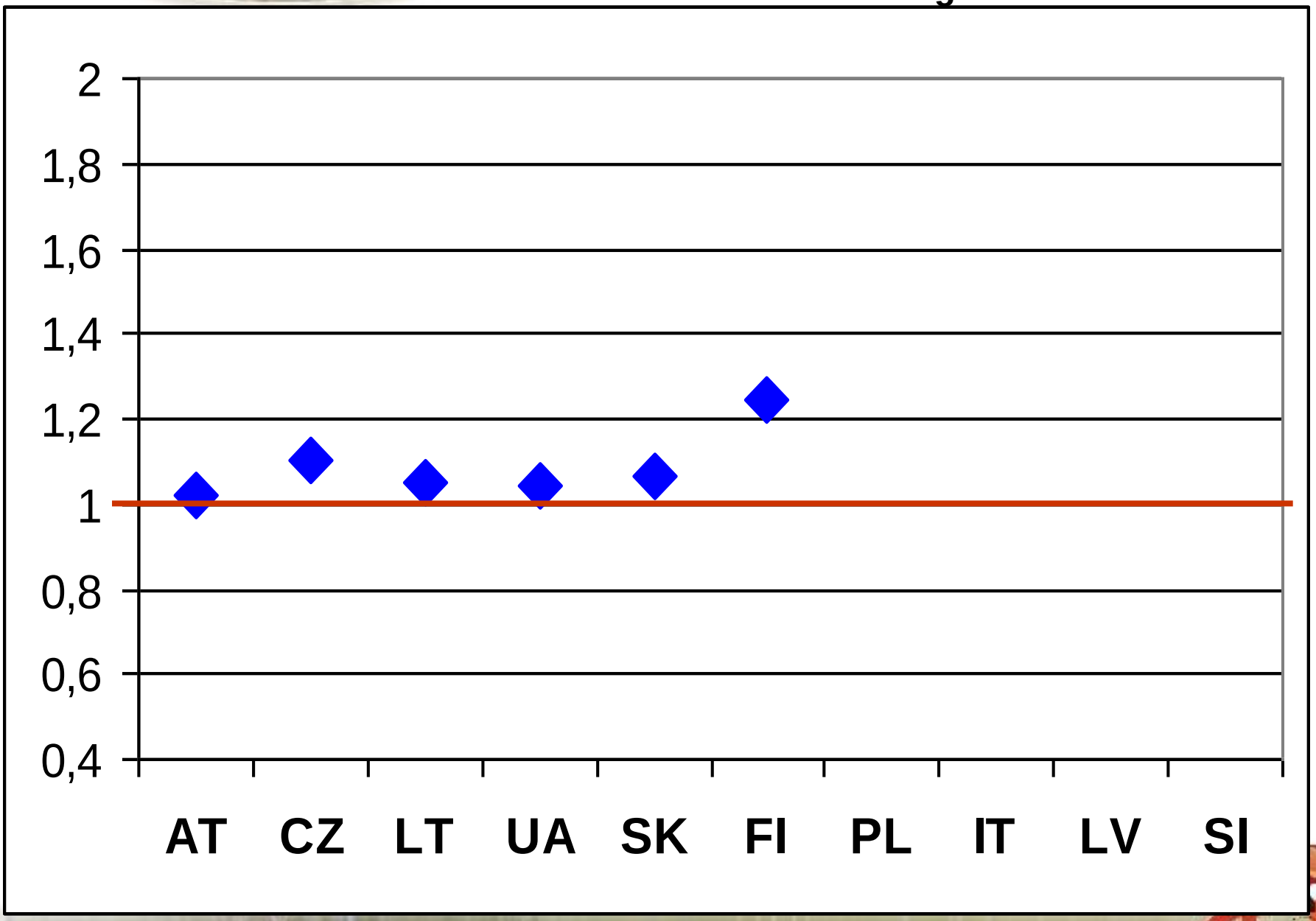
Easier for girls
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# **OX** (Senior - Medium)

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.

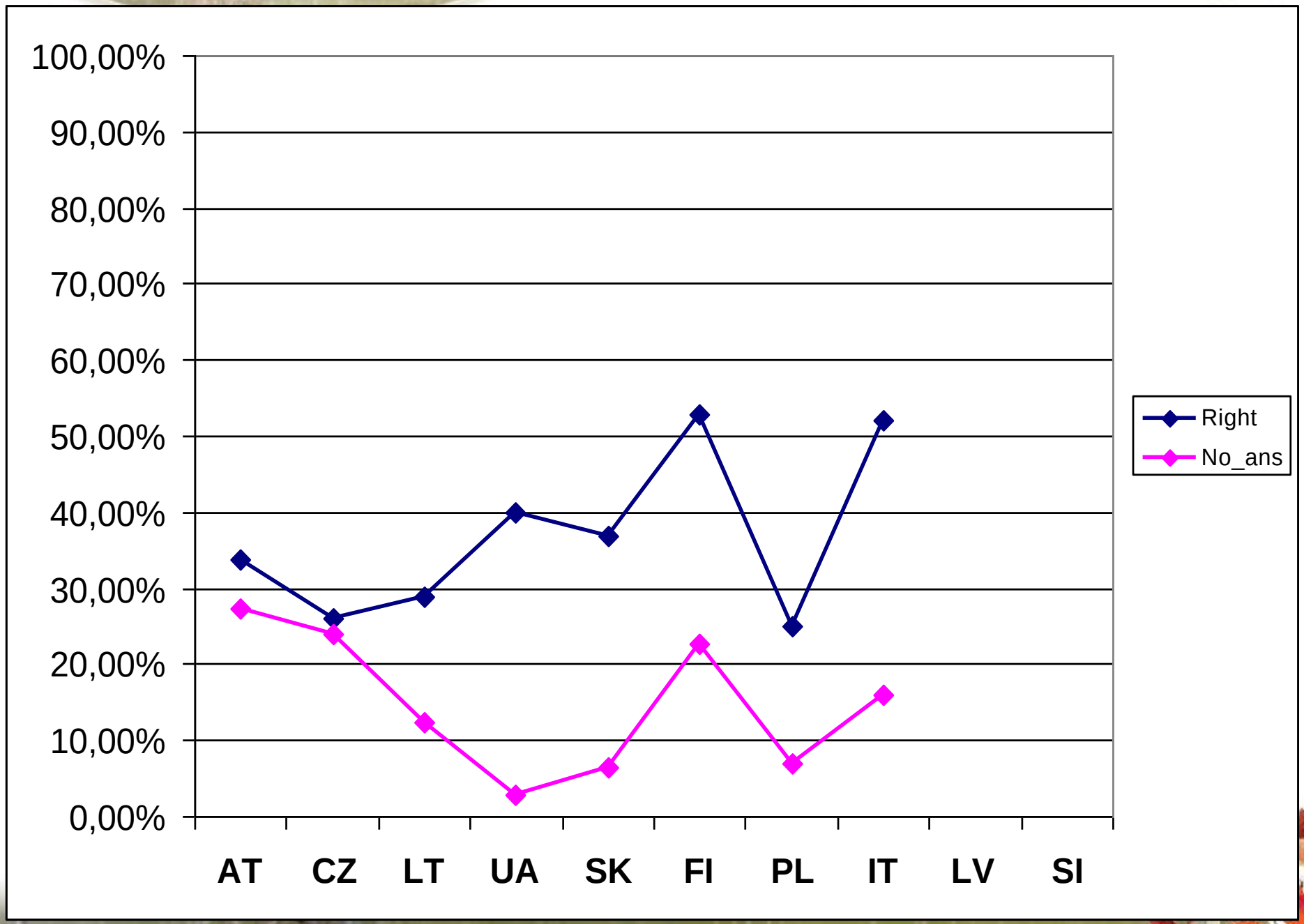
|_ _ _ _ _ _ _ _ _ _ _ _ _ _ X _ _ _ _ _ _

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?

A) X X X X X X X X X X X X X O O O O O O|
B) O O O O O O O O O O O O O O X X X X X X|
C) |_ O O O O O O O O O O O O O _ _ _ _ _ _
**D) |O X X X X X X X X X X X X X _ _ _ _ _ _**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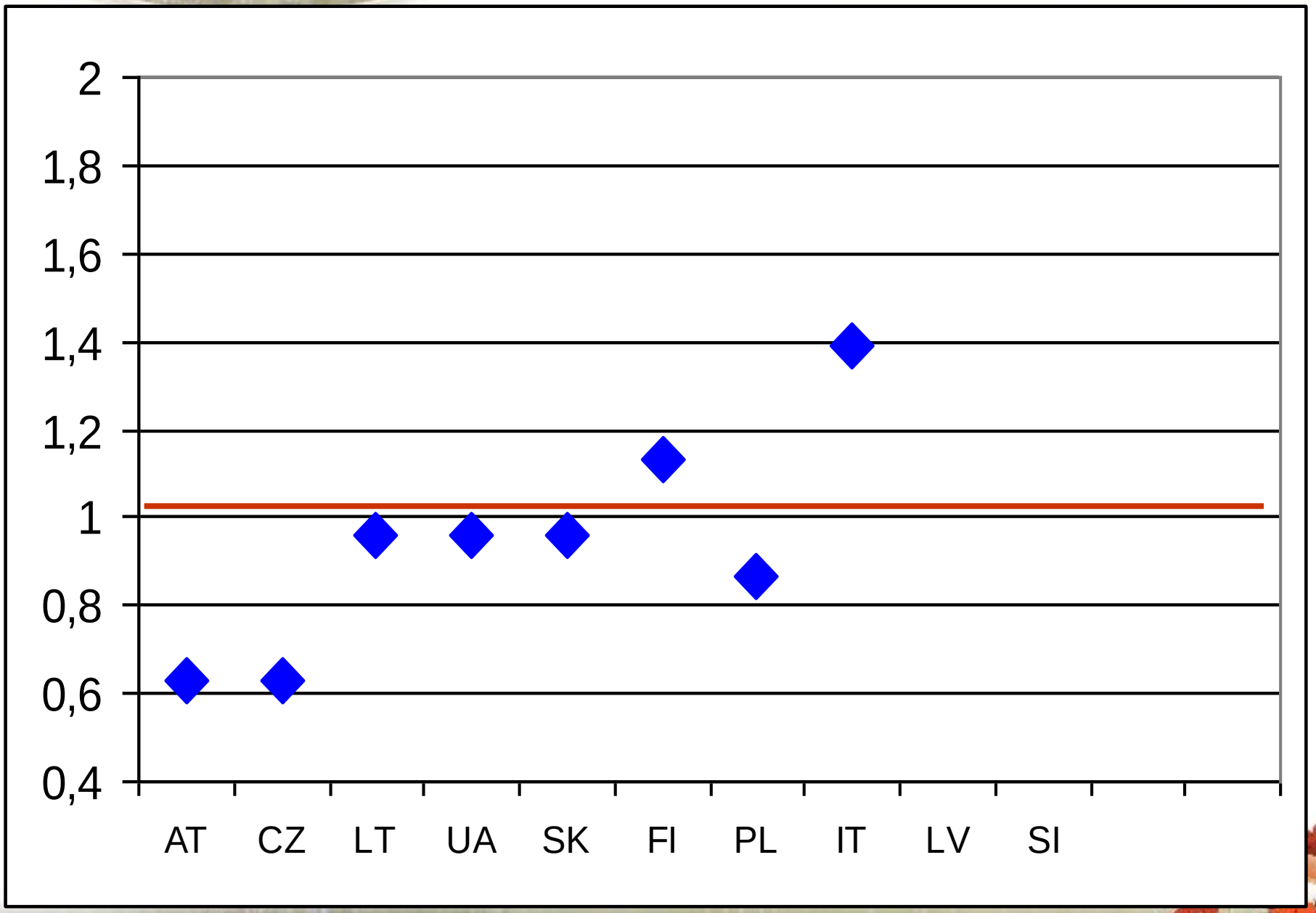
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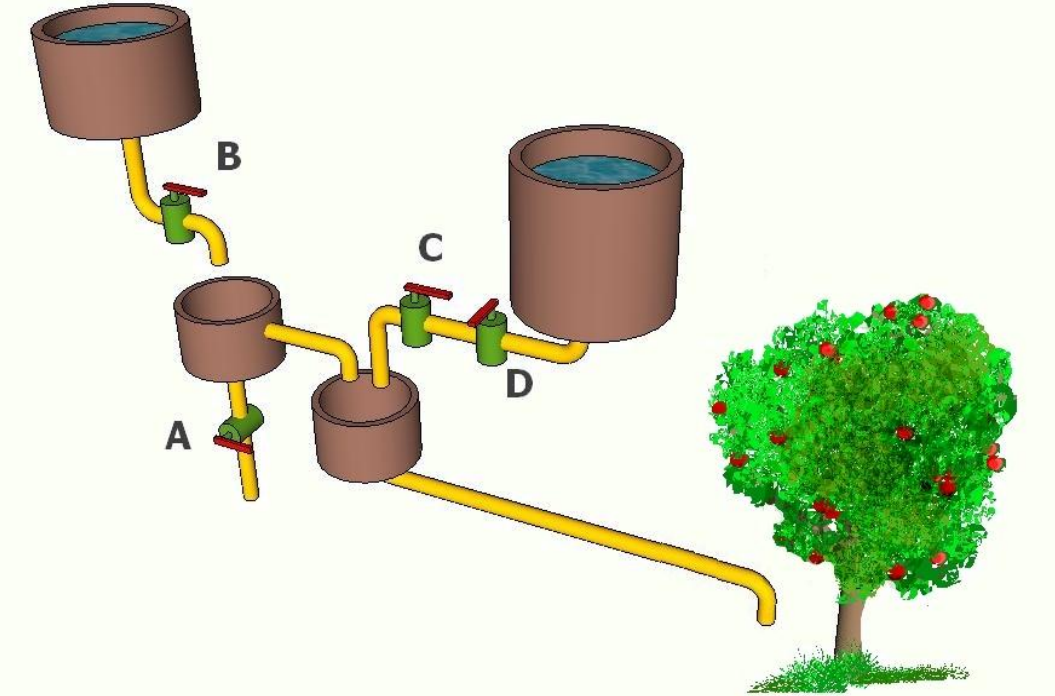
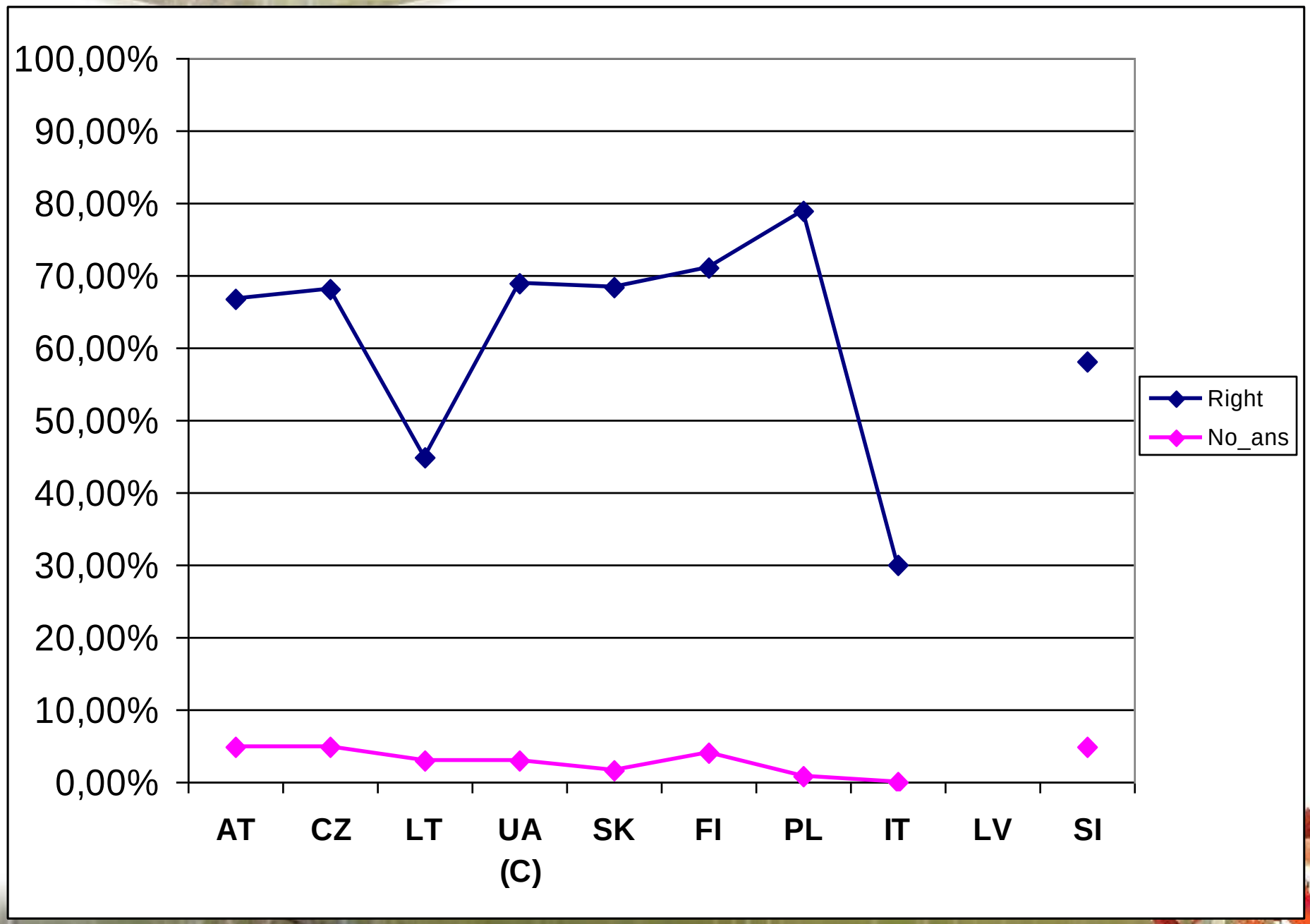
# **Water supply** (Benjamin - Medium)

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.




**1) A = false, B = true, C = false, D = false**
2) A = true, B = true, C = false, D = false
3) A = true, B = false, C = false, D = true
4) A = false, B = false, C = false, D = true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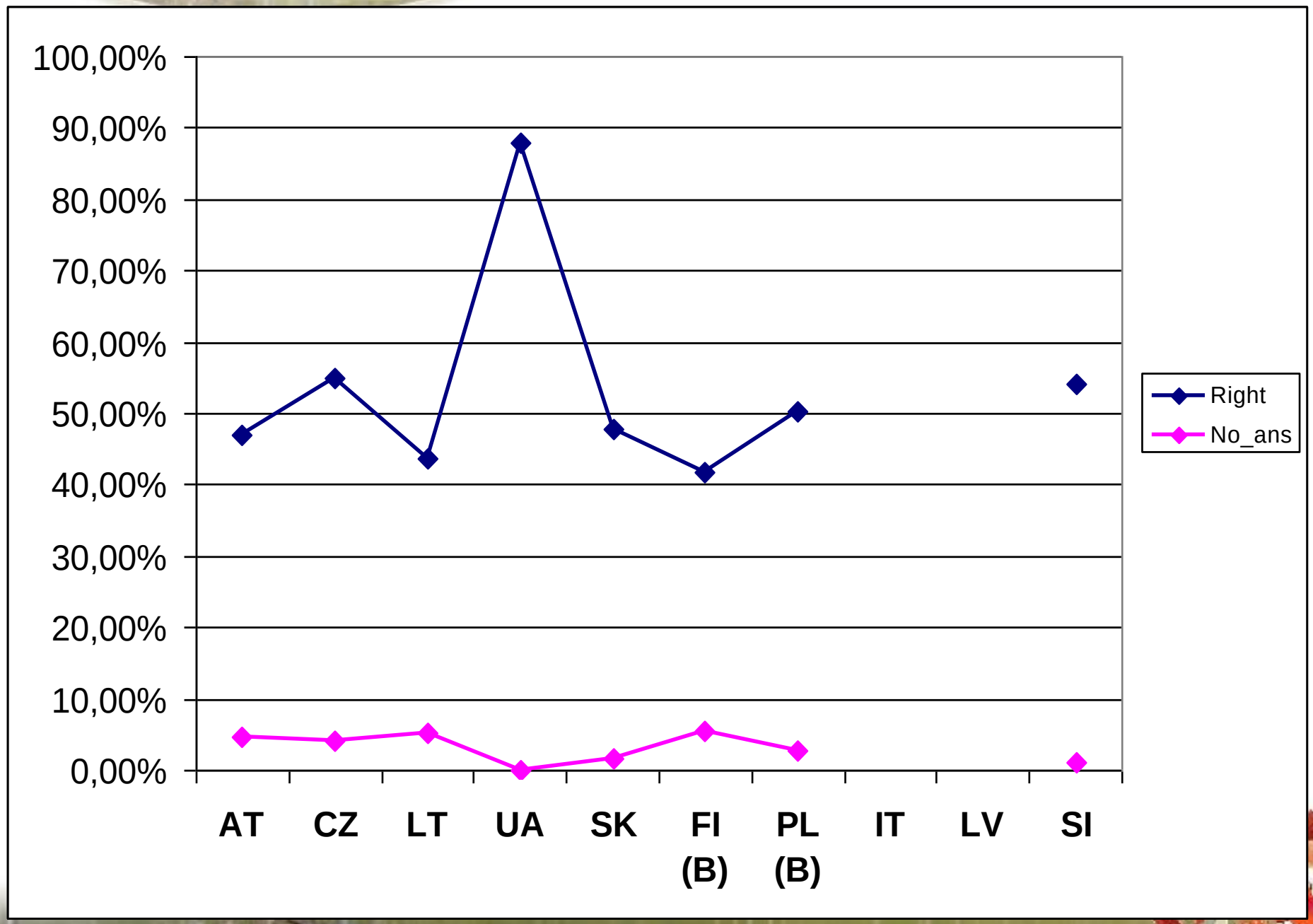
# **Sorting game** (Cadet - Hard)

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?

a) 4 **b) 5** c) 6 d) 7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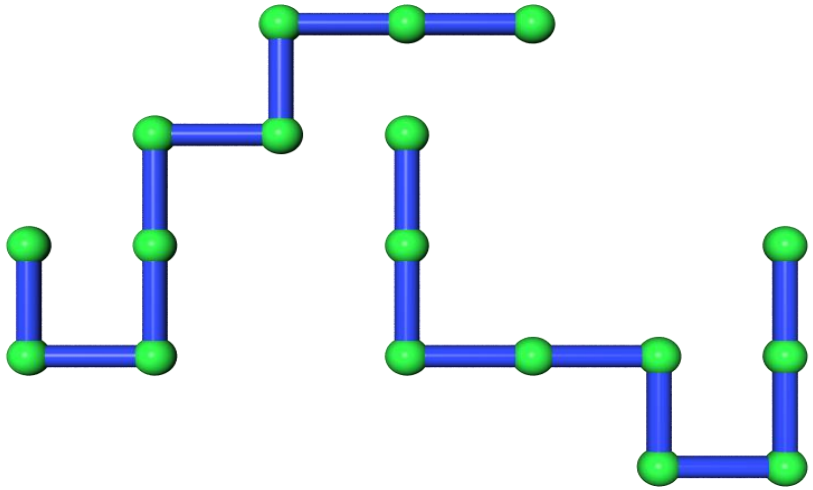
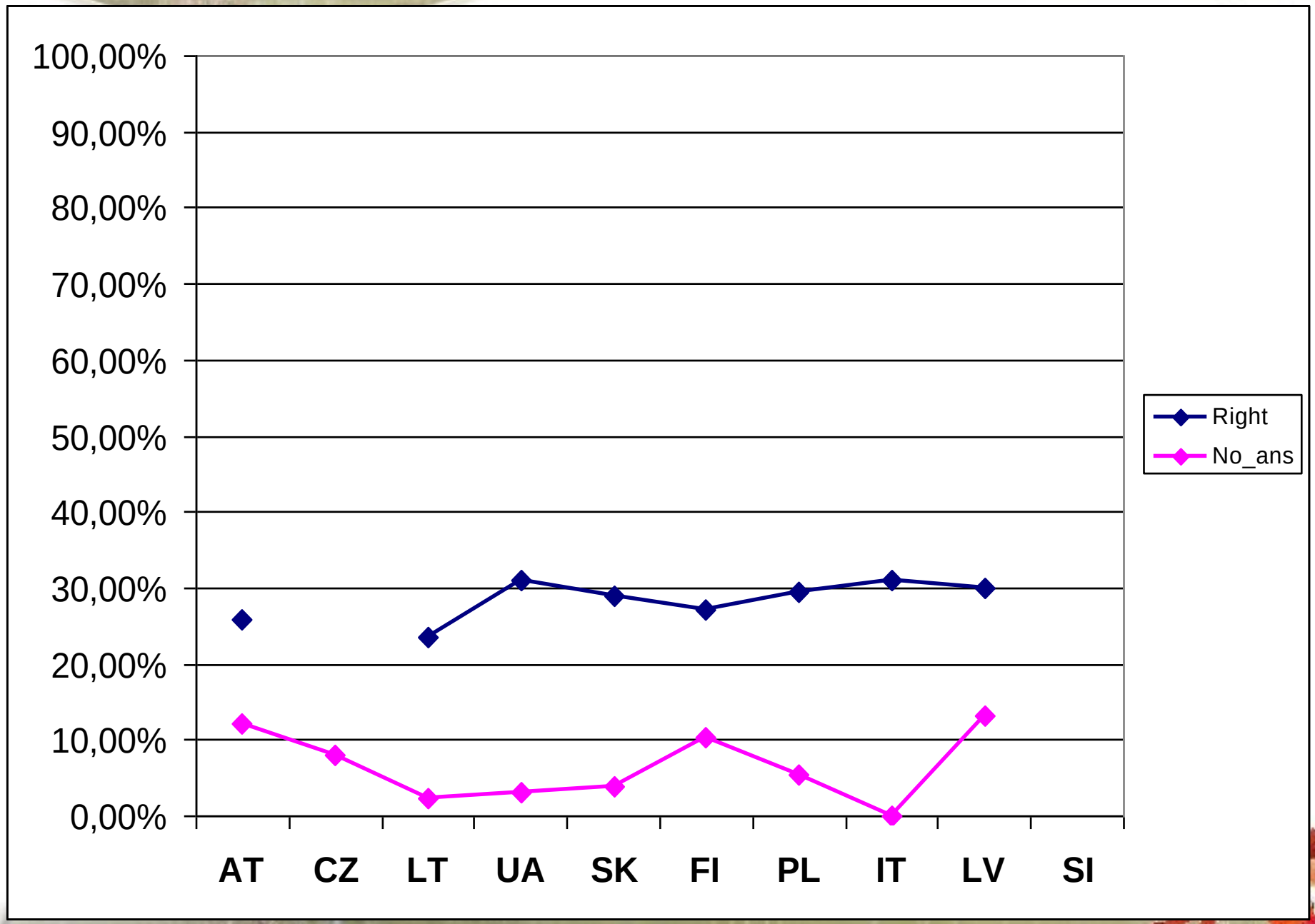
# **Twiddling** (Junior - Medium) - hardest (28,13%)

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?

A) 6 **B) 5** C) 4 D) 3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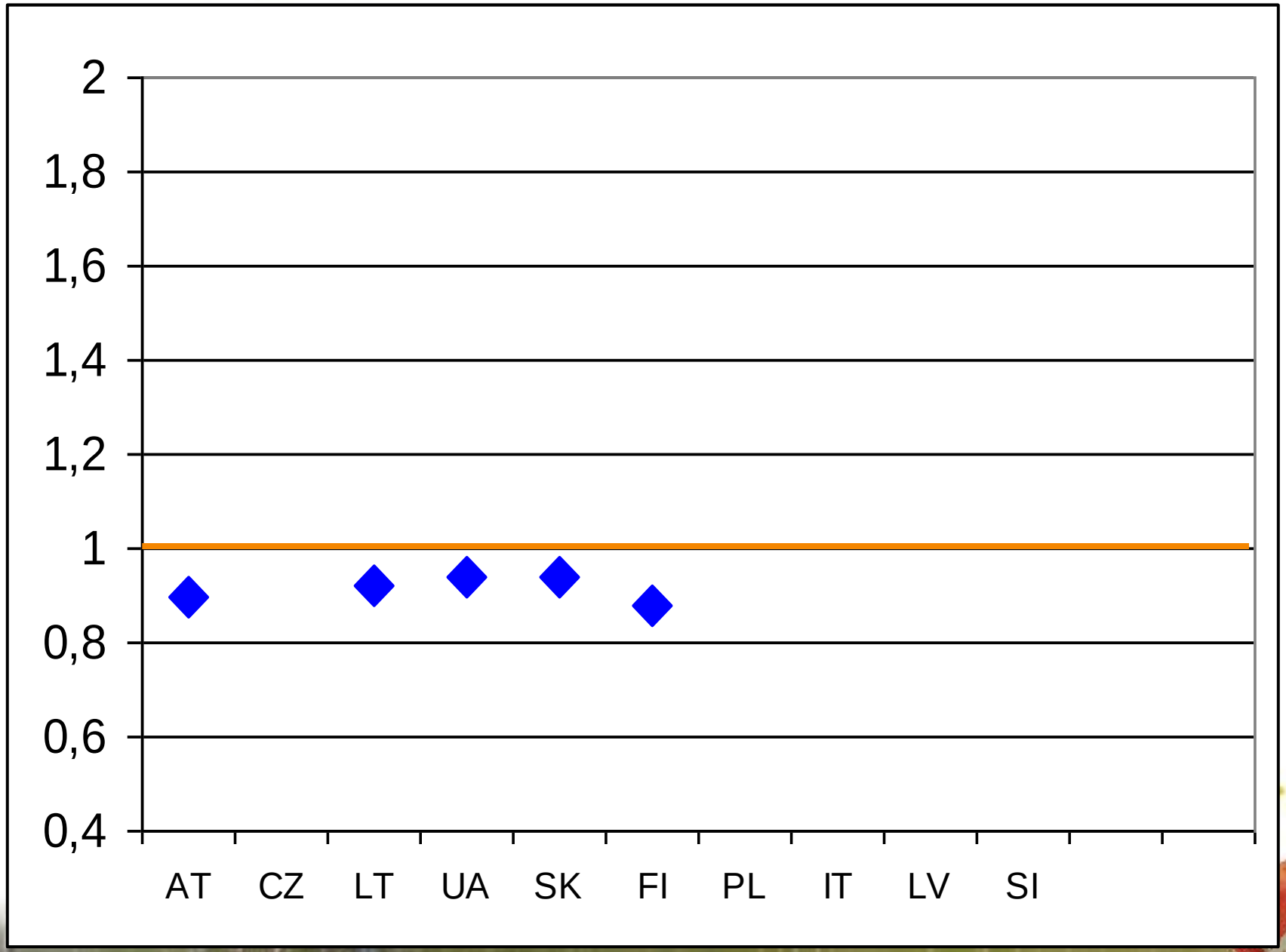
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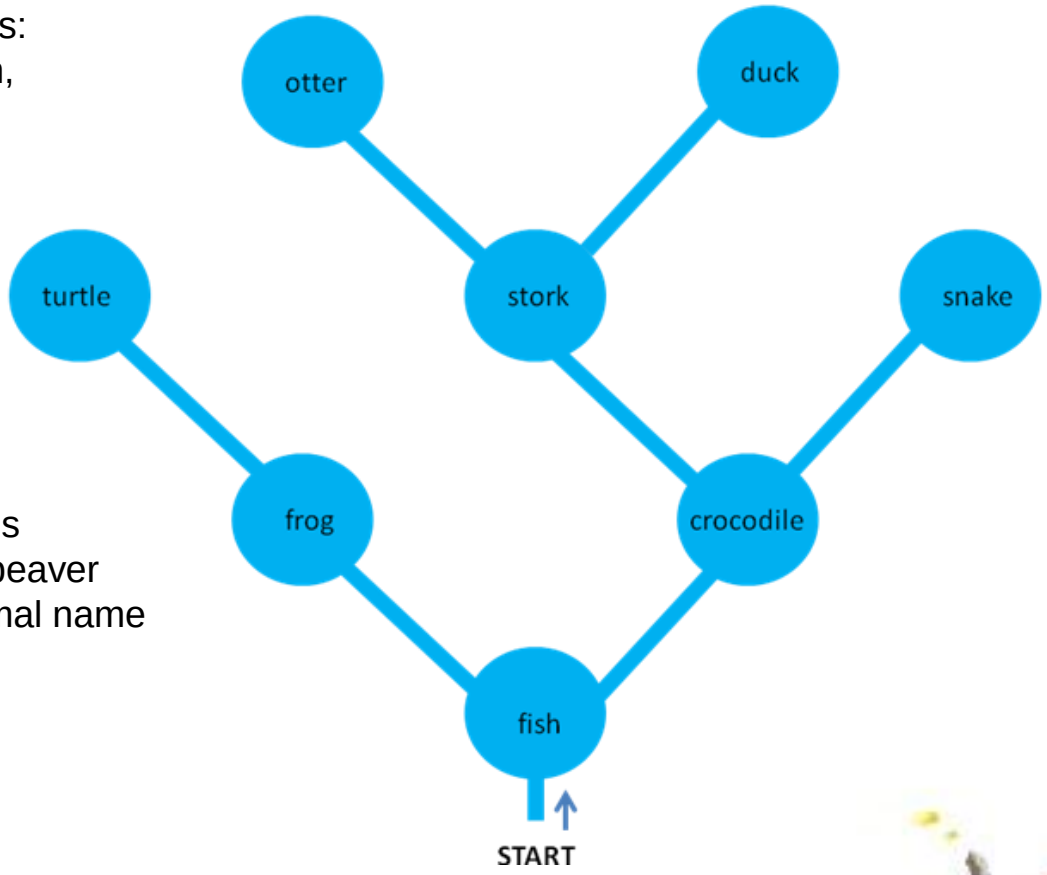
# **Beaver in his canoe** (Senior - Medium)

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.

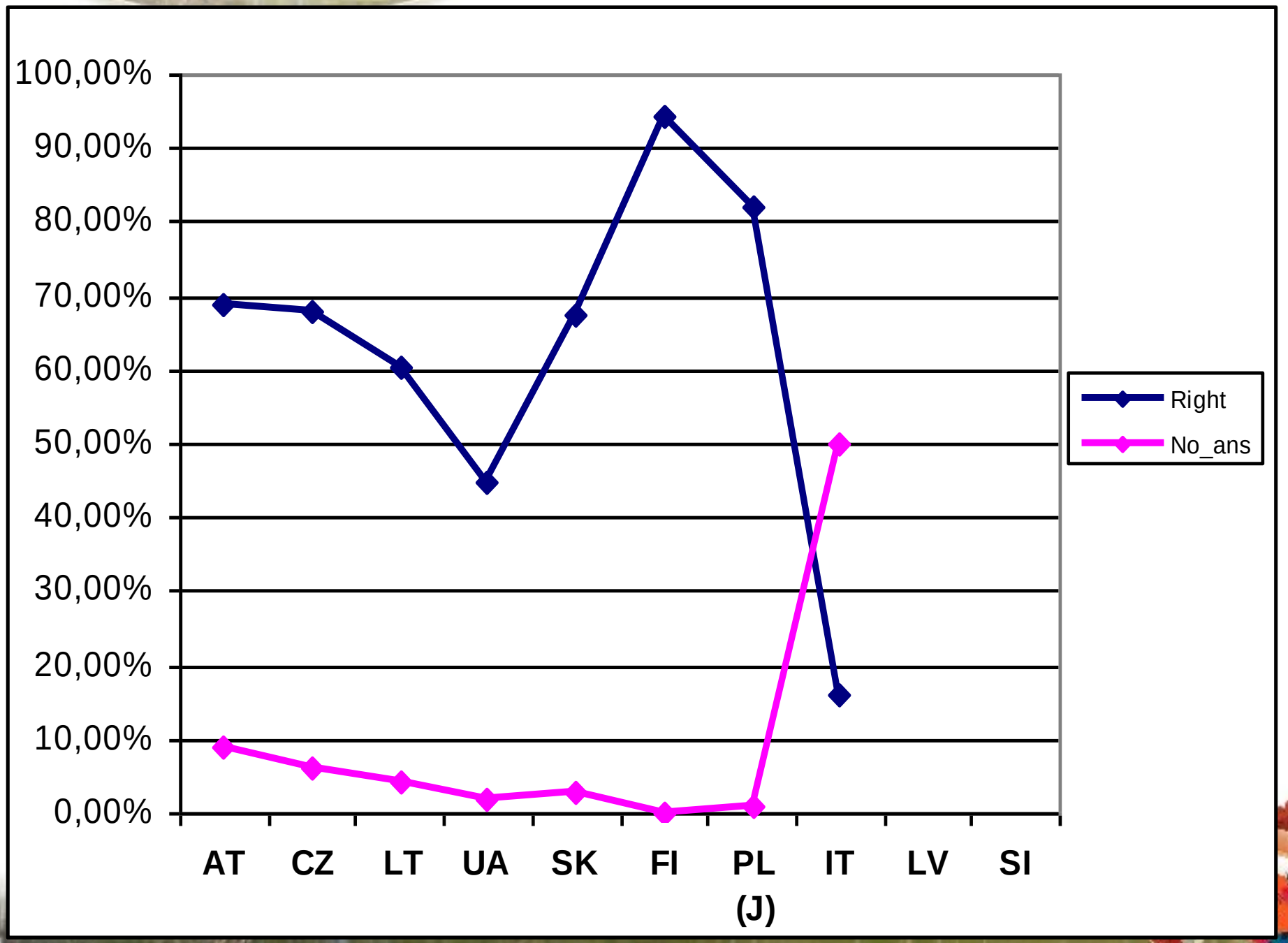
e knows that at each lake there is a maximum of two vers that he hasn't yet seen. If beaver arrives at a lake e decides which river to take with the following rules:

- 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 ees 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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# Thank you