Designing activities with digital technologie in early childhood and primary education

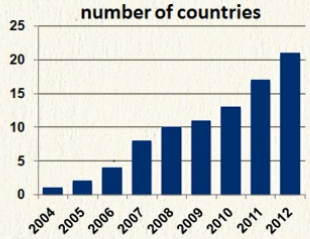
1 Introduction; UNESCO IITE and ECCE and me
2 About the workshop: its goals & forms
3 Digital technologies or ICTs
4 Why do we need them in school and kindergarten
5 How to use them in kinergarten
6 Key factor: teacher
7 Designing activities: why and how

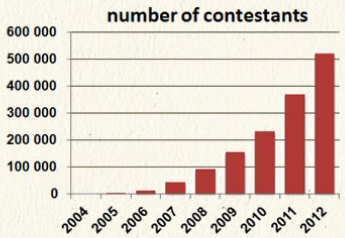
I. Kalas
Comenius University
Bratislava, Slovakia
Institute of Education, London

londonknowledgelab
exploring the future of learning with digital technologies

1 Informatics education in Slovakia

- **Informatics as a subject**
  - since the beginning: different from ICT
  - mandatory since 1985; 2004; 2008 (primary)
  - successes and problems
  - teacher development
- **supporting activity**
  - iBeaver international contest (Bebras, Lithuania, 2004)

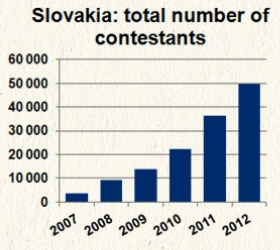


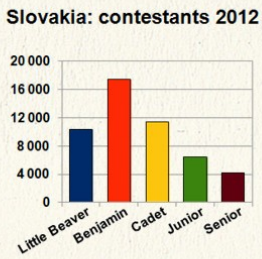


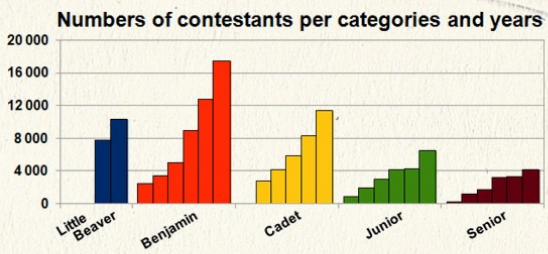
1 Informatics education in Slovakia

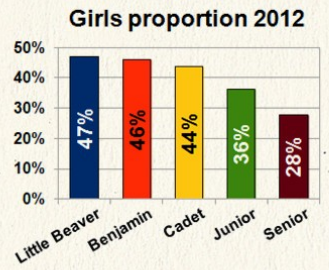
- **Informatics as a subject**
  - since the beginning: different from ICT
  - mandatory since 1985; 2004; 2008 (primary)
  - successes and problems
  - teacher development
- **supporting activity**
  - iBeaver international contest (Bebras, Lithuania, 2004)

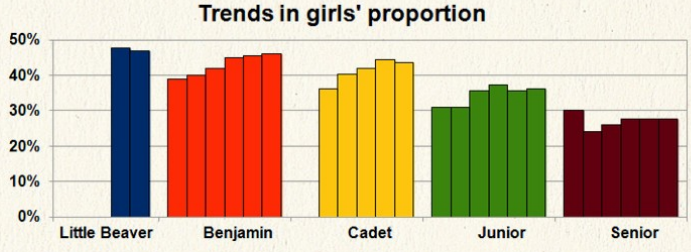
1 Informatics education in Slovakia











02/20

iBeaver tasks: our message to Slovak schools

our tasks cover the following components of Informatics education

- **digital literacy**
  basic knowledge and concepts
  computer literacy, working with applications
  social, ethical and legal issues, security...
- **educational programming**
  representations of solutions, processes, & behaviours
  handling such representations
  algorithmic thinking
- **problem solving**
  logical reasoning
  puzzles, riddles, problems
  strategies for problem solving
- **data handling**
  representations, coding, patterns, structures
  mathematical basics of Informatics
  data, data structures, information and data processing

2 Educational programming: its roles & forms

- **professional programming and programmers**
- **recently:** increased number of computer users routinely using scripting languages, models...

end-user programming *(Blackwell, 2002)*
identifies characteristic **cognitive challenges** of prog.
suggests to study **cognitive demands and operations** of

- **programming is when somebody:**
  - is not directly manipulating observable things, but
  - is **specifying behaviours** to occur at some future time
- **why is it hard?** *(Blackwell, 2002)*
  - loss of the benefits of direct manipulations
  - use of special notation to represent future behaviours
  - use of abstraction as a tool to handle complexity

- **educational programming**

  = end-user programming **in an educational context**
  express (externalise) **future behaviours** and 'play' with them

- **we want to explore resulting learning processes**
  - study cognitive demands of edu programming
    - elementary cognitive operations
  - study social and cultural contexts of edu p

- **E. Ackermann, developmental psychologist**
  - studies how children...

  *... use and think of programming as a means for exploring and optimizing the interplay between a **human** and unequally responsive, surprising, or reliable **devices**...*

- **... what programming means for children:**

  Mastering things tell a device what to do; make things do things
  Animating things give autonomy; make it look out for itself
  Modulating things do not start from scratch; use, tweak, share

3 What interests us... (in primary edu programming)

far-reaching goal: understand cognitive demands of primary educational programming

in this research:
- identify elementary cognitive operations in primary programming
- better understand what is difficult...
- what is developmentally appropriate
- how to design tasks and gradations...
- how to exploit the tasks in pedagogy

- A. solving problems and handling solutions
- B. controlling an agent
  - direct manipulations
  - handling simple behaviours
  - commands with parameter
  - repeated pattern`s of steps
  - abstractions
- C. building interactive environments
  - more actors with individual behaviours
  - *forever* behaviours
  - interactions and events

3 What interests us... (in primary edu programming)

far-reaching goal: understand cognitive demands of primary educational programming

in this research:
- identify elementary cognitive operations in primary programming
- better understand what is difficult...
- what is developmentally appropriate
- how to design tasks and gradations...
- how to exploit the tasks in pedagogy

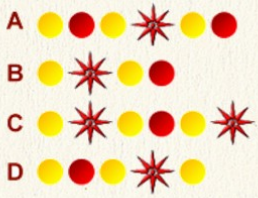
- A. solving problems and handling solutions
- B. controlling an agent
  - direct manipulations
  - handling simple behaviours
  - commands with parameter
  - repeated pattern`s of steps
  - abstractions
- C. building interactive environments
  - more actors with individual behaviours
  - *forever* behaviours
  - interactions and events

handling simple behaviours
- interpreting simple program
- planning simple program
- deducing the final state
- deducing the initial state
- filling in missing step(s)
- planning with constraints
- correcting incorrect solution
- comparing...
- describing...
- explaining...
- modifying...

4 Programming tasks for primary pupils

- **Necklace** (10 to 12 year olds)

  Beaver girls are dressy; they create new necklaces for every party using a special **necklace machine**. They only have to set a **pattern**, which the machine then repeats while threading the necklace. Which pattern will produce this necklace?



Algorithmic drawing (13 to 15 year olds)

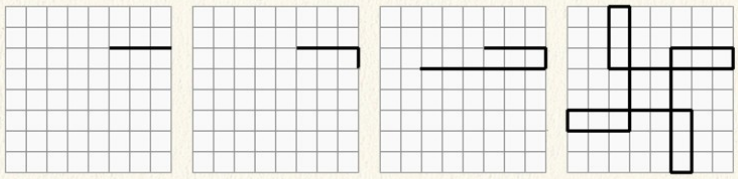
This is an algorithm to creates various drawings on the squared paper: We choose three numbers between 1 and 9; for example **3, 1 and 6**.

Step 1. Draw a line of the length set by **the first number** (that is, 3 squares on the paper) and turn right by 90°.

Step 2. Draw a line of the length set by **the second number**, then and turn right by 90°.

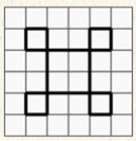
Step 3. Draw a line of the length set by **the third number**, then turn right by 90°.

Step 4. Repeat steps 1 to 3 three more times.



Which trio of numbers will create the drawing to the right?

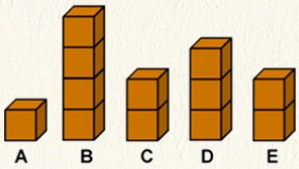
A. 4, 1, 1
B. 1, 1, 4
C. 1, 3, 1
D. 3, 1, 3



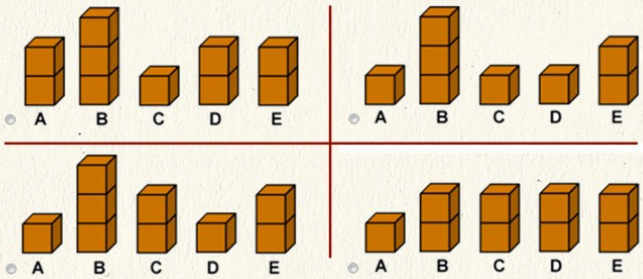
Towers (8 to 10 year olds)

Peter and Emily got a robot to play with. It knows how to **put wooden blocks one atop the other** on the towers named A, B, C, D, and E. For example, if they say D, the robot adds a new cube atop the tower D.

Peter went out for a while and Emily commanded the robot to build the following towers:

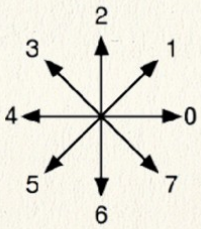


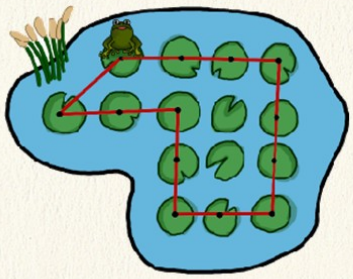
When he got back, Emily told him that the last four commands she gave to the robot were **D, B, C, and D**. How did the towers look like before those commands?



The Frog (8 to 10 year olds)

Little frog loves to jump on the leaves of the water lilies. When she wants to jump to a neighbouring leaf, she first turns in one of eight possible directions (look at the compass with numbers) then jumps. In the figure below, you see **where she started and where she finished** her trip.



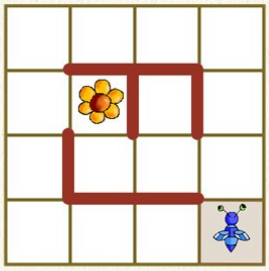


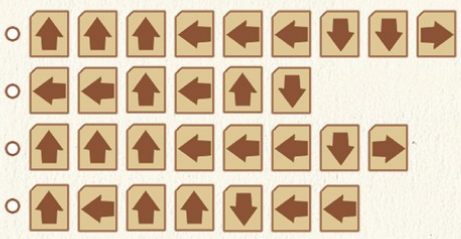
Which sequence of directions corresponds to the red tour of the frog?

- 4, 4, 1, 0, 0, 0, 6, 6, 4, 4, 2, 2, 1
- 0, 0, 0, 6, 6, 6, 4, 4, 2, 2, 4, 4, 1
- 5, 0, 0, 6, 6, 6, 0, 0, 2, 2, 4, 4, 4
- 0, 6, 6, 4, 4, 4, 2, 4, 1, 1, 1

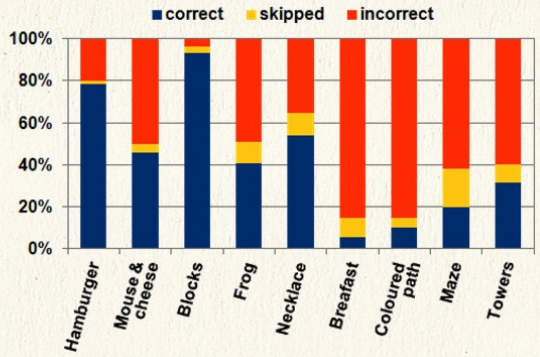
The Bee (8 to 10 year olds)

One of the four programs below will lead the bee to the flower. Which one is it? Note that the bee cannot fly over the red barriers.





what are the elementary cognitive operations? 1/2
what are the cognitive demands of those tasks?



what are the elementary cognitive operations? 1/2
what are the cognitive demands of those tasks?

future teachers perspective

our teacher students:

- **estimating how difficult the tasks are...**
  correct for some, wrong for the majority; contradictory
- **developmentally appropriate, respecting their experience**
  tasks = small stories with attractive characters
- **noted that the tasks stimulate critical and analytical thinking**
- **were asked to list cognitive operations**
  - thinking about sequences of steps
  - interpreting such sequences
  - solving problems through sequences of steps
  - working with different representations
  - backward thinking from a given state
  - planning parallel events
  - classifying objects according to certain condition
  - algorithmic thinking

our teacher students:

- some noted that these programming tasks also...
  develop 21st C skills --- mostly creativity,
  because... many tasks have multiple valid solutions
- identified, which elements of the tasks could be confusing
  to fill in missing parts of a solution,
  if provided with more pieces than they would need
- all noted that for solving the tasks correctly it is crucial...
  that pupils carefully read the assignments

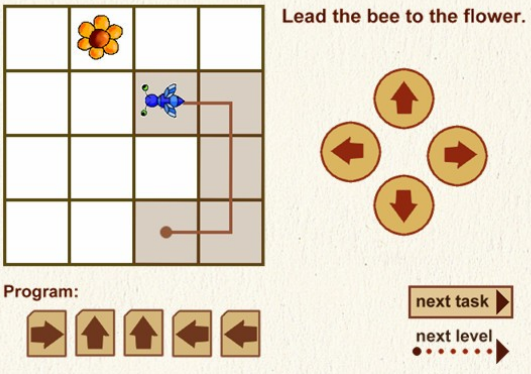
recommended how to refine the tasks
their wording or arrangement

were able to explain their ways of thinking (strategies)
these however were clearly 'professional'

5 The Bee Tasks: an instrument of our study

- Imagine Logo microworld with 7 levels
  they represent our proposed gradation of elementary
  cognitive operations culminating with The Bee

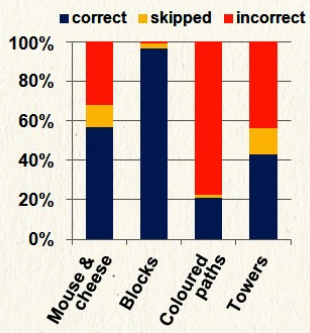
1. direct control
2. interpreting given program step by step
3. building the program to follow a given path
4. reading the program and identifying the 'result'
5. filling in 1 or 2 missing 'bits'
6. building the program while respecting certain constraints
7. selecting correct program from 4 options

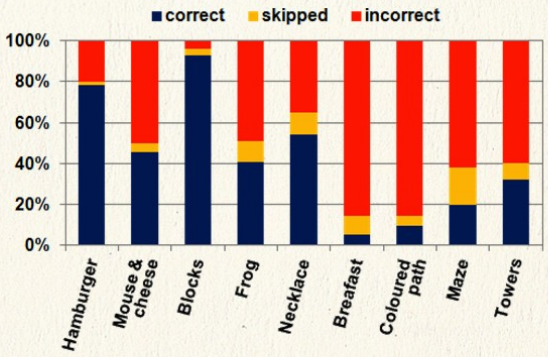


6 Data, analysis, and findings

- 128 pupils aged 8 to 10;
  - 1) their scores when solving 4 programming tasks
  - 2) the process and results when solving The Bee Tasks
  - 3) our observations of pupils

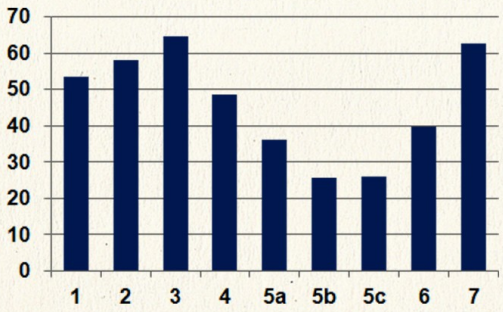
a)

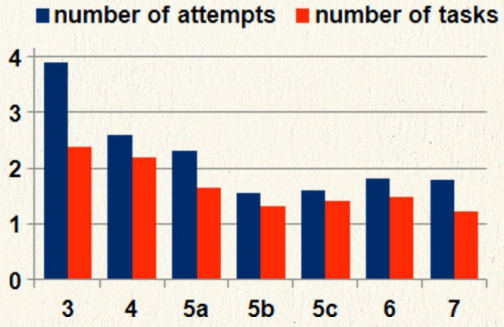




- b1) average time in seconds spent in each level
- b2) average number of attempts and tasks per level

what is an attempt, what is a task



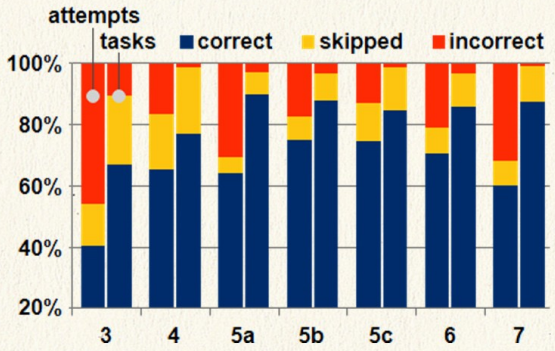


- **b3) how difficult the cognitive operations are**

  the highest portion of the incorrect decisions in level 3. Compare it with level 6!

  7 (cf. 4): more incorrect attempts, more correct solutions

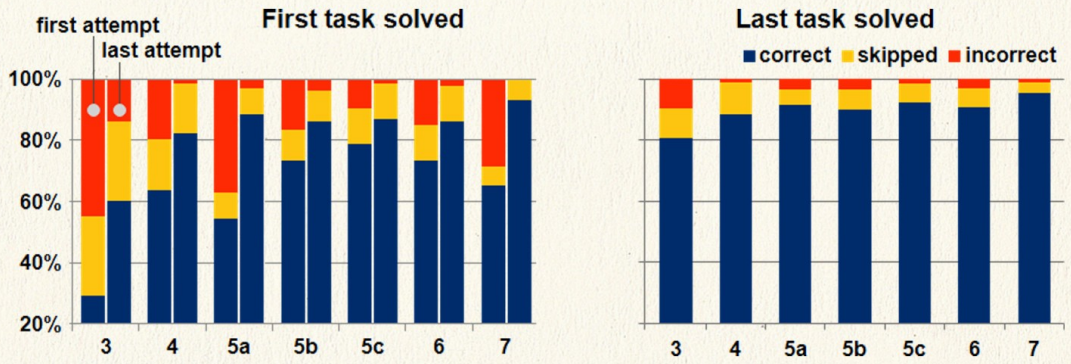
  5: filling in one inner missing instruction is difficult



- **b4) how much did the students develop their skills**

  in each level – i.e. performing corresponding operations

  => by comparing how successful they were in the first task and the last task in each level

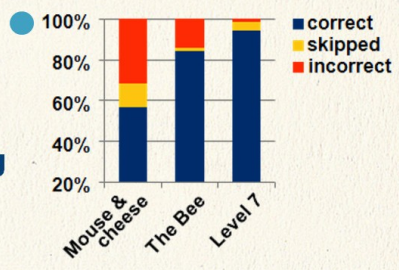


- typical patterns of pupils' strategies and behaviours
  <to report later>

- observing pupils when solving the tasks… and after
  4 tasks – perceived as contest, the Bee Tasks – as 'fun'
  they liked the Bee Tasks, rating them as *very easy*
  according to them most difficult:
  filling in missing inner instruction
  programming with constraints – level 6
  biggest problem:
  they did not pay enough attention to texts
  one boy noticed:
  constraints lead to longer programs
  teachers were impressed by the deep preoccupation

Some final thoughts

- the topic and the methods are new and not well validated
  carefully draw conclusions!
- there are many (other) factors that determine the difficulty
  text itself; affective attitudes (of the teacher as well); …
- we believe in 'Informatics for everybody' including primary
  => we need to understand the cognitive demands
  => we try to identify the *elementary cogn. operations*
  within… ***handling simple sequences of operations***
- one faulty assumption (but productive)
  when two tasks are 'similar'?
- we believe our study contributes to the development of better understanding of the cognitive demands and operations



Thank you for your attention

kalas@fmph.uniba.sk