Human Body Systems: Using Simulations to Foster Integrated Understanding of Complex, Dynamic, Interactive Systems

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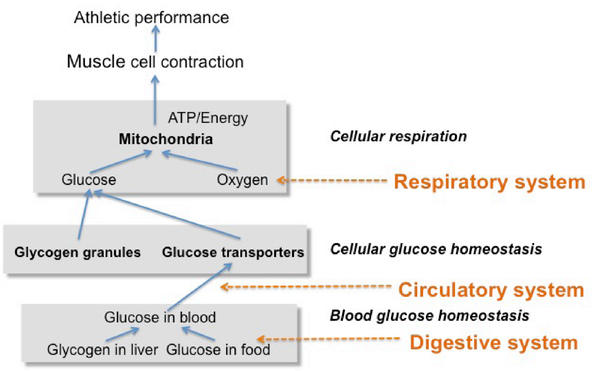
SimScientists WestEd

GOALS

Help students integrate their high school biology knowledge into emergent system models that span all levels of the human body.

- Develop instructional and assessment tasks to foster and assess model-based learning.
- Study the influence of these materials on students' knowledge and ability to reason.

COMPLEX SYSTEM MODEL



ITERATIVE DEVELOPMENT CYCLE

Initial Module Development

- Think-Alouds with high school biology teachers and students
- External Review by AAAS and Advisors for alignment and accuracy
- Internal Review of representations, assessment hygiene, storyline

Module Revisions

- Feasibility study with biology classes of teacher co-developer
- Think-Alouds
- IRT analysis

Module Revisions

- Pilot study with 5 teacher (543 students)
- Professional development
- Think-Alouds and teacher post-interviews
- IRT analysis (benchmark item reliabilities: 0.82 to 0.92)

Module Revisions

- RCT study with 40 general biology teachers (1885 students)
- Online professional development
- Data analyses

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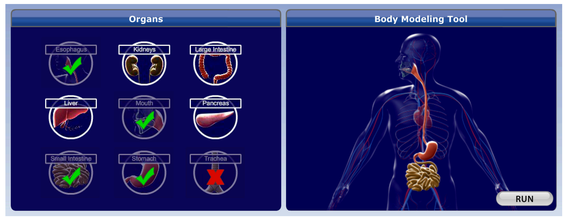
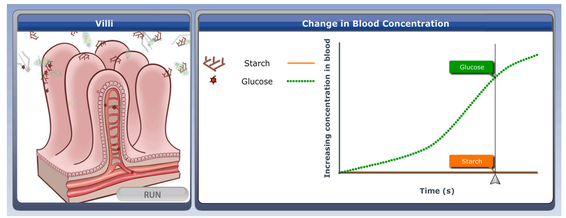
MAKING CONNECTIONS TO DEEPEN UNDERSTANDING

INVESTIGATING LIVING SYSTEMS WITH MULTIPLE LINKED REPRESENTATIONS

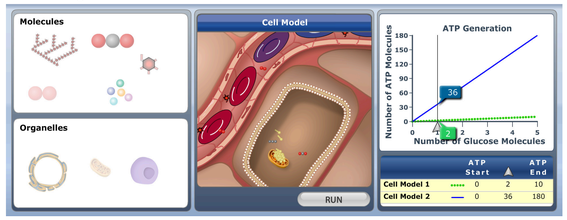
Build a model of the digestive system



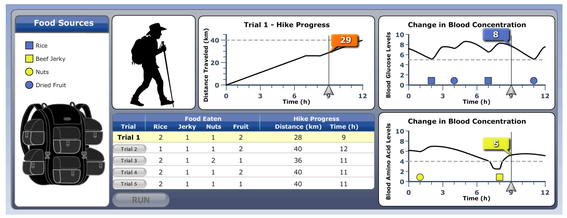
Investigate absorption of molecules into blood



Investigate cellular respiration



Investigate homeostasis using hiker model



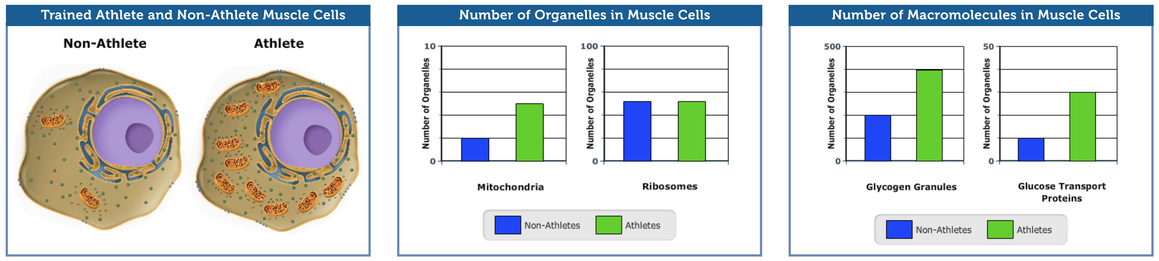
EVIDENCE OF INTEGRATED UNDERSTANDING

Raw scores are an inadequate measure of integrated understanding. For model-based learning about complex systems, we need to look at what components and interactions they express, coherence of their statements, consistency with correct response.

The complex system representation below on the left identifies the components and interactions that are the essential parts of the model students need to answer questions testing the integration of their understanding.

Based on our conceptual analyses, the question in the benchmark that best elicits integrated understanding is the final task of the assessment:

"How do these cellular components work together to help athletes perform well?"



Integrated Understanding

"More mitochondria are able to help produce more ATP to use as energy in the muscle so it can function well. More glycogen is useful because it can be broken down into glucose through glycolosis which allows more ATP to be created. More glucose transport proteins allow more glucose to enter the cell so it can be turned into ATP for the athlete to use."

"Glucose transport proteins transport glucose across the cell membrane. More glucose means more energy that the mitochondria can produce. This means that having more mitochondria lets athletes produce more energy and thus use energy for longer periods of time."

Isolated Structure-Function Statements

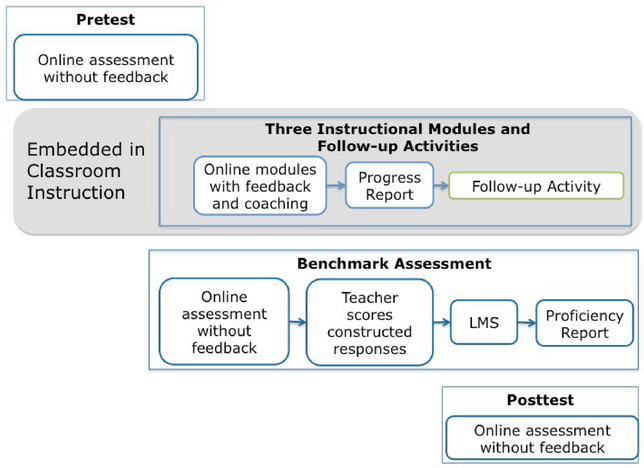
"MItochondria makes energy with glucose, glycogen granules make glucose, and glucose transport proteins take in more glucose."

"The transport proteins take in glucose, the mitochondria changes it to energy, and the glycogen is the storage of glucose."

"Well the mitochondria produces ATP through cellular respiration. And in cellular respiration, glucose is also needed. the glucose transport protiens, transport glucose into the cell. And glycogen is stored glucose."

HBS SimScientists Team: Mark Loveland, Kim Luttgen, Carol Chen, Marina Varfolomeeva

HBS CLASSROOM IMPLEMENTATION



RCT STUDY RESULTS

EAP reliability of outcome measures (2PL-IRT)

- Posttest 0.86
- Benchmark 0.92

Significant attrition

- Only half of the teachers in each group completed the study

HLM analyses

- Used imputed data

No significant difference

- Between treatment and control groups

Standardized effect size

- Pre/post = 0.09
- Benchmark = 0.12

Teachers

- Found HBS easy to use
- Had difficulty integrating modules into their curricula
- Integration was difficult in part due to computer access issues

DISSEMINATION

The suite is being converted from Flash to HTML5 to make these materials accessible on iPads and tablets and allow more wide-spread use in the classroom. The modules will be available for the 2016-2017 school year.

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