Developing Simulation-Based Assessments for Learning Next Generation Science

Matt Silberglitt & Edys Quellmalz

WestEd

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SimScientists Team

Edys Quellmalz, PI
Daniel Brenner
Barbara Buckley
Jodi Davenport
Mark Loveland
Matt Silberglitt
Arthur Sussman
Mike Timms (ACER)
Jon Boxerman
Andrew Grillo-Hill

Kevin Huang
Kevin Jordan
Kim Luttgen
Michelle Lamar (UCB)
Ellen Mandinach
Anita Moorjani
May Miller-Ricci
Jackie Powers
Marina Varfolomeeva

Teacher co-developers

Consultants

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Past/Present Advisors Evaluators • Design Panel Members

George DeBoer, AAAS

Roy Levy, ASU

Rodger Bybee[1], BSCS

Randy Bennett, ETS

Russel Almond, FSU

Joan Heller, HRA

Joseph Krajcik, MSU

Richard Duschl, NSF

Craig Heller, Stanford

Ed Haertel, Stanford

Margaret Heritage, UCLA

Joan Herman, UCLA

James Pellegrino, UIC

Madeline Bergeron, Mary Anne Butler[2], Susan Foss, CT

Katie Bowler, MA

André DeLeón, Richard Vineyard, NV

Janet Bailey, Sarah McManus, Beverly Vance, NC

Kevin King[3], Brad Talbert, UT

Gail Hall, David White, VT

Joe Willhoft[4], WA

Representatives of school districts and other LEAs

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SimScientists Current and Recent R&D Projects

SimScientists Assessments: Physical Science Links (NSF DR K–12)

SimScientists Human Body Systems (NSF DR K–12)

SimScientists Assessment System (IES Measurement)

SimScientists Model Progressions (IES Development)

Calipers II: Using Science Simulations to Assess Complex Science Learning (NSF DR K–12)

Foundations of 21st Century Science Assessments (NSF REESE)

Multilevel Assessments of Science Standards (IES Measurement)

SimScientists: Interactive Simulation-based Science Learning Environments (IES Development)

Integrating Science Simulations into Balanced State Science Assessment Systems (OESE EAG)

Theoretical Foundations

Evidence-Centered Assessment Design

Student Model → **Task Model** → **Evidence Model**

What claims do you want to make about **students'** knowledge and skills?

What **tasks** prompt students to demonstrate the knowledge and skills?

How can student performance on the tasks be interpreted as **evidence** to support the claims?

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Mislevy, Almond & Lukas, 2004

Theoretical Foundations

Model-Based Learning

Model Formation → Model Use → Model Evaluation

Complex tasks prompt students to integrate knowledge with new information

Students try to make sense of phenomena as they complete the tasks

Models may be rejected, revised, reinforced or enhanced based on the interaction with the task

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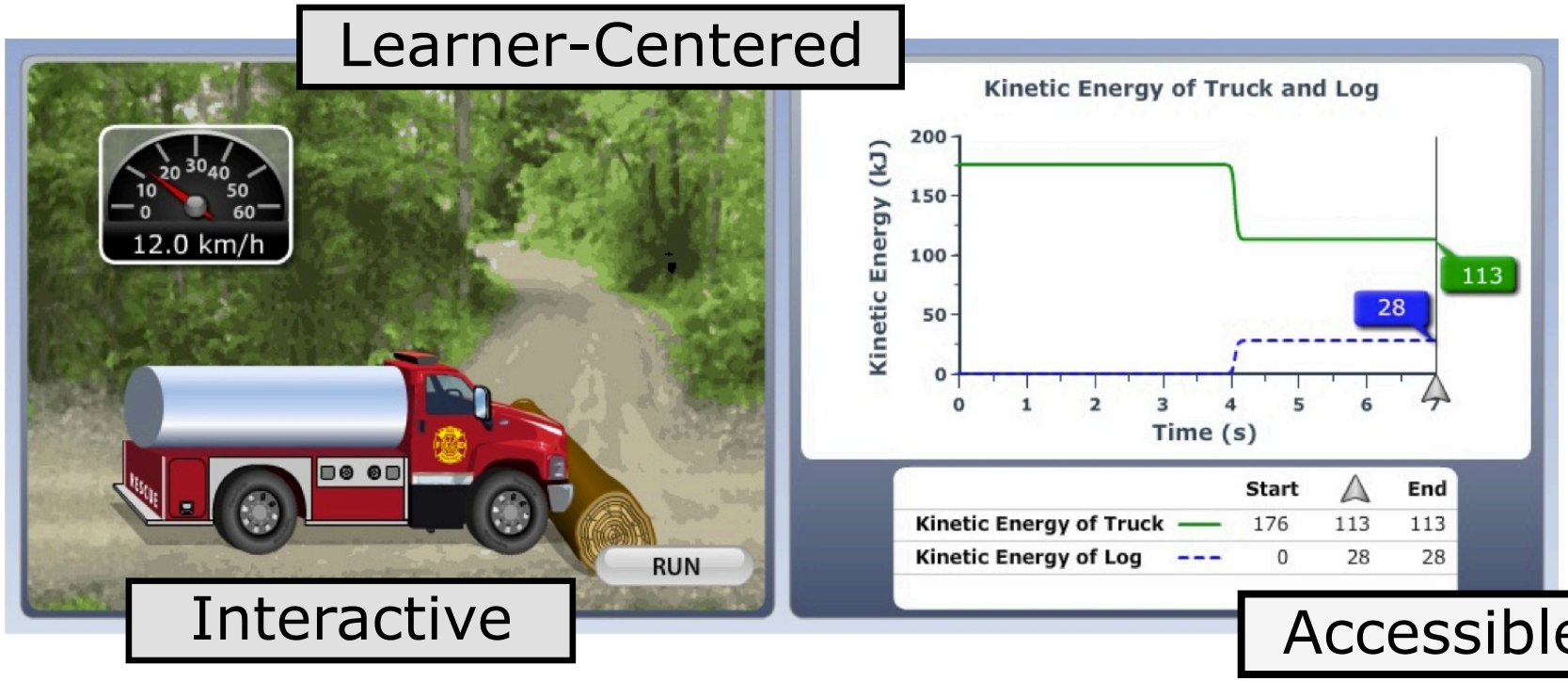
Buckley, 2012; Gobert & Buckley, 2000

Theoretical Foundations

Universal Design for Learning (UDL) and Computer-Based Testing (UD-CBT)



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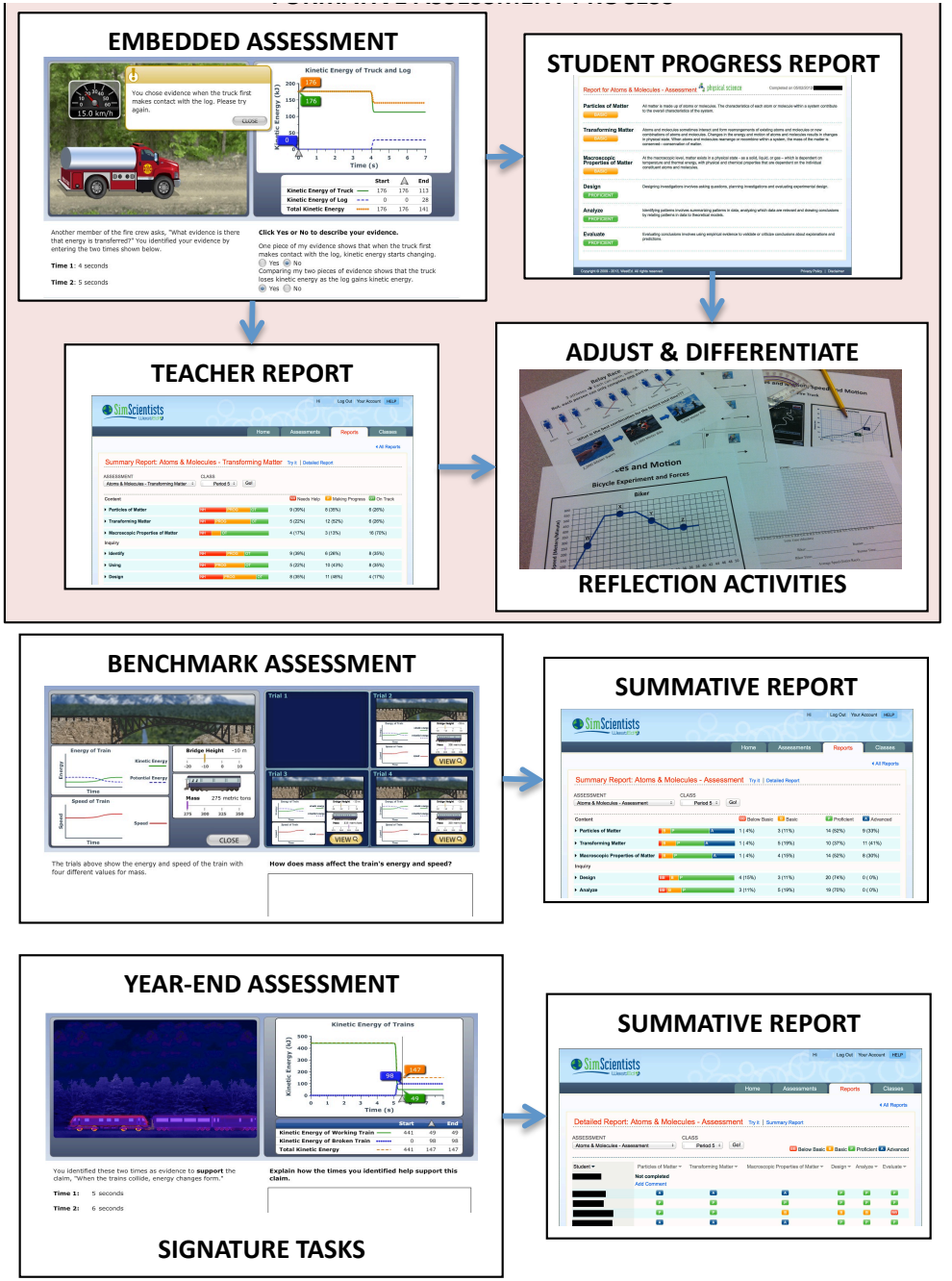
Rose & Meyer, 2002; Dolan, Rose, Burling, Harms & Way, 2007

Theoretical Foundations

Multilevel Assessment Systems

Integrated assessment design—using common specifications to develop parallel tasks for different levels of the system

Integrated report design—gathering data from all levels of the system



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Applying Evidence-Centered Design to NGSS

Claim

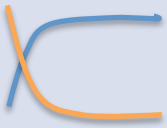
Construct, use, and present arguments to support the claim that when the motion energy of an object changes, energy is transferred to or from the object.

Evidence Statement

Construct arguments by …

- Using data as evidence to support a claim

Integrating Evidence-Centered Design & Model-Based Learning

Model Level	Descriptions
Component 	What are the components of the system and their properties?
Interaction 	How do the individual components interact?
Emergent 	How are system behaviors and properties caused by interactions among components?

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Applying Evidence-Centered Design & Model-Based Learning to the *Next Generation Science Standards*

MS-PS3-1 … relationships of kinetic energy to mass and speed

Model Level	Descriptions
Component	Kinetic energy
Interaction	Energy transfer
Emergent	Changes in motion

MS-PS3-5 … when the motion energy of an object changes, energy is transferred to or from the object

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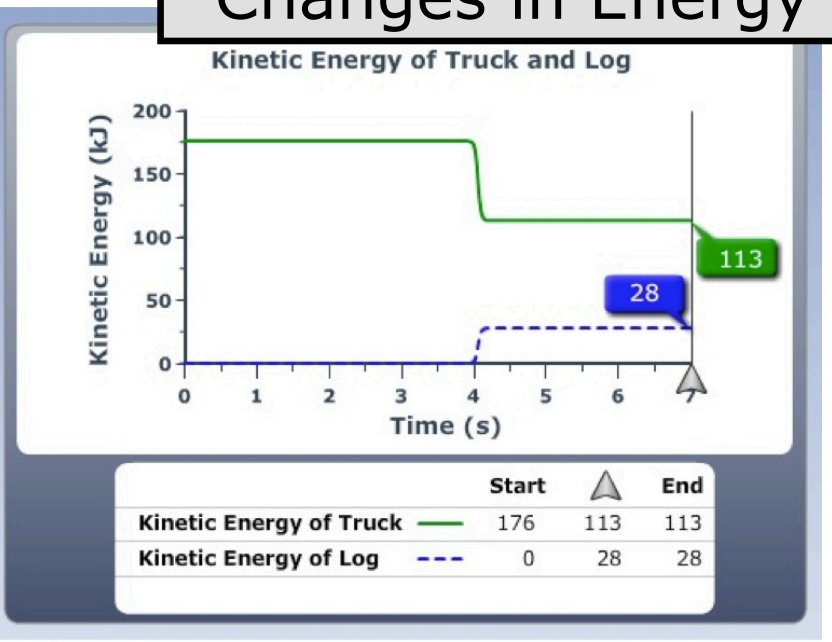
Task Model

Changes in Motion

Changes in Energy



Energy Transfer?

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Demo

Think

What did you observe?

How can you explain your observation?

What evidence supports your explanation?

Discuss in a pair

Share with the group

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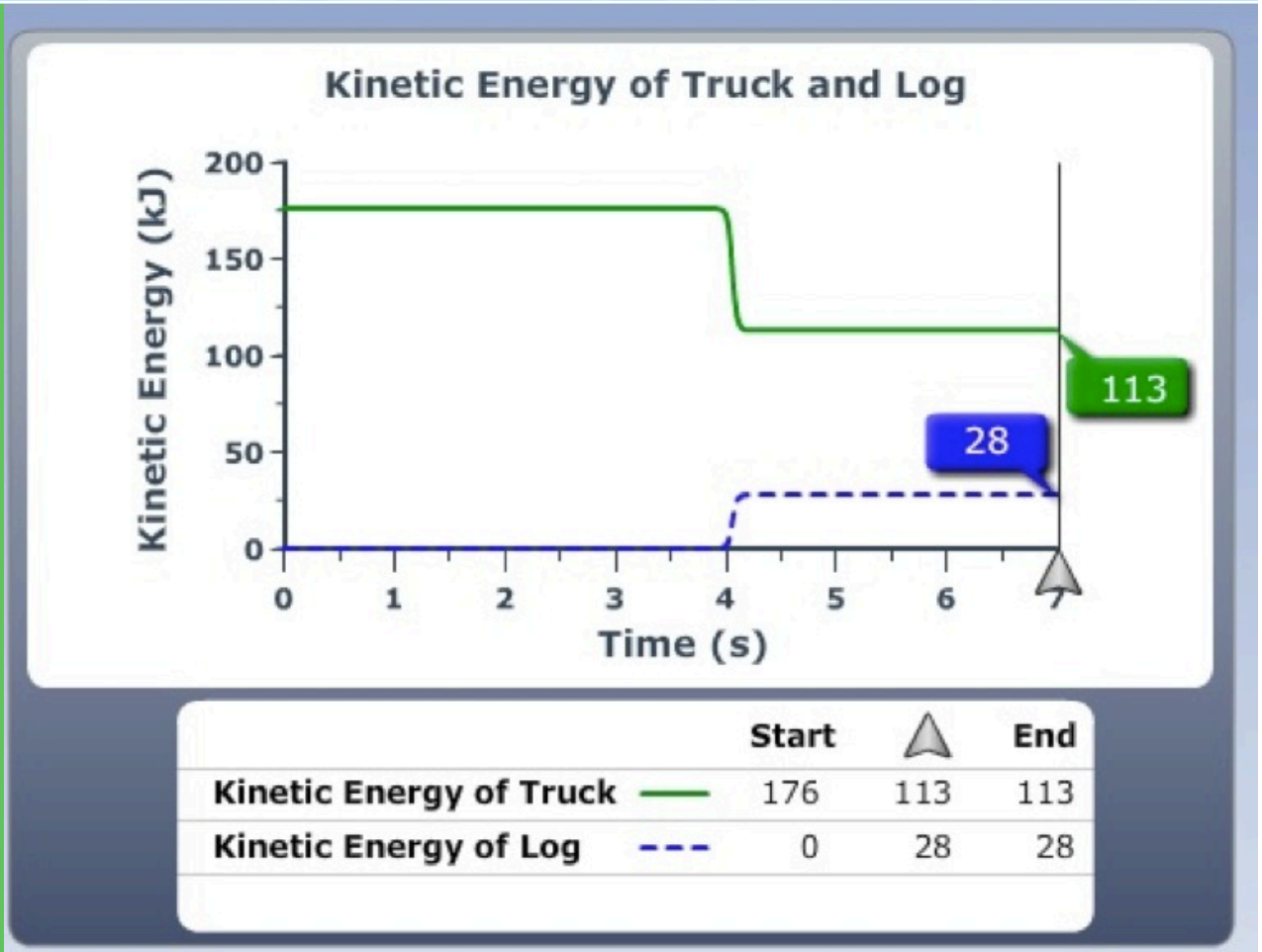
Hands-On

Small groups

Discuss observations, explanations and evidence



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Feedback

What does three-dimensional assessment look like?

Are we there yet?

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Assessment Development

Data Collection

- Alignment and quality reviews of energy and waves units
- Classroom feasibility testing of two embedded and one benchmark assessment
- Observations, formative evaluation

Sample

- One teacher, 5 classrooms, ~100 Students

Analyses

Descriptive statistics

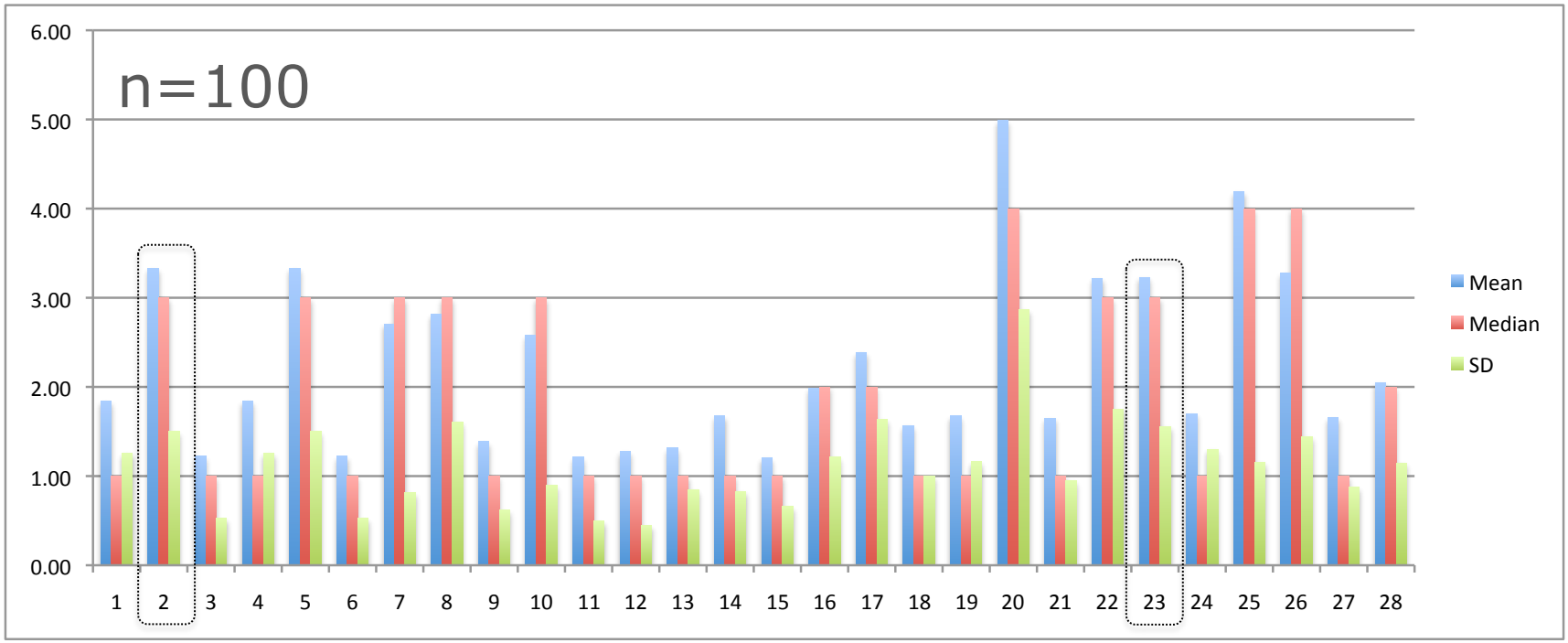
Data mining

Classical psychometrics

IRT

Bayes' Nets

Embedded Assessment 1
Number of Tries to Correct



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Embedded Assessment 1
Data Dive

The force transfers energy from the engine to the rest of the truck. The Fire Chief wants your help investigating the energy of the truck.

Click Yes or No to describe the energy of the truck.

Energy is a type of force.	○ Yes	◉ No
The truck's engine creates energy for the truck.	○ Yes	◉ No
The truck's engine uses energy to create the force.	◉ Yes	○ No
An increase in energy causes the mass of the truck to increase.	○ Yes	◉ No

Show Data | Prev | Next

Energy [3]
PSLEnergyEM1 v8.01.06

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NEXT ▶

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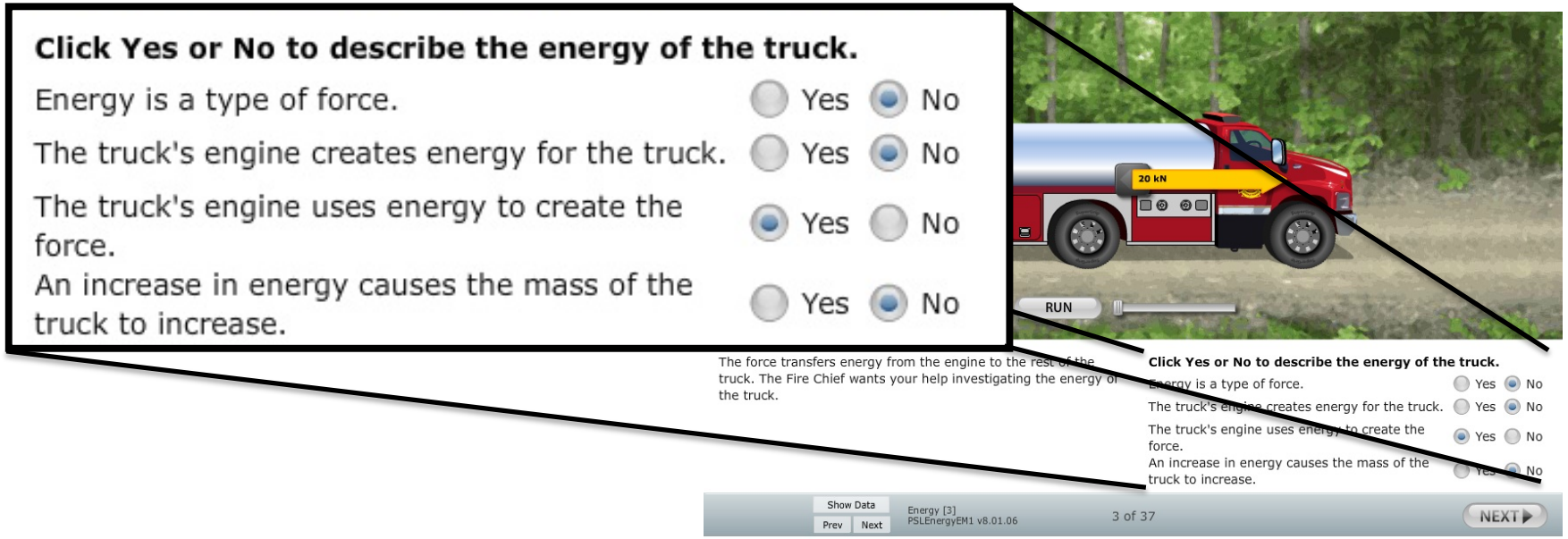
Embedded Assessment 1
Data Dive



Tries = 1	Tries = 2	Tries = 3	Tries = 4	Tries = >4
14	13	**27**	22	22

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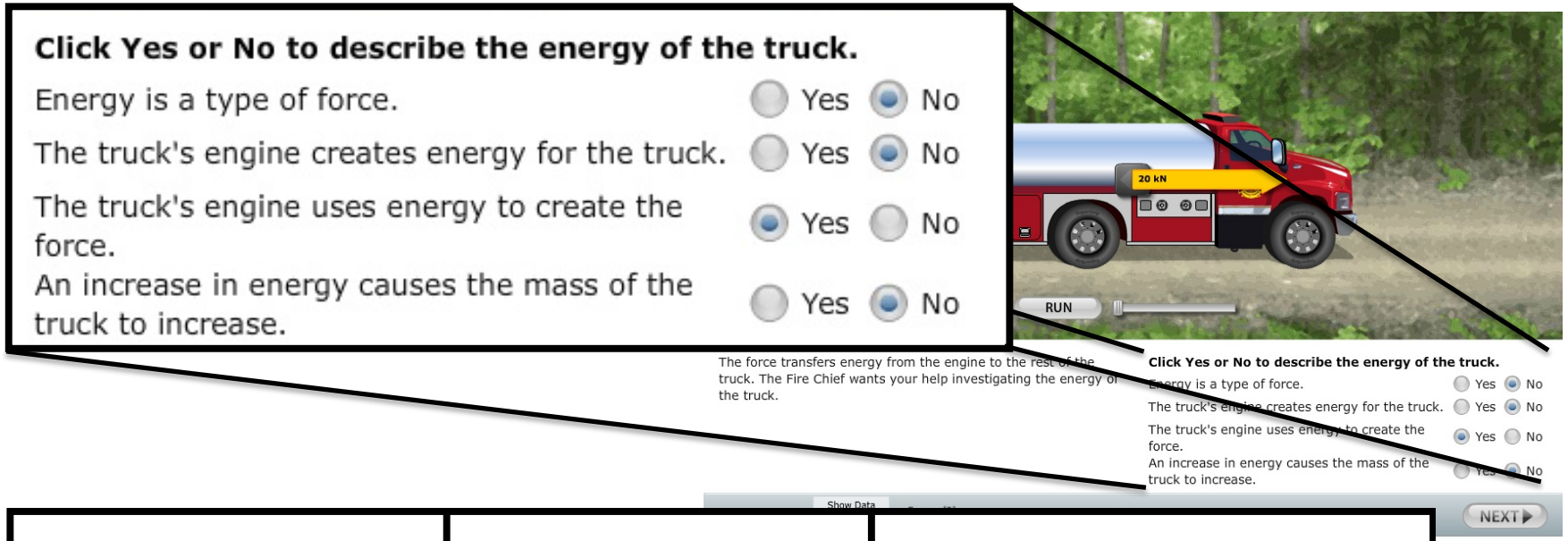
Embedded Assessment 1
Data Dive



FirstAnswer=Yes	FirstAnswer=No	Changed Right to Wrong
72%	28%	15%
76%	24%	15%
87%	13%	35%
17%	82%	8%

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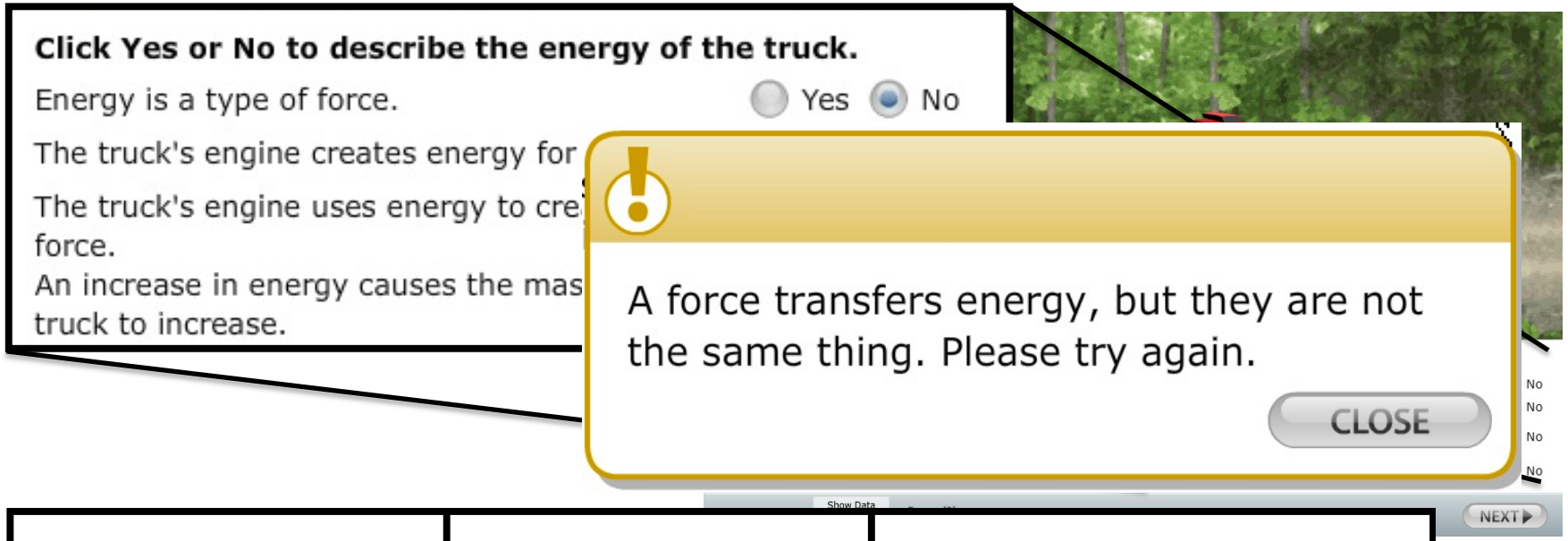
Embedded Assessment 1
Data Dive



FirstAnswer=Yes	FirstAnswer=No	Changed Right to Wrong
72%	28%	15%
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87%	13%	35%
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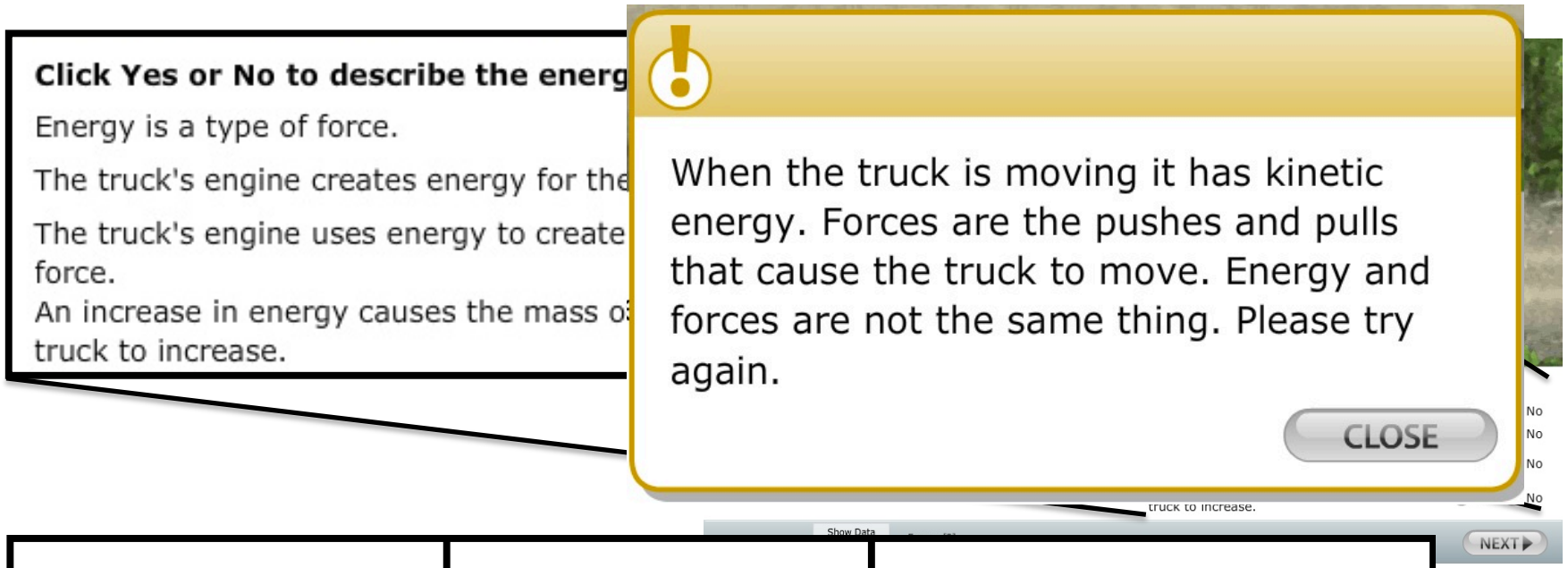
SimScientists WestEd

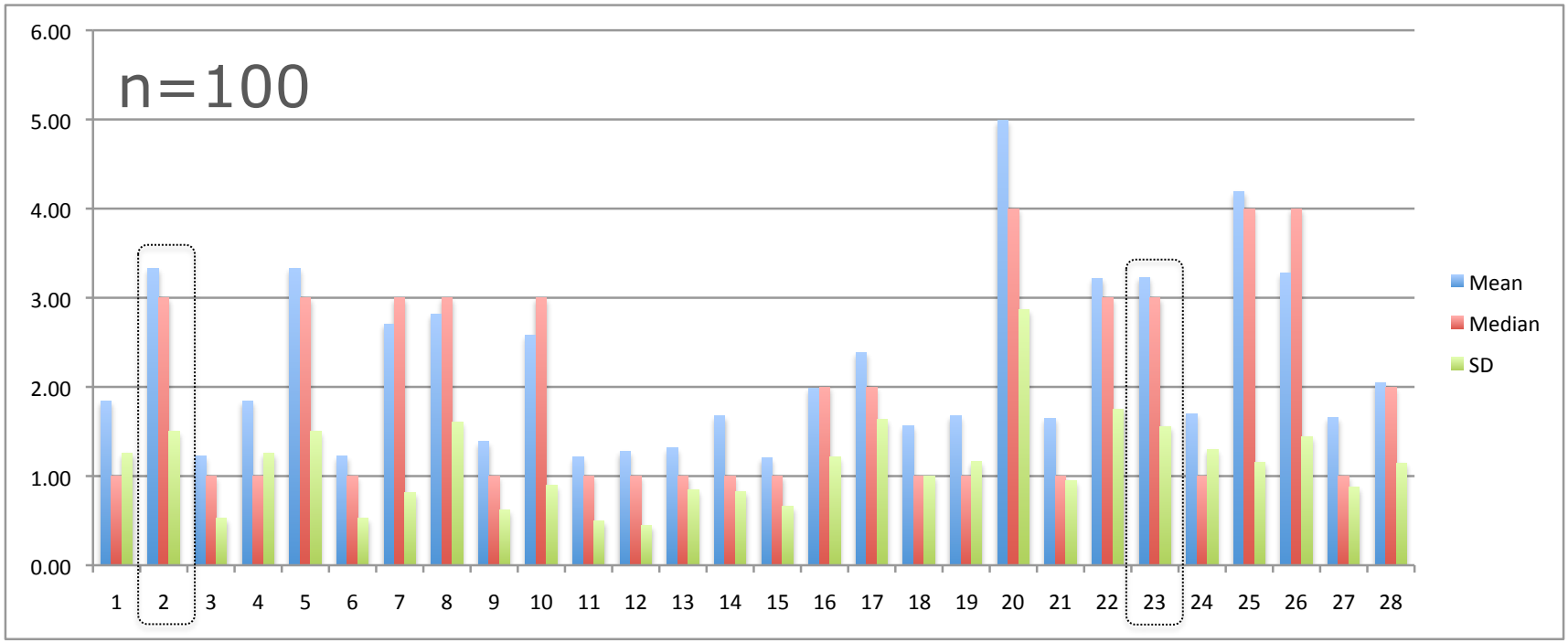
Embedded Assessment 1
Data Dive



FirstAnswer=Yes	FirstAnswer=No	Changed Right to Wrong
72%	28%	15%
76%	24%	15%
87%	13%	35%
17%	82%	8%

SimScientists WestEd

Embedded Assessment 1
Number of Tries to Correct



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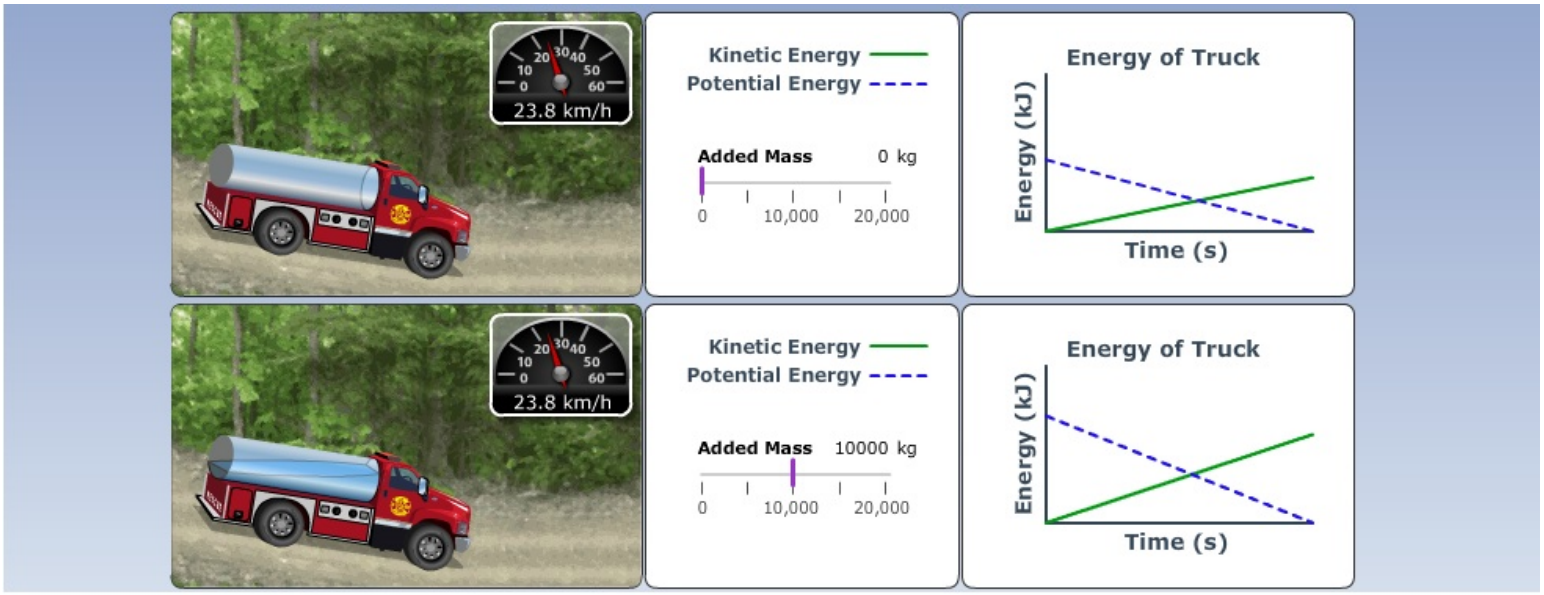
Embedded Assessment 1
Data Dive



Click Yes or No to explain how the truck's energy changes as it coasts downhill.

Potential energy is changed into kinetic energy. ◉ Yes ○ No

Mass is changed into potential energy. ○ Yes ◉ No

Potential energy disappears as kinetic energy is created. ○ Yes ◉ No

Mass is changed into kinetic energy. ○ Yes ◉ No

Show Data | Prev | Next

DownhillConclude2 [27]
PSLEnergyEM1 v8.01.06

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NEXT ▶

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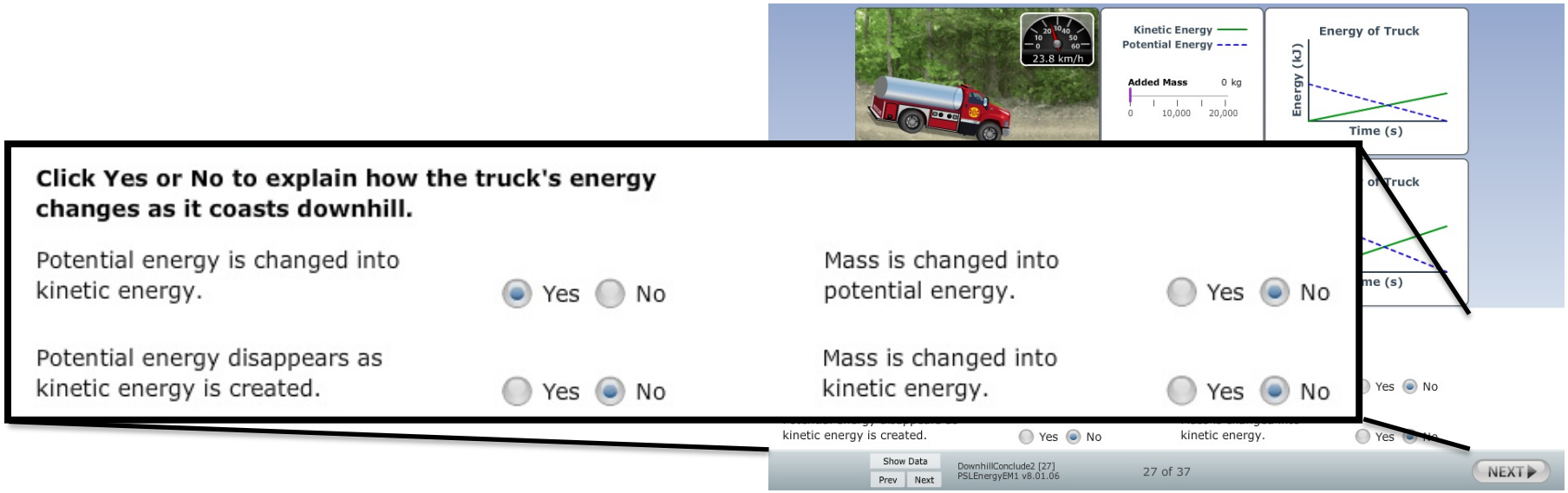
Embedded Assessment 1
Data Dive



Tries = 1	Tries = 2	Tries = 3	Tries = 4	Tries = >4
26	21	7	20	23

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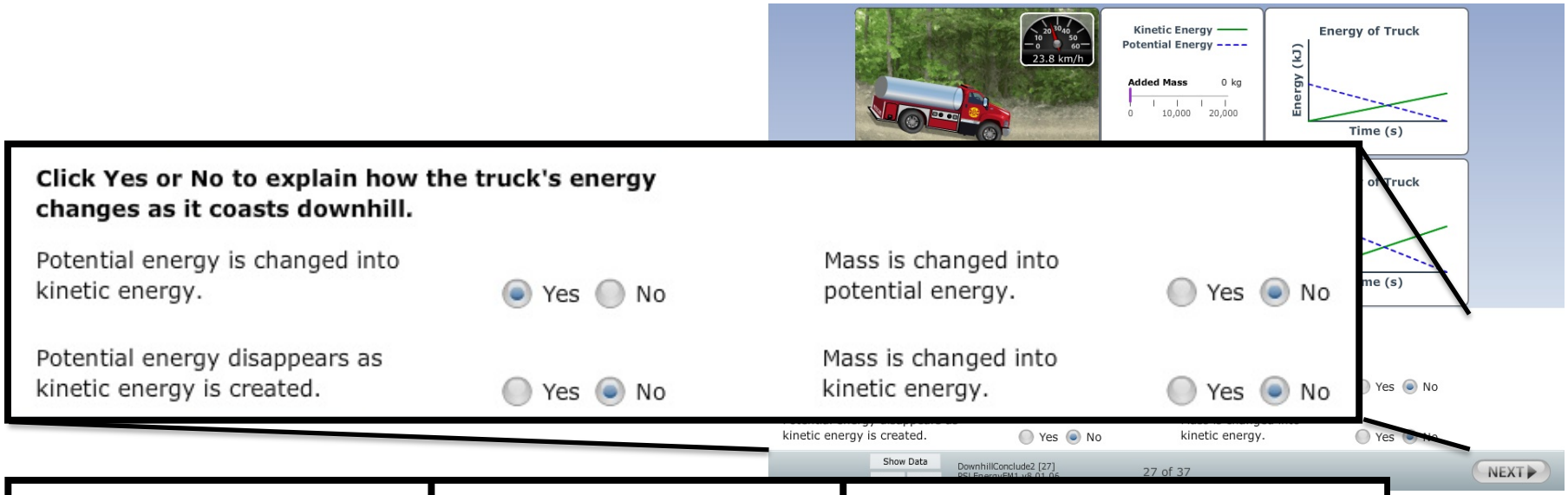
Embedded Assessment 1
Data Dive



FirstAnswer=Yes	FirstAnswer=No	Changed Right to Wrong
88%	12%	19%
34%	66%	20%
36%	64%	30%
37%	63%	19%

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Embedded Assessment 1
Data Dive

Variable Values	[0,0,0,0,0,0,1]	VariableValuesTotals	1
Variable Values	[0,0,0,0,1,1,1]	VariableValuesTotals	2
Variable Values	[0,0,0,0,1]	VariableValuesTotals	1
Variable Values	[0,0,0,1,1,1,1,0,1]	VariableValuesTotals	1
Variable Values	[0,0,0,1,1,1,1]	VariableValuesTotals	1
Variable Values	[0,0,0,1,1]	VariableValuesTotals	2
Variable Values	[0,0,0,1]	VariableValuesTotals	4
Variable Values	[0,0,1,1,1]	VariableValuesTotals	1
Variable Values	[0,0,1,1]	VariableValuesTotals	4
Variable Values	[0,1,0,1]	VariableValuesTotals	1
Variable Values	[0,1,1,1,0,1]	VariableValuesTotals	1
Variable Values	[0,1,1,1,1,1]	VariableValuesTotals	1
Variable Values	[0,1,1,1]	VariableValuesTotals	3
Variable Values	[0,1,1]	VariableValuesTotals	2
Variable Values	[0,1]	VariableValuesTotals	8
Variable Values	[1,0,0,0,0,1]	VariableValuesTotals	1
Variable Values	[1,0,0,1,1]	VariableValuesTotals	1
Variable Values	[1,0,0,1]	VariableValuesTotals	1

Potential energy disappears as kinetic energy is created. ○ Yes ◉ No

Variable Values	[1,0,1,1]	VariableValuesTotals	4
Variable Values	[1,1,0,0,0,0,1]	VariableValuesTotals	3
Variable Values	[1,1,0,0,1,1]	VariableValuesTotals	1
Variable Values	[1,1,0,0,1]	VariableValuesTotals	1
Variable Values	[1,1,0,1]	VariableValuesTotals	2
Variable Values	[1,1,1,0,0,0,0,1]	VariableValuesTotals	1
Variable Values	[1,1,1,1,1,0,1]	VariableValuesTotals	1
Variable Values	[1,1,1,1,1,1]	VariableValuesTotals	1
Variable Values	[1,1,1,1,1]	VariableValuesTotals	2
Variable Values	[1,1,1,1]	VariableValuesTotals	1
Variable Values	[1,1,1]	VariableValuesTotals	5
Variable Values	[1,1]	VariableValuesTotals	13
Variable Values	[1]	VariableValuesTotals	26
		Grand Total	98

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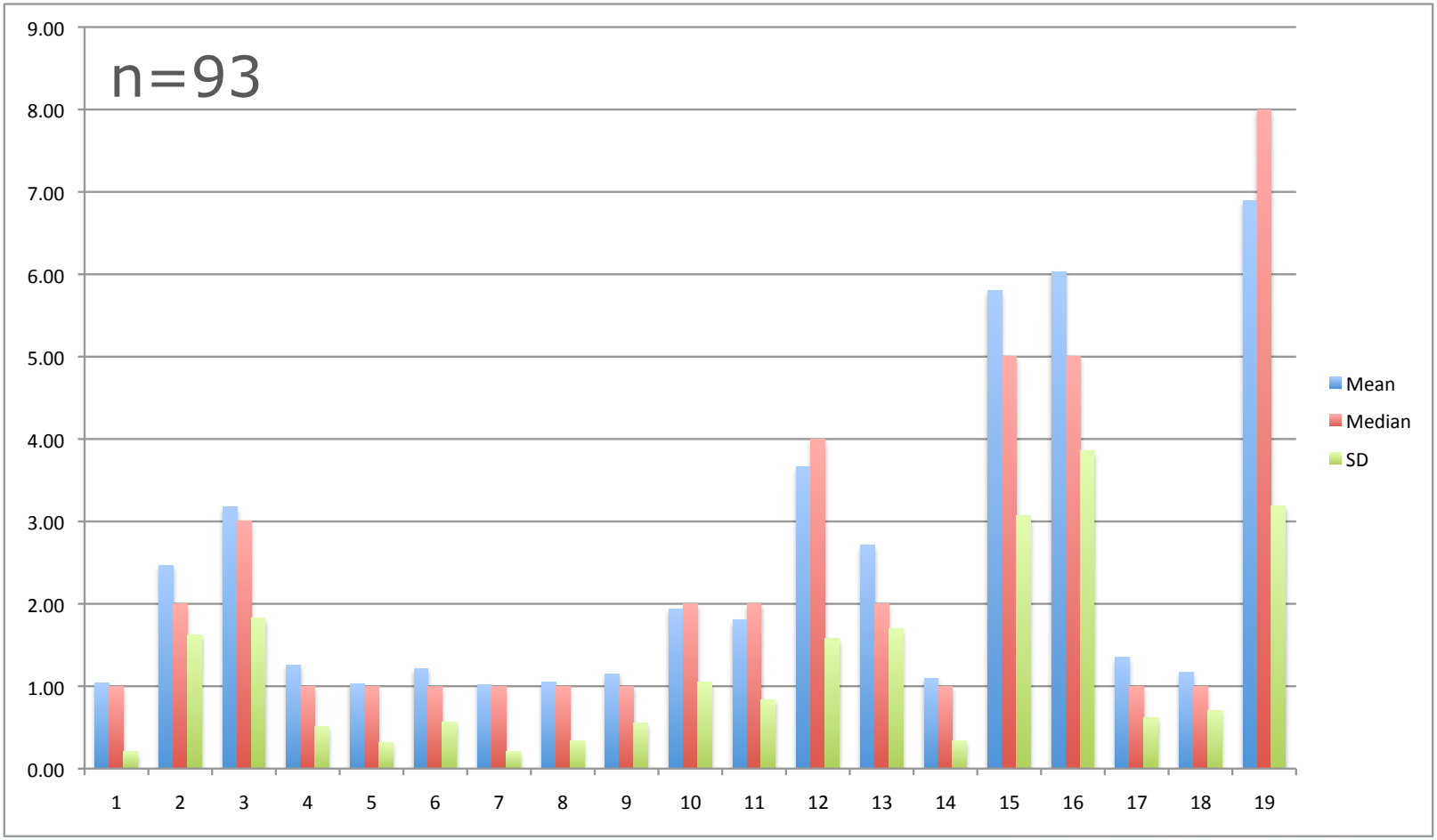
Embedded Assessment 2
Number of Tries to Correct



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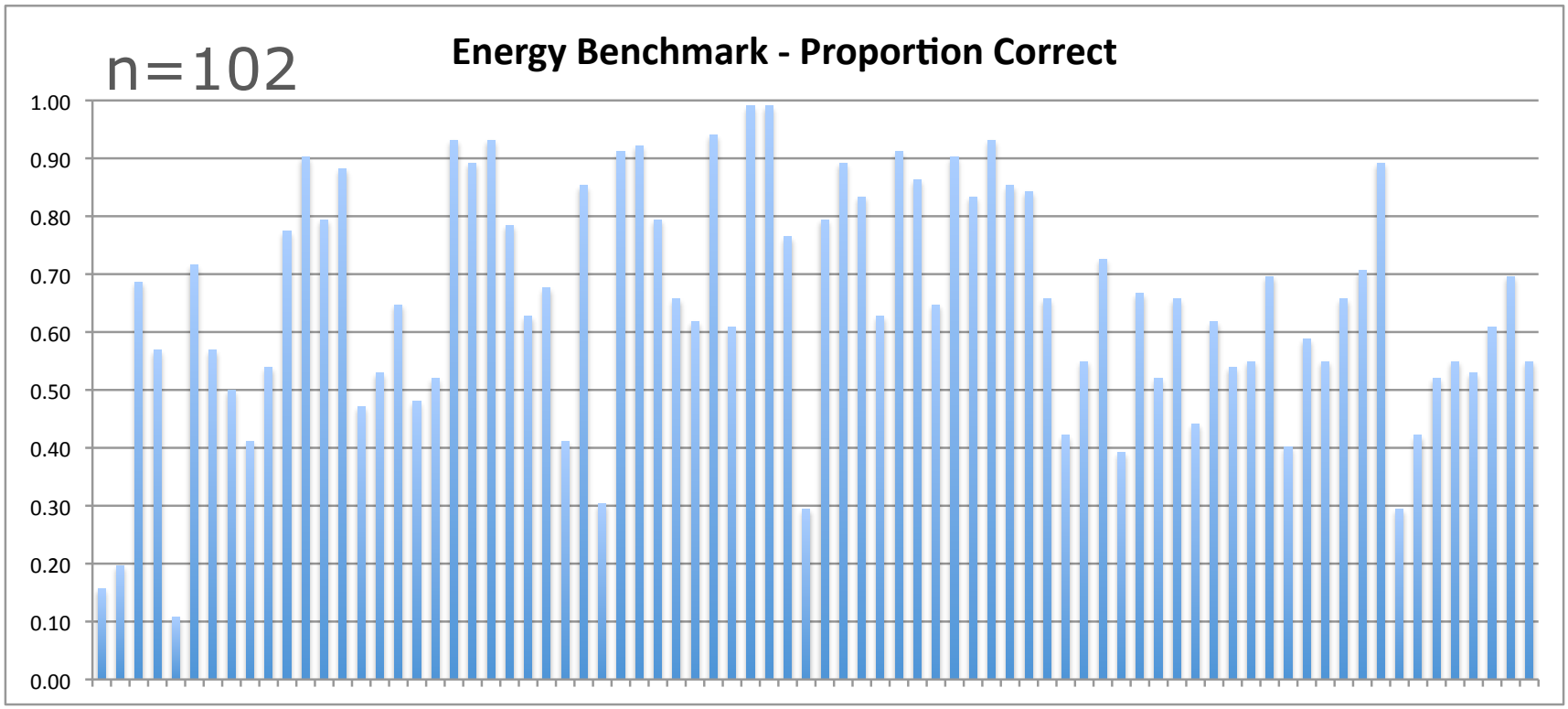
Benchmark Assessment Proportion Correct



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Next Steps

Complete feasibility testing

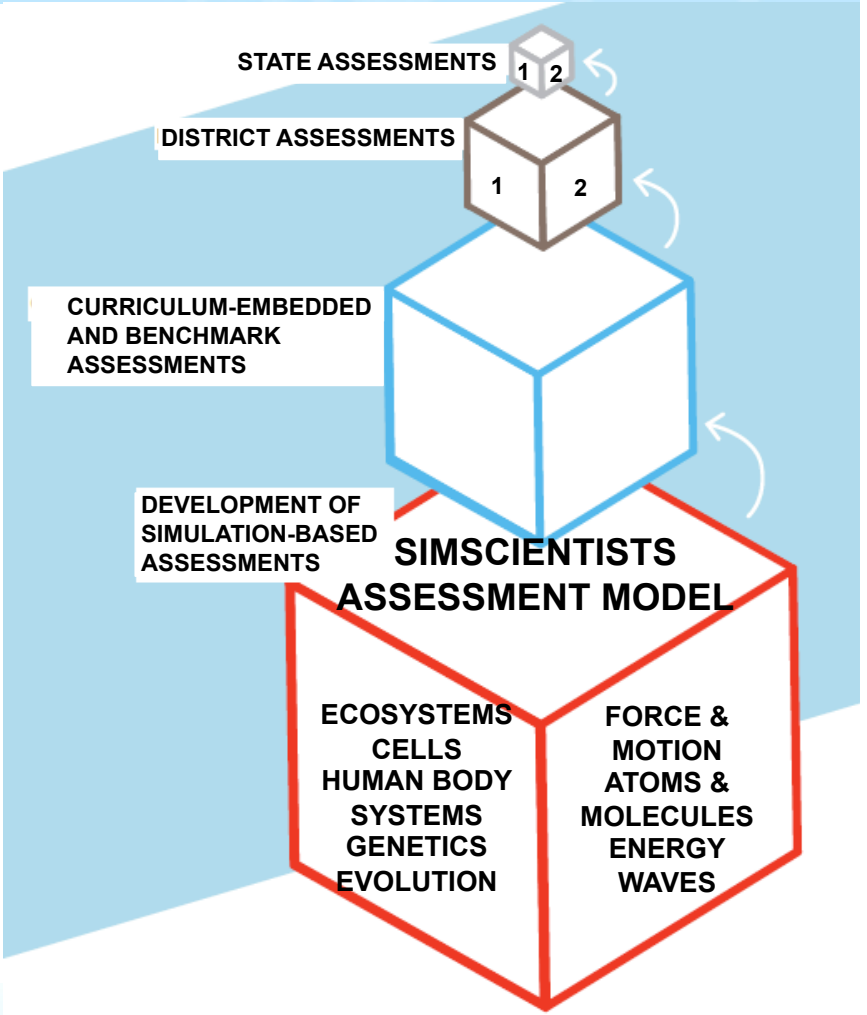
Revise assessments

Pilot and validation study (2015)

Cross-validation (2016)

Balanced Multilevel Assessment Systems

1. Reporting benchmark results alongside district and state data
2. Matrix sampling of short "signature" tasks from different topics



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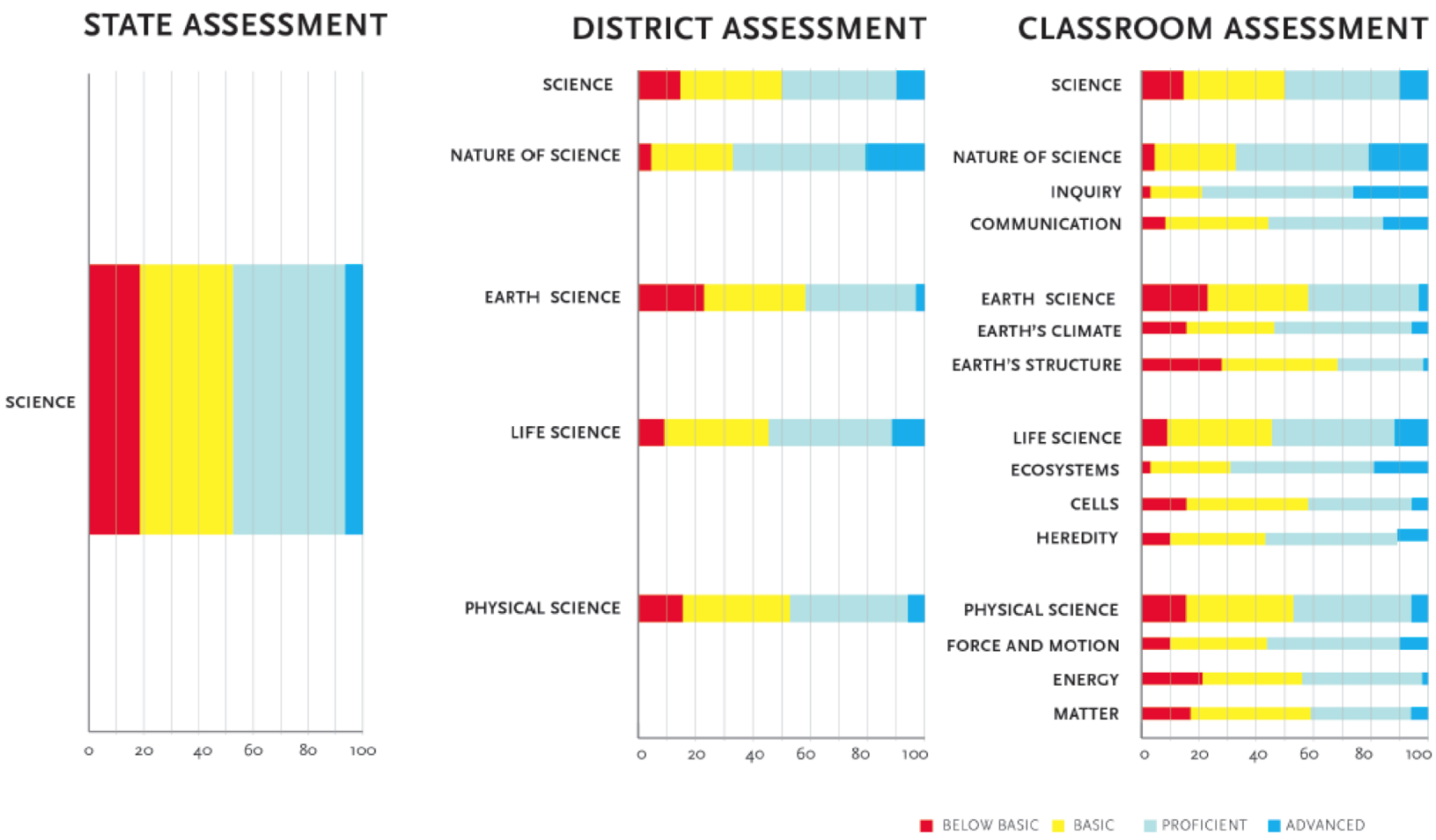
Side-by-Side Model



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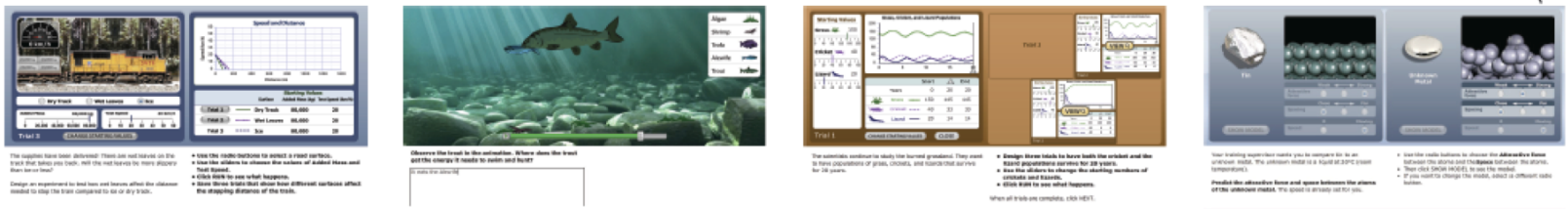
Signature Task Model

State Test Forms

Matrix Sampling



Simulation-based task item bank

Specifications and Simulation environments

Simulation-Based Classroom Assessments

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SimScientists Recent Publications

Davenport, J. L., & Quellmalz, E. S. (in press). Assessing science inquiry and reasoning using dynamic visualizations and interactive simulations. Forthcoming chapter in *Learning from Dynamic Visualizations: Innovations in Research and Practice.*

Quellmalz, E. S., Davenport, J. L., Timms, M.J., DeBoer, G.E., Jordan, K.A., Haung, C., & Buckley, B.C. (2013). Next-generation environments for assessing and promoting complex science learning. *J Ed Psych*, 51, 523-554.

Buckley, B. C., & Quellmalz, E. S. (2013). Supporting and assessing complex biology learning with computer-based simulations and representations. In D. Treagust & C.-Y. Tsui (Eds.), *Multiple Representations in Biological Education* (pp. 247-267). Dordrecht: Springer.

Quellmalz, E. S., Timms, M. J., Silberglitt, M. D. & Buckley, B. C. (2012). Science assessments for all: Integrating science simulations into balanced state science assessment systems. Invited article, *Journal of Research in Science Teaching (JRST), 49*, 363–393.

Quellmalz, E. S., Timms, M. J., Buckley, B. C., Davenport J., Loveland, M., & Silberglitt, M. D. (2012). 21st century dynamic assessment. In M. Mayrath, J. Clarke-Midura, & D. H. Robinson (Eds.), *Technology-based assessments for 21st century skills: Theoretical and practical implications from modern research* (pp. 55–90). Charlotte, NC: Information Age.

Quellmalz, E. S., Silberglitt, M. D., & Timms, M. J. (2011). How can simulations be components of balanced state science assessment systems? *Policy brief*. San Francisco: WestEd.

Quellmalz, E. S., Timms, M. J., & Buckley, B. C. (2010). The promise of simulation-based science assessment: The Calipers project. *International Journal of Learning Technologies, 5*(3), 243–265.

Quellmalz, E. S., DeBarger, A. H., Haertel, G., Schank, P., Buckley, B., Gobert, J., Horwitz, P., & Ayala, C. (2008). Exploring the role of technology-based simulations in science assessment: The Calipers Project. In J. Coffey, R. Douglas, & C. Stearns (Eds.), *Science assessment: Research and practical approaches* (pp. 191–202). WDC: National Science Teachers Association.

Contact Information

Website:

www.simscientists.org

Email:

equellm@wested.org

msilber@wested.org