Developing Simulation-Based Assessments for Learning Next Generation Science

Matt Silberglitt & Edys Quellmalz
WestEd

NSF DR K–12 PI Meeting • August 6, 2014

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<table>
<thead>
<tr>
<th>SimScientists Team</th>
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<tbody>
<tr>
<td>Edys Quellmalz, PI</td>
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<tr>
<td>Daniel Brenner</td>
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<tr>
<td>Barbara Buckley</td>
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<tr>
<td>Jodi Davenport</td>
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<td>Mark Loveland</td>
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<td>Matt Silberglitt</td>
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<tr>
<td>Arthur Sussman</td>
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<tr>
<td>Mike Timms (ACER)</td>
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<td>Jon Boxerman</td>
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<td>Andrew Grillo-Hill</td>
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# Past/Present Advisors

**Evaluators • Design Panel Members**

<table>
<thead>
<tr>
<th>George DeBoer, AAAS</th>
<th>Madeline Bergeron, Mary Anne Butler², Susan Foss, CT</th>
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<tbody>
<tr>
<td>Roy Levy, ASU</td>
<td>Katie Bowler, MA</td>
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<tr>
<td>Rodger Bybee¹, BSCS</td>
<td>André DeLeón, Richard Vineyard, NV</td>
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<tr>
<td>Randy Bennett, ETS</td>
<td>Janet Bailey, Sarah McManus, Beverly Vance, NC</td>
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<tr>
<td>Russel Almond, FSU</td>
<td>Kevin King³, Brad Talbert, UT</td>
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<td>Joan Heller, HRA</td>
<td>Gail Hall, David White, VT</td>
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<tr>
<td>Joseph Krajcik, MSU</td>
<td>Joe Willhoft⁴, WA</td>
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<tr>
<td>Richard Duschl, NSF</td>
<td><strong>Representatives of school districts and other LEAs</strong></td>
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<tr>
<td>Craig Heller, Stanford</td>
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<td>Ed Haertel, Stanford</td>
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<tr>
<td>Margaret Heritage, UCLA</td>
<td></td>
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<td>Joan Herman, UCLA</td>
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<td>James Pellegrino, UIC</td>
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[1] BSCS
[3] Ph.D.
[4] Ph.D.
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?

*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

Buckley, 2012; Gobert & Buckley, 2000
Theoretical Foundations

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

Learner-Centered

Interactive

Accessible

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
Applying Evidence-Centered Design to NGSS

<table>
<thead>
<tr>
<th>Claim</th>
<th>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.</th>
</tr>
</thead>
</table>
| Evidence Statement | *Construct arguments by ...*  
• Using data as evidence to support a claim |
# Integrating Evidence-Centered Design & Model-Based Learning

<table>
<thead>
<tr>
<th>Model Level</th>
<th>Descriptions</th>
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<tbody>
<tr>
<td>Component</td>
<td>What are the components of the system and their properties?</td>
</tr>
<tr>
<td>Interaction</td>
<td>How do the individual components interact?</td>
</tr>
<tr>
<td>Emergent</td>
<td>How are system behaviors and properties caused by interactions among components?</td>
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</table>
### Model Level Descriptions

<table>
<thead>
<tr>
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<th>Descriptions</th>
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<tbody>
<tr>
<td>Component</td>
<td>Kinetic energy</td>
</tr>
<tr>
<td>Interaction</td>
<td>Energy transfer</td>
</tr>
<tr>
<td>Emergent</td>
<td>Changes in motion</td>
</tr>
</tbody>
</table>

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

**MS-PS3-5** ... when the motion energy of an object changes, energy is transferred to or from the object
Task Model

Changes in Motion

Changes in Energy

Energy Transfer?
Think

What did you observe?
How can you explain your observation?
What evidence supports your explanation?

Discuss in a pair
Share with the group
Hands-On

Small groups

Discuss observations, explanations and evidence

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<th>Start</th>
<th>113</th>
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<tbody>
<tr>
<td>Kinetic Energy of Truck</td>
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<tr>
<td>Kinetic Energy of Log</td>
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Feedback

What does three-dimensional assessment look like?

Are we there yet?
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

n=100
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
Embedded Assessment 1
Data Dive

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

Energy is a type of force.  
The truck's engine creates energy for the truck.  
The truck's engine uses energy to create the force.  
An increase in energy causes the mass of the truck to increase.

Tries = 1  Tries = 2  Tries = 3  Tries = 4  Tries = >4
14  13  27  22  22
Embedded Assessment 1
Data Dive

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]

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.

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Embedded Assessment 1: Data Dive

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

Energy is a type of force.
The truck's engine creates energy for the truck.
The truck's engine uses energy to create force.
An increase in energy causes the mass of the truck to increase.

A force transfers energy, but they are not the same thing. Please try again.

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Embedded Assessment 1
Data Dive

Click Yes or No to describe the energy:
Energy is a type of force.
The truck's engine creates energy for the truck.
The truck's engine uses energy to create kinetic force.
An increase in energy causes the mass of the truck to increase.

When the truck is moving it has kinetic energy. Forces are the pushes and pulls that cause the truck to move. Energy and forces are not the same thing. Please try again.

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Embedded Assessment 1
Number of Tries to Correct

n=100

SimScientists

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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

Potential energy disappears as kinetic energy is created.

Yes  No

Mass is changed into potential energy.

Yes  No

Mass is changed into kinetic energy.

Yes  No
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

Potential energy disappears as kinetic energy is created.  
- Yes  - No

Mass is changed into potential energy.  
- Yes  - No

Mass is changed into kinetic energy.  
- Yes  - No

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<td>21</td>
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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.

Mass is changed into potential energy.

Potential energy disappears as kinetic energy is created.

Mass is changed into kinetic energy.

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Potential energy disappears as kinetic energy is created.

Yes  No
Embedded Assessment 2
Number of Tries to Correct

n=93
Benchmark Assessment
Proportion Correct

Energy Benchmark - Proportion Correct

n=102
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
Side-by-Side Model
Signature Task Model

State Test Forms

Matrix Sampling

Simulation-based task item bank

Specifications and Simulation environments

Simulation-Based Classroom Assessments


Contact Information

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