# Closing the math achievement gap for English Learners: Technology resources for pre-algebra


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www.animalwatch.org

# Background: AnimalWatch ITS

- algebra readiness topics
  - 14 Learning Objectives
- emphasis on word problems
  - authentic environmental science content
- positive results in quasi-experimental studies
  - now in IES Efficacy trial directed by WestEd


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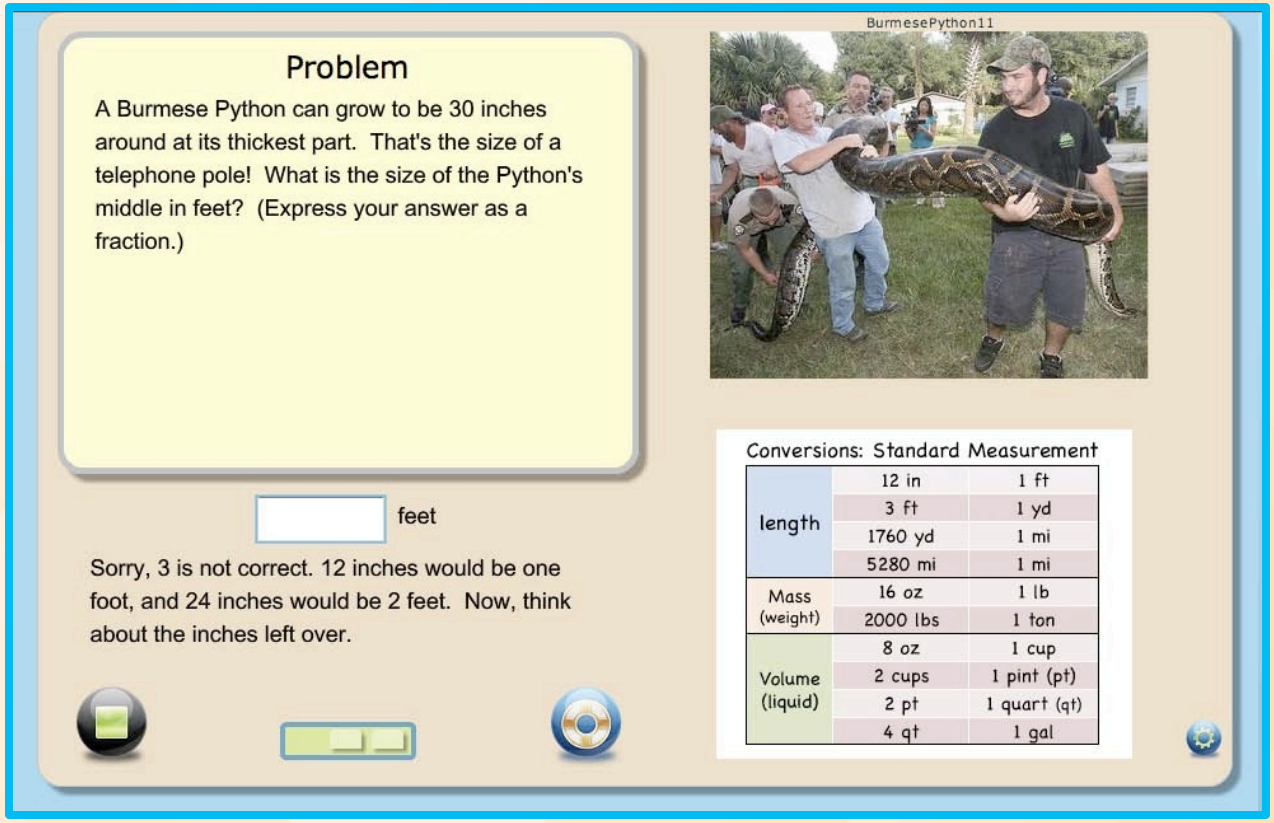
# Background: AnimalWatch ITS



# Background: AnimalWatch ITS

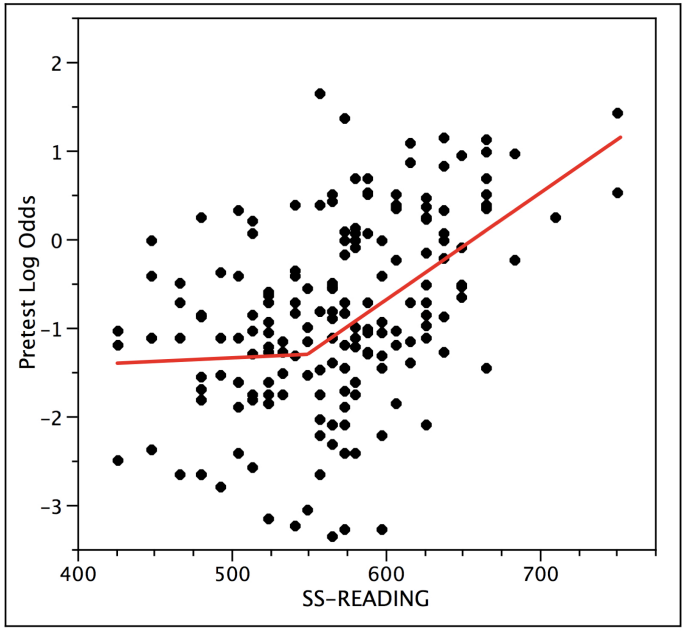
- Gap between English Primary and English Learners
- Both groups benefit from AW but gap persists

# DRK12 Project goals

- Research: What is the impact of linguistic complexity on English Learners' math problem solving?
  - prior work surprisingly inconclusive!
- Development: Add features to AnimalWatch to support word problem solving by English Learners
- Research: Evaluate impact on study-specific and standardized learning outcome measures

# Research: Impact of language on math problem solving by English Learners

- Cognitive Load Theory
  - limited cognitive resources
  - additional demands of text comprehension
  - poorer problem solving
- Prediction: relation w/ reading proficiency




Beal, C. R., Adams, N., & Cohen, P. R. (2010). Reading proficiency and mathematics problem solving by English Language Learners. Urban Education, 44,58-74.

# Research: Data mining study

- Prediction: poorer performance on items w/ greater linguistic complexity
- Data source: 233 EPs, 209 ELLs who used AnimalWatch
  - 30 -140 problems completed
- Method: locate word problems solved by both EPs and ELLs in AW database
  - at least 20 students per language group

# Research: Data mining study

- Results: English Learners
  - less likely to solve problem correctly
  - make more incorrect attempts
  - take longer per problem
  - *more likely* to view multimedia help
  - *less likely* to "game"
- Gap w/ English Primary students was greater on problems with higher reading demands

Cirett, F. G., & Beal, C. R. (2010). Problem solving by English Learners and English Primary students in an algebra readiness ITS. In H. W. Guesgen & R. C. Murray (Eds.), Proceedings of the 23rd Florida International Artificial Intelligence Society Research Conference. Menlo Park: Association for the Advancement of Artificial Intelligence.

# Research: Data mining study

## Grade 3 readability

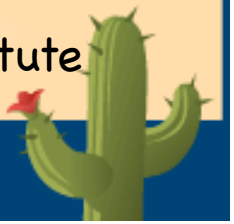
- This baby panda is only 7 months old. She still really needs her mother to protect her and teach her about food. She needs to learn what to eat and where to find it. In another 8 months she will be ready to live on her own without her mother. How many months old will she be then?

## Grade 8 readability

- Natural breeding of pandas is not always very successful when the pandas are in captivity. Some scientists have started artificially inseminating female pandas with males' sperm. In one zoo, 6 panda cubs were born as the result of natural breeding, and another 9 cubs were born through artificial means. How many cubs were born in all?

Readability metrics via REAP algorithm CMU Language Technologies Institute





# Research: Experimental Study

- Sample: 41 middle school English Learners
- Task: solve word problems constructed to vary in math and language challenges

| | |
|---|---|
| Easy Math, Easy Text | Hard Math, Easy Text |
| Easy Math, Hard Text | Hard Math, Hard Text |

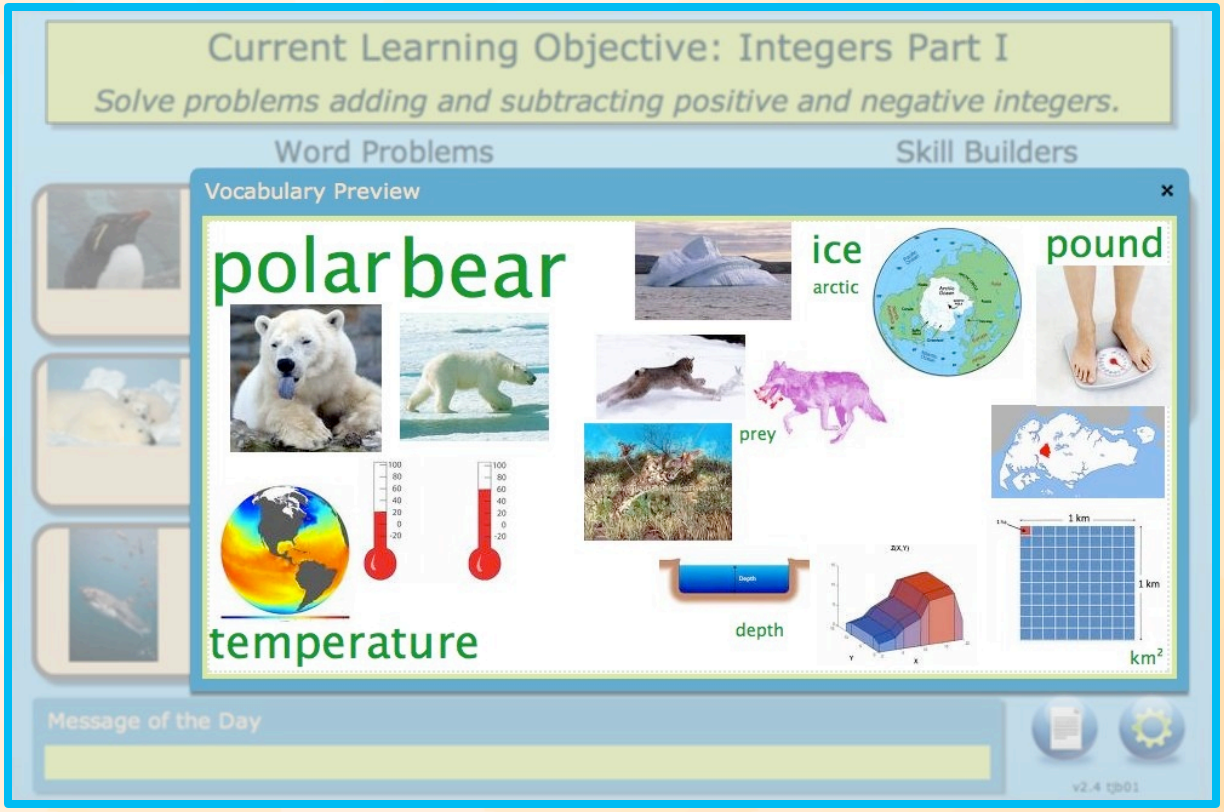
- Procedure: one-one w/ interviewer-tutor
- Metrics: identify operation, solve w/ tutor help, rate language & math

# Experimental Study: Results

- On hard math problems, hard text means:
  - lower probability of identifying the operation
  - higher frequency of computational errors
    - even though operation errors have been corrected
  - increased perception of problem as "too hard to solve"
    - even though students can successfully perform the math on the parallel easy-text version

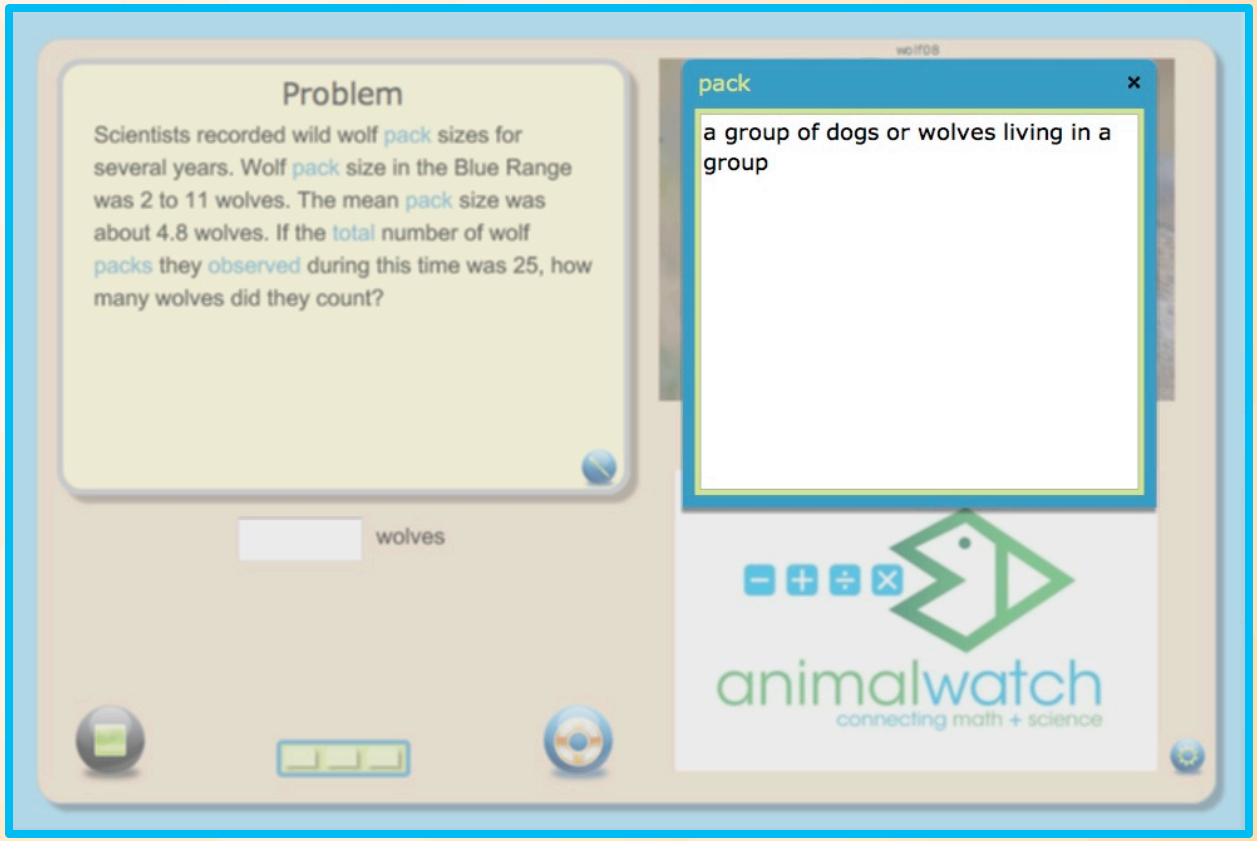
Barbu, O., & Beal, C. R. (2010, in press). Effects of linguistic complexity and math difficulty on word problem solving by English Learners. International Journal of Education.

# Development: New features in AnimalWatch



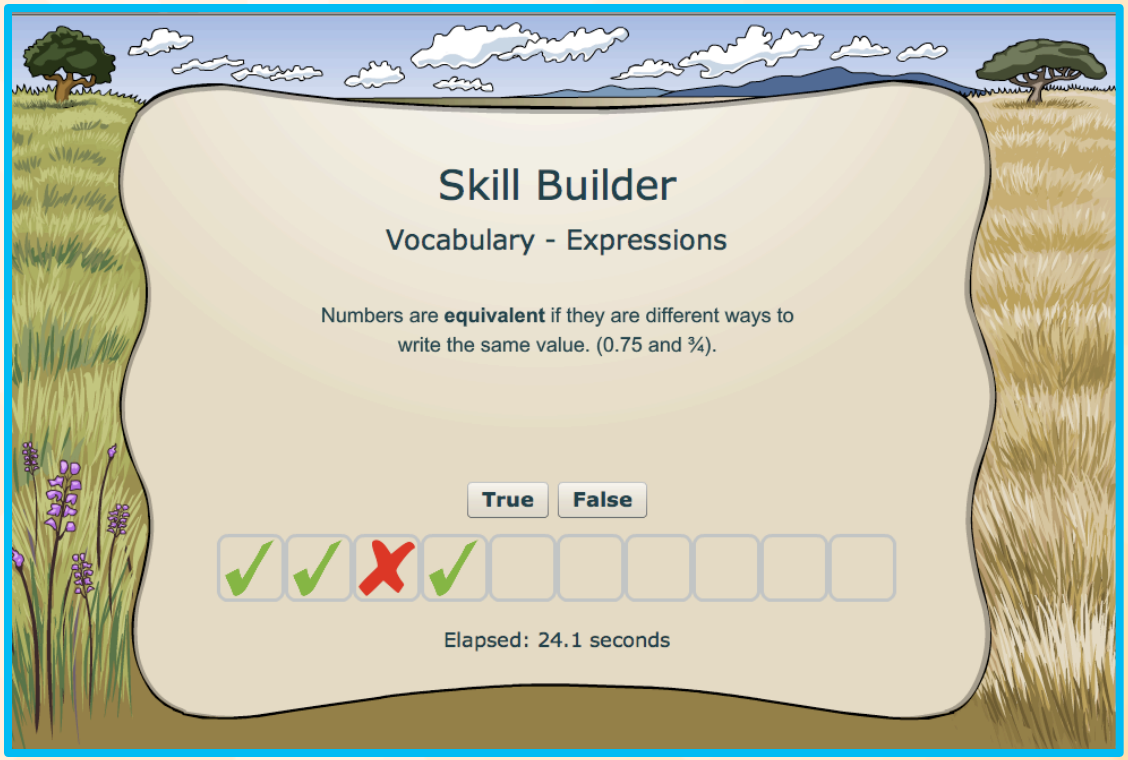

visual vocabulary

# Development: New features




integrated glossary

# Development: New features




math vocabulary drills

# Research: Evaluate impact of new features on ELLs' problem solving

- Pilot study: Spring 2011
- Experimental study: 2011-2012 year
  - pre-post tests
  - end-of-year scores
  - problem solving behaviors in ITS

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