



# Modeling and Predicting Students Problem Solving Times

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SofSem 2012

# Problem solving tutor


admin | Odhlásit  

## PROBLEM SOLVING TUTOR

ÚVOD | VÝZKUM | KONTAKT

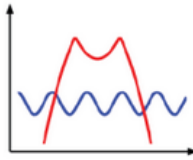
Problémy | Učitel | Statistiky | Osobní údaje | Napište nám | Uživatelé | Statistiky | Zadání | Texty | Data


### Vzdělávací úlohy



↑ ↶ F1

Robotanik



$-abs((x-2)^2-1)$  

Grafář


pes	zajíc
kočka	rys
husa	kozel

$^[a-z]{3,4}\$$

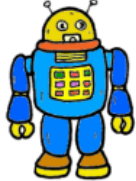
Regulární výrazy

	X	Y	Z
A	1	1	1
B	0	0	
C		1	1

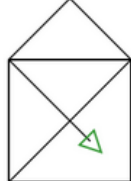
Binární křížovka



Matematické pexeso



Robot Karel



Želví grafika

Vozy  
projely  
šrašnou  
bránou.

Korektor

```
def NSD_Euclid(a,b)
  while b != 0:
    t = b
    ???
    a = t
  return ???
```

Programování v Pythonu

```
#include <stdio.h>
#define N 8

main() {
  int x, y;

  printf(" ");
  for (x = 1; x <= N;
    printf(" ???\n"));
  printf("\n\n");
```

Programování v C

# Choosing a problem

Problems Teacher Statistics Personal info Contact us Users Statistics Instances Texts Data

## Recommendation



## Problems ordered by difficulty:

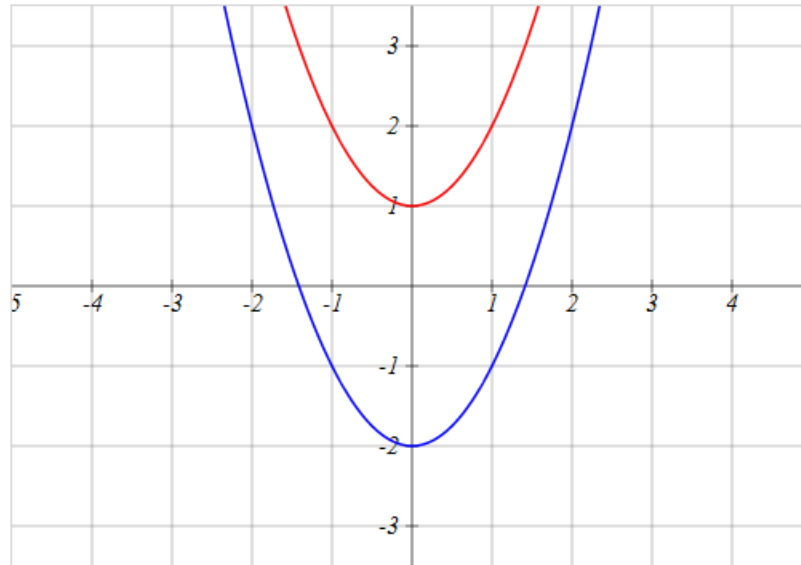
Legend: ■ Unsolved ■ Attempted but yet unsolved ■ Solved

Constant Solved 0:02	Training rational Solved 0:07	Training absolute Solved 0:04	Training cubic Solved 0:39	Training quadratic Solved 0:29	Sinus under the shell Solved 0:08	Straight upwards Solved 0:12	Tent 0:16 Prediction 0:15	Downhill Solved 4:28	Linear 2 0:00 Prediction 0:16
Training exponential Unsolved Prediction 0:16	Training cosinus Unsolved Prediction 0:16	Training tangens Unsolved Prediction 0:18	Linear 0:00 Prediction 0:18	Mountains 0:01 Prediction 0:19	Cotangens 0:00 Prediction 0:21	Resonance Solved 2:33	Exponential 1 0:24 Prediction 0:23	Curles 0:02 Prediction 0:23	Exponential 0:00 Prediction 0:24
Square root 0:00 Prediction 0:24	Linear 3 0:03 Prediction 0:25	Cubic and opposite 0:00 Prediction	Squared and opposite 0:00 Prediction	Rational to the right 1:26 Prediction	Trigo 1 Unsolved Prediction 0:31	Logarithm wings 0:00 Prediction	Polynomial 1 0:01 Prediction 0:31	No comment 1 Solved 1:05	Rychlik pod hladinou 0:01 Prediction

# Solving math problem

## Training quadratic

Try the quadratic function



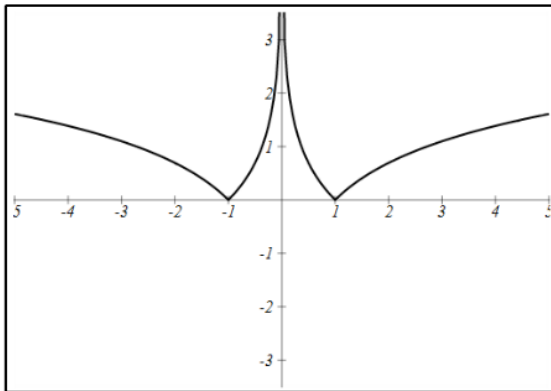
Y=

New attempt

Try another problem

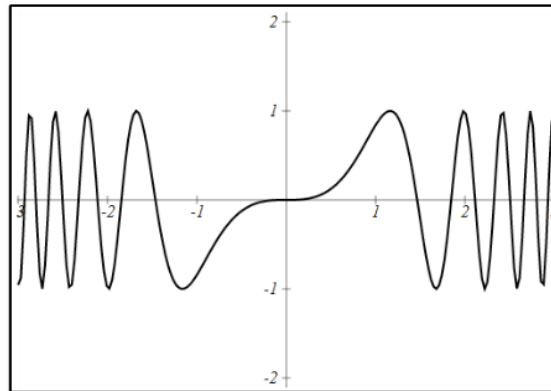
# Which one should we recommend?

Logarithm wings



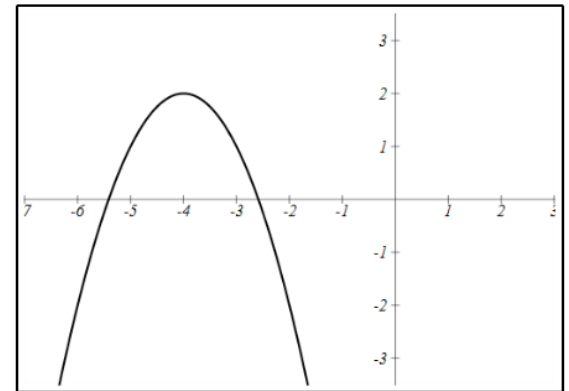
$$\text{abs}(\log(\text{abs}(x)))$$

Resonance



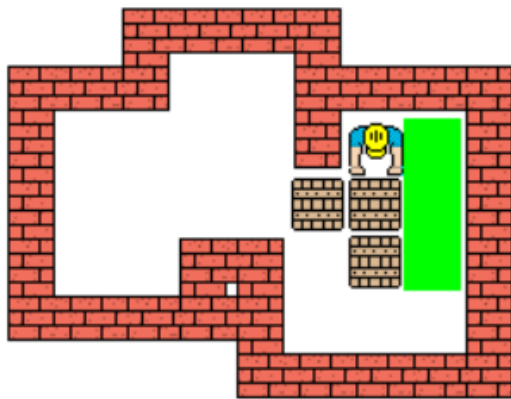
$$\sin(x^3)$$

Squared and opposite

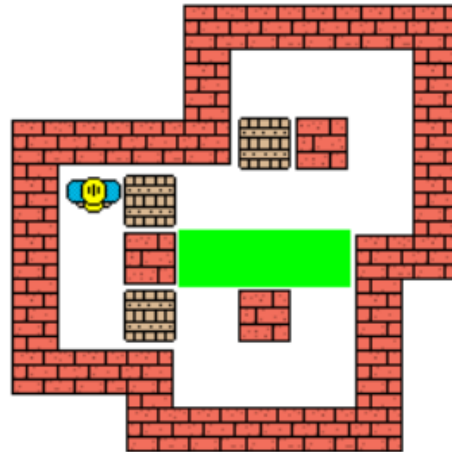


$$-(x+4)^2+2$$

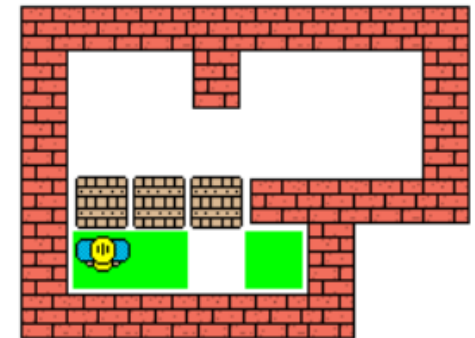
# Which one should we recommend?



Undo



Undo

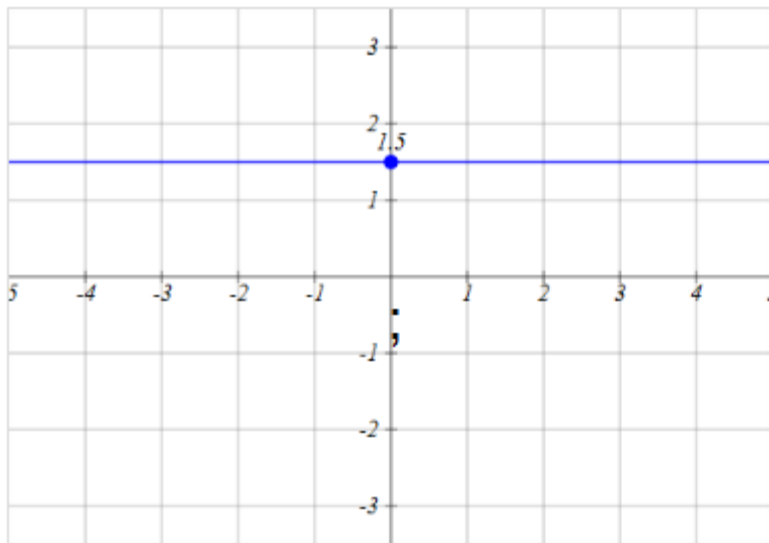


Undo

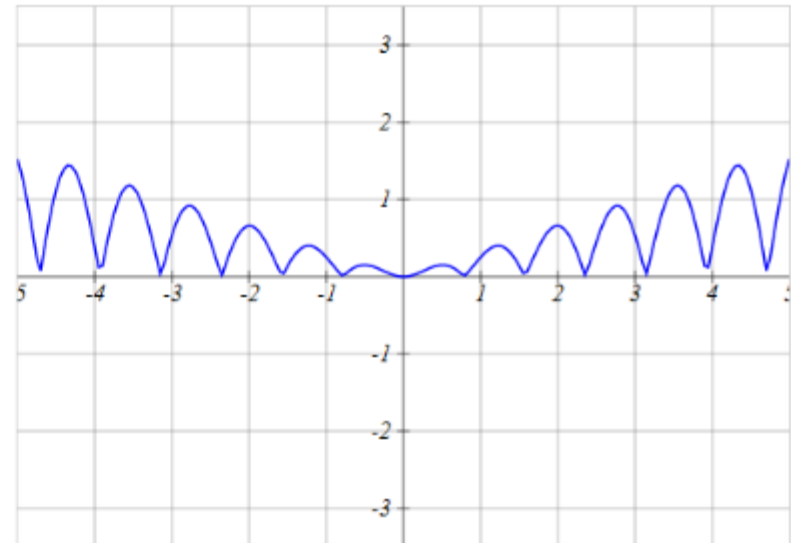
# Suitable problem

## Flow state

- Psychological concept
- Fully energized and concentrated state



Y= too easy



Y= too difficult

# Domain

## Intelligent tutoring systems

- Tools for learning with computers
- Problem solving activities

## Item response theory

- Items, response functions, ability
- Modeling response in the tests

## Question

- **How to recommend suitable problem?**

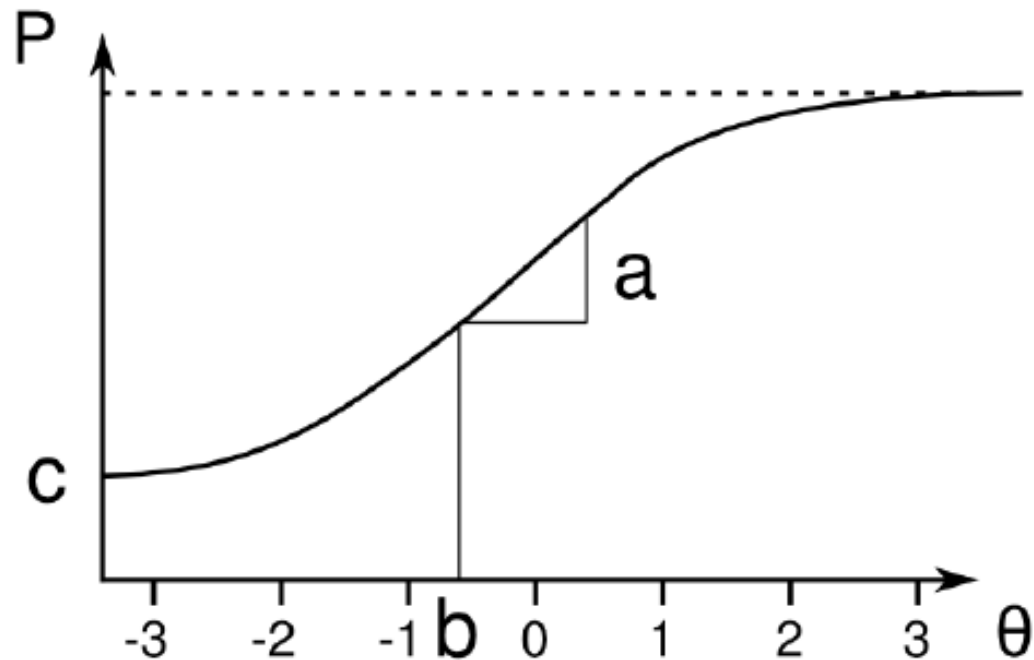


# Setting

- Setting
  - Data (user, problem, time)
  - Unsolved problems
- Goal
  - Predict problem solving time
  - Recommend a problem
- Inspiration
  - Item response theory

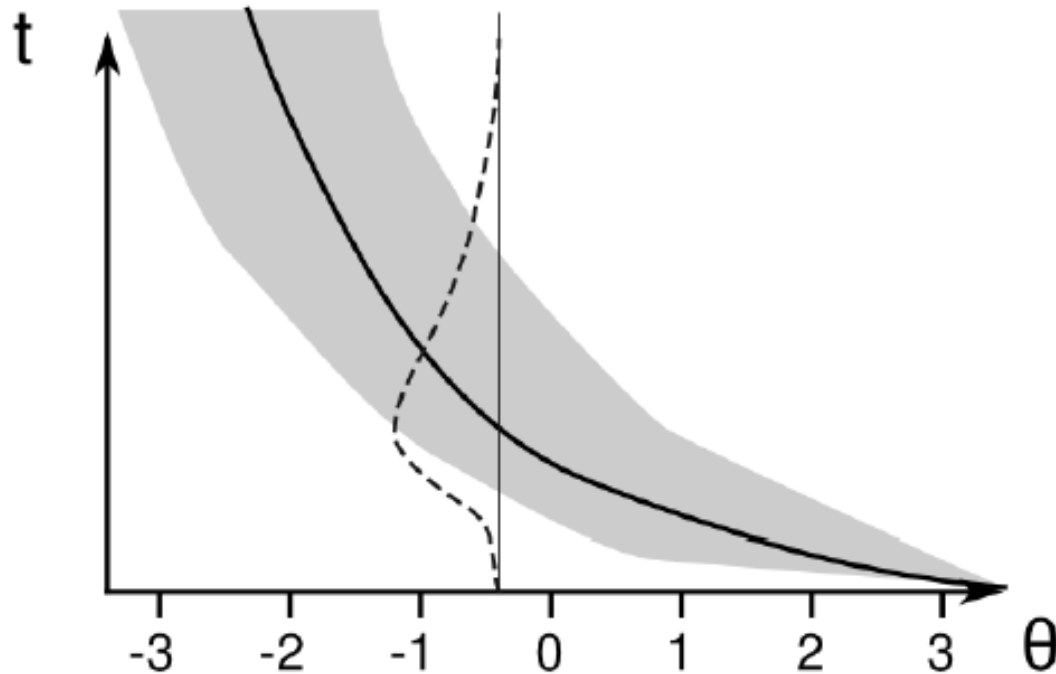
# Item response theory

- Item response function
- Probability of a correct answer



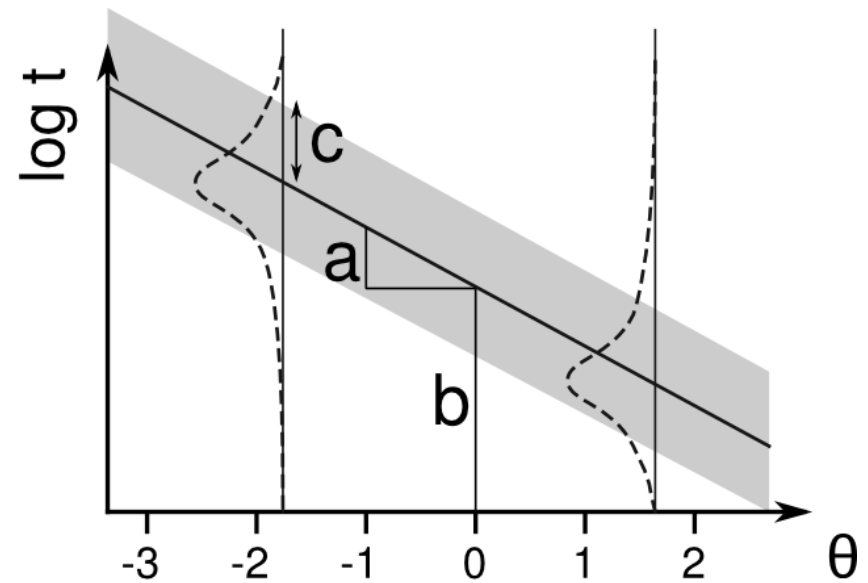
# Model of problem solving times

- Problem reponse function
- Prediction of problem solving time



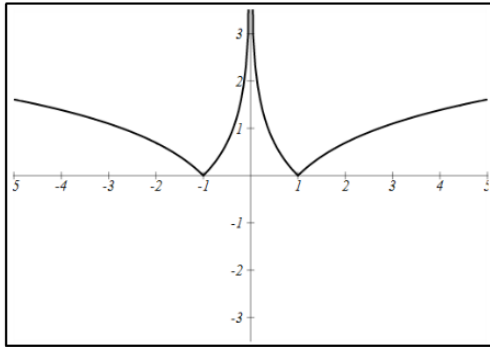
# Logarithm scale

- Fit the line
- 3 parameters
  - A: discrimination
  - B: difficulty
  - C: randomness
- Normal distribution



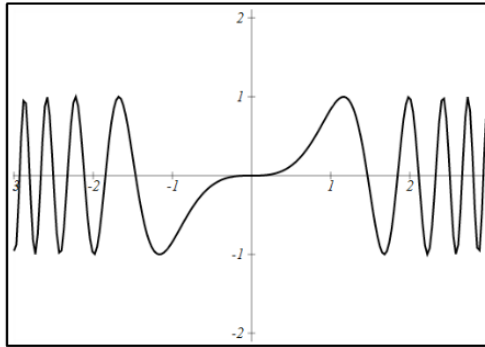
# Example

Logarithm wings



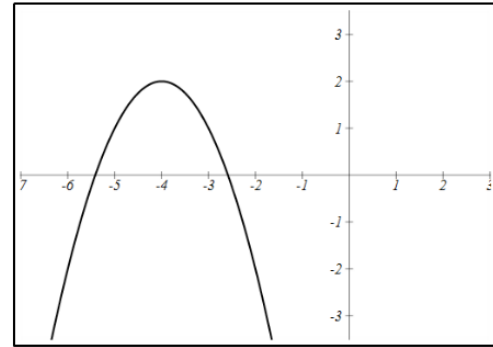
$$\text{abs}(\log(\text{abs}(x)))$$

Resonance



$$\sin(x^3)$$

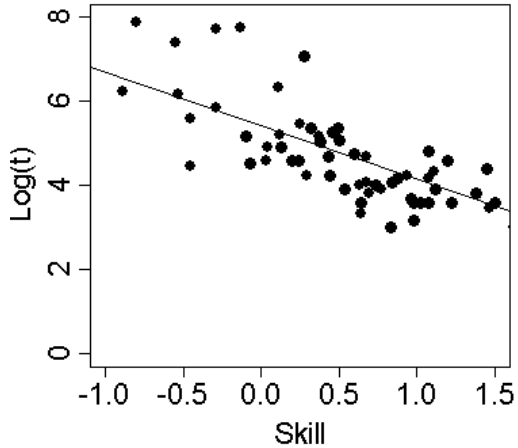
Squared and opposite



$$-(x+4)^2+2$$

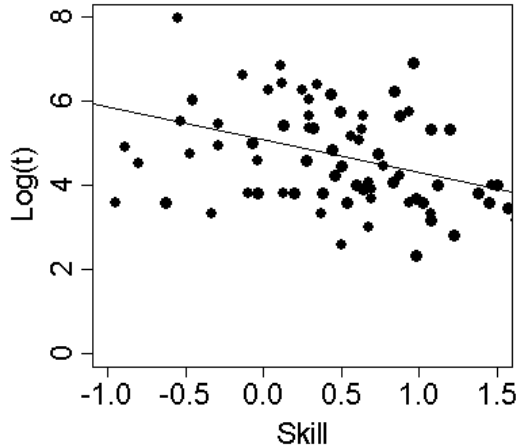
Logarithm wings

a = -1.36 b = 5.48 c = 0.6



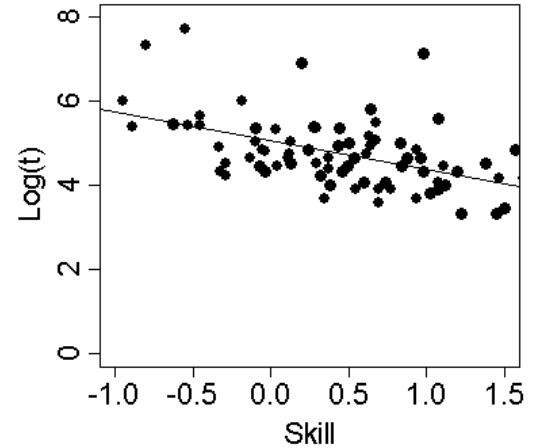
Resonance

a = -0.77 b = 5.17 c = 0.93

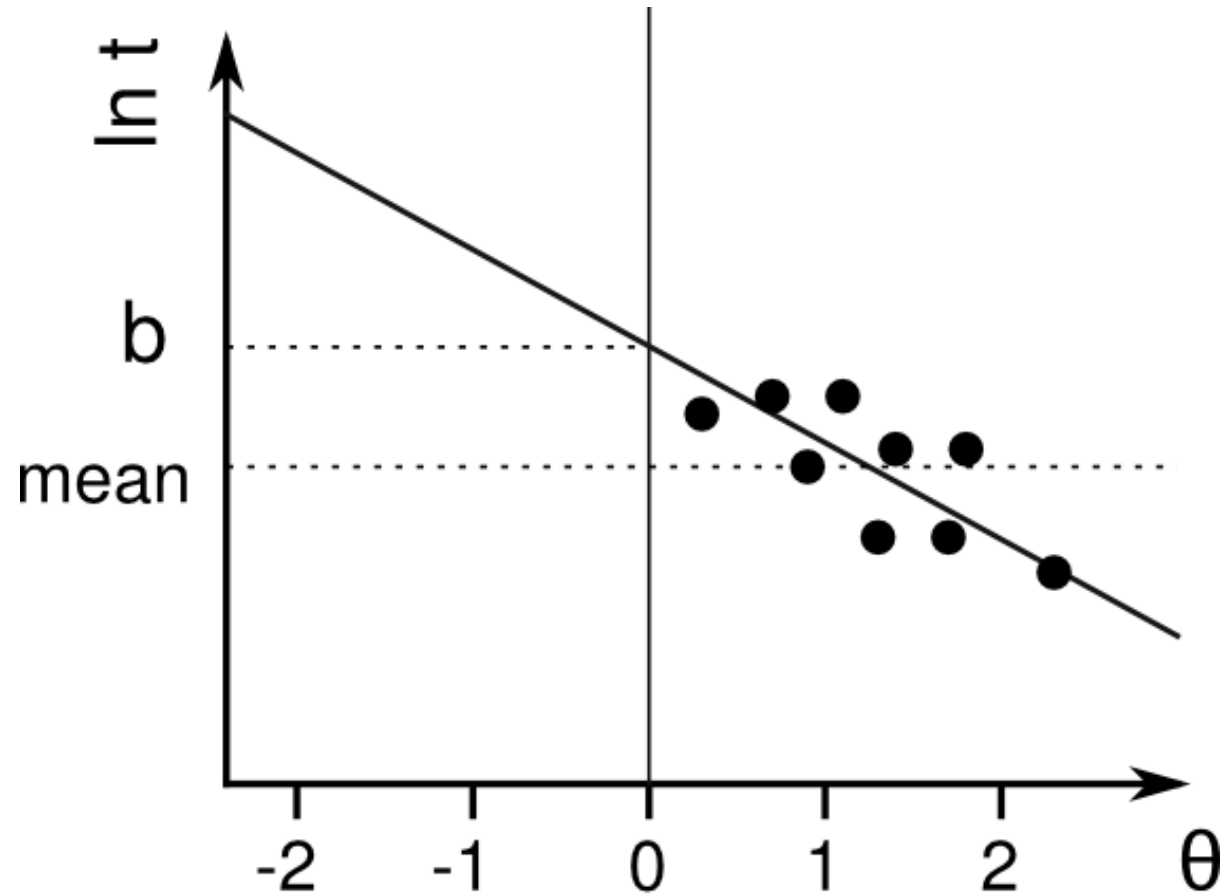


Squared and opposite

a = -0.73 b = 5.11 c = 0.55



# Group invariance

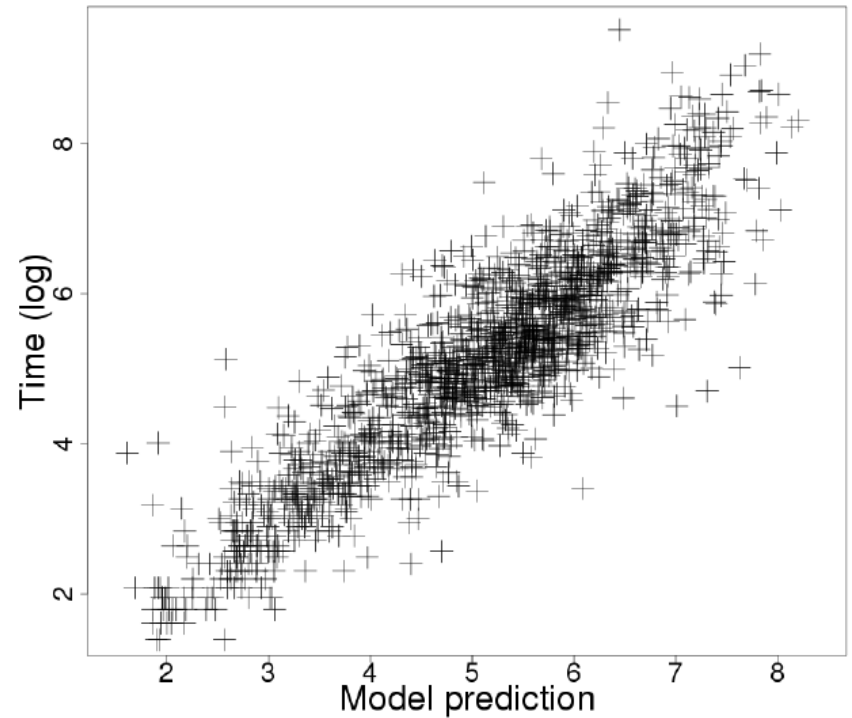
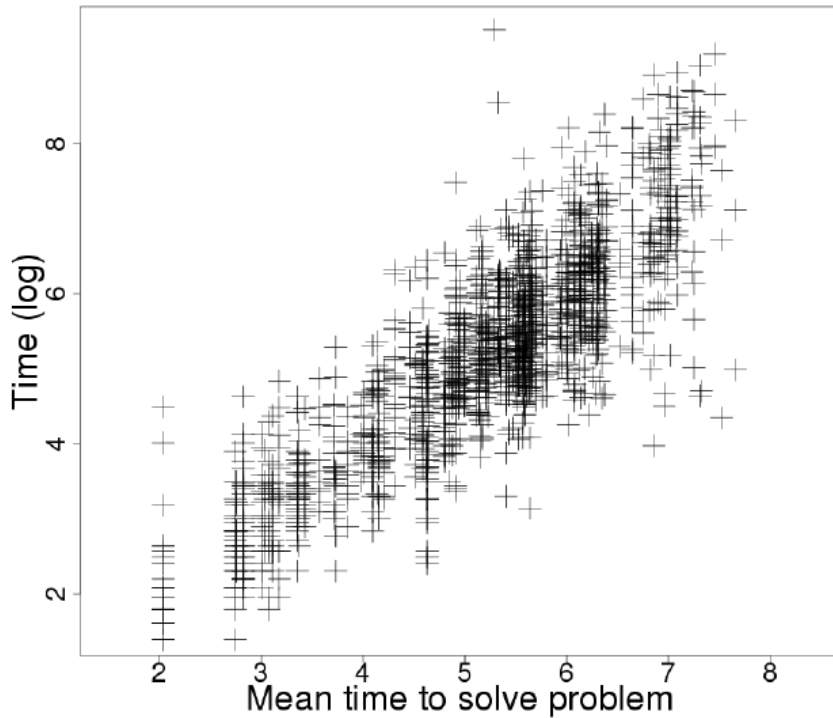


# Estimation of parameters and ability

- Maximal likelihood method
  - Estimating ability (parameters fixed)
  - Estimate parameters (ability fixed)
- Joint estimation (iterative approximation)
  - Estimate ability
  - Estimate problem parameters
  - Repeat until parameters change

# Evaluation

- Global improvement of predictions
- New insight





# Problem solving tutor

- [www.tutor.fi.muni.cz](http://www.tutor.fi.muni.cz)
- Stats
  - 21 problem types, 1400 problems
  - 5000 users
  - 220 000 solved problems
  - 20 schools using the system

The screenshot shows the homepage of the 'PROBLEM SOLVING TUTOR' website. The header includes the site name, a navigation menu with 'ÚVOD', 'VÝZKUM', and 'KONTAKT', and user options like 'admin', 'Odháslit', and a language selector. Below the header is a secondary menu with 'Problémy', 'Učitel', 'Statistiky', 'Osobní údaje', 'Napište nám', 'Uživatelé', 'Statistiky', 'Zadání', 'Texty', and 'Data'. The main content area is titled 'Vzdělávací úlohy' and features ten problem categories, each with a representative icon and a small preview of the problem content:

- Robotanik**: Icon of a green grid with a flower and a camera. Preview: '↑ ← F1'.
- Grafář**: Icon of a graph with a red curve and a blue wave. Preview:  $-abs((k-2)^2-1)$ .
- Regulární výrazy**: Icon of a word search grid. Preview: 'pes zajíc', 'kočka rys', 'husa kozel', and the regex  $^[a-z]{3,4}$$ .
- Binární křížovka**: Icon of a 3x3 grid. Preview: X Y Z, A 1 1 1, B 0 0, C 1 1.
- Matematické pexeso**: Icon of mathematical symbols like  $\pi$ ,  $2$ ,  $3$ , and  $+$ .
- Robot Karel**: Icon of a blue robot.
- Želví grafika**: Icon of an envelope with a green arrow.
- Korektor**: Icon of a red 'X' over the text 'Vozy projely vřašnou bránou.'.
- Programování v Pythonu**: Icon of a code editor. Preview: `def wdd_Euclid(a,b)`, `while b != 0:`, `t = b`, `b = a % b`, `a = t`, `return`.
- Programování v C**: Icon of a code editor. Preview: `#include <stdio.h>`, `#define N 8`, `main() {`, `int x, y;`, `printf("1)`, `for (x = 1; x <= N;`, `printf(" ??? ");`, `printf("%w\n");`.

# Conclusion

- Model of Problem Solving Times
  - Slightly better predictions
  - Novel insight in problem difficulty
  - Group invariant
- **Better predictions, better recommendations, better learning**