Probing Middle-School Students' Understanding of Computer Models

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How do 7th Graders Interpret Computer Models of Science Phenomena?

Goal: Determine how students make sense of rules governing computer models.

Method: 133 7th graders of one teacher responded to questions about interactive computer simulations., which modeled scientific phenomenon and produced graphs of the data.
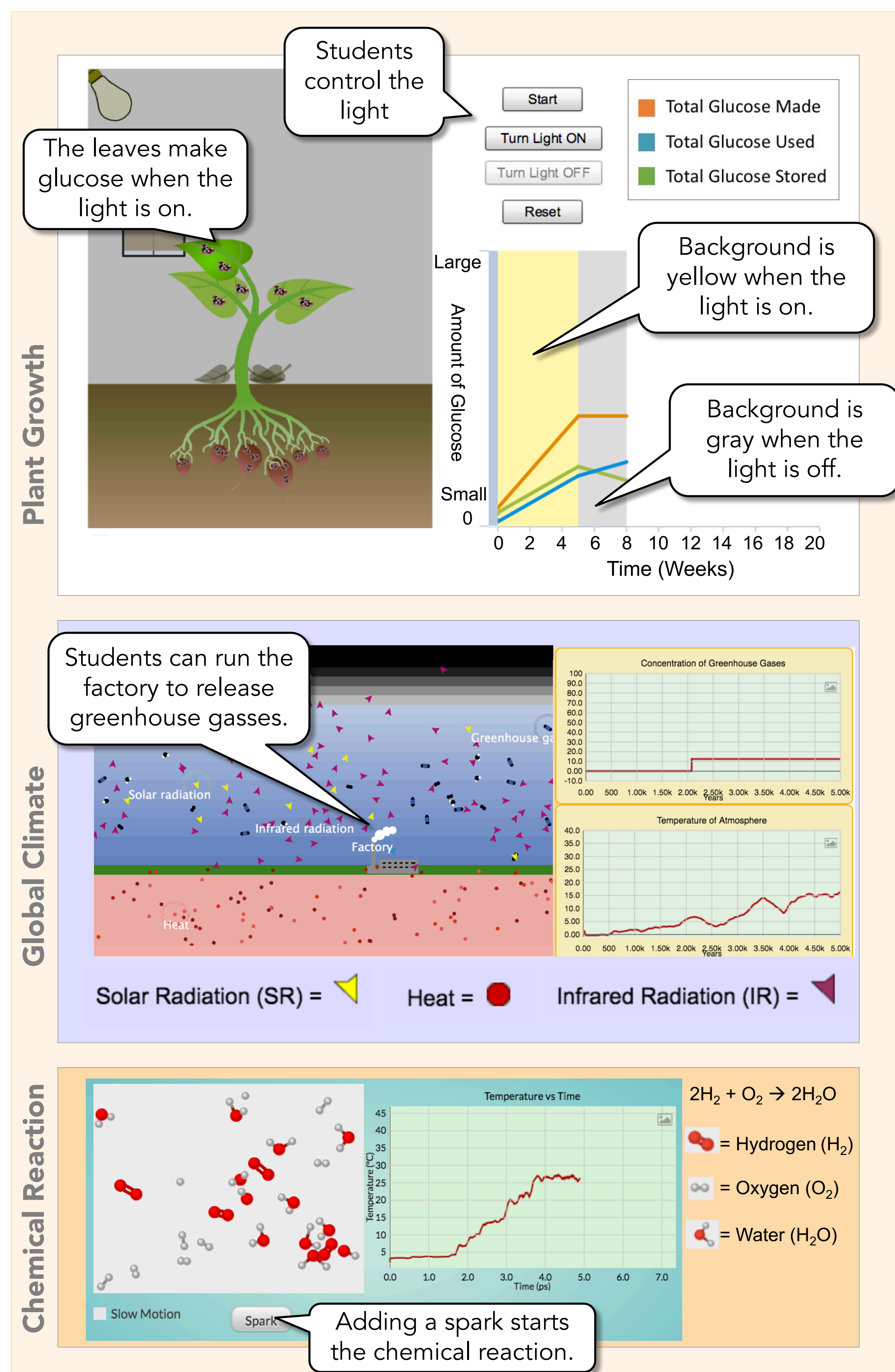
We Found that Students:

- Rarely extract normative causal relationships.

- Often expressed ideas about the underlying science when asked about rules that govern a model.

- Rarely consider the concept of model accuracy.

Conclusion: 7th graders need support to understand models as tools for communicating and testing hypotheses. Instruction on models will likely support learning the science content.

Students Often Misunderstand the Nature of a Model

Role of icons. Some students believe that changing the icons in a model will automatically change their behavior. They do not realize that the behavior is specified by a programmer.

Role of the model. Some students recommended prosocial or anthropomorphic model changes, rather than ones that will test a scientific hypothesis.

Plant Growth: *How can the model show the effect of natural light?*
MC: Remove the on/off switch, and replace the light bulb with the sun shining. *Explain:* It'll be more helpful if they got the real thing instead of the light bulb.
MC: Daylight is longer in the summer than in the winter. *Explain:* Because in the summer you get more light and when you get more light your plant will grow bigger and bigger

Climate: *What would you change to make the model more accurate?*
I would put in solar panels; I think we should get rid of or destroy factories

Chemical Reactions: *Tom says the model must include a rule that says, "The temperature must always be higher than 0 degrees Celsius."*
MC: Agree. *Explain:* Because it would be too cold for the molecules to warm up and they would die.

Students Rarely Find Normative Causal Relationships When Asked to Explain What the Model Shows:

Plants: According to the model, what is the relationship between light and glucose? What does the graph show about the relationship between glucose made, glucose stored and glucose used?

Climate: What is the effect of running the factory? Explain how the model shows the relationship between greenhouse gases and the temperature?

Chemical Reactions: Explain the relationship between the movement of the molecules and the temperature.

Responses with Causal Mechanisms or Observations	Plant Growth	Global Climate	Chemical Reactions
No causal mechanisms. The temperature is always higher than 0.	60%	53%	18%
Incorrect causal mechanism. The light is attracted to the glucose in the plant.	9%	< 1%	9%
Partial or incorrect direction of causation. The concentration of the greenhouse gases rises with the temperature of the atmosphere.	0%	5%	45%
Causal mechanism. When the factory started running the infrared radiation got knocked in the other direction by the gas and the atmosphere's temperature slowly started to rise.	8%	6%	0%
Other Responses			
Unportrayed event. The red stays away from the white and when they hit the white they disappear.	16%	17%	16%
Model Mechanics. The effect of running the factory is that it releases greenhouse gasses into the atmosphere.	< 1%	16%	3%
Other (e.g., self-contradictory, extrapolation): The light may effect the plants ability to make or not make food because plants use photo synthisis; The model shows how global warming is bad.	5%	3%	0%

Blank and non-substantive responses as a percentage of total for each topic: Plant: 4%, 13%; Climate: 24%, 12%, Chemical Reactions: 14%, 11%.

Students Rarely Evaluate Accuracy Meaningfully, And When They Do They Are Skeptical:
Baohui says: "This model is completely accurate: it shows exactly what happens when there are hydrogen molecules, oxygen molecules, and a spark." Agree or Disagree? Explain.

Percent of Substantive Reponses in Each Category	
Descriptive. They had a graph, they had a picture of everything moving and I think that this explains a lot of things for me to understand.	49%
Superficial or Non-Substantive. The model is as accurate as it gets.	38%
Skeptical. Since there is no evidence where the model is from, I don't believe it is completely accurate. Maybe some parts of it could be accurate; This is not true because you can never account for randomness; I disagree because a spark doesn't occur naturally to make the molecules move.	13%

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Students Have Difficulty Applying Counterfactual Model Rules, Yet Doing So Can Elicit Causal Mechanisms:
A programmer added a new rule to this model: "When solar radiation reaches the surface of the earth, the solar radiation will always bounce off." Given this new rule, what would be the effect upon temperature compared to the original model?

	Non-normative Scientific Mechanism	Normative Scientific Mechanism
Non-normative rule application.	It will take a slower time to reach us and bounce off. 60%	[not found]
Normative rule application.	The temperature of the air would rise but the temperature of the ground would decrease. 15%	It would be less hot because the reaction solar energy has with the ground is what makes the heat energy. 25%

Of 133 responses, 38% were blank, 12% were not substantive, and 8% were correct without elaboration.
Table shows the 42% of responses (n = 55) that included elaboration.