Assessments as Complex Systems Learning Events: Tensions and Opportunities

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Abstract

As part of an investigation on cumulative learning, Web-based Inquiry Science Environment projects related to global climate change, plate tectonics, and photosynthesis have been redesigned. Visualizations provide opportunities for students to explore the consequential role of energy in each system. Two tools – Energy Stories and MySystem- serve as assessments and learning events. Energy Stories ask students to synthesize their ideas about how energy is transferred and transformed. MySystem serves as a way for students to represent their understanding of a non-linear process, provided it occurs at a singular level.

Curriculum and Context

Web-based Inquiry Science Environment
Technology-enhanced visualization-rich materials
Consistent with California standards

Knowledge integration framework (Linn, Davis & Bell, 2004)

Promote cumulative learning
Energy as core idea
Redesign of projects
Visualizations= explore the consequential role of energy in each system
Assessments as learning events

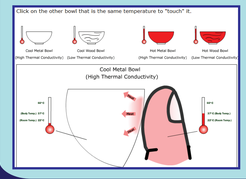
Elicit Ideas

Add Ideas

Develop Criteria

Sort Ideas

Thermodynamics



6th grade

Conduction as transfer of energy

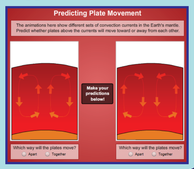
Predict-Observe-Explain: Which is warmer, metal or wood?

Plate Tectonics

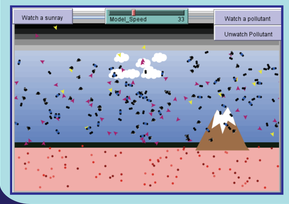
6th grade

Convection as transfer of energy and material

Predict-Observe-Explain: What will happen to dye in water?



Global Climate Change



6th grade

Radiation as transfer of energy; Transformation of energy

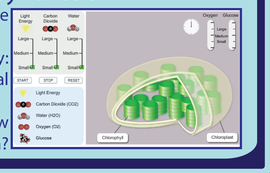
Predict-Observe-Explain: How do variables impact global temperature?

Photosynthesis

7th grade

Transformation of energy: Radiation to chemical

Predict-Observe-Explain: How do variables impact growth?



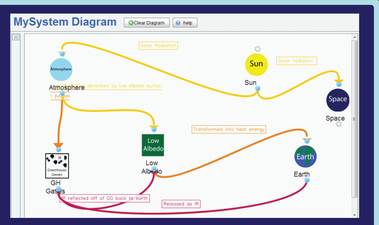
Knowledge Integration Levels	
Complex Link Two or more full, valid links between normative, relevant ideas	5
Full Link Explicit, valid link between normative, relevant ideas	4
Partial Link Explicit normative, relevant ideas but not connected	3
No Link Non-normative but relevant ideas or non-normative links	2
Irrelevant Non-normative and irrelevant ideas or "I don't know"	1
Blank No response	0

Complex Systems

Human category learning: Explicit, rule based phenomena vs complex phenomena (Ashby & Maddox, 2005)
Ontological differences across direct and emergent processes (Chi, 2005)
Identifying nonsalient, mechanistically consequential aspects (Liu & Hmelo-Silver, 2009)

Assessments as learning events
Energy Stories = synthesize ideas about how energy is transferred and transformed.

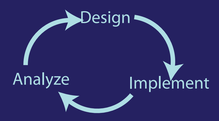
MySystem = represent understanding of a non-linear process, provided it occurs at a singular level.



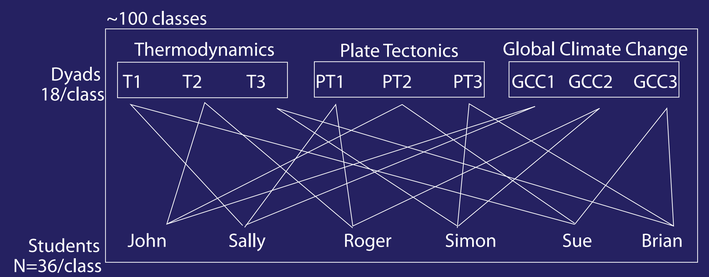
Write a story to explain to Gwen how the earth is warmed by energy. Be sure to include:
*Where energy comes from
*How energy moves
*Where energy goes
*How energy changes/transforms

Methods and Data

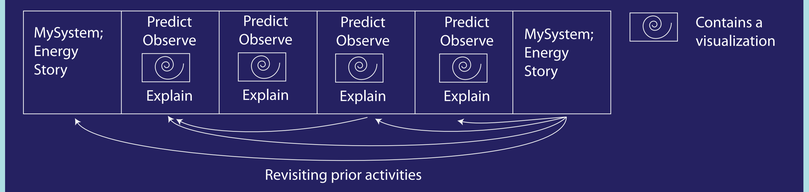
Design Based Research

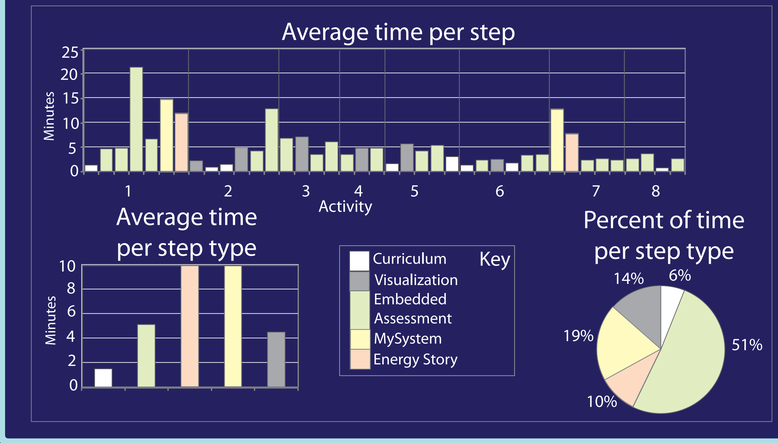


Cross Classified Structure



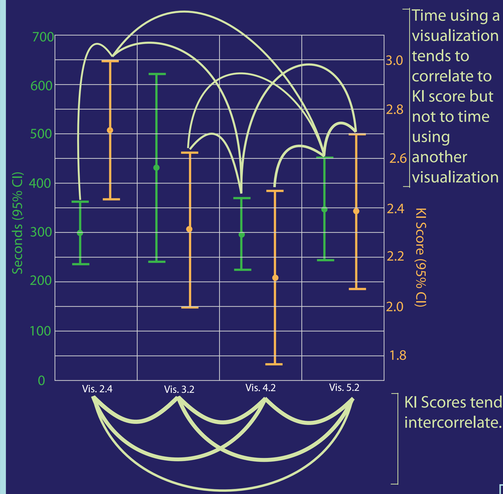
Nonlinear Progress, Synthetic





Findings

Dyads add new ideas and form new scientifically valid links between ideas
Dyad performance on a late, integrative question was modeled as a linear combination of two prior questions, an early question asking students to explain a phenomenon after learning about a type of heat transfer e.g., (conduction or convection) and a later question asking students to provide a more mechanistic explanation of the phenomenon (e.g., conduction relates to rate of heat transfer or heat energy is related to density). Thermodynamics : (F (2,59)= 6.98, p<0.05) Plate tectonics (F (2,62)= 18.28, p<0.05)



Line thickness represents significant correlation coefficients.

Global climate change

Student who viewed the atmosphere-as-shield tended to spend little time with the visualization

Higher scores related to the atmosphere question predict higher scores on the Post-project Energy Story

Dyads made significant gains from pre- to post project on their energy stories (t= 2.14, df=66, p < 0.05).

	B	Std. Error	Beta	t	p
Constant	0.36	0.29		1.22	0.23
Post Energy Story	0.34	0.18	0.22	1.90	0.06
Vis. 3.3	0.27	0.09	0.34	2.95	0.004

Design Implications

Challenges relate to determining what constitutes an appropriate level of systems science given:

The age and experiences of 6th grade students

Pressures to cover the scope/breadth of the curriculum

Pressures to teach to California State Science Standards

Desire to represent topics in ways that reflect disciplinary perspectives

Integrating energy as a core idea

Improving MySystem

S	W
Helps students organize ideas before writing Supports dyad collaboration Fosters understanding of relationships	Authoring limitations Download and related analysis challenges Link to Energy Story Versioning not recorded
O	**T**
Support cumulative learning with consistent icons, links to energy stories Support systems understanding	Student data easily lost

Next Steps

Analyze latest data from Global Climate Change and Redesign to foster understanding of complex systems and the role of energy in them

Cumulative learning related to energy: cohort and Individual student trajectories across projects

Explore dimensional analysis if indicated, for Energy Stories and MySystem

References

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Acknowledgments

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