LASI: modeling students

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July 5, 2013
Session questions

• What would we like students, teachers or other stakeholders to know?

• What insights can be gained from analyzing educational data?

• What insights cannot be gained from analyzing educational data?

• In what way can research and educational practice help each other?

• How to deal with the fact that not the entire learning experience will be captured?
What are we doing?

Research

- Student models
  - eIRT (LAK12)
  - Logistic student models
- Adaptive e-tutoring using OER

where

we = [ (Johan Jeuring), (Ad Feelders),
       (Lieuwe Rekker), (Sander Latour),
       (Maarten van Someren), ]

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What data do we want to analyze?

http://ideas.cs.uu.nl/genexas/index.php
What data do we want to analyze?

- 14 students (id)
- 21 rewrite rules (id),
- about 8 instances per rule per student
- Correct (0 or 1)
- Sequential data: 2097 datapoints
- 3 sessions of 2 to 3 hours
What data can we use?

\[(1,17,0), (1,15,0), (1,3,0), (1,5,0), (1,24,1), (1,5,1), (1,18,0), (1,13,1), (1,11,1), (1,18,0), (1,15,1), (1,3,0), (1,12,1), (1,24,0), (1,8,1), (1,11,1), (1,15,1), (1,12,1), (1,18,0), (1,24,1), (1,13,1), (1,12,1), (1,22,0), (1,24,1), (1,16,1), (1,6,1), (1,18,0), (1,17,0), (1,15,1), (1,15,1), (1,6,1), (1,2,1), (1,24,1), (1,18,1), (1,19,0), (1,16,1), (1,15,1), (1,8,1), (1,11,1), (1,24,0), (1,7,0), (1,12,0), (1,3,0), (1,15,1), (1,12,1), (1,17,0), (1,21,0), (1,24,0), (1,3,0), (1,5,0), (1,9,0), (1,17,0), (1,18,0), (1,8,0), (1,11,1), (1,3,0), (1,23,1), (1,6,1), (1,13,1), (1,24,0), (1,15,1), (1,19,0), (1,3,1), (1,20,0), (1,5,1), (1,19,1), (1,24,0), (1,18,1), (1,7,0), (1,10,1), (1,9,0), (1,3,0), (1,9,0), (1,9,1), (1,24,1), (1,21,1), (1,17,0), (1,7,0), (1,9,1), (1,16,1), (1,4,0), (1,24,0), (1,18,0), (1,19,0), (1,17,1), (1,16,0), (1,15,1), (1,24,1), (1,18,0), (1,6,1), (1,13,1), (1,11,1), (1,12,1), (1,24,0), (1,16,1), (1,9,1), (1,12,1), (1,3,1), (1,24,1), (1,19,1), (1,16,1), (1,1,1), (1,17,1), (1,1,1), (1,5,1), (1,1,1), (1,3,1), (1,5,0), (1,24,0), (1,4,0), (1,20,1), (1,20,1), (1,20,0), (1,3,1), (1,3,0), (1,5,1), (1,18,0), (1,16,1), (1,24,0), (1,3,1), (1,18,0), (1,3,1), (1,18,0), (1,3,1), (1,24,1), (1,18,1), (1,12,1), (1,24,0), (1,2,1), (1,18,1), (1,19,1), (1,3,1), (1,24,1), (1,18,1), (1,12,1), (1,24,0), (1,8,1), (1,12,1), (1,17,0), (1,24,0), (1,18,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,0), (1,16,
What do we want to know?

About

- Students
  - Competence
  - Learning
  - Probability of success
  - ...
- Our teaching and tests
  - Difficulty
  - Discriminativity
  - Effectiveness
  - ...

Why

- To improve education
  - Manually
  - Automatically
Modeling

Mathematical model

Concept intuition

operationalization

evaluation

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Our vision of a good model

- Makes the right concepts operational
- Corresponds to domain expert intuition
- Is applicable to the data
  - Format
  - Amount
- Is robust
- Is tested
  - Expert evaluation
  - Simulation

Why did we think this would be very doable?

- Very detailed information: every rule application observed
- Reliable starting point: IRT
- Models for much less detailed data exist
Item response theory (IRT): 2PL

Operational definitions of

- difficulty, $b$
- discriminativitiy, $a$
- competence, $\theta$

Logistic function: $\sigma(a(\theta - b))$

\[
P(o_{i,j} = 1 | \theta_i, b_j, a_j) = \frac{e^{a_j(\theta_i - b_j)}}{1 + e^{a_j(\theta_i - b_j)}}
\]
The following probability function describes our model:

\[
P(o_{r,s}, t = 1) = \frac{e^{a_r(\theta_{0,s} + \eta_s t_{r,s} - b_r)}}{1 + e^{a_r(\theta_{0,s} + \eta_s t_{r,s} - b_r)}}
\]

where \( r \) is the rule ID, \( s \) the student ID, \( \theta_{0,s} \) is the starting competence of the student, \( \eta_s \) the learning speed of the student, and \( t_{r,s} \) the number of times student \( s \) attempted rule \( r \) before.

Form chosen using **domain experts and viability analysis through simulation**.
If we have reliable rule parameter estimates:

25 rules, 15 students, 8 instances (=data points) per rule.
Simultaneous item and student parameter recovery for extended IRT, in a 25 students 15 rules simulation
eIRT: simultaneous rule and student parameter estimation

η recovery

estimated η vs. original η for different instances (8, 12, 14, 16).
eIRT: conclusions

- Proven to be able to estimate reliable parameters
- Accuracy 0.8
- Student start competence as expected
- High rank correlation between domain experts and learned parameters for difficulty
- Some surprises (interviews), useful observations
- But, we need more data for $\eta$ and $a$
Domain experts are really important

As are participant interviews

Be very careful with reliability in relation to the amount of data
Data need for logistic student models

- eIRT is the smallest model we know in the family of logistic student models
- Other models (LFA, PFA) also contain
  - more than one rule per instance/item
  - different learning speeds for correct and incorrect
- but the datasets are usually not much bigger...
Current research: Lieuwe Rekker

- Generalized model (of which LFA, PFA and eIRT are special cases)
- Compare reliability of logistic student models as a function of the amount of data

Current research goals

- Know what models we can use reliably, with
  - Different assumptions
  - Different amounts of data
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