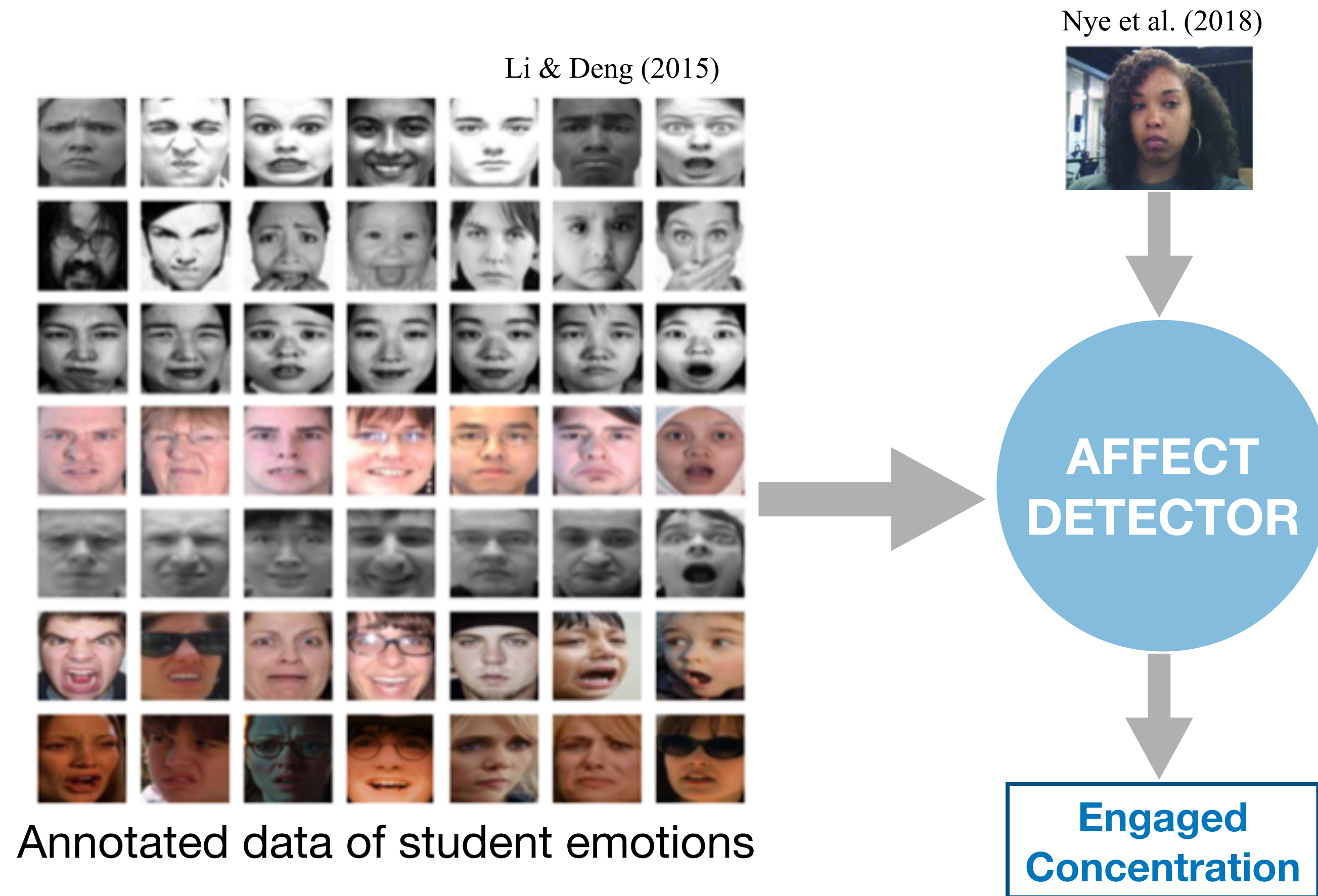


Ethics, Equity, and Algorithmic Bias

Module 6

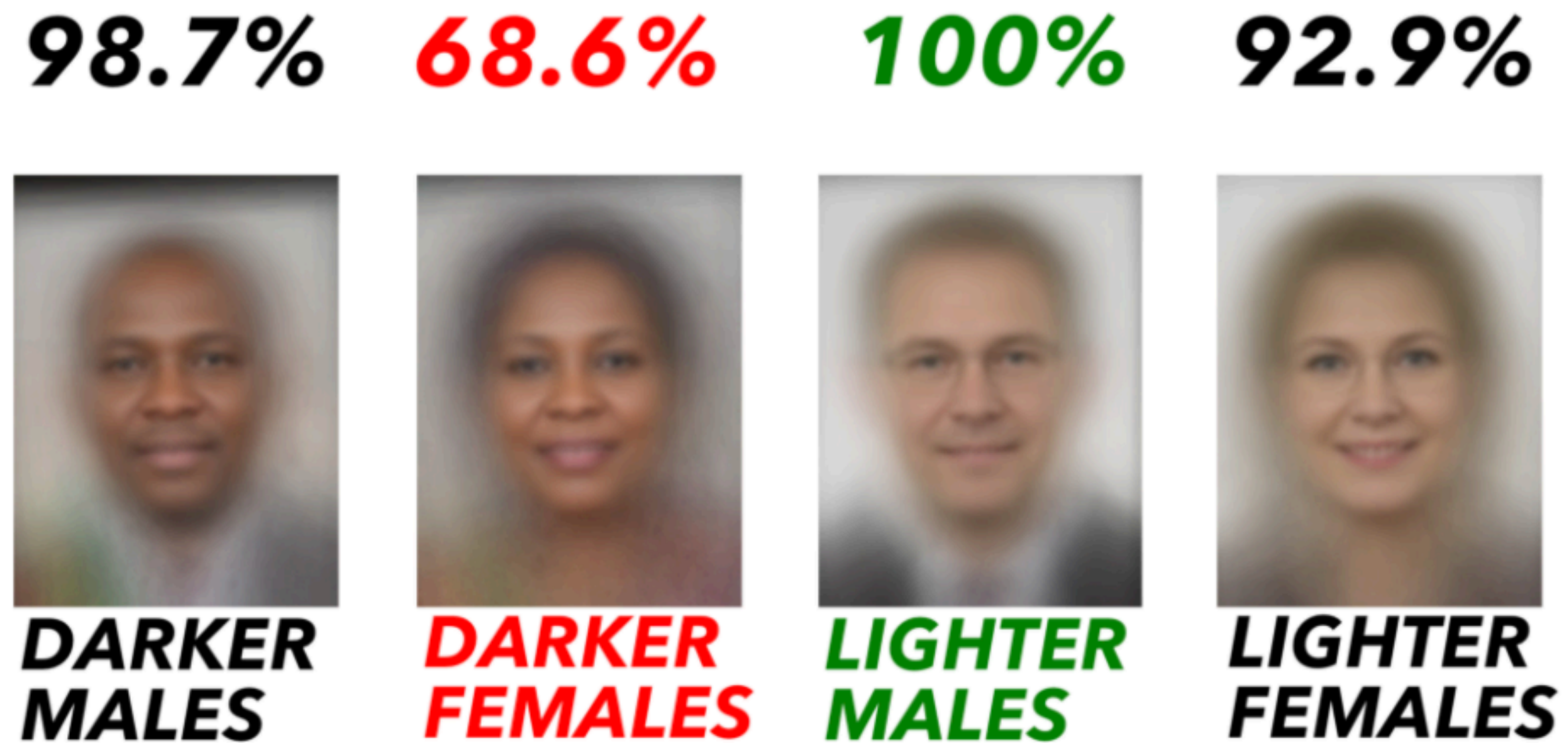
SHAMYA KARUMBALIAH, PhD
Assistant Professor
Department of Educational Psychology
University of Wisconsin-Madison

Learner Context



In what ways do ignoring learner context introduce harmful biases in adaptive learning systems?

Learner Context



Performance Disparity in Gender Classification by Amazon Recognition
Joy Buolamwini (2019)

Learner Context

Please write down 1-2 examples of **predictive models** from your context and the student **populations** they are expected to serve.

What is Bias? Why Study Bias?

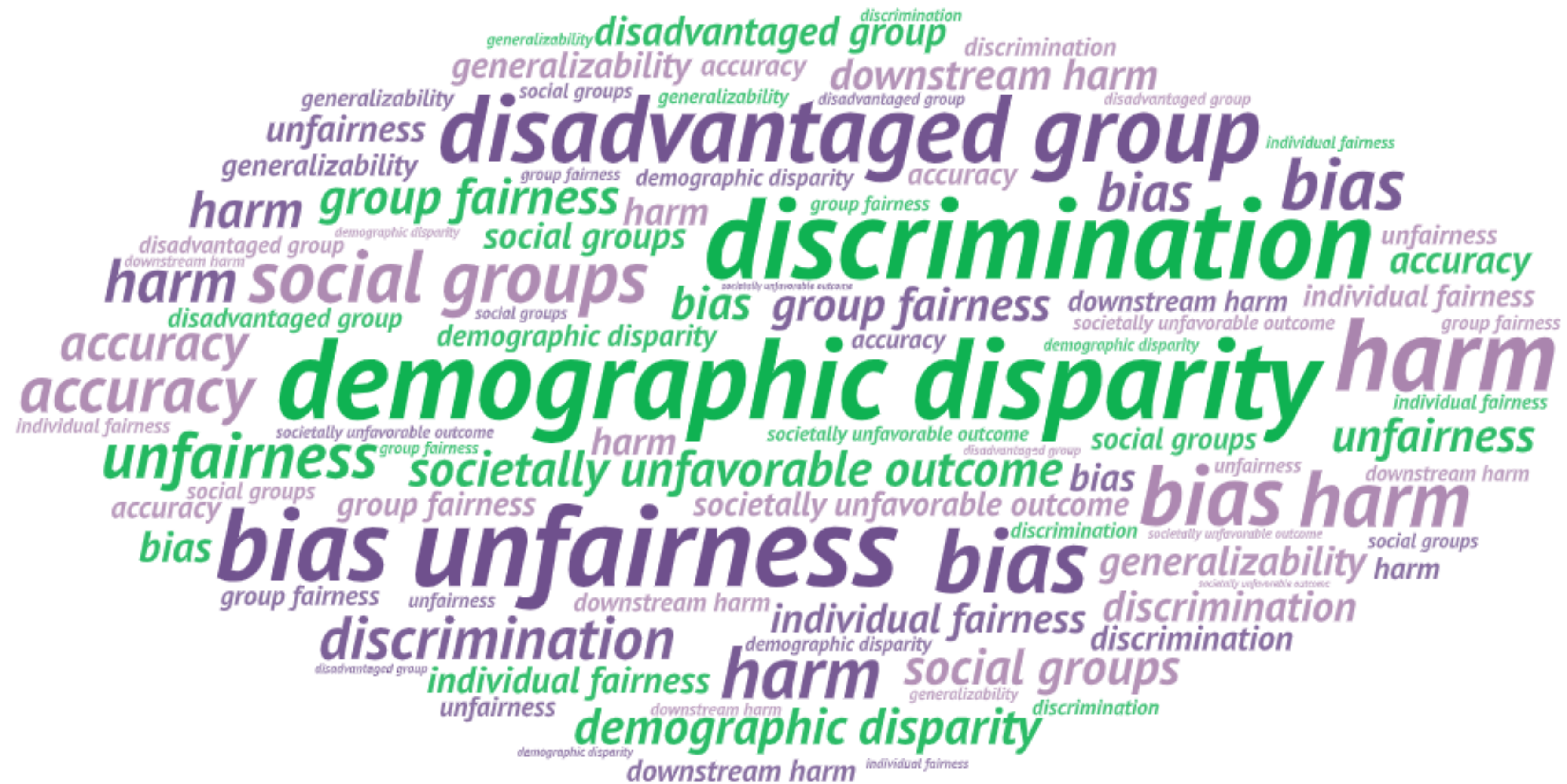




Machine Bias

There's software used across the country to predict future criminals. And it's biased against blacks.

What is Bias in an Adaptive System?



**Biases as the possible
sources of downstream harm that can lead to
societally unfavorable outcomes in specific
student subpopulations.**

Why Study Bias in Learning Analytics?

- Downstream harm of inequitable student outcomes
- Allocative harm
 - e.g., bias in standardized test leading to denied college admissions (Dorans, 2010)
- Representational harm
 - e.g., African American English tagged as hate speech in discussion forum posts (Sap et al, 2019)



Francesco Bonchi

Adaptive Learning Systems

Self, 1999; Shute & Psozka, 1994; Corbett et al., 1997; Koedinger et al., 1997; VanLehn, 2011; Luckin et al., 2016

Adaptive Learning Systems

Self, 1999; Shute & Psootka, 1994; Corbett et al., 1997; Koedinger et al., 1997; VanLehn, 2011; Luckin et al., 2016

Inequalities

Which inequality statement matches this graph?

← | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 | →

Line Points to the Left ←	Line Points to the Right →
< less than	> greater than
≤ less than or equal to	≥ greater than or equal to

A {x|x > 2}
B {x|x < 2}
C {x|x ≥ 2}
D {x|x ≤ 2}

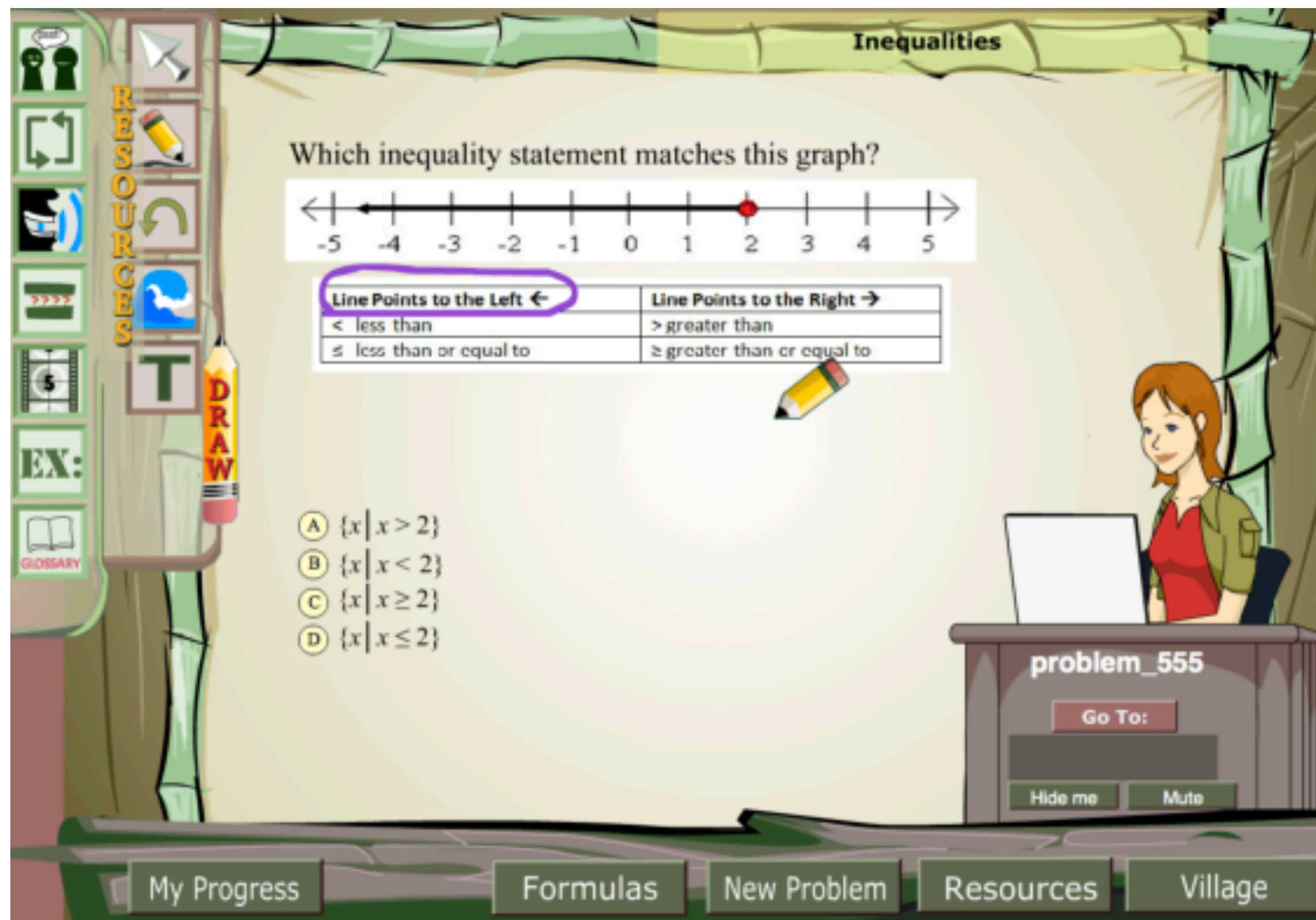
problem_555
Go To:
Hide me Mute

My Progress Formulas New Problem Resources Village

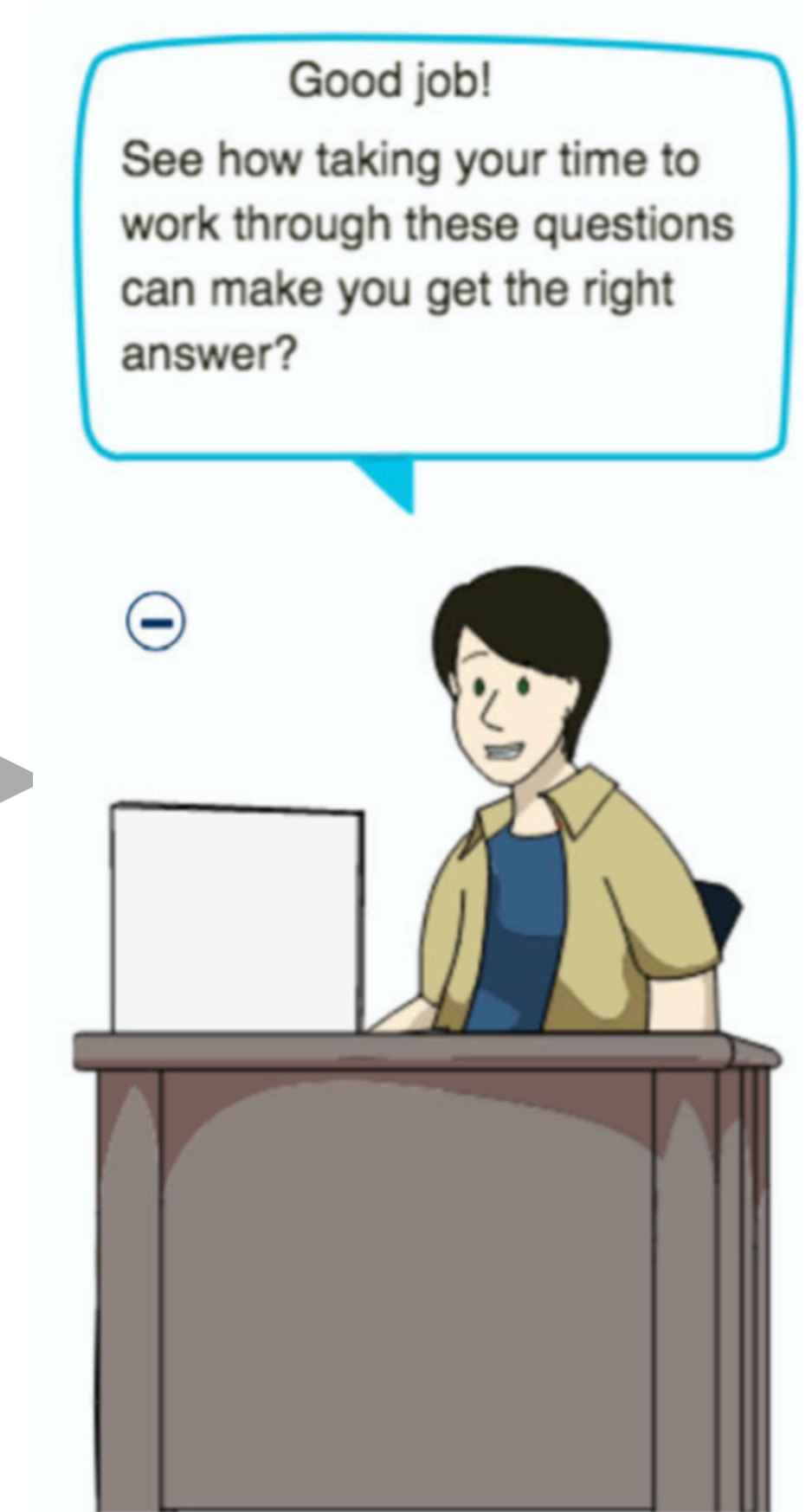
MathSpring

Adaptive Learning Systems

Self, 1999; Shute & Psootka, 1994; Corbett et al., 1997; Koedinger et al., 1997; VanLehn, 2011; Luckin et al., 2016



MathSpring



MathSpring

Adaptive Learning Systems

aleks.com

The screenshot shows the ALEKS Algebra 1 interface. At the top, it says 'ALEKS Algebra 1' and 'Hi, Sam!'. A progress bar indicates 'Mastered: 300 Learned: 11 Remaining: 68'. The main area features a circular 'ALEKS Pie' chart with 311 topics. To the right, a list of topics includes: Arithmetic Readiness (59 Topics), Real Number (39 Topics), Linear Equations (29 Topics), Functions and Lines (83 Topics), Systems (20 Topics), Exponents (47 Topics), Polynomials and Factoring (47 Topics), Quadratic Functions (27 Topics), Radicals (25 Topics), and Rational Expressions (29 Topics). The sidebar on the left has sections for 'UP NEXT' (Plotting integers on a number line), 'WORKING TOWARD' (Chapter 3 - Linear Equations in Two Variables), and 'WORK ON SOMETHING ELSE' (Quiz 2 and Homework 3).

ALEKS

~600,000 students

Ritter et al. (2007)

The screenshot shows the Cognitive Tutor aka Mathia interface. It is divided into several panels: 'scenario' (text describing a commission-based subscription business), 'Worksheet' (a table with columns for 'SUBSCRIPTIONS SOLD' and 'PROFIT'), 'skills' (a bar chart showing proficiency in skills like 'Identifying units' and 'Writing an expression'), and 'Grapher' (a coordinate plane with axes labeled 'X Bounds' and 'Y Bounds').

Cognitive Tutor aka Mathia

~500,000 students

inqits.com

The screenshot shows the Inq-ITS interface. It features a 'Goal' section ('Determine how the sugar in the water affects the petal loss'), a 'My Hypothesis' section ('If I increase the sugar in the water, then the petal loss will decrease'), a virtual flower pot with dye, salt, and sugar, and two graphs: 'Petals Remaining vs. Days Passed' (a bar chart) and 'Petal Color vs. Days Passed' (a line graph).

Inq-ITS

~100,000 students

Adaptive Learning Systems

aleks.com

ALEKS

~600,000 students

Ritter et al. (2007)

Cognitive Tutor aka Mathia

~500,000 students

inqits.com

Inq-ITS

~100,000 students

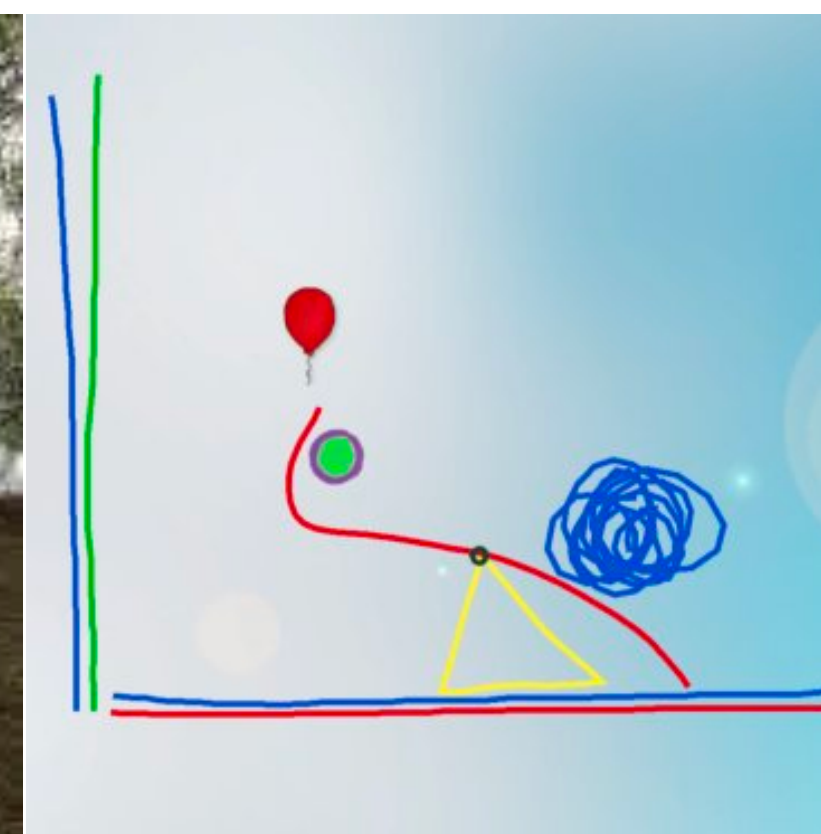


Zoombinis

AutoTutor



Crystal Island



Physics Playground



TransfrVR



Studying Bias: important, yet challenging

1. Makes real-time decisions that impact students' learning and experiences closely
2. Involves models of complex educational constructs that utilize fine-grained interaction data
3. Despite wide usage, biases not yet studied thoroughly

Cognitive Tutor Algebra

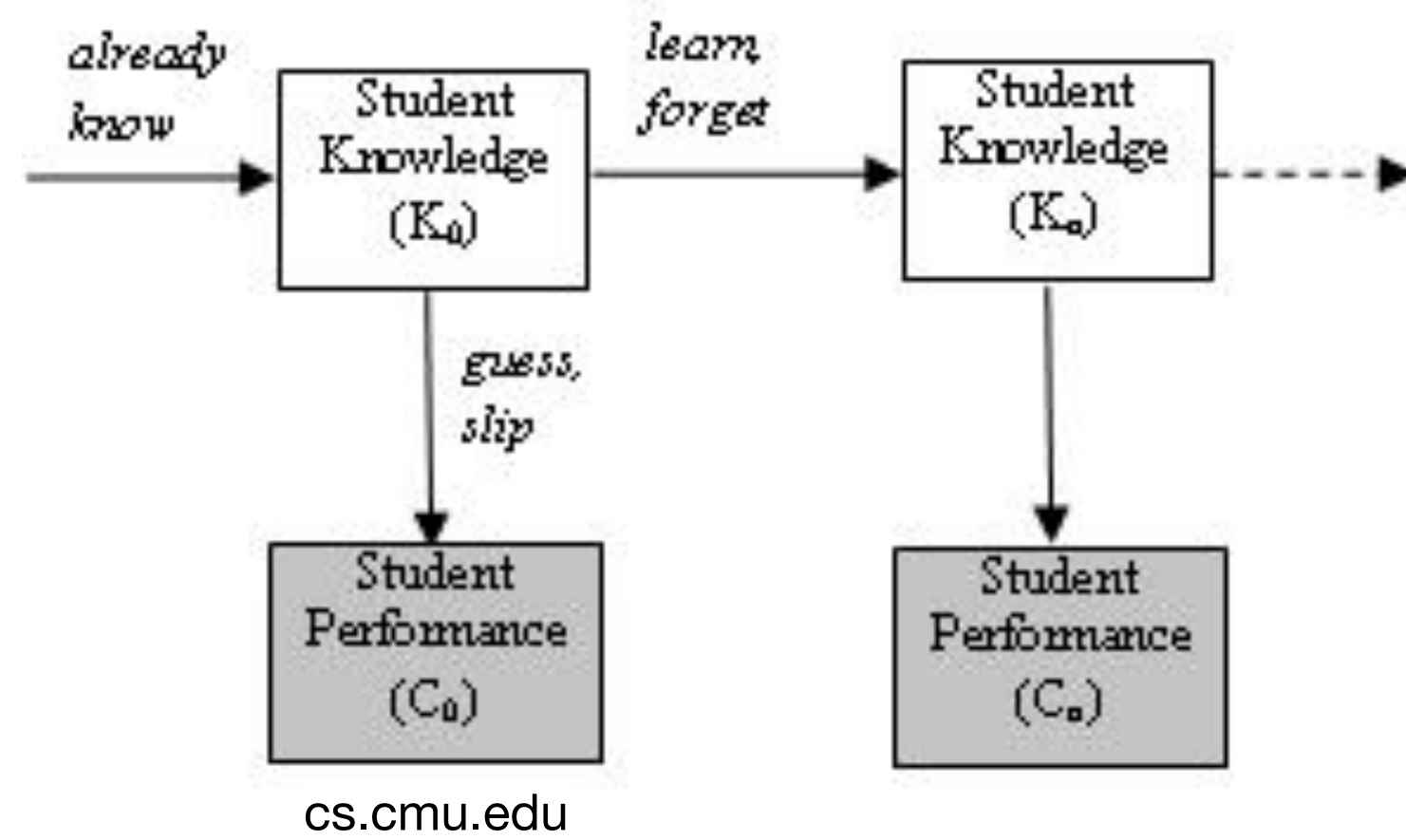
The screenshot displays the Cognitive Tutor Algebra interface. It is divided into several sections:

- Scenario:** A text box describing a person working on a commission basis, selling magazine subscriptions. It includes five questions about profit based on the number of subscriptions sold.
- Worksheet:** A table with columns for 'Quantity Name', 'NUMBER OF SUBSCRIPTIONS SOLD', and 'PROFIT'. It has rows for 'Unit', 'Question 1', 'Question 2', 'Question 3', 'Question 4', and 'Question 5'.
- Skills:** A list of skills with progress bars, including 'Identifying units', 'Entering a given', 'Write equation, positive slope', 'Find Y, positive slope', 'Using large numbers', 'Using simple numbers', 'Correctly placing points', 'Changing axis bounds', and 'Changing axis intervals'.
- Grapher:** A graphing window with a coordinate plane. The X-axis is labeled 'NUMBER OF SUBSCRIPTIONS SOLD' and the Y-axis is labeled 'PROFIT'. The graph shows a blue line representing the profit function.

Below the grapher, there is a question: "How does information that you type in get passed from the keyboard to the hard disk?" and a diagram of computer hardware components: Memory, Input Device, Central Processing Unit, and Hard Drive. The diagram shows arrows indicating the flow of information from the Input Device to the CPU, and from the CPU to the Hard Drive.

An Example

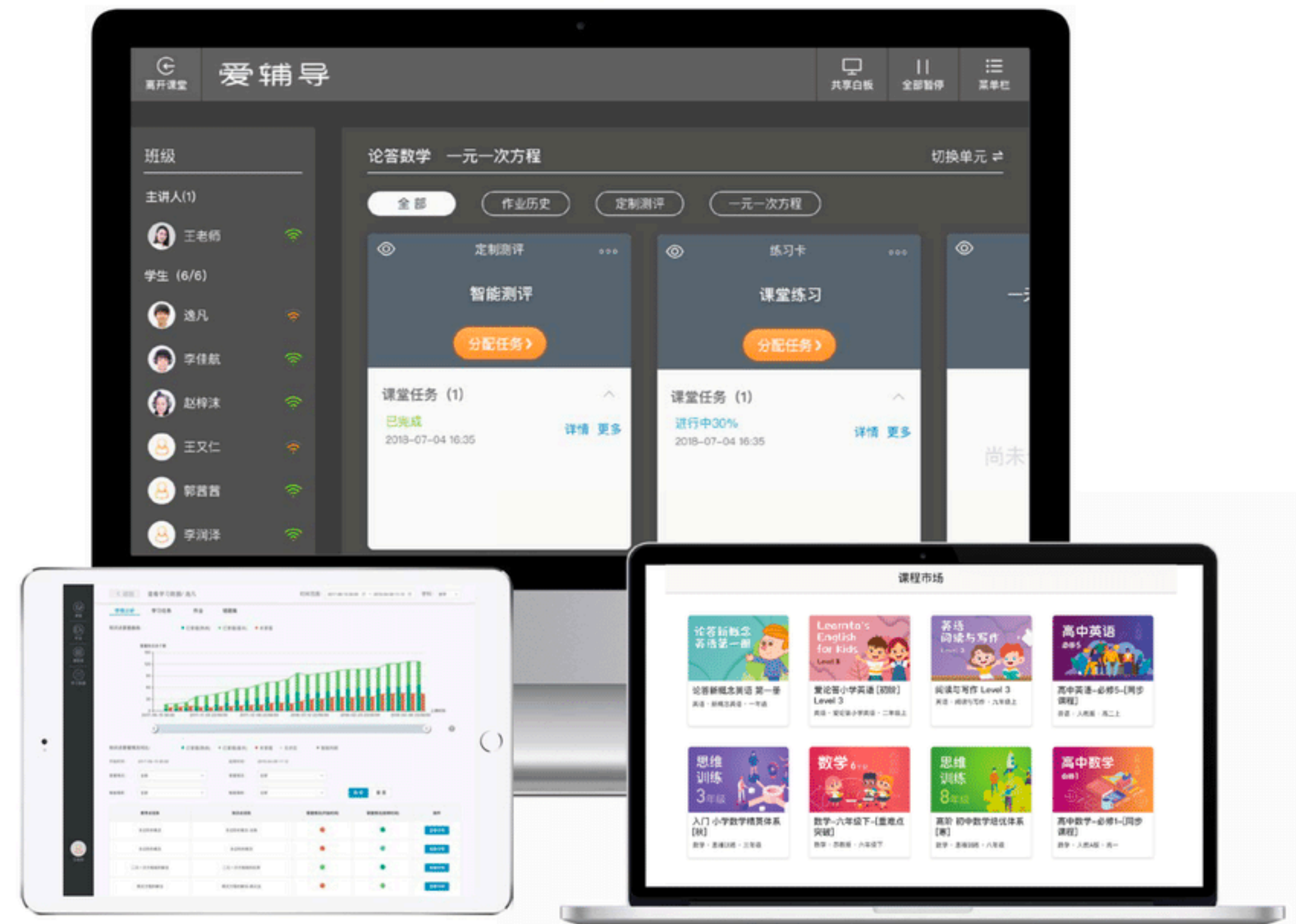
Knowledge Tracing



Corbett, A. T., & Anderson, J. R. (1994). Knowledge tracing: Modeling the acquisition of procedural knowledge.

Learnta

Intelligent Teaching



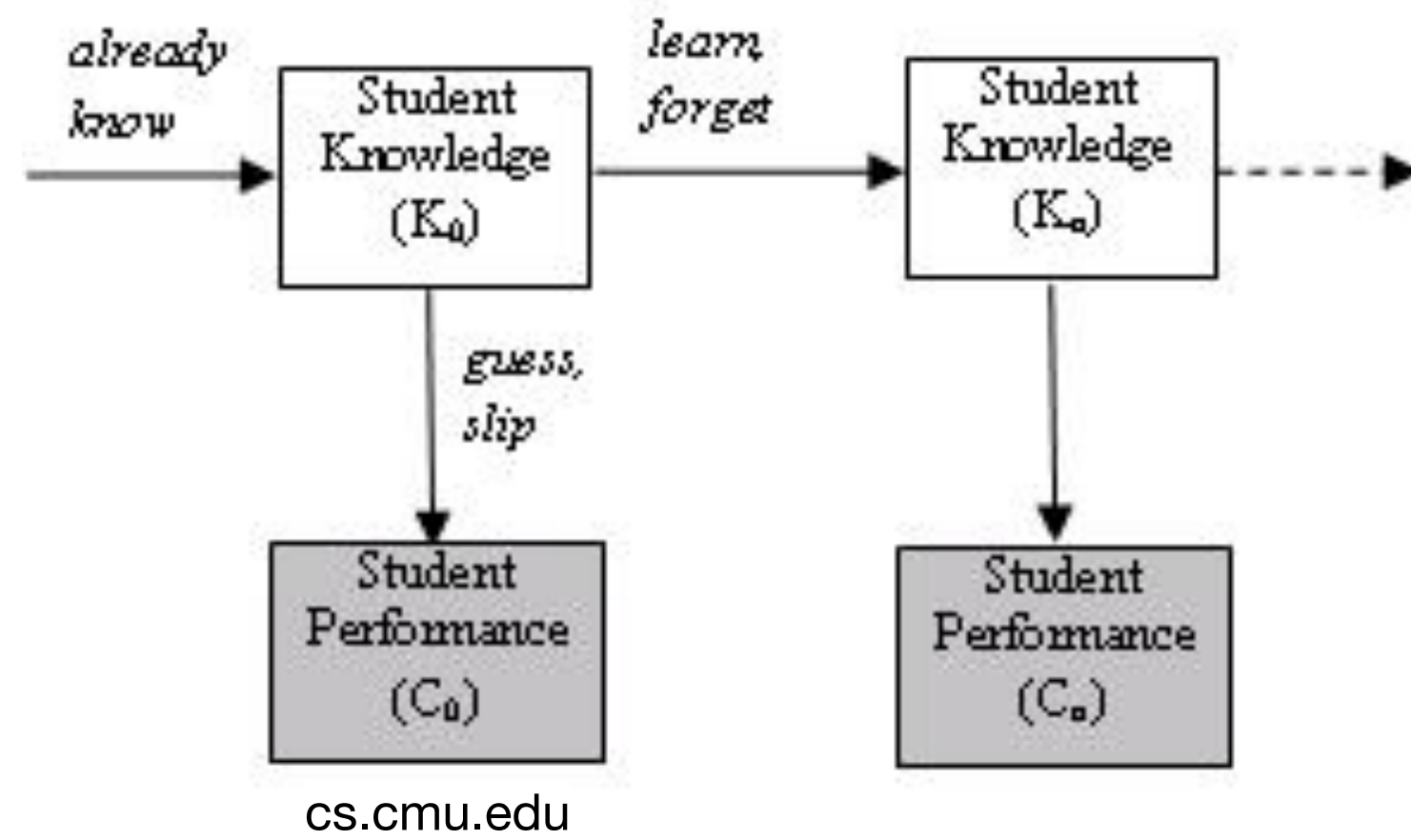
Learning Analytics

Customized Contents

Baker et al. (2020)

Allocative Harms of Bias

Knowledge Tracing



Francesco Bonchi

Diversity in Learner Context

Ritter et al. (2007)

nexgenedu.com

The screenshot displays the Cognitive Tutor interface. On the left is a 'scenario' panel with text and five numbered questions. The middle 'Worksheet' panel contains a table with columns for 'Quantity Name', 'NUMBER OF SUBSCRIPTIONS SOLD', and 'PROFIT', and rows for 'Unit', 'Question 1-5', and 'Expression'. To the right is a 'skills' list with a progress bar for 'steve ritter's skills'. At the bottom is a 'Grapher' window with a coordinate plane and axis bounds.

Quantity Name	NUMBER OF SUBSCRIPTIONS SOLD	PROFIT
Unit	SUBSCRIPTIONS	DOLLARS
Question 1		
Question 2		
Question 3		
Question 4		
Question 5		
Expression		

	Lower Bound	Upper Bound	Interval
X Bounds	0.0	10.0	1.0
Y Bounds	0.0	10.0	1.0

Cognitive Tutor aka Mathia

Used in the United States and Chile

The screenshot shows the Alef NexGen interface for a math problem. It features a text box with a problem statement, a 'Submit' button, and a 'Fill in the blanks below' section with input fields for the ratio components. A 'Submit' button is also present at the bottom.

Alef NexGen

Serves students from elementary through high school

Why Study Bias in Learning Analytics?

- Downstream harm of inequitable student outcomes
- Allocative harm
 - e.g., bias in standardized test leading to denied college admissions (Dorans, 2010)
- Representational harm
 - e.g., African American English tagged as hate speech in discussion forum posts (Sap et al, 2019)

For your example model, please share some potential harms to student populations if it were to be biased against them.

Discussion Board Question