Reasoning on Children's Cognitive Skills in an Informatics Contest: Findings and Discoveries from Finland, Lithuania, and Sweden

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Bebras

International Contest on Informatics and Computer Fluency

Contest idea proposed in Lithuania in 2004

Task oriented contest for school pupils aged 8 to 19

Goals:

- to **develop** Computational Thinking skills
- to **stimulate** pupils' interest in informatics and IT
- to **encourage** pupils to *think* deeper while using computers and technology
- to **disseminate** concepts of informatics

Bebras Contest - Participants

Different tasks for 5 age groups:

- MINI 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 11-12)

Bebras Contest - Tasks

- Pupils solve 18-24 tasks within 40 to 60 minutes
- Interactive tasks and multiple-choice tasks
- 2 - 3 minutes per task
- Difficulty of tasks: easy, medium and hard
- Performed on computers or tablets, usually during school lectures

Developing Problem Solving Skills

- Solving Bebras tasks trains “Computational Thinking” skills
- 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 learning outcome

- Each stated Bebras task involves an aspect of an informatics concept
- Learning by doing and exploring
- No theory or concepts mentioned by name in the task descriptions
- Even advanced concepts possible to cover in a playful manner
- Proper descriptions/stories important to make a task easy to understand
- Starting point for further interest

Bebras Contest influence

- On teaching informatics (computing)
  - Introduces students to concepts in a playful manner
  - Encourages exploring
  - Gives examples of good tasks
  - Stimulates learning some topics of Informatics
- On curriculum
  - Sets an international standardization
- On teacher training
  - Challenges teachers to deal with new concepts
  - Improves deeper understanding of informatics

Bebras Contest - a setting for research

Differences between countries are valuable resources in understanding how specific tasks are managed. It also offers opportunities for comparison and political incentives for change in school system. The contest is therefore considered beneficial for research.

Research questions based on

- **Students' understanding** of task – construction of task (country differences offer a broader diversity)
- **Teachers' impact** on gender differences (stereotype issues become obvious)
- **Country** school system **comparison** (special tracks for the talented and hidden selection processes)

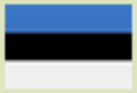

Austria
(2013: 12.154 participants)


Belgium
(2013: 565 participants)


Bulgaria
(2013: 551 participants)


Canada
(2013: 4.229 participants)


Czech Republic
(2013: 34.454 participants)


Estonia
(2013: 3.517 participants)


Finland
(2013: 4.423 participants)


France
(2013: 171.932 participants)


Germany
(2013: 206.430 participants)


Hungary
(2013: 6.246 participants)


Ireland
(2013: 3.141 participants)


Italy
(2013: 3.288 participants)


Israel
(2013: 2008 participants)


Japan
(2013: 4.371 participants)


Latvia
(2013: 1.038 participants)


Lithuania
(2013: 25.909 participants)


The Netherlands
(2013: 12.592 participants)


New Zealand
(2013: 217 participants)


Poland
(2013: 15.933 participants)


Republic of South Africa
(2013: 1.111 participants)


Russian Federation
(2013: 17.584 participants)


Serbia
(2013: 6.230 participants)


Slovakia
(2013: 55.017 participants)


Slovenia
(2013: 12.040 participants)


Spain
(2013: 711 participants)


Sweden
(2013: 1.869 participants)

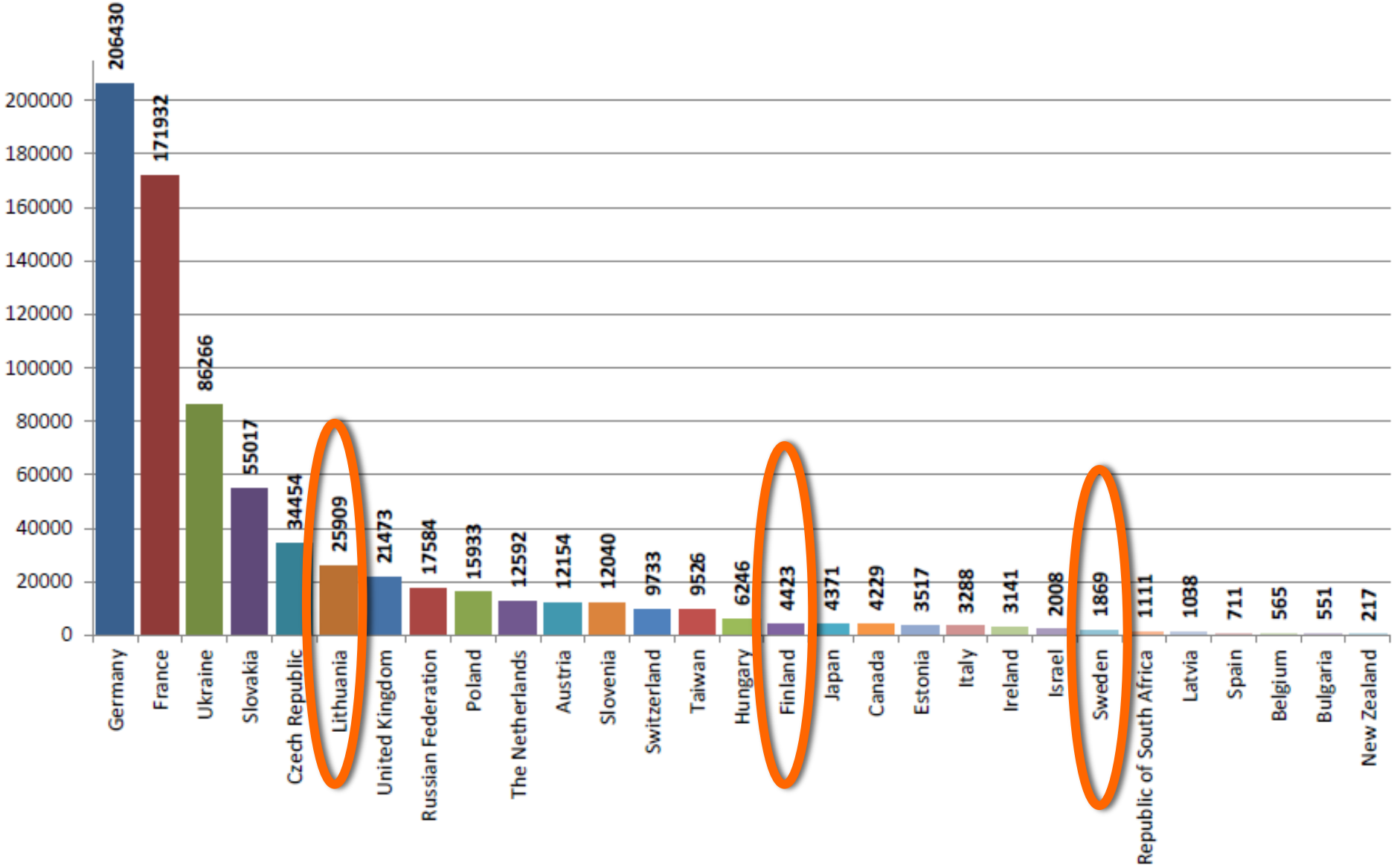

Switzerland
(2013: 9.832 participants)


Taiwan
(2013: 9.526 participants)


Ukraine
(2013: 86.266 participants)


United Kingdom
(2013: 21.473 participants)

In 2013 the contest had almost 750 000 participants



First year

Third year

10th year

Number of participants in Finland, Sweden and Lithuania in 2013

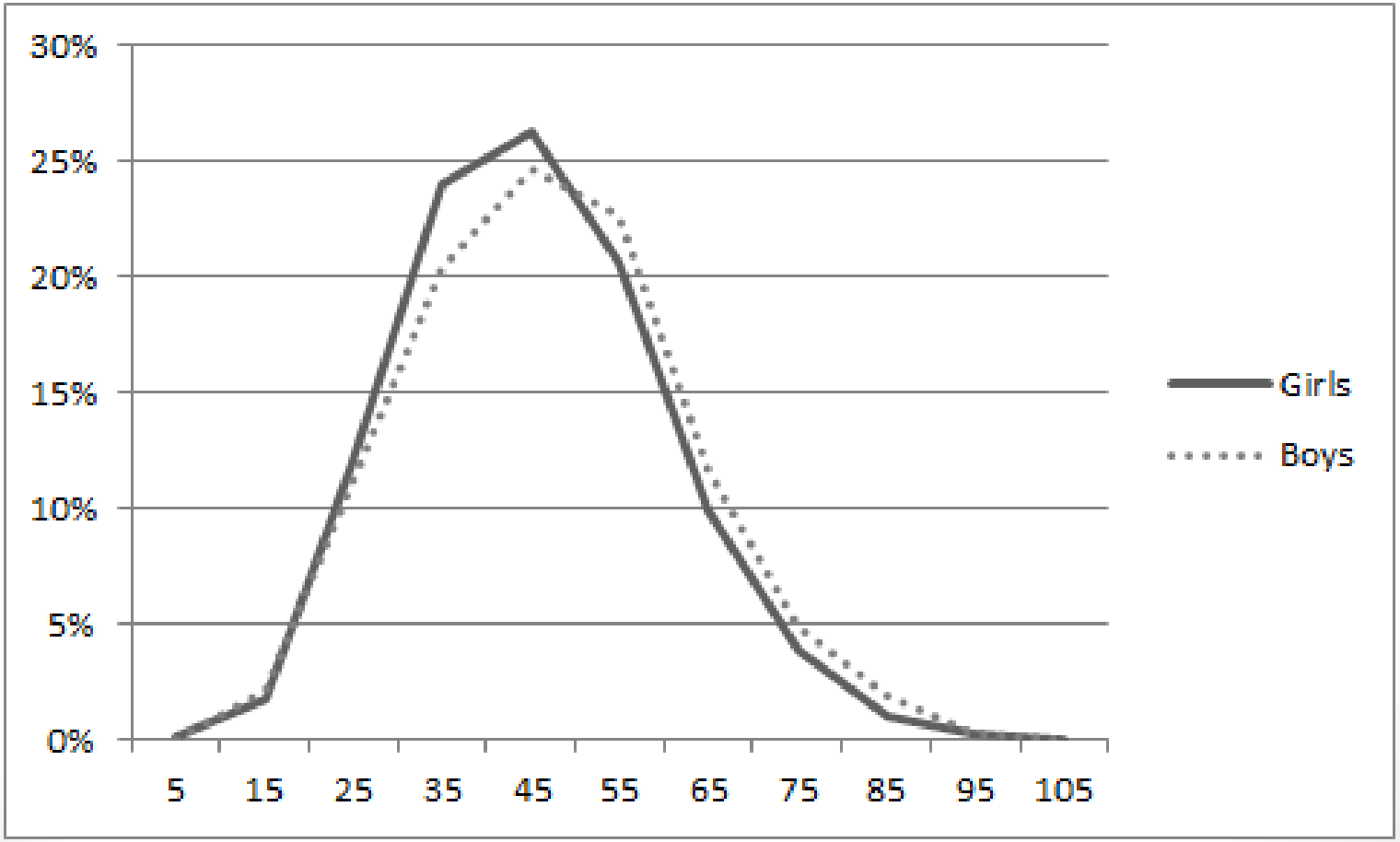
	Finland (X% boys, Y% girls)	Sweden (X% boys, Y% girls)	Lithuania (X% boys, Y% girls)
Mini	826 (52%, 48%)	262 (49%, 51%)	2 176 (55%, 45%)
Benjamin	852 (50%, 50%)	201 (56%, 44%)	7 022 (54%, 46%)
Cadet	1 294 (55%, 45%)	451 (55%, 45%)	6 550 (57%, 43%)
Junior	1 281 (69%, 31%)	413 (54%, 46%)	6 490 (60%, 40%)
Senior	170 (78%, 22%)	471 (91%, 9%)	3 671 (68%, 32%)
Total	4 423 (58%, 42%)	1 798 (63%, 37%)	25 909 (58%, 42%)

We chose Benjamin for several reasons:

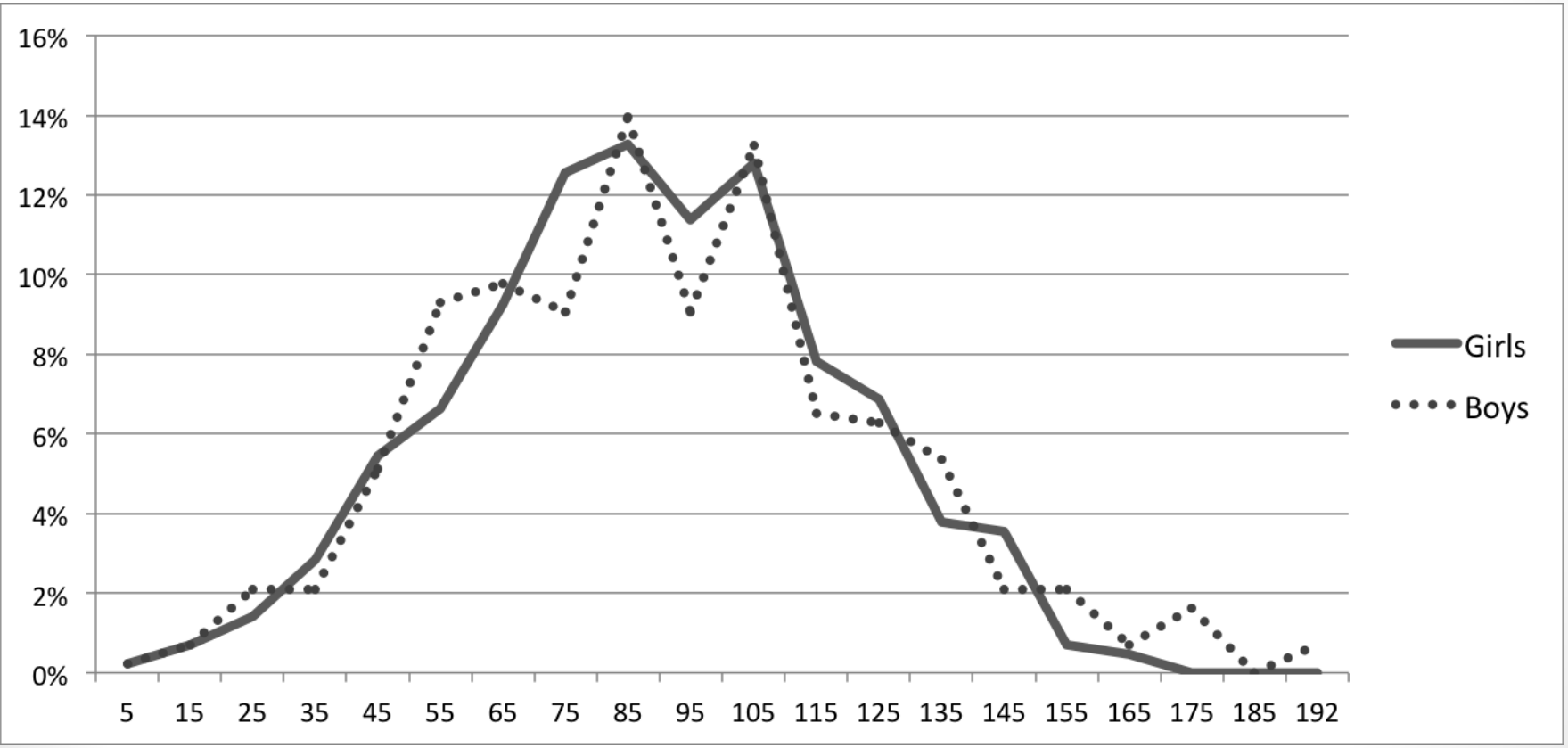
- The gender distribution is most equal for this group in all three countries (if not considering Minis)
- Students are still below the age where attitude changes towards computers and ICT commonly occur
- Lithuanian students of this age should have at least 15 mandatory lessons on Scratch or Logo according to the IT curriculum

Proportion of Lithuanian Benjamins achieving a given number of scores

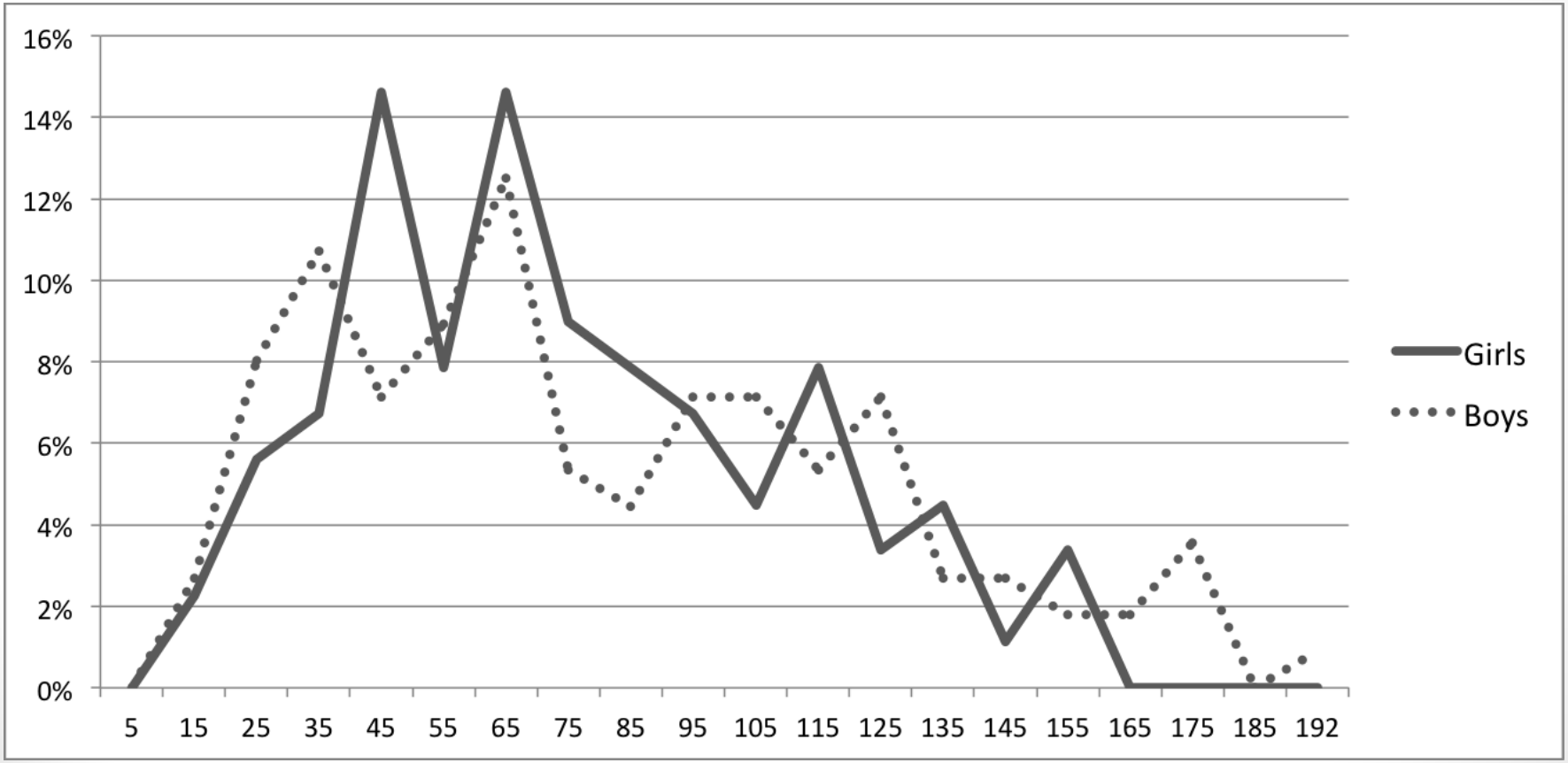
(7 022 participants, 21 tasks, maximum score 105)



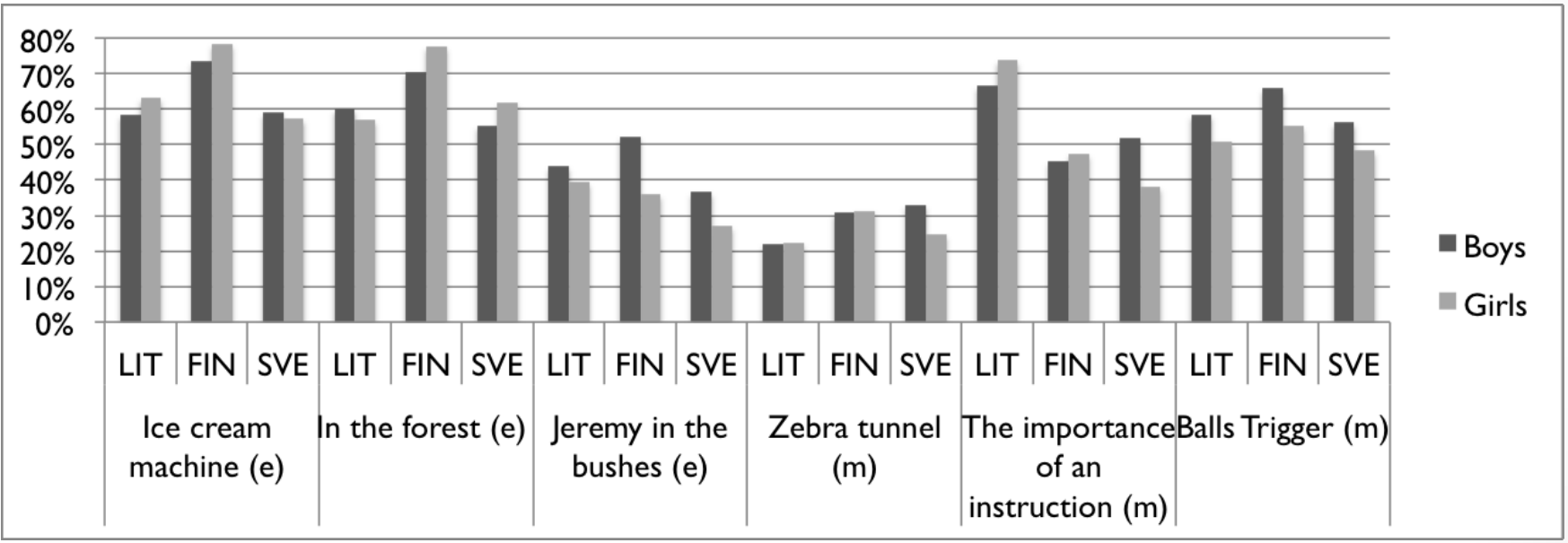
Proportion of Finnish Benjamins achieving a given number of scores (852 participants, 15 tasks, maximum score 192)



Proportion of Swedish Benjamins achieving a given number of scores (201 participants, 15 tasks, maximum score 192)



The difference in relation to gender and country



The difficulties are abbreviated as e = easy, m = medium and h = hard.

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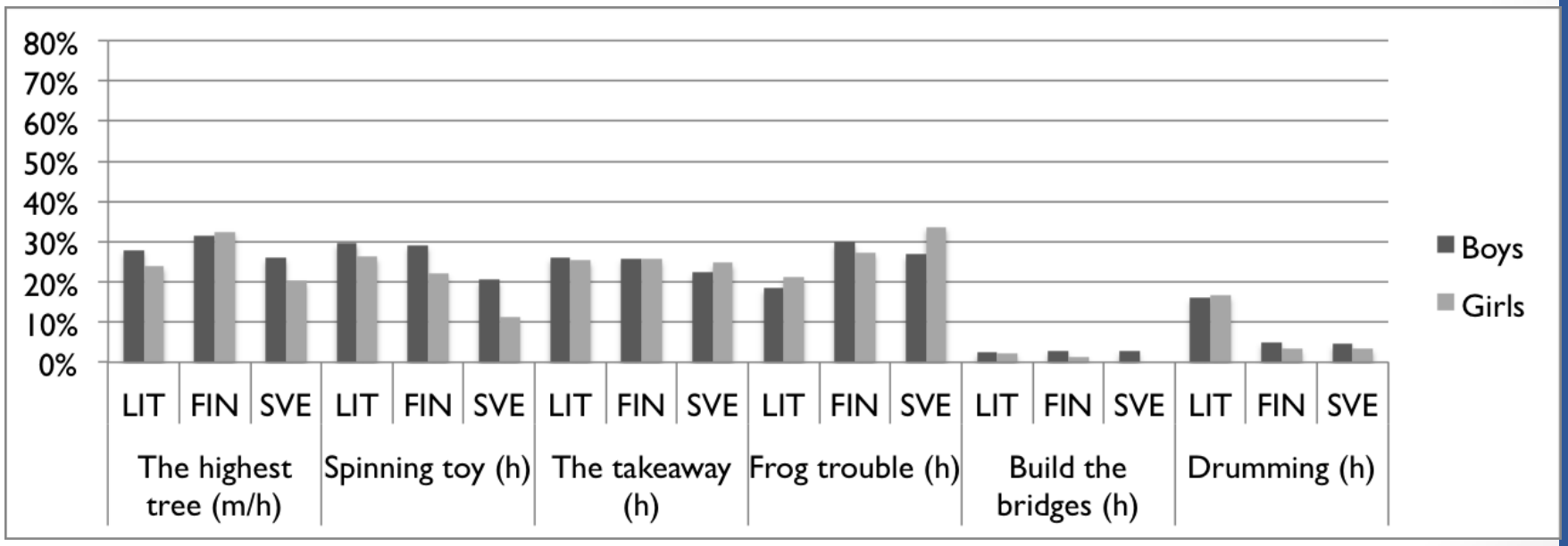


The difficulties are abbreviated as e = easy, m = medium and h = hard.

Bloom's taxonomy

1. **Remembering:** Recalling previously learnt information.

2. **Understanding:** Comprehending the meaning, translation, interpolation, and interpretation of instructions and problems.

3. **Applying:** Using a concept in a new situation or unprompted use of an abstraction.

4. **Analyzing:** Separating material or concepts into component parts so that its organisational structure may be understood. Distinguishing between facts and inferences.

5. **Evaluating:** Making judgments about the value of ideas or materials.

6. **Creating:** Building a structure or pattern from diverse elements. Putting parts together to form a whole, with emphasis on creating a new meaning or structure.

The common 12 Bebras tasks, described in terms of cognitive domains

Task name	Difficulty level	What concepts are involved in the task	Cognitive domain
Ice cream machine	Easy	detecting an algorithm; machine work; sequencing; loop	**understanding** description of non-trivial process; detection the operation of an algorithm; steps of algorithm instruction
In the forest	Easy	graph; tracing; route planning; backward strategy	**understanding** situation and planning a route from the end; separating and organising objects under given rules; distinguishing between input and result
Jeremy in the bushes	Easy	algorithm; robot navigation; tracing	**understanding** given generative rules to an input and situation; following simple; 3-5 steps algorithm instruction
Zebra tunnel	Medium	to follow instructions; algorithm analysis; data structures: FIFO (queue) and LIFO (stack)	**applying** non-trivial rules of behaviour of animals; there are representation of two ways to put data in a structure and retrieve it later; steps of algorithm instruction
The importance of an instruction	Medium	instruction; human machine instruction; unambiquous instruction	**understanding** description of processes and rules of behaviour of your partner; imagine the steps of an algorithms; interpretation of instructions
Balls trigger	Medium	instructions; logics; trigger; logical gate	**understanding** given generative rules and instructions to an initial state; following logical derivation

(cont.)

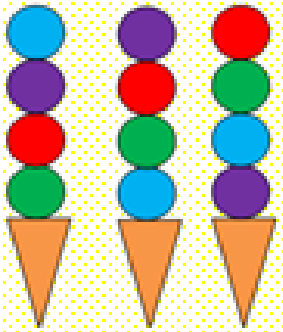
The highest tree	Medium (Fin/Swe), hard (Lit)	following instruction; repetition; searching algorithm; local optimisation; global optimum	**applying** given few steps non-trivial instructions with repetition; strictly following a list of prescribed instructions
Spinning toy	Hard	binary tree representation; tree traversal; operations abstraction	**applying** - identifying constituent parts and functions of an object; de-construct a process, final state or final product; applying high level abstraction
The takeaway	Hard	memory; management of data structure; stack	**applying** a given complex rule to the process; processing objects as data combinations (data structures)
Frog trouble	Hard	shortest path; breadth-first search algorithm	**applying** given instructions in the process; going from one state to another state; invention of efficient algorithm
Build the bridges (interactive task)	Hard	graph; tree; minimum spanning tree; Kruskal's algorithm; Prim's algorithm	**creating** - reviewing strategic plan in terms of efficacy; building a structure (bridges connecting islands) from diverse elements under rules; putting parts together to form a whole and to count values
Drumming (interactive task)	Hard (Fin/Swe), easy (Lit)	iteration; repetition; loops; following instructions	**analyzing** sequences (rhythms) and understanding repetition; using patterns (component parts) to organise required structure

Example task

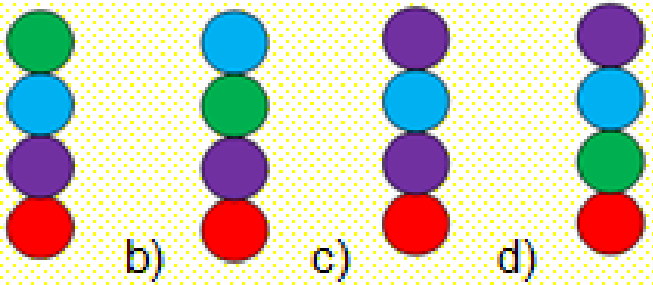
Bebras contest 2013

Task 1: Ice cream machine

The ice cream machine always put scoops in the same order. In the picture (on the right), you can see three examples for it:



Which order could come from the machine?



Example task

Bebras contest 2013

Task 2: Spinning toy

Beavers discovered a piece of wood into which worms had made a system of tunnels and pits. A handy father used it to make a toy.

To start we put a marble in the middle. The goal is to get the marble out by turning the wheel to the left (L) and right (R). By each turn the marble either runs to the next pit or (at the end) out of the wheel.

By which of the following sequences will the marble reach the exit?

a) LRRLR b) RLRLL c) LRRLRL d) LRRRRL

Conclusion and Future Work

Creation of tasks: Deciding on a suitable difficulty level for a given task upfront is quite difficult. Hence, coming up with an efficient and valid way of creating good tasks and evaluating them is a main priority both for us as researchers and for the Bebras community as a whole.

To some extent the actual difficulty level seems to correlate with the classification in Bloom's taxonomy. It might hence be worth while to classify each task picked for a given age group before assigning the difficulty level.

Conclusion and Future Work

Gender issues: Informatics is still a male-dominated discipline, but our results suggest that girls aged 10-13 manage equally well (or even better) than boys in this contest.

Since self-confidence and perceived self-efficacy seem to play a big role for students‘ choice of further studies, the Bebras contest appears to be one way of increasing girls' belief in their own skills and knowledge in informatics.

A more detailed analysis of the tasks (type, area, content) solved better by boys and girls respectively would be very interesting, as this could reveal some useful information on e.g. the characteristics of gender-neutral tasks, i.e. tasks appealing to both boys and girls.

Conclusion and Future Work

Differences in school systems: When comparing the results from the three countries, we can see a difference in particular for tasks related to programming and algorithms. Lithuanian students managed notably better on these tasks, which can be explained at least partially by these students having experience in Logo and/or Scratch. Hence, these students can be expected to be familiar with instructions in the form of commands and procedures, whereas the “Benjamins” from Finland and Sweden are most likely not exposed to programming at school.

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Thank you!

International *Bebras* website: bebras.org

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