Carnegie Mellon University

HCI - Learning Discontinuity (Third Progress Report)

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Agenda

- Introduction
- Data
- Methods
- Results
- Next Steps & Roadblocks

Introduction

Advisor:

Zach Branson, Assistant Teaching Professor, CMU

Members:

Name: Yiwen Zhang Background: MSP	Name: Naifei(Julia) Pan Background: MSP	Name: Jie Luo Background: MSP

Client Info

Vincent Aleven

- **Professor and Director of Undergraduate Programs in Human-Computer Interaction Institute, CMU**
- **Co-founder of Carnegie Learning & MathTutor**

Introduction

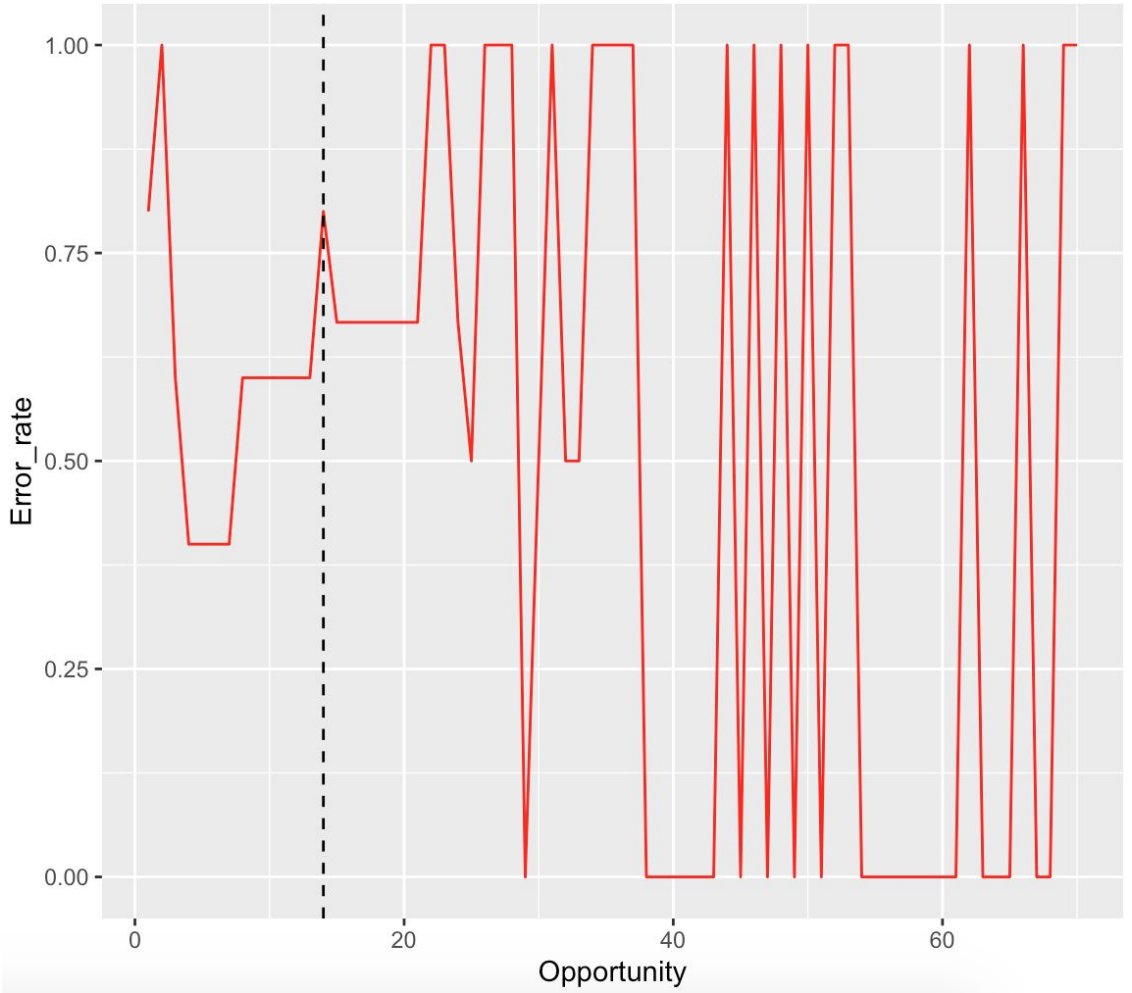
- This project is tasked with developing a way to detect learning discontinuities within tutor log data to measure effects of out-of-tutor events in Intelligent Tutoring System.
- Research Questions:
  - Do these interventions put students on a different learning trajectory, with respect to the specific skills?
  - How can we measure effect?
  - Do we see struggles before tutor interventions?
- Purposes:
  - Improve Learning with tutor system
  - Improve scientific understanding of learning with ITS and teachers

Data

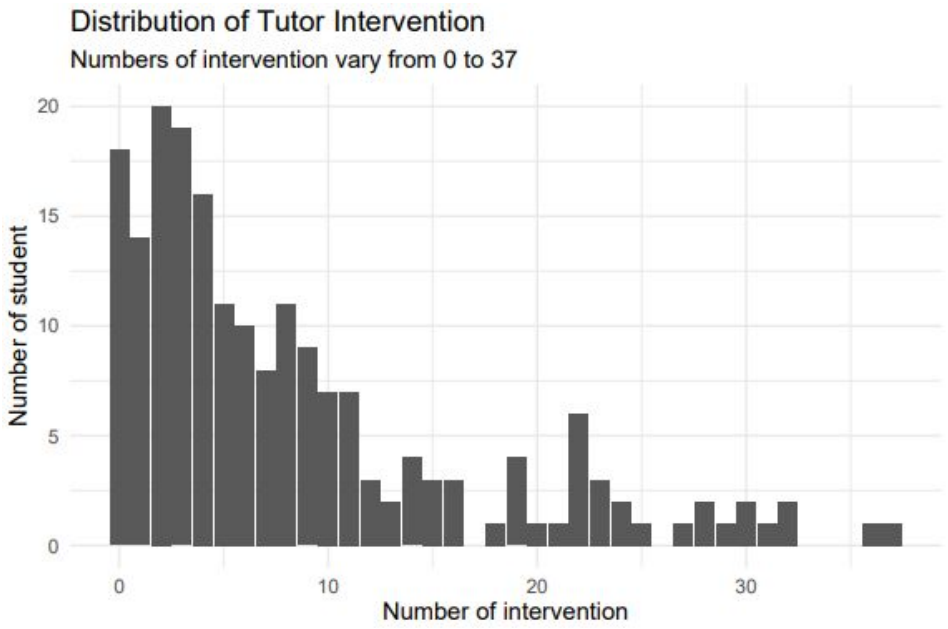
- 2 Datasets: Students transaction dataset (104,550 transactions). Student-Step dataset (195 students).
- Transaction dataset: transaction time, **tutor response**, problem name, relevant KC, student actions, ...
- Student-step dataset: **opportunity**, problem name, relevant KC, …. Derived from Transaction dataset.
- **KC**: A Knowledge Component needed to solve related tasks. We have 7 KCs in our dataset. (Combine variable terms, Compute quotient for constant, etc)
- **Opportunity**: An opportunity is the first chance on a step for a student to demonstrate whether he or she has learned the associated KC. Opportunity number increases by one each time the student encounters a step with the listed knowledge component.

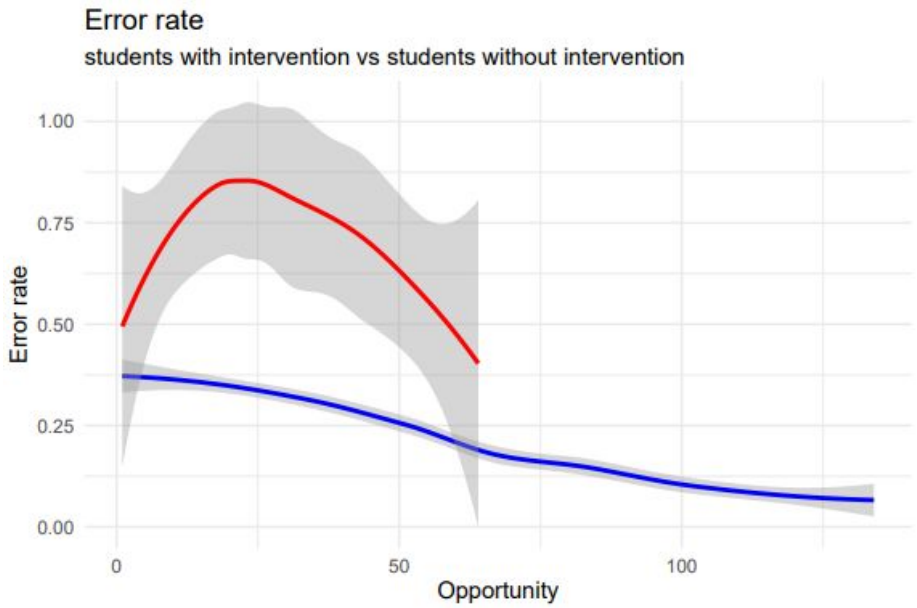
Data

- Incorrect attempt: once a student makes a mistake or asks for a hint in one attempt, we would call it an incorrect attempt
- Error rate: the proportion of incorrect attempts among total attempts
- Tutor intervention time: the opportunity that tutors intervene for a specific student.

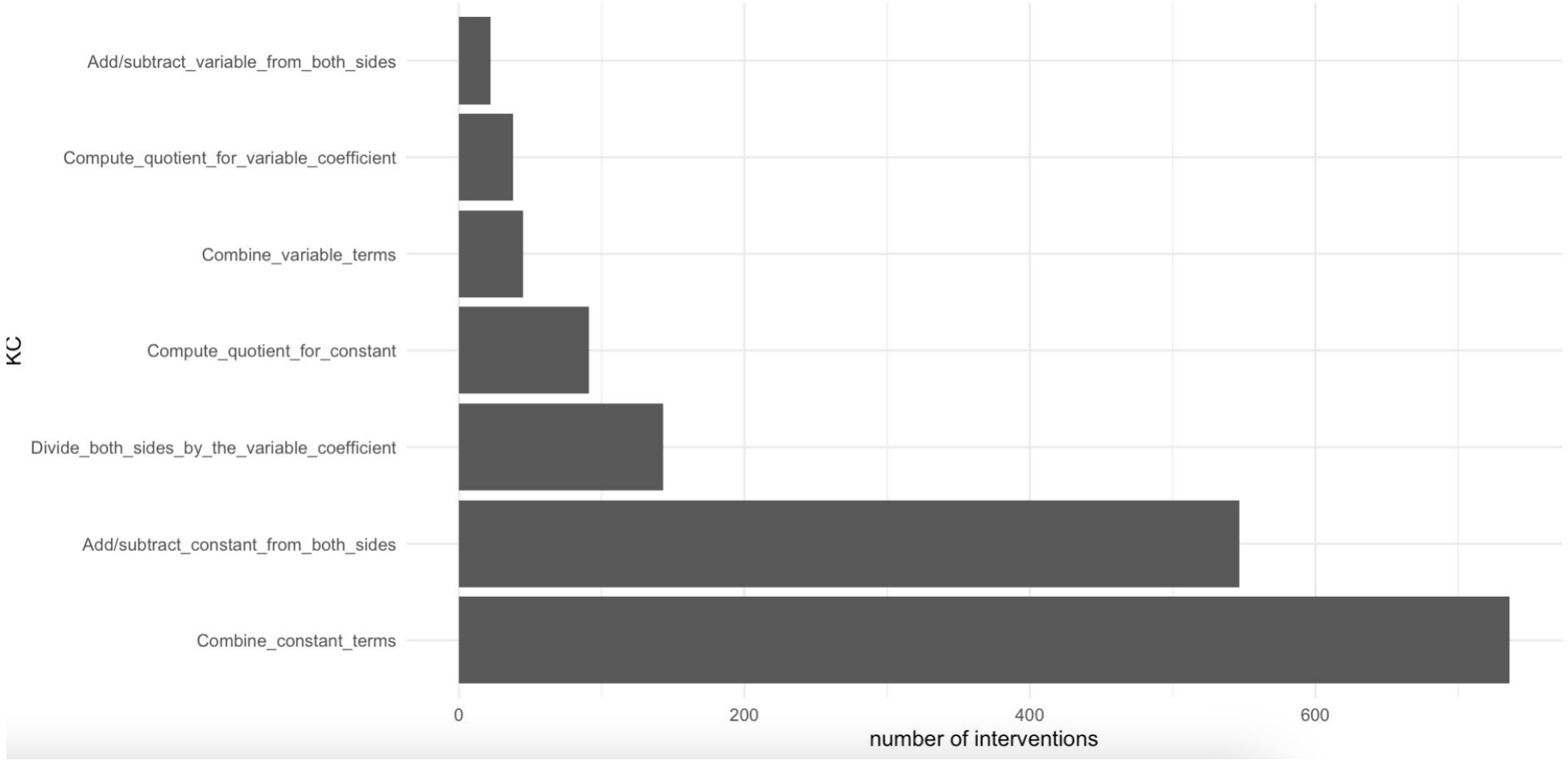


Data


Distribution of Tutor Intervention
Numbers of intervention vary from 0 to 37
Number of student
Number of intervention
0
5
10
15
20
0
10
20
30


Error rate
students with intervention vs students without intervention
Error rate
Opportunity
0.00
0.25
0.50
0.75
1.00
0
50
100

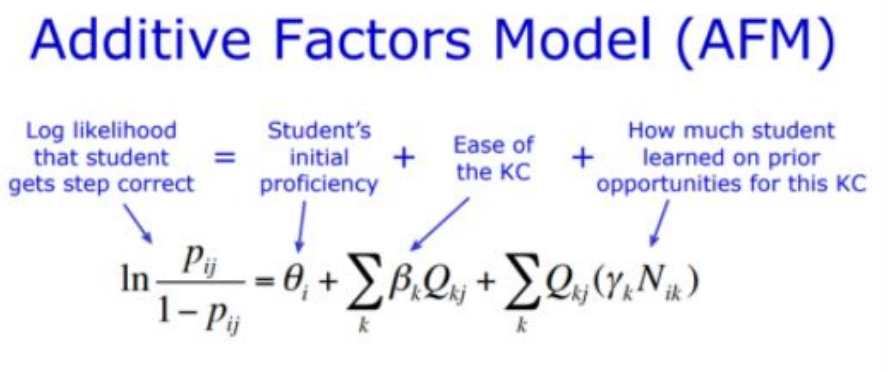
Data


Add/subtract_variable_from_both_sides
Compute_quotient_for_variable_coefficient
Combine_variable_terms
Compute_quotient_for_constant
Divide_both_sides_by_the_variable_coefficient
Add/subtract_constant_from_both_sides
Combine_constant_terms
KC
0
200
400
600
number of interventions

Methods - 1

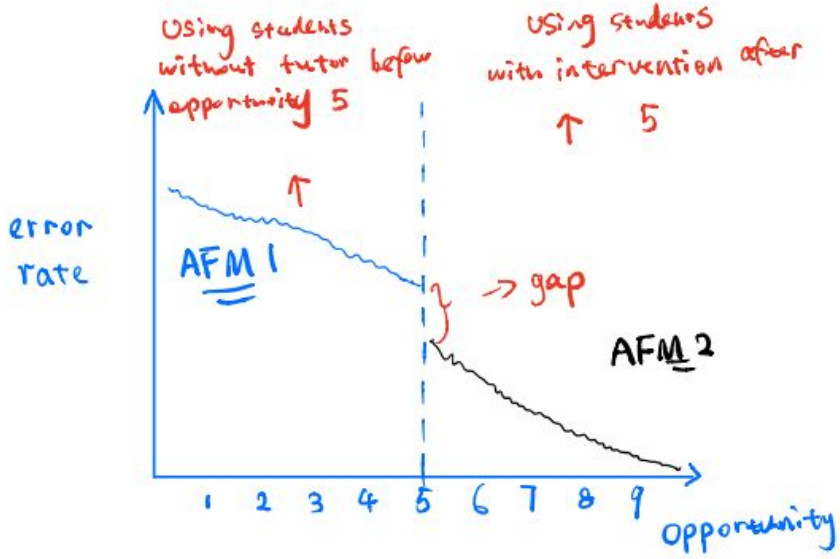
1. Fit two AFM models
   a. For pre-tutor data: fit a AFM
   b. For post-tutor data: fit another AFM (If intervention happens at opportunity M, then opportunity M+1 will be treat as opportunity 1)
   c. Compare the two AFM model (jump?)

*AFM model: logistic regression for predicting the success of the next step



Methods - 1

Assumption: One intervention influences all KC



Methods - 2

2. Improve AFM model (adding intervention to the model)

Fit PFA (Performance Factors Analysis) model

AFM:

$$m(i, j \in KCs, n) = \alpha_i + \sum_{j \in KCs} (\beta_j + \gamma_j n_{i,j})$$

PFA:

$$m(i, j \in KCs, s, f) = \sum_{j \in KCs} (\beta_j + \gamma_j s_{i,j} + \rho_j f_{i,j})$$

Methods - 2

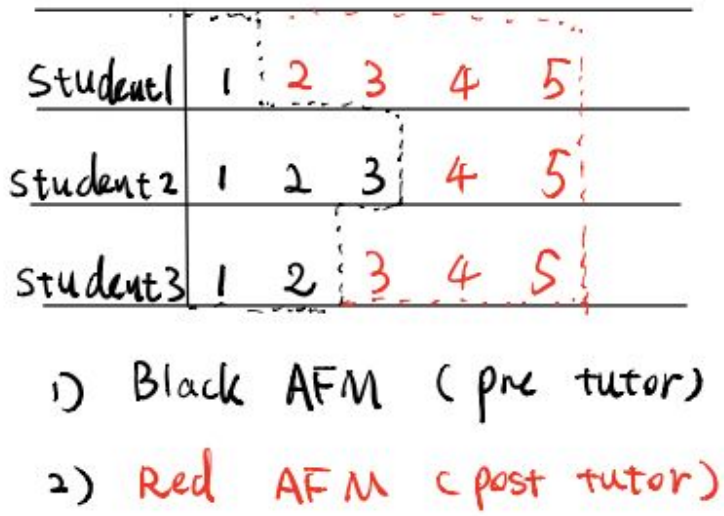
Our Assumption

- One intervention only influence problem-relevant KC(s)
- Our model:

$$AFM_k = \theta_i + \gamma_k N_{ik} + \phi_k N_{ik} I_{ik}\{Post\}$$

glmer(Success1 ~ (1 | Anon.Student.Id)+Oppo_num+ Oppo_num:Post, family=binomial(), data= HCI1)

Separation Method



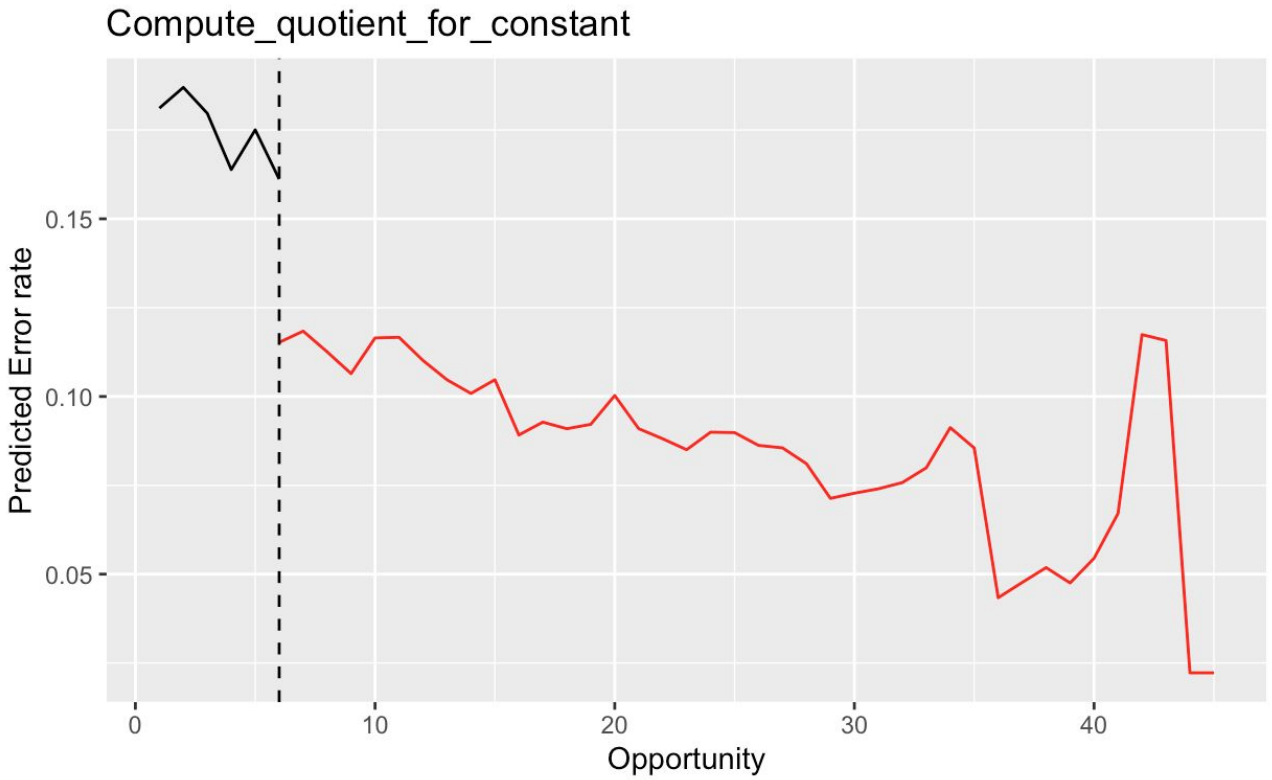
Results - Method 1

Assumption: One intervention influencing all KCs

- **2 AFM models fit for each subset (pre and post)**
- **All students participated in this KC**
- **Pre-tutor students (Black): intervention happened after opportunity 6**
- **Post-tutor students (Red): intervention happened before opportunity 6**
- **Significant gap at opportunity 6**

Results - Method 1

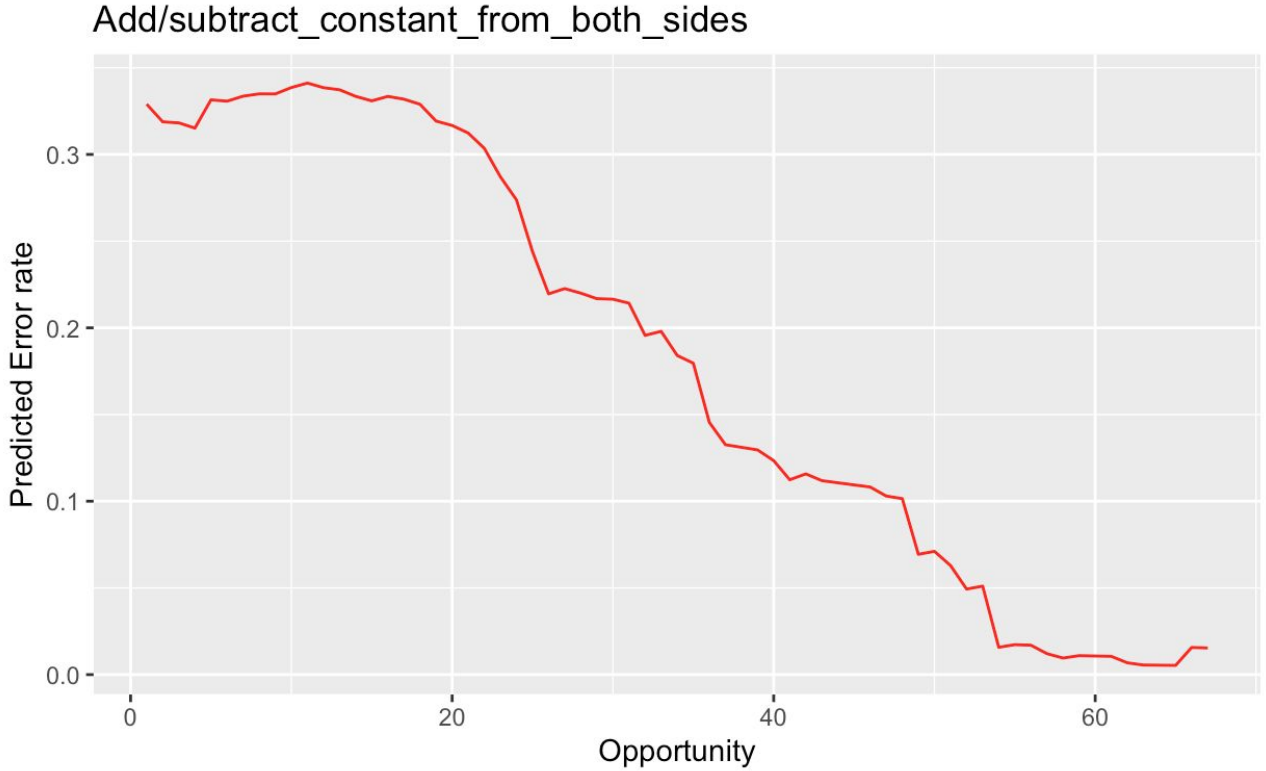
Assumption: One intervention influencing all KCs



- **2 AFM models fit for each subset (pre and post)**
- **All students participated in this KC**
- **Pre-tutor students (Black): intervention happened after opportunity 6**
- **Post-tutor students (Red): intervention happened before opportunity 6**
- **Significant gap at opportunity 6**

Results - Method 2

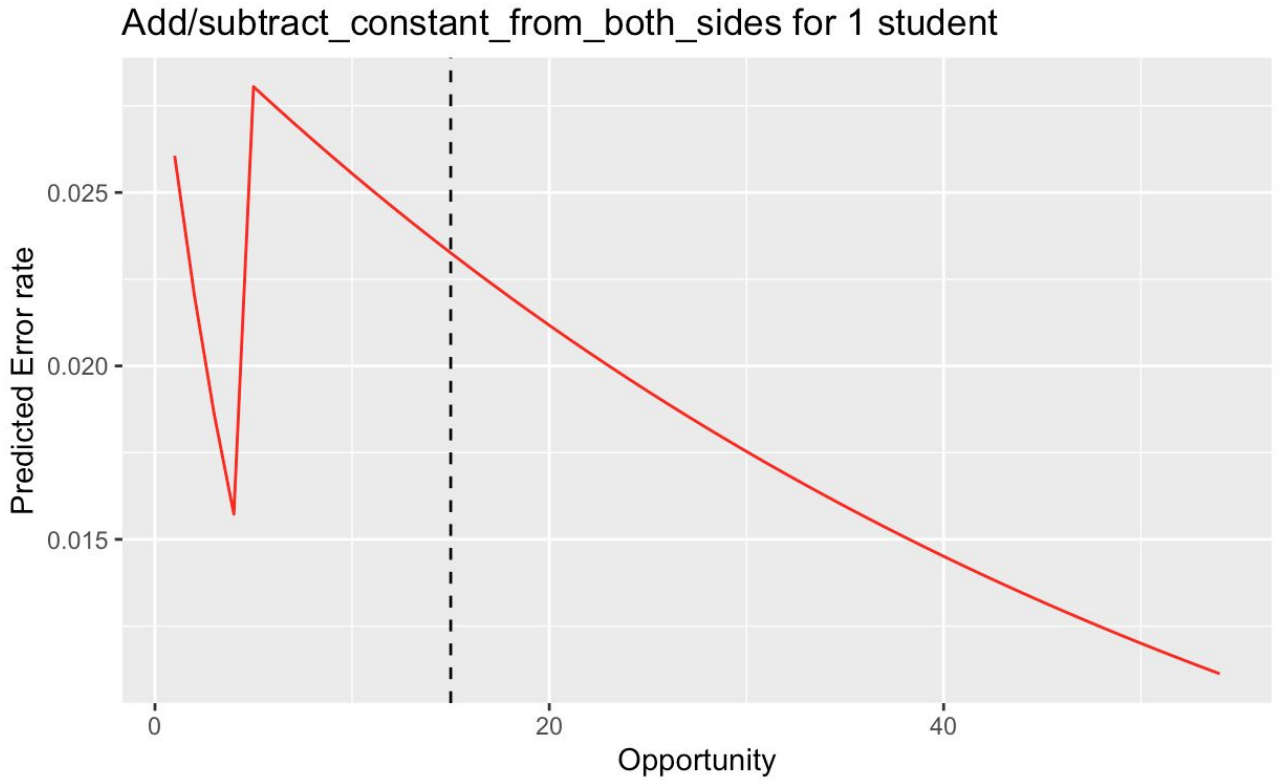
Assumption: One intervention only influencing problem-relevant KC(s)



- **1 AFM model (improved version)**
- **All students participated in this KC**

Results - Method 2

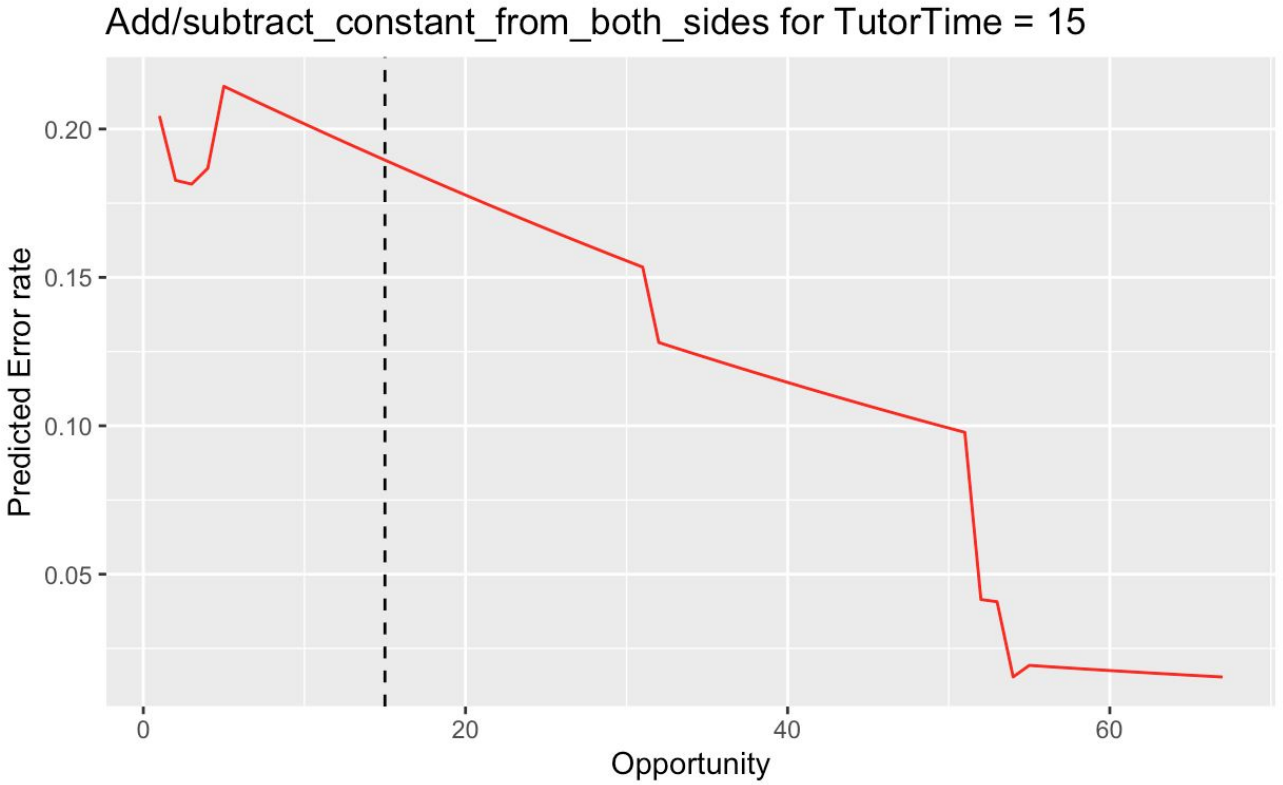
Assumption: One intervention only influencing problem-relevant KC(s)



- **Focus on 1 student**
- **Intervention happened at opportunity 15**
- **No obvious difference in slopes (learning rate) before and after intervention**
- **Intervention happened at opportunity 15**

Results - Method 2

Assumption: One intervention only influencing problem-relevant KC(s)



- **Students with tutor intervention happened at opportunity 15**
- **No obvious difference in slopes (learning rate) before and after tutor intervention**

Discussion

Method 1

- From the visualization, there exists a gap between the before and after tutor intervention time, which potentially suggests that the tutors' interventions are effective at improving students' performance
- Subsetting method requiring adjustment -- inappropriate to split the dataset when separation rule is arbitrarily selected
- Imbalance sample size between pre and post groups
- Client preferred an integrated model instead of two separate models and assumption that interventions only affect the relative KC(s)

Discussion

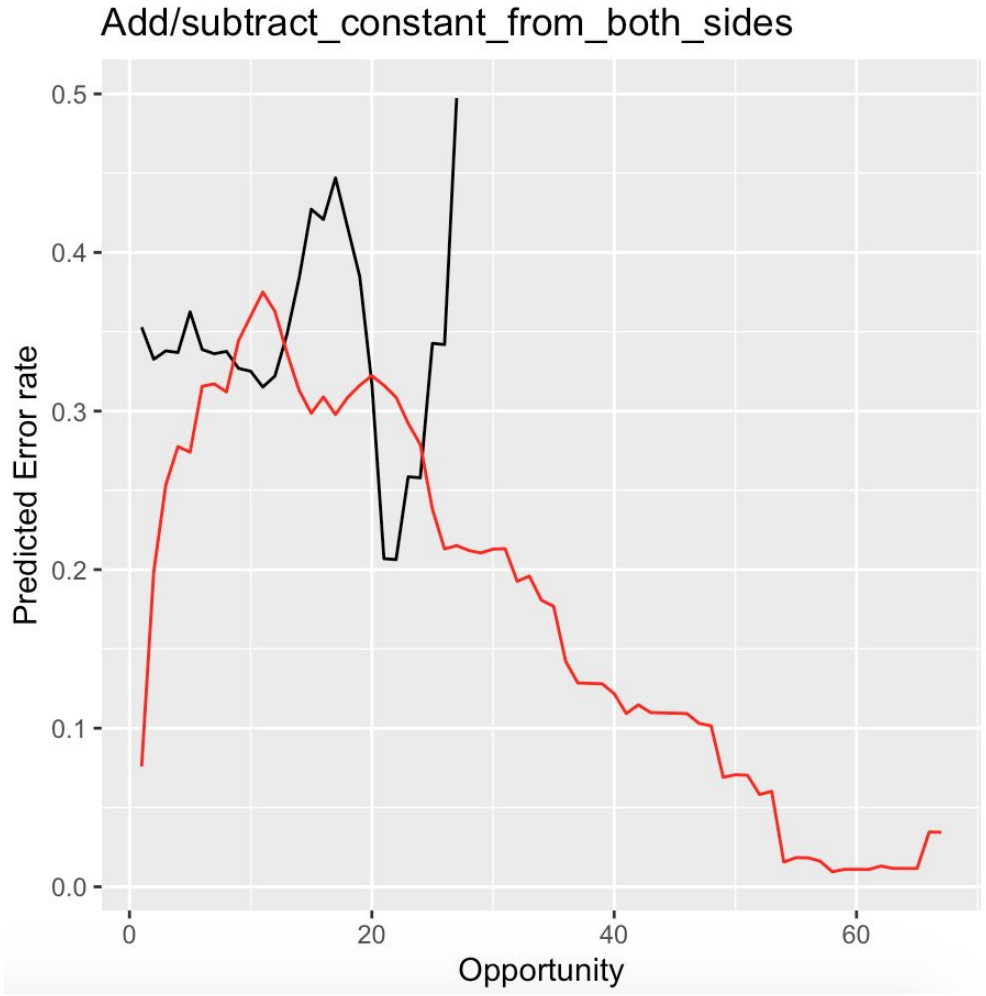
Method 2

- There’s an increase in error rate followed by a sharp turn with decreasing error rate, which might suggest that tutors intervene after noticing the struggle
- We did not observe the expected changes in slopes before and after intervention for single student
- Tutor intervention time does not match with the break point of the slopes

Next Steps

- New Method3: Fit 3 AFM models for different subsets by each KC
  - Fit 1 AFM (original version in Method 1) for all students
  - Fit 1 AFM (original version in Method 1) for students who did not get tutor intervention
  - Fit 1 AFMs (improved version in Method 2) for students who got intervention, one for pre-tutor observations and another for post-tutor observations

Compare the slopes and intercepts, also test the results

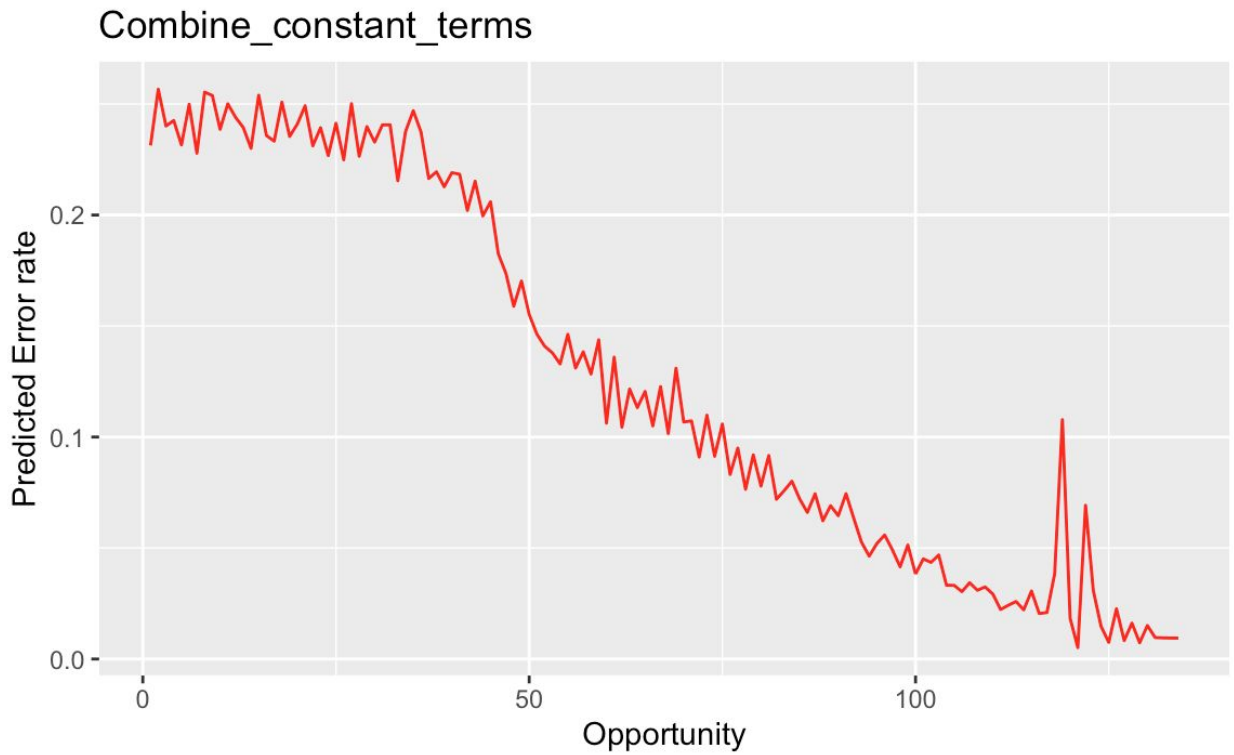


Q&A

Thank You

Appendix

Results of Method2 for KC2



Appendix

Results of Method2 for KC2