Using Science Simulations to Promote and Assess Complex Science Learning

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WestEd

Presented at the STEM Smart Workshop, University of Nevada Las Vegas, Las Vegas, NV

September 19, 2012

Funding provided by the National Science Foundation and the US Department of Education

Formative Assessment Definition (CCSSO FAST SCASS)

"Formative assessment is a *process* used by teachers and students *during* instruction that provides feedback to *adjust* ongoing teaching and learning to improve students' achievement of *intended* instructional outcomes."

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Calipers II: Using Simulations to Assess Complex Science Learning Goals

- Develop formative and benchmark simulation-based assessments of science knowledge for key content in physical and life science and for science inquiry strategies.
- Enhance formative assessment simulation modules with immediate, individualized feedback, coaching, and reflection activities.
- Develop and document technology-based assessment designs and exemplars that take advantage of simulation environments to provide assessments of science standards for formative and summative purposes.

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Calipers II Goals (cont'd)

- Document the technical infrastructure and re-usable designs and processes employed.
- Provide evidence of the technical quality, feasibility, and usability of the new assessments.
- Study the influence of formative assessments on complex science and inquiry learning.
- Link the enlarged collection of Calipers II benchmark and formative, assessment to national science standards and the AAAS item clusters.

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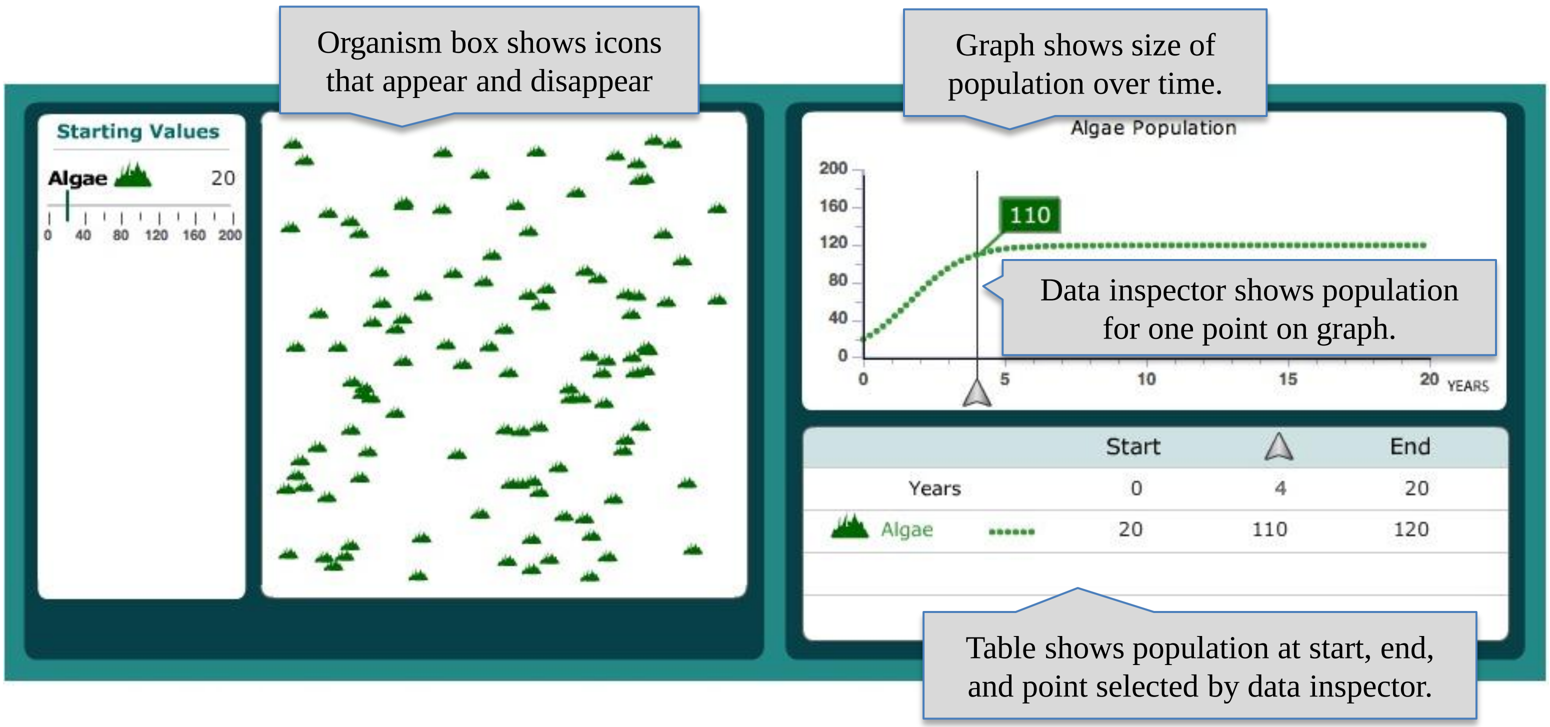
Technology Affordances

- Animations of dynamic system phenomena
  - Can observe and review
- Simulation-based investigations
  - Iterative design
  - Virtual data collection
  - Conducting and saving multiple trials
  - Multimodal information and data displays
- Multiple, overlapping, simultaneous representations
- Scientific "tools of the trade"
  - Simulations, graphs, tables, zoom, drawing, highlighting
- Immediate, contingent feedback and hints, adaptive scaffolding
- Bayes Nets within simulations to assess proficiencies

Multiple Modes of Representation
Active Inquiry



SimScientists Assessments

Embedded & Benchmark

Regular Instruction → Embedded Assessment + Reflection Activity

Regular Instruction → Embedded Assessment + Reflection Activity

Regular Instruction → Embedded Assessment + Reflection Activity

Regular Instruction → Benchmark Assessment

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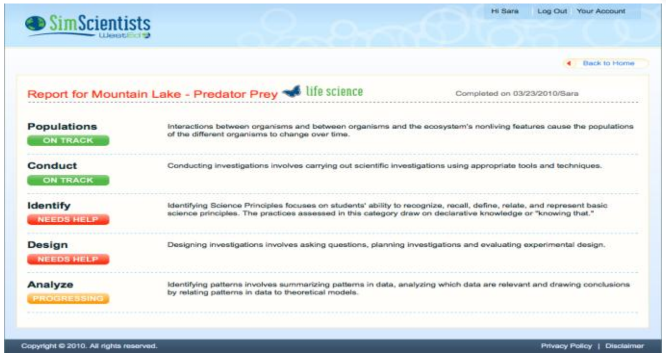
Embedded Assessment Components

Online assessment with feedback & coaching

ASSESSMENT TASK

STUDENT PROGRESS REPORT



TEACHER REPORT

NH = needs help P = making progress OT = on track

Reflection Activities

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NGSS Standards Assessed

- Cross-cutting concepts
  - Systems and System Models
  - Energy flow
- Science Practices
  - Using models
  - Investigations
- Ecosystem core ideas

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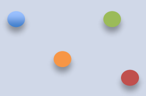
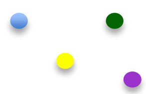
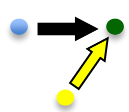
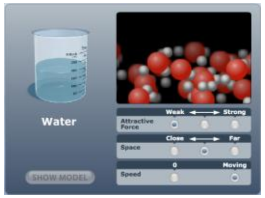
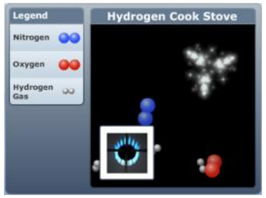
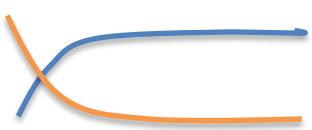
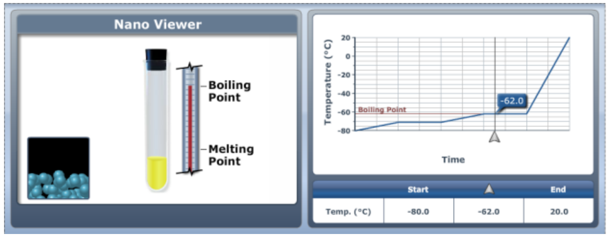
SimScientists Ecosystems System Model

Model Level	Descriptions	Content Targets	Science Practices
Component 	What are the components of the system and their rules of behavior?	Every ecosystem has a similar pattern of organization with respect to the roles (producers, consumers, and decomposers) that organisms play in the movement of energy and matter through the system. (NGSS: LS2.A—Interdependent Relationships in Ecosystems)	Analyzing and Interpreting Data
Interaction 	How do the the individual components interact?	Matter and energy flow through the ecosystem as individual organisms participate in feeding relationships within an ecosystem. (NGSS: LS2.B—Cycles of Matter and Energy Transfer in Ecosystems)	Developing & Using Models; Analyzing and Interpreting Data
Emergent 	What is the overall behavior or property of the system that results from many interactions following specific rules?	Interactions among organisms and among organisms and the ecosystem's nonliving features cause the populations of the different organisms to change over time. (NGSS: LS2.C—Ecosystems Dynamics, Functioning and Resilience)	Planning and Carrying Out Investigations; Analyzing and Interpreting Data

Atoms & Molecules Target System Model

Component	Atoms and Molecules	Skill
	Nitrogen · Water Vapor · Argon	Observe
Interaction	**Speed – Spacing – Collisions**	**Skill**
	 	Analyze
Emergent	**Boiling & Melting Point – States of Matter**	**Skill**
		Measure & Investigate

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Demo:
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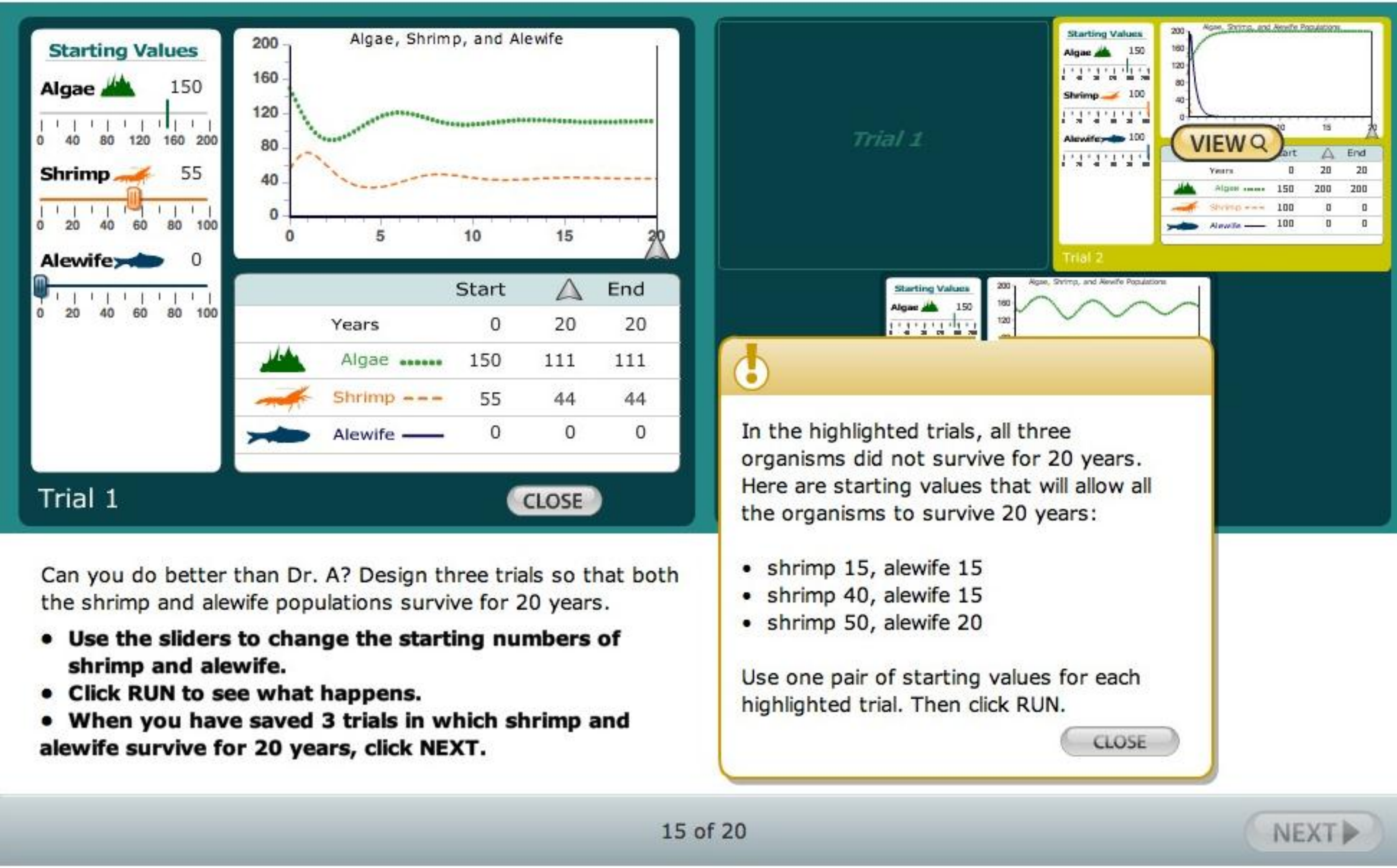
Formative Assessment Features

- Immediate, individualized feedback and coaching
- Reflection activities that address students' needs, promote transfer and scientific discourse
- Timely information that teachers can use



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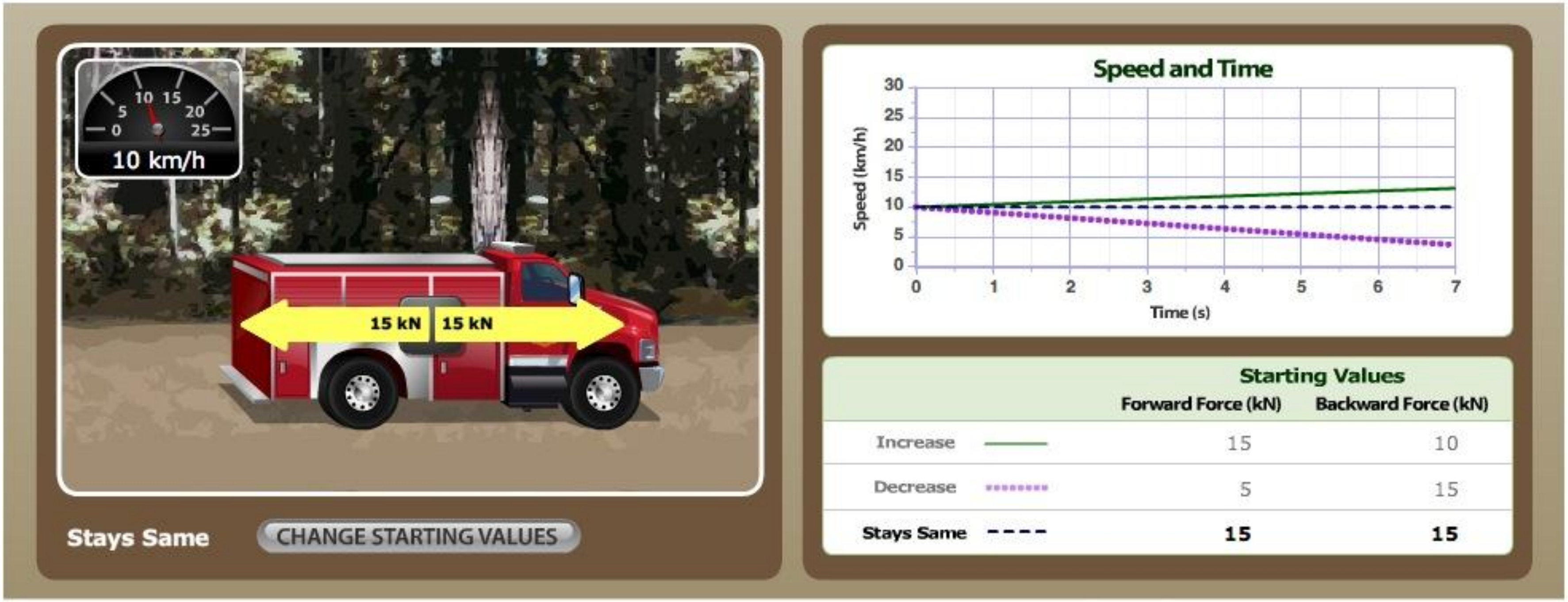
Force and Motion



The truck is moving at 10 km/h. Now the fire chief wants you to show how to make the truck's speed **stay the same**.

- **Draw the forward and backward forces so that the truck's speed stays the same.**
- **Click RUN to observe how the truck's speed changes with the forces you selected.**
- **If the forces made the truck's speed stay the same, click SAVE TRIAL.**
- **If not, click CHANGE STARTING VALUES and try again.**

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Progress Reports to Students

Back to Home

Report for Mountain Lake - Predator Prey life science

Completed on 03/23/2010/Sara

Populations ON TRACK	Interactions between organisms and between organisms and the ecosystem's nonliving features cause the populations of the different organisms to change over time.
Conduct ON TRACK	Conducting investigations involves carrying out scientific investigations using appropriate tools and techniques.
Identify NEEDS HELP	Identifying Science Principles focuses on students' ability to recognize, recall, define, relate, and represent basic science principles. The practices assessed in this category draw on declarative knowledge or "knowing that."
Design NEEDS HELP	Designing investigations involves asking questions, planning investigations and evaluating experimental design.
Analyze PROGRESSING	Identifying patterns involves summarizing patterns in data, analyzing which data are relevant and drawing conclusions by relating patterns in data to theoretical models.

Progress Reports to Teachers

Summary Report: Mountain Lake - Food Web

Try it | Detailed Report

ASSESSMENT: Mountain Lake - Food Web

CLASS: Period 7

Go!

Content		NH Needs Help	P Making Progress	OT On Track
Roles	NH OT	12 (46%)	4 (15%)	10 (38%)
Interactions	NH OT	15 (58%)	4 (15%)	7 (27%)
Inquiry				
Identifying	NH OT	15 (58%)	5 (19%)	6 (23%)
Using	NH OT	10 (38%)	5 (19%)	11 (42%)

NH = needs help P = making progress OT = on track

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Grouping Recommendations for Classroom Reflection Activity

ASSESSMENT: Mountain Lake - Food Web

CLASS: Period 7

Go!

NH Needs Help P Making Progress OT On Track

Reflection Activity PDF

Group A students needed little help on either roles or interactions
Group B students needed help with interactions, but not with roles.
Group C students needed help with understanding the roles of organisms in an ecosystem.

Student	Refl Gr.	Roles	Interactions	Identifying	Using
Student 1	C	P	NH	NH	OT
Student 1	C	NH	NH	NH	NH
Student 3	A	OT	OT	OT	OT
Student 4	A	OT	OT	OT	OT
Student 5	C	NH	NH	NH	NH
Student 6	C	NH	NH	NH	P
Student 7	C	P	NH	NH	P
Student 8	C	NH	NH	NH	NH
Student 9	C	NH	OT	NH	P
Student 10	B	OT	NH	OT	P

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Classroom Reflection Activity

- Formative use of assessment results
  - Students assigned to teams based on embedded results
- Transfer to different, more complex system
- Jigsaw structure
  - Allows differentiated instruction via tasks of varying difficulty
  - Promotes small and large group discourse and collaboration
- Guidance for teacher
  - Teacher review of key points in simulation
  - What to look for during group work and questions to pose in response
  - Posters and presentations
  - Evaluation of posters and presentations by students and teachers

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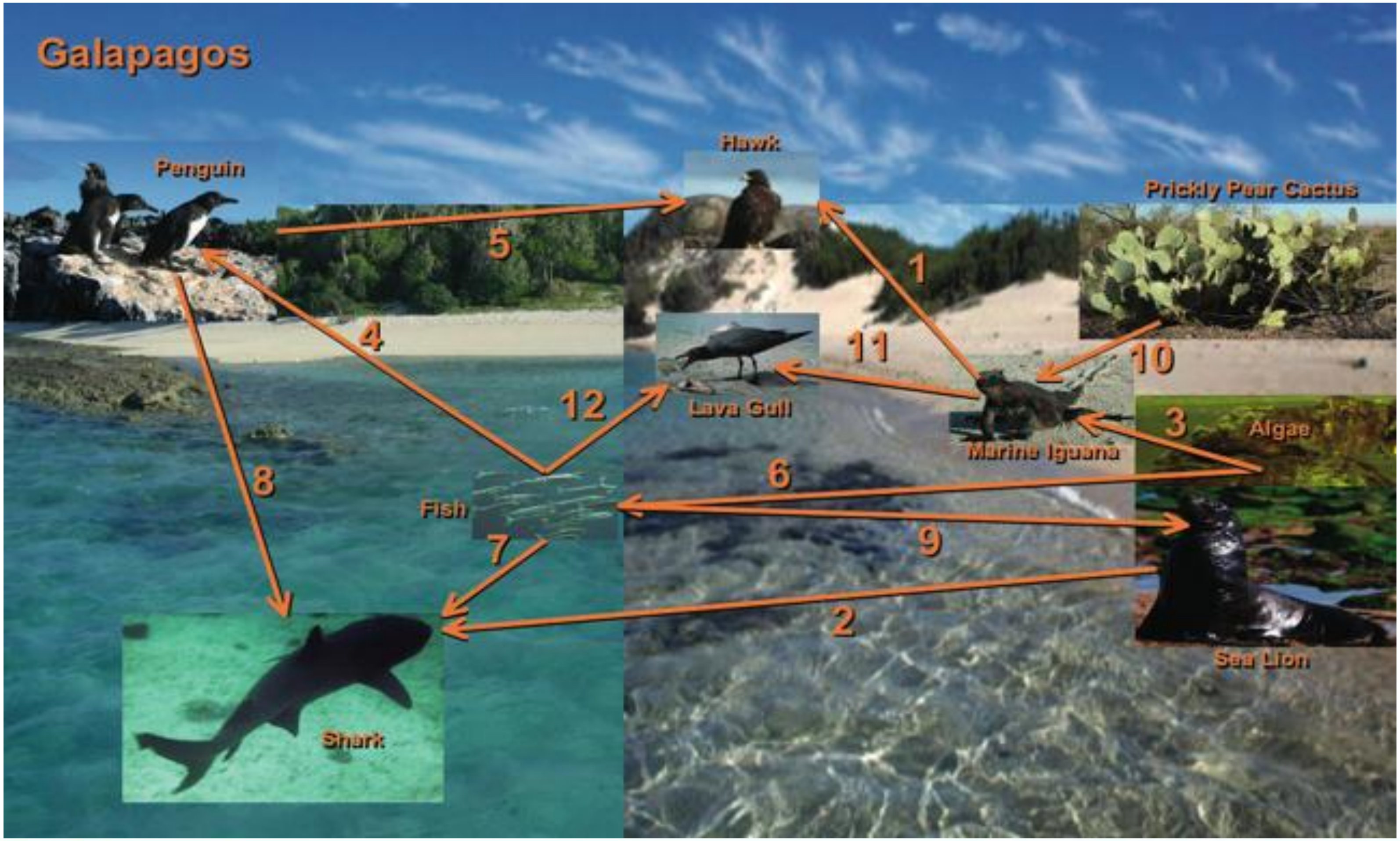
Workshop Reflection Activity

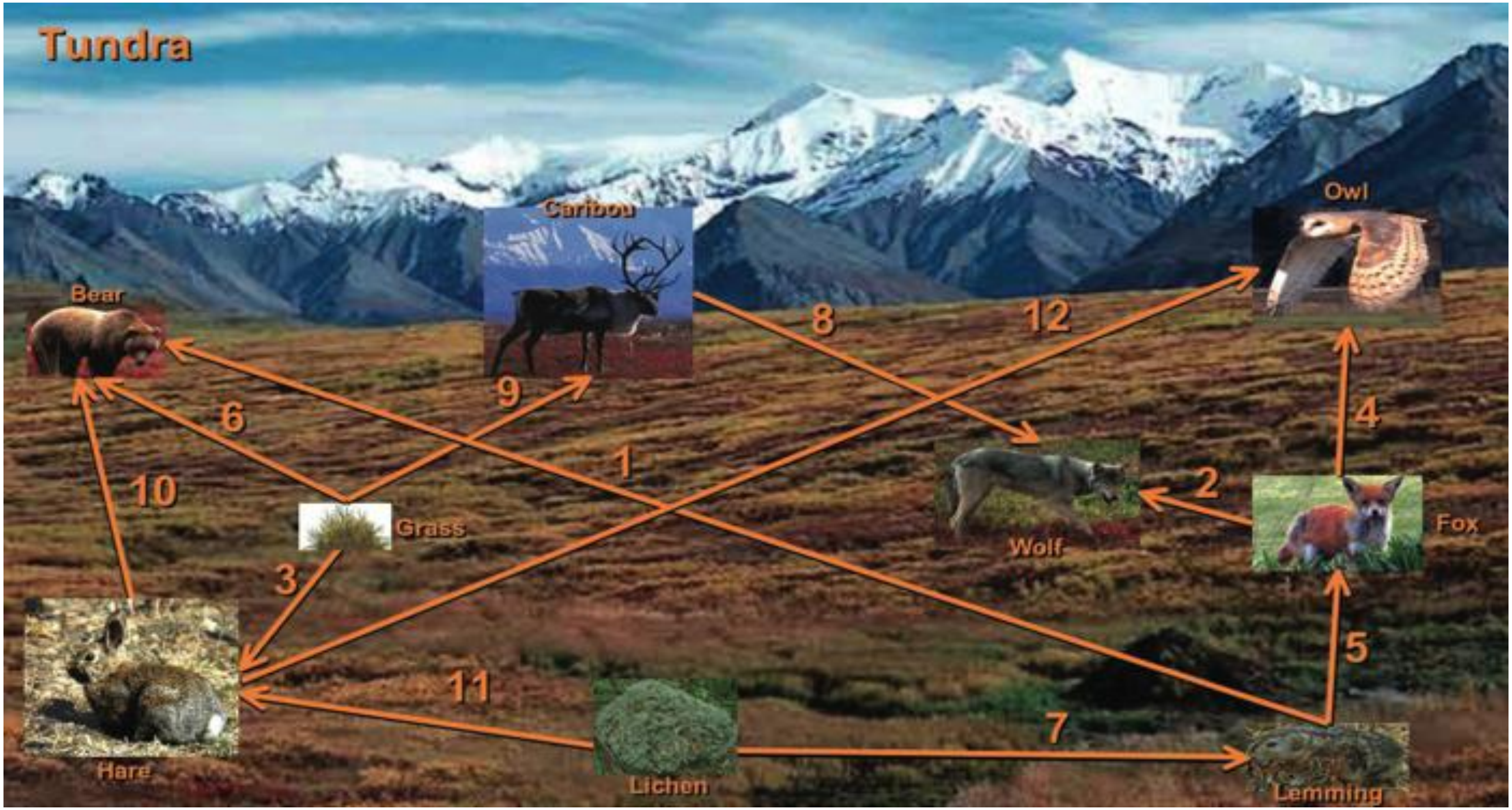
For each ecosystem

- Divide into 3 groups
  - Distribute Interaction Cards (3 groups)
    - Identify roles of organisms as consumers or producers
  - Draw arrows showing flow of matter and energy
  - Answer riddles
  - Make up a new riddle
- Present ecosystem
  - Identify two consumers, one producer
  - Show the energy and matter arrows for each
- Present riddle

Transfer to new, more complex ecosystem



Calipers II
Reflection Activities: Ecosystems



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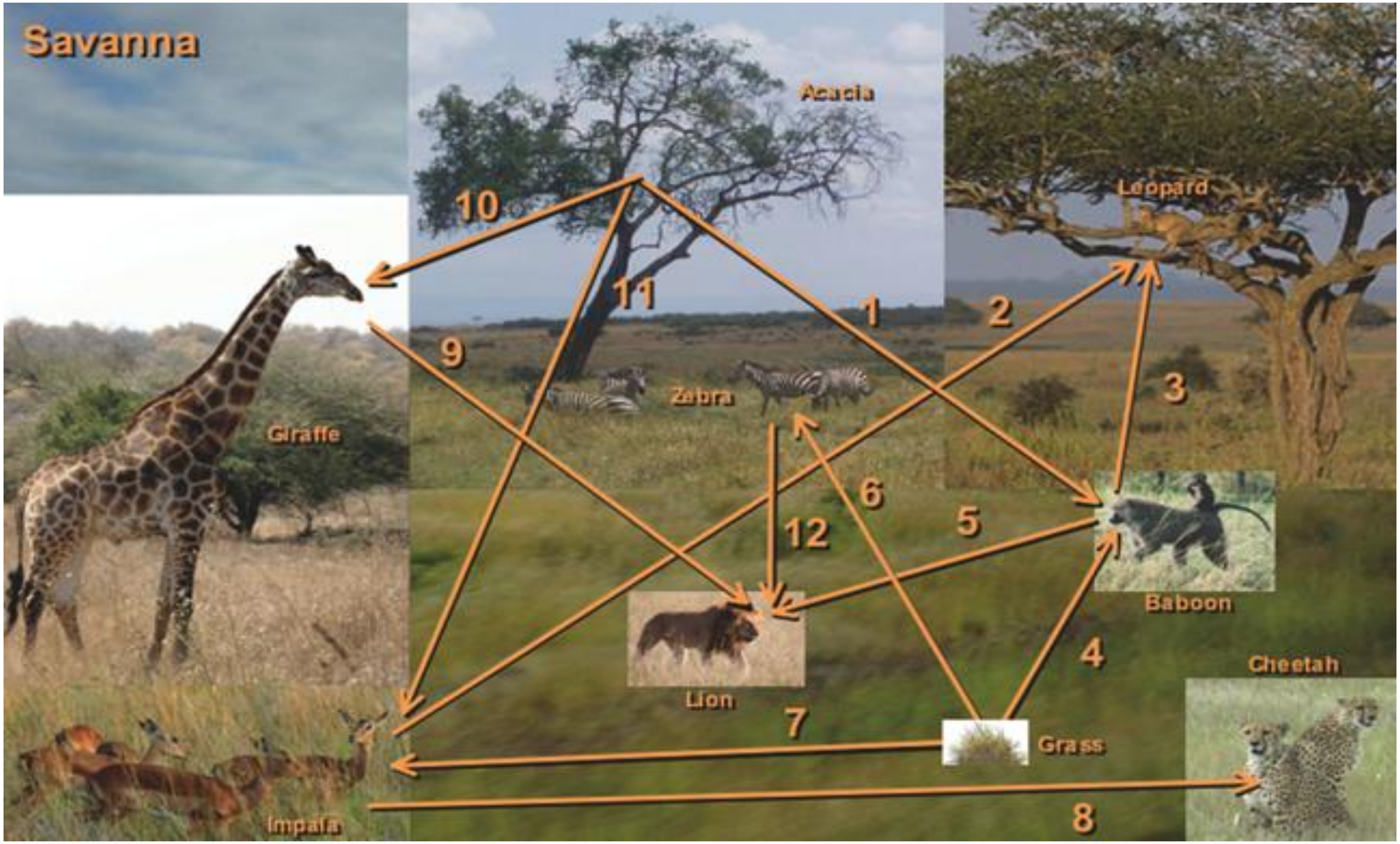
Calipers II
Reflection Activities: Ecosystems



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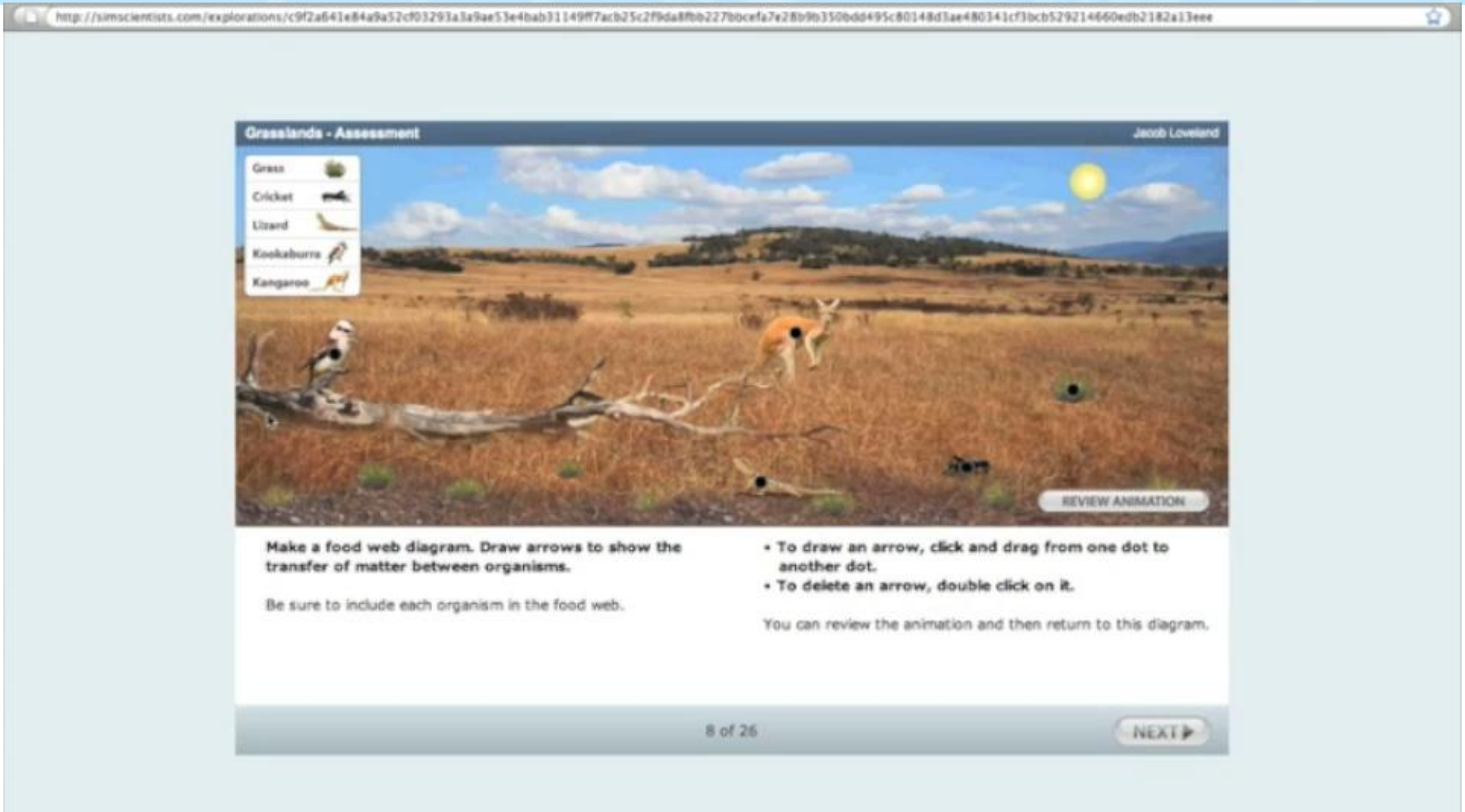
Ecosystem Benchmark Assessment: Assess Transfer to New Ecosystem



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Summary Benchmark report

Content		BB Below Basic	B Basic	P Proficient	A Advanced
Roles	BB	3 (100%)	0 (0%)	0 (0%)	0 (0%)
Interactions	BB	3 (100%)	0 (0%)	0 (0%)	0 (0%)

Matter and energy flow through the ecosystem as individual organisms interact with each other. Food web diagrams indicate the feeding relationships among organisms in an ecosystem. All ecosystems have a flow of energy from a nonliving source, to producers, to consumers.

Populations	A	0 (0%)	0 (0%)	0 (0%)	3 (100%)
Inquiry					
Identify	BB A	1 (33%)	0 (0%)	0 (0%)	2 (67%)
Use	BB B	1 (33%)	2 (67%)	0 (0%)	0 (0%)
Design	BB B	1 (33%)	2 (67%)	0 (0%)	0 (0%)
		0 (0%)	3 (100%)	0 (0%)	0 (0%)

Detailed Report by Student and Target

Student	Roles	Interactions	Populations	Identify	Use	Design	Conduct	Analyze	Evaluate	Communicate
Simmons85, Sara85	BB	BB	A	BB	BB	BB	B	BB	BB	A
Simmons86, Sara86	BB	BB	A	A	B	B	B	BB	BB	A
Simmons87, Sara87	BB	BB	A	A	B	B	B	BB	BB	B

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SimScientists Research Findings

- AAAS review of alignment of content and inquiry targets with national and state standards
- Cognitive labs
- Classroom feasibility testing
- Pilot testing
- Field testing
  - EAG study involving 4 states, 28 districts, 58 teachers, 6,000 students
  - Calipers II and MASS, 3 states, 3 districts, 28 teachers, 2,500 students

SimScientists Research Findings

- Technical quality
- Implementation evaluation
- Effects of embedded on summative simulation benchmark and conventional posttest

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CRESST Case Study Interviews

"I think that [students] are way more engaged. When I told them that we were going next door to work on the computers again, they all seemed pretty excited to go next door and work on it."

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CRESST Case Study Interviews

- "…I like that kind of feedback when it doesn't just go to the next page and they don't know whether they did it right or not."
- "…Yes, the science content is really being tested. Students are asked to conduct experiments, investigate, and draw conclusions and to use scientific skills. Students are not able to guess on the multiple choice questions because it probes them until they choose the right answer. Students are also taught about food webs in one biome and they are tested on another biome."

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CRESST Evaluation Conclusions

- Observations showed that students were actively engaged most of the time during assessments.
- Both teachers and students generally believed that the SimScientists program was beneficial to learning.
- Teachers found the automatically scored, immediate feedback—especially the reports generated by the questions—helpful to students. The instant reports allowed teachers to easily see which questions students had the most difficulty with so that they could tailor their lessons accordingly.

CRESST Evaluation Conclusions

- Teachers collectively agreed that the simulation assessments had greater benefits than traditional paper-and-pencil tests because of the simulation's instant feedback, interaction, and visuals.
- Teachers agreed that the assessments would be useful in measuring their individual state standards.

Current Findings

The SimScientiststs simulation-based assessments

- Measure constructs not tested well by static modalities
- Can discriminate measures of inquiry and content
- The curriculum-embedded assessments seem to have positive effects on student learning
- The summative benchmark assessments have sufficient technical quality to be components of a state science assessment reporting system

Summary of Technical Quality Analyses

- Correlations
  - Moderate correlations between benchmark and post test (0.57–0.64)
  - Correlations between content and inquiry are higher on the post test than the benchmark
- Gap analysis for ELLs and SWDs
  - Both groups perform better than expected on the benchmark assessment (based on their post test ability estimates)
- Reliability
  - High for all measures (coefficient alpha: 0.83–0.89)
- Effect of the treatment
  - Small, significant effect on the post test (0.07–0.08)
  - Moderate, significant effect on the benchmark (0.3–0.4)
  - Larger effect on benchmark inquiry than content (up to 0.58)

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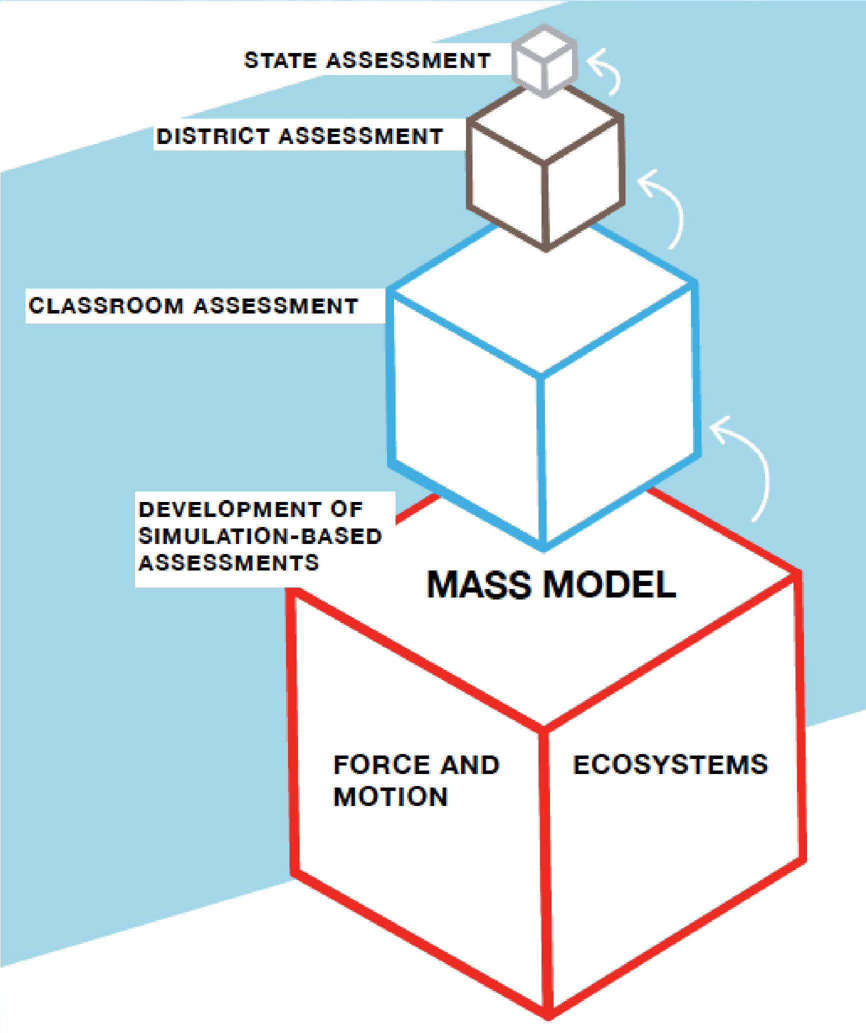
Balanced, Multilevel Assessment System Models

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



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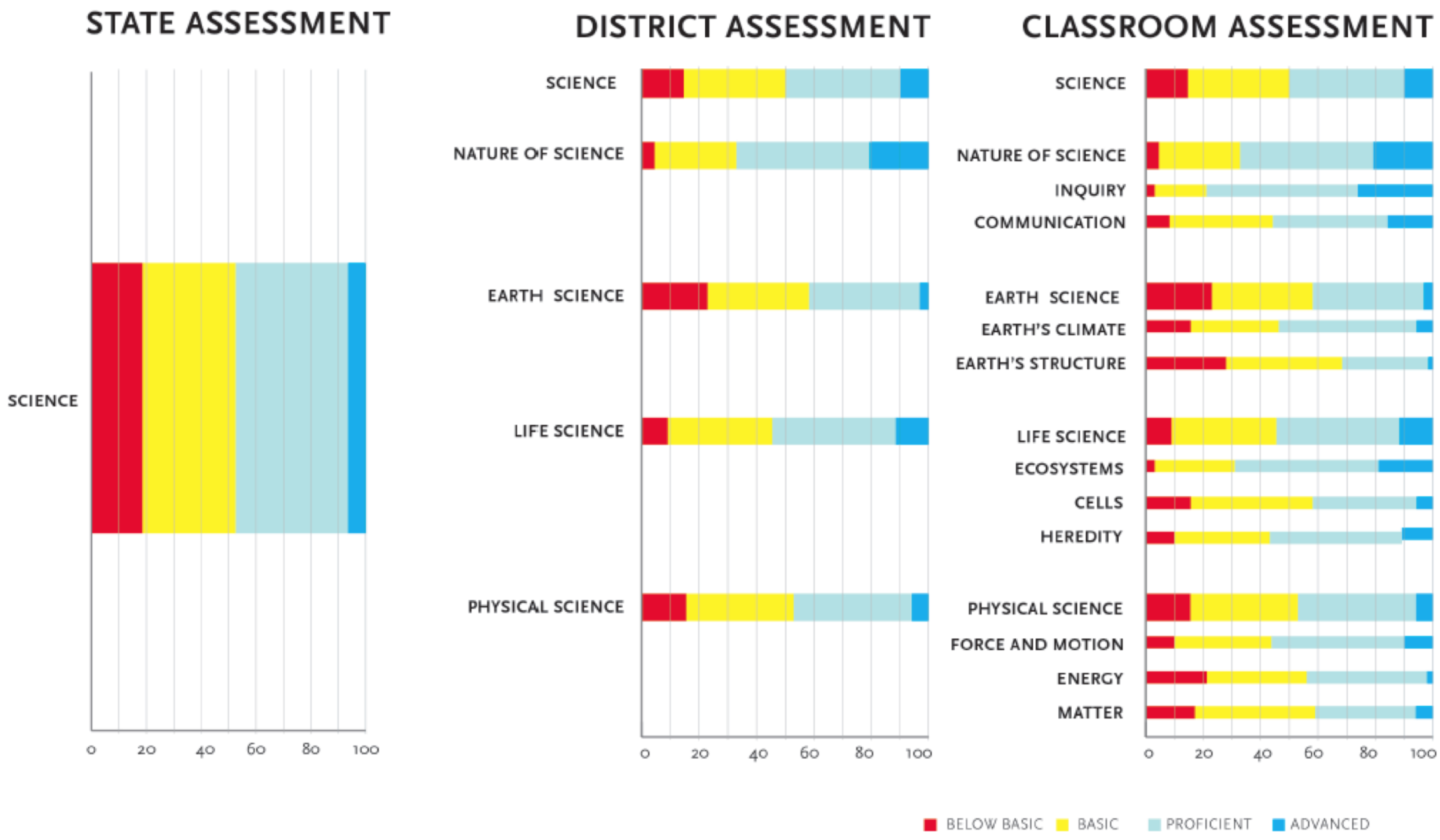
Side-by-Side Model



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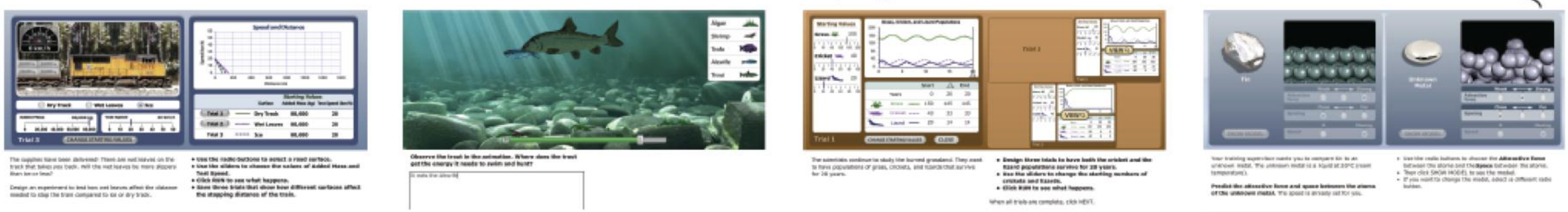
Signature Task Model

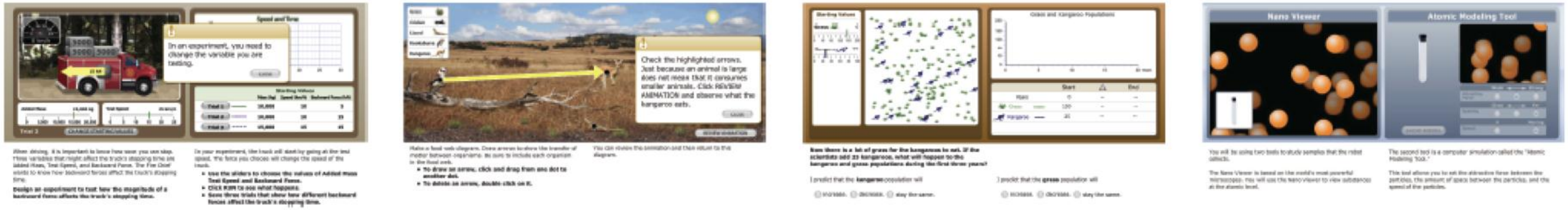
State Test Forms

Matrix Sampling



Simulation-based task item bank

Specifications and Simulation environments



Simulation-Based Classroom Assessments

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Continuing Research

- Study vertically aligned simulation based assessment suites for life and physical science of
  - Classroom assessments
    - curriculum embedded assessments (for formative purposes)
    - benchmark assessments (for summative purposes)
  - Large scale assessments
    - signature tasks (for summative purposes)
- Create simulation-based curriculum supplements

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