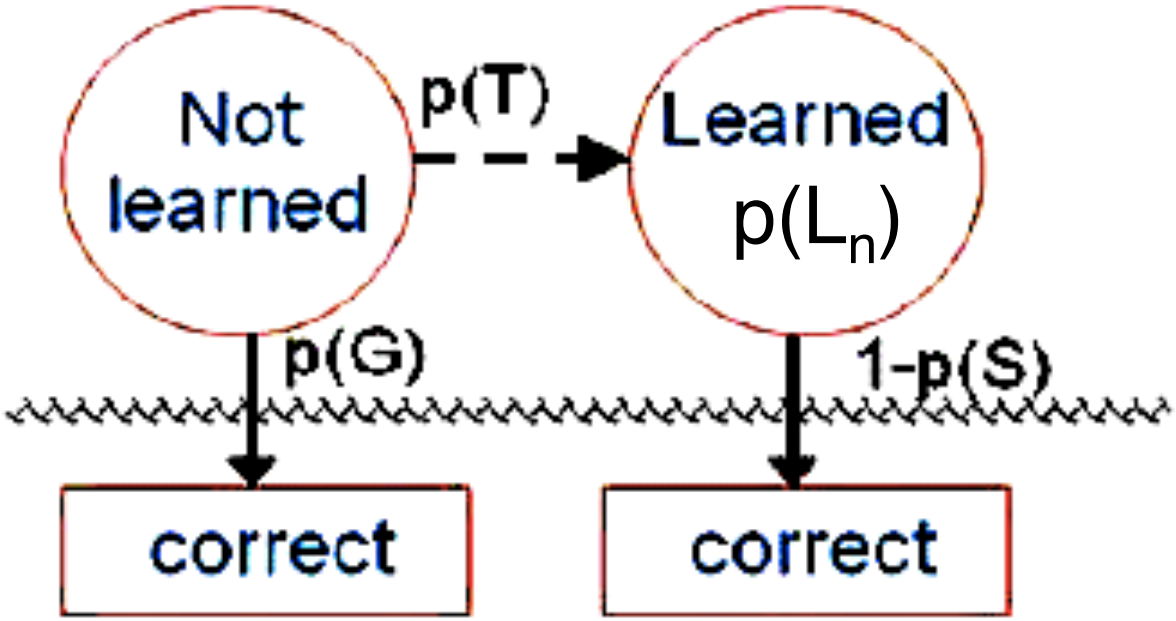
Using Gaming-Related Features to Improve Contextual Guess and Slip Models

Sujith Gowda and Jonathan Rowe

Mentors:
Ken Koedinger and Min Chi

Bayesian Knowledge Tracing Model



Original model [Corbett & Anderson, 1995] assumed four fixed parameters:

- Initial Knowledge $p(L_0)$
- Learning rate p(T)
- Guess p(G)
- Slip p(S)

Contextual Prediction of Guess and Slip

Use Bayesian analysis to contextually estimate guess and slip probabilities for each student response [Baker, Corbett, & Aleven, 2008a; Baker, Corbett, & Aleven, 2008b; Baker, et al. 2010]

- Guess and slip probabilities are based on successive opportunities to apply the skill
- Use machine learning to identify features associated with guess and slip
- Incorporate contextual models of guess and slip into Bayesian knowledge tracing model

Gaming the System

- Student behavior that exploits the design of a tutoring system in order to advance through the curriculum without applying the associated knowledge [Baker, et al. 2004; Baker, et al. 2008a]

- Generalizable gaming detection models can be machine learned from intelligent tutor lesson data [Baker, et al. 2008b]

Research Question

Does gaming detector data enhance knowledge-tracing model accuracy?

Previous Linear Regression Model of Guess and Slip

Feature	p(G)	p(S)
Action is a help request		-.154
Response is a string	.037	.062
Response is a number	-.037	.080
Time taken	.001	
Time taken (SD off avg)	-.006	.005
Time taken in last 3 actions (SD off avg)	-.002	
Time taken in last 5 actions (SD off avg)		.002
Number of past opp. wrong on skill	.007	-.002
Percentage of past opp. wrong on skill		-.016
Number of past 3 actions involved this step	.062	
Number of past 5 actions involved this step		
Number of help requests in past 8 actions		-.023
Number of errors in past 5 actions	.024	.033
Number of past opportunities on skill	.492	.001

New Gaming-Related Features

- Number of past opportunities gamed
- Percentage of past opportunities gamed
- Non-gaming practice opportunity count
- Probability of correct response on skill (across all students)

Gaming-Enhanced Linear Regression Model of Guess

Feature	p(G)
Response is a string	.017
Time taken (SD off avg)	.001
Time taken in last 3 actions (SD off avg)	-.002
Time taken in last 5 actions (SD off avg)	.002
Number of past opp. wrong on skill	.004
Time on past opp. on skill across all problems	.001
Number of help requests in past 8 actions	.021
Number of errors in past 5 actions	.033
Number of past non-gamed opportunities	.002
Number of past actions gamed	.007
Percentage of past actions gamed	-.034
Prob. of correct response on skill (all students)	-1.01
Intercept	.995

Gaming-Enhanced Linear Regression Model of Slip

Feature	p(S)
Action is a help request	-.097
Response is a string	.132
Response is a number	.112
Time taken (SD off avg)	.003
Percentage of past opp. help requested	.036
Number of past opp. wrong on skill	-.002
Number of help requests in past 8 actions	-.030
Number of errors in past 5 actions	-.041
Number of past non-gamed opportunities	-.002
Number of past actions gamed	-.006
Percentage of past actions gamed	.028
Prob. of correct response on skill (all students)	.929
Intercept	-.224

Results – Gaming-Enhanced Guess and Slip in Bayesian Knowledge Tracing

Assess accuracy of new Bayesian Knowledge-Tracing model using gaming-enhanced contextual guess and slip

Previous CGS-BKT	Gaming-Enhanced CGS-BKT
A’ = .811	A’ = .815

$Z = .373$, $p > .12$

Results – Cross Validation of Contextual Guess and Slip Models

- Slip has been shown to be a significant predictor of post-test performance [Baker, et al. 2010]
- Conducted leave-one-student-out cross validation

	Previous CGS	Gaming-Enhanced CGS	
Guess	$r = .139$	$r = .364$	$t(229) = 12.75$, $p < .0001$
Slip	$r = .231$	$r = .389$	$t(227) = 7.68$, $p < .0001$

Conclusions and Future Work

- Skill difficulty is highly predictive of guess and slip behavior
- Gaming-related features also contribute to contextual guess and slip models
- Future directions include:
  - Investigating additional gaming-related features to improve contextual guess and slip models
  - Investigating whether gaming-enhanced contextual guess and slip improves predictions of student post-test performance