

# {Teaching, Learning} Algorithmic Thinking of Beginners

Gerald Futschek

Vienna University of Technology

Institute of Software Technology & Interactive Systems

Druskininkai, Dec. 2011

# Austria and EU





Vienna University of Technology

# Vienna University of Technology

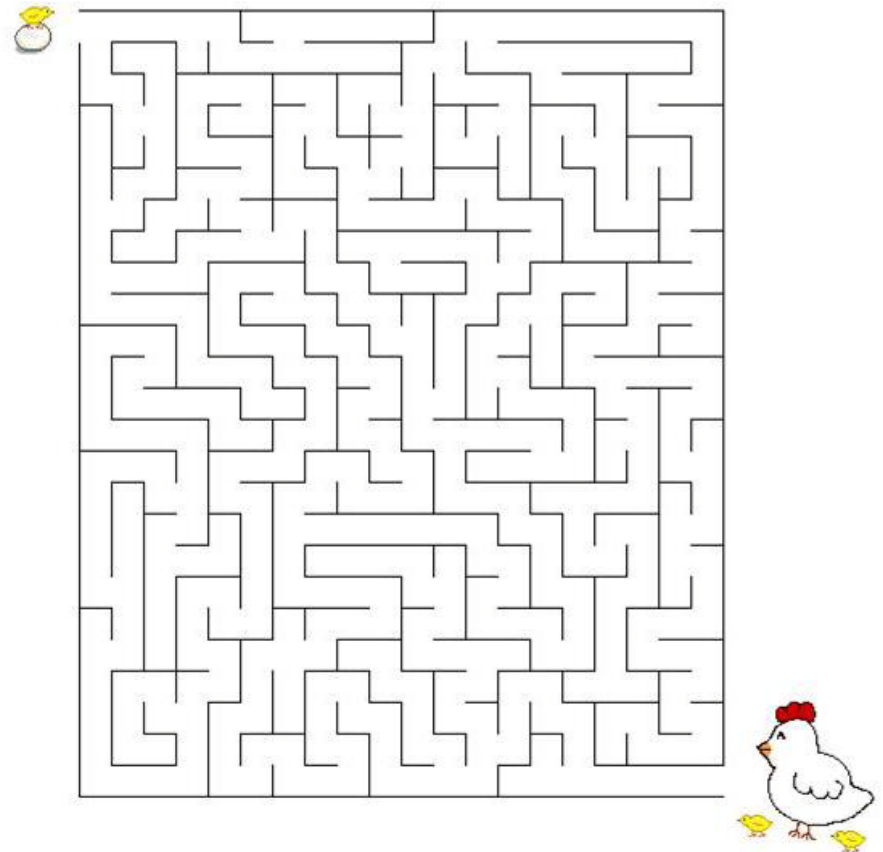
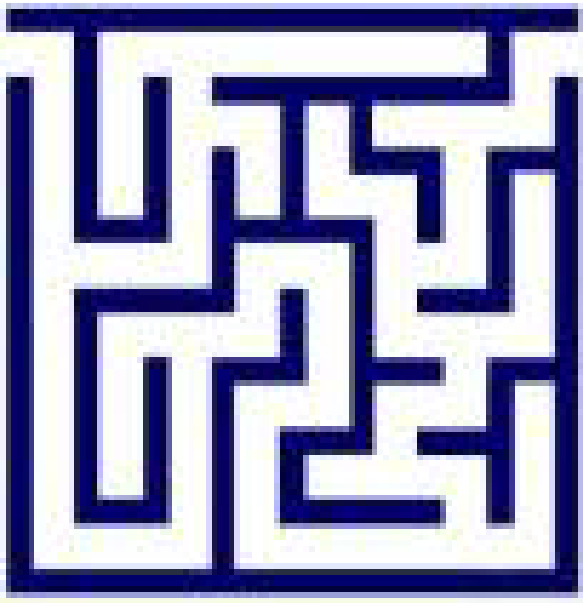


- 20000 students
- Faculty of Informatics:
  - ~ 6000 students (5 Bachelor, 7 Master, Teacher Edu., PhD)
  - ~ 1000 beginners per year

# Algorithmic Thinking

- Find a path in a maze

Aide le poussin à retrouver sa maman.





# Let's do it in real world!



Underground labyrinth in Buda (Budapest)



# Algorithmic Thinking

Find a path out in absolute darkness



# Questions

## Algorithmic Thinking

- What is it?
- Who should know?
- Why to learn?
- How to learn?

## Beginning with algorithms/programming

- What are the problems?
- Why it is complex?
- Why are some successful and others not?

How to start learning?

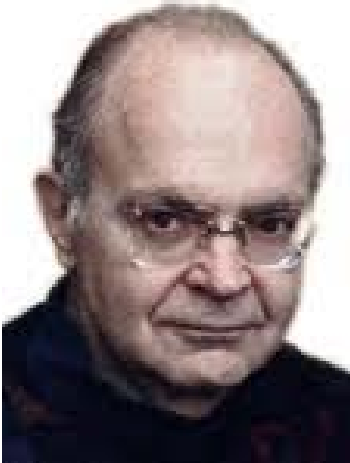
How to motivate beginners?

What tools?

How much effort (ECTS)?



# Algorithmic Thinking – What?



	Formula manipulation	Representation of reality	Behavior of function values	Reduction to simpler problems	Dealing with infinity	Generalization	Abstract reasoning	Information structures	Algorithms
1 (Thomas)	xx	xx	xx						
2 (Lavrent'ev)	xx		x		xx				
3 (Kelley)	x					xx	xx		
4 (Euler)	xx		xx	x		xx			x
5 (Zariski)	x			x	xx	x	xx	xx	
6 (Kleene)	x					xx	xx		x
7 (Knuth)	xx	x		x					
8 (Pólya)	xx		xx	xx	xx				
9 (Bishop)	xx		xx	xx		x	xx	xx	x
"Algorithmic thinking"	x	xx		xx			xx	xx	xx

From: Donald E. Knuth **Algorithmic Thinking and Mathematical Thinking**  
 Page 180 of 170-181, [The American Mathematical Monthly](#)  
[Vol. 92, No. 3, Mar., 1985.](#)

# Algorithmic Thinking - NRC

- **Being fluent with information technology.** National Research Council Committee on Information Technology Literacy. (1999). Washington, D.C.: National Academy Press.

*"... general **concepts of algorithmic thinking**, [include] functional decomposition, repetition (iteration and/or recursion), basic data organizations (record, array, list), generalization and parameterization, algorithm vs. program, top-down design, and refinement. Note also that some types of algorithmic thinking do not necessarily require the use or understanding of sophisticated mathematics."*

**Lawrence Snyder: programming is algorithmic thinking in a tangible form.** Chairman of NRC Committee on Information Technology Literacy, From The Chronicle of Higher Education, Information Technology, issue dated May 5, 2000

# Algorithmic Thinking - Courses

## Algorithmic Thinking (COMP 182)

*Rice University, Houston, Texas*

This course introduces algorithmic thinking as a discipline for reasoning about systems, taming their complexities, and elucidating their properties. Algorithmic techniques, along with their correctness and efficiency, will be taught through reasoning about systems of interactions, such as markets, that are ubiquitous in our highly connected world.



## Pre-programming: Algorithmic Thinking (Course #600.106 )

Problem Solving and Programming Practices

*Johns Hopkins University, Baltimore, Maryland*

**Course Objectives:** Provide students with logical thinking and methodological tools to elaborate abstract solutions necessary in writing computer programs. Provide learning experiences regarding fundamental concepts of **Algorithmic Thinking** (abstraction, not ambiguity, strict stepwise solution, handtracing, etc.) involved in most programming languages like Basic, PHP, Assembly, C++, Java. Practice algorithmic problem solving with minimal aid of computers, emphasizing paper-based strategies.



# Statements: Algorithmic Thinking

*Algorithmic thinking is a procedure, how we can solve a problem.* Demus Ruben, student

„In my opinion algorithmic thinking is useful for everybody. Everbody, who solves his problem by algorithmic thinking, rationalizing his procedures and saves time. Who is used to algorithmic thinking can learn faster.“ Viktoria Willner, student

„For me, it is a formal and structured thinking type which helps us to design and understand modern software. Learning algorithmic thinking is not easy and needs a lot of practice and endurance.“ Verena Tollaschek, student

# Algorithmic Thinking & Computational Thinking

- "Computational Thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent."

*Cuny, Snyder, Wing*



Jeanette M. Wing

Computational thinking means thinking algorithmically and with the ability to apply mathematical concepts such as induction to develop more efficient, fair, and secure solutions.

*Center for Computational Thinking, Carnegie Mellon*



# Who can Learn Algorithmic Thinking?

Nerds only?

Talented only?

Boys only?

Everybody from 4 to 99 ?



# Learning 0.0 Activity

## Invent and Play Algorithms

- Each of you will get a number
- Work in your group:
  - Invent an algorithm how you all together sum up all these numbers

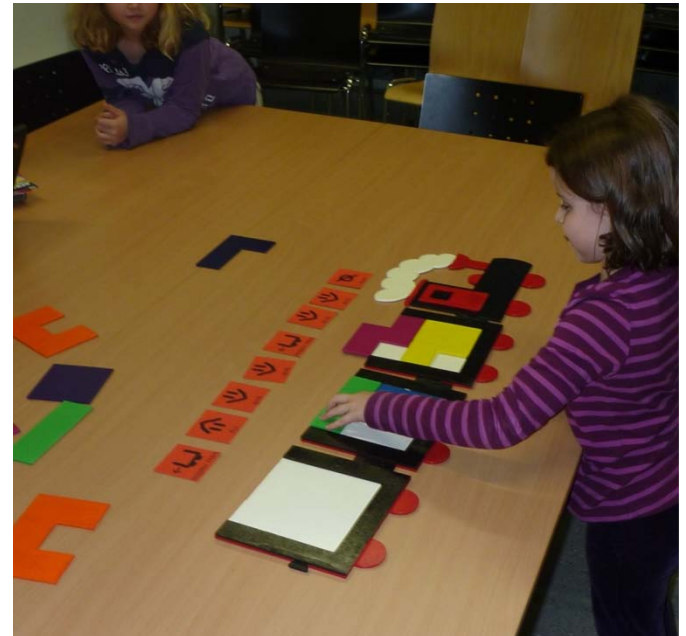
# Tim the Train

- consists of a set of wooden elements for train, containers and load parts
- and a set of symbolic commands
- it describes a bin packing scenario.



# Tangible Objects in Education

- Inspired by pedagogical concepts of Reggio and Montessori
- Possibility to learn from experiences
- Making experiences with several senses helps to solve new problems (Reggio)





# Tim the Train: Playing a given algorithm



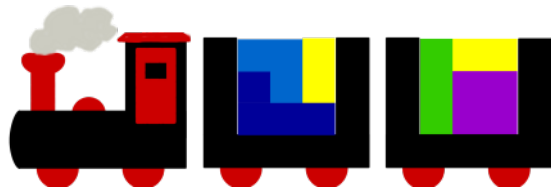
...the train at the beginning of the algorithm

1 <sup>st</sup> part	2 <sup>nd</sup> Part	3 <sup>rd</sup> part	4 <sup>th</sup> part	5 <sup>th</sup> part	6 <sup>th</sup> part

... a sequence of incoming parts



... a sequence of commands (algorithm)



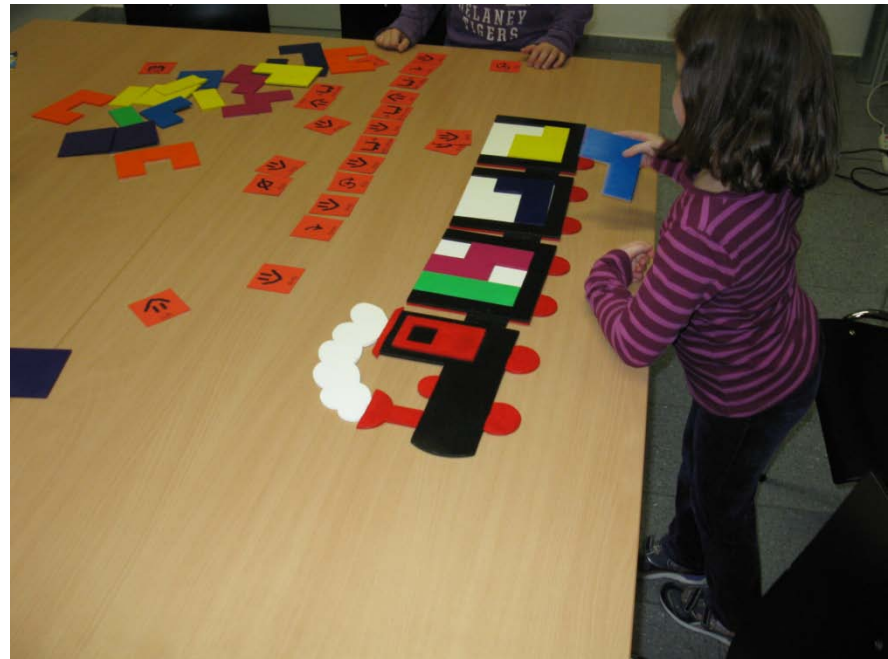
... the train at the end of the algorithm



# Tim the Train: Binpacking

## Problem:

Given is a sequence of parts. Find a sequence of commands that fill the wagons of the train with as many parts as possible. The wagons must not be overloaded.



# Group Tasks

- Give some methods to learn/teach Programming
- Give some competences of Algorithmic Thinking
- What problems have beginners in learning algorithms/programming?
- Give some examples why algorithmic thinking is useful in other subjects/daily life
- Try to give a definition of Algorithmic Thinking