Identifying Relevant User Behavior, Predicting Learning, and Persistence in an ITS-based After-school Program

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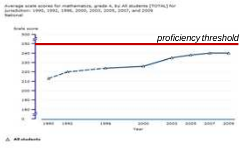
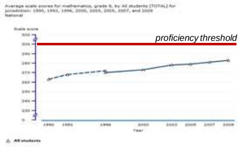
Project Summary

- Mathematics is an essential 21st century skill.
- Many countries are failing to reach proficient levels in Mathematics
- National Center for Education Statistics (2008, 2010)



4th grade students



8th grade students

Learning Outside of School

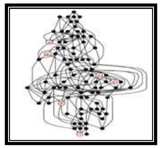
- After-school programs are an untapped resource (Gayl, 2004; Kugler, 2001; Miller, 2003)
  - only 11% of students participate in after-school programs
  - most programs are skill based and do not target academic topics
- After-school programs can improve mathematics performance
  - 6th and 7th grade students that regularly attend after-school programs score about 12 percentile points higher in mathematics than their peers (Vandell, 2007).
  - after-school programs that implement valid tutoring techniques display the greatest gains (Lauer, 2003).
- After-school programs encounter several challenges (Vandell et al., 2005)
  - student attendance is sporadic
  - an academic focus can feel like additional school or classroom time

Our After-school Math Program

- Occurred within the **Jackson-Madison County School System** (J-MCSS)
- Targeted 6th grade students at 5 middle schools
- Duration of 21 weeks (two days per week, two hours per day)
- Conducted by 16 certified math teachers
- Point-based retention program
  - student received points for attendance
  - spend points for gifts at the end of the program

Daily Schedule

- Training 20 min.
- Break 20 min.
- Training 20 min.
- Break 20 min.
- Training 20 min.


Example Knowledge Space

- Used the **ALEKS (Assessment and Learning in Knowledge Spaces)** web-based learning system
- AI-based Knowledge Space Theory (KST)
  - Representation of a large number of possible knowledge states within a topic (e.g. Mathematics)
  - Models learners' current knowledge: including what the student knows, does not know, and is ready to learn

- **Supporting evidence for ALEKS software**
  - **ALEKS in middle school classrooms** (Sullins et al., 2013)
    - 6th grade math classrooms
    - positive correlations between state test scores and ALEKS topics learned
  - **ALEKS in college classrooms** (Hu et al., 2013)
    - college statistics courses
    - ethnicity performance gap disappeared for ALEKS classes
    - gap persisted in traditional classrooms
  - **ALEKS in an after-school program** (Craig et al., 2013; Hu et al., 2012)
    - 6th grade mathematics
    - ALEKS-led classes performed at the same level as teacher-led classes
    - program students outperformed non-program students in math
    - required less assistance from teachers during the program
    - time working in ALEKS was positively correlated with performance
    - $r(126) = .474$, $p<.001$ (Craig et al. 2011).

Three Investigations of How Student Behaviors within ALEKS Impact Learning in an After-school Setting

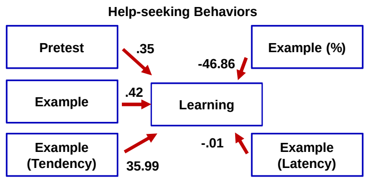
Predicting Learning within ALEKS

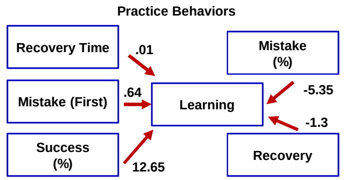
Method

- 204 sixth grade students in Years 2 and 3 of the program
- Analyses related to behavior and learning
  - Analysis 1: help-seeking
  - Analysis 2: practice
- Logistic mixed effect models
  - used 10-fold cross validation
  - Help-seeking: M2e = .81
  - Practice: M2e = .75

Learning Behaviors within ALEKS

- **Example:** read the explanation before attempting a topic
- **Example (Proportion):** proportion of explanations being read (the number of explanations/ the number of learning behaviors)
- **Example after Mistake:** read the explanation immediately after making the mistake
- **Example (Latency):** delay to seek explanations after making mistakes
- **Example (Tendency):** tendency to seek explanations to avoid making mistakes (the number of explanations/ the number of mistakes and explanations)
- **Mistake (First):** make a mistake in the first question of the topic
- **Mistakes (Proportion):** proportion of mistakes (the number of mistakes/ the number of learning behaviors)
- **Success (Proportion):** proportion of successes (the number of successes/ the number of learning behaviors)
- **Recovery:** proportion of successes after mistakes (the number of successes after mistakes/ the number of activities after mistakes)
- **Recovery Time:** time used to correct errors without reading explanations





Learning Strategies within ALEKS

Method

- 372 6th grade students from Years 2 and 3
- Included 55,281 learning sequences:
- Typical activities: *correct*, *wrong*, *explain*, *mastery*, *failed*, *left the attempt*

Identifying Learning Strategies

- **Sequencing**: Discrete Markov Models
- **Clustering**: k-means algorithm
- Identified **10 strategy clusters** (C)

- **C1:** three correct practices in a row, with mastery (9% of attempts)
- **C2:** quick mastery (11%)
- **C3:** continue practicing after mastery (6%)
- **C4:** frequently request worked examples; only attempt when confident (7%)
- **C5:** request worked examples after mistake; attain correct answer and mastery (12%)
- **C6:** request worked examples then quit without practice (13%)
- **C7:** request worked examples after error, continue to give incorrect response, then quit (17%)
- **C8:** correct at 1st practice but wrong at 2nd & 3rd; request worked examples but only get half of practices correct (6%)
- **C9:** all practices are wrong; request worked example after two errors; continue with errors; quit/failure (9%)
- **C10:** all practices are wrong; reach failure twice (9%)

Conclusions

Three Major Findings

- clustered learner strategies and demonstrated that context is important
- predicted learning based on behavior within ALEKS (help-seeking and practice)
- successfully predicted student persistence on ALEKs problems

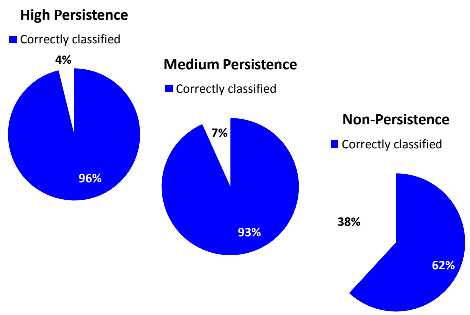
Overall, the after-school program with ALEKs was highly successful

- improved students math ability (Hu et al., 2011)
- students continued to perform at the same levels of impact over 4 years
- evidence for decreasing achievement gaps typically found with minority populations (Huang et al., 2016)
- ITS after-school program could be an effective alternative for school systems that have limited trained teachers
- still need to better understand the process of learning with this technology

Predicting Student Persistence within ALEKS

Method

- 114 6th grade students from Years 2 and 3
  - included 92,235 log files
- Predicting student persistence
  - "high persistence" (trials > 15)
  - "medium persistence" (10 ≤ trials ≤ 15)
  - "non-persistence" (trials < 5, no mastery)
- Logistic regression predictors
  - prior knowledge
  - topic difficulty
  - time period in the program
- **Results**
  - High persistence: $R^2 = .03$; correctly classified 96.2% of cases
  - Medium persistence: $R^2 = .02$; correctly classified 93.3% of cases
  - Non-persistence (without mastery): $R^2 = .07$; correctly classified 62.5% of cases



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