

# Learning about Climate Change through Cooperation

Lauren R. Applebaum, University of California, Berkeley, lauren.applebaum@berkeley.edu

Kyle W. Fricke, University of Texas at Austin, kyle.w.fricke@gmail.com

Jonathan M. Vitale, University of California, Berkeley, jonvitale@berkeley.edu

Marcia C. Linn, University of California, Berkeley, mclinn@berkeley.edu

**Abstract:** Students maintain a range of alternative ideas around the causes of climate change (Rye et al., 1997). To help students diversify their repertoire of ideas, we engaged students in a cooperative activity in which individual students chose to investigate one of three possible topics (meat-eating, albedo, or ozone), and then reported back to their peers. Students investigated Netlogo (Wilensky, 1999) models that included features relevant to their chosen topic. After exploring one of the computer models, students met in jigsaw groups (Aronson & Patnoe, 2011). Results on assessment items matched to each investigation show that scores improved across all topics for all students. However, students in the meat-eating investigation show more improvement for the meat-eating item, while students who investigated albedo and ozone performed equally well on all items. These findings suggest that the jigsaw activity helped all students learn about the causes of climate change from their peers.

**Keywords:** knowledge integration, climate change, jigsaw, computer models

## The major issue

Middle school students maintain a range of alternative ideas around the causes of global climate change (Rye, Rubba, & Wiesenmayer, 1997). One of the most strongly held ideas is that ozone hole depletion and ultraviolet radiation are the primary causes for global warming. In order to help students integrate new ideas about climate change into their repertoire, we implemented student-led computer-based investigations, as well as a collaborative jigsaw activity (Aronson & Patnoe, 2011) to promote understanding of causes of global warming.

One way to help students integrate new ideas about global climate, such as the effects of greenhouse gases, is through computer models (Vitale, McBride, & Linn, 2016). Through model use, students can alter model features and observe the impact on temperature. For example, students can change the number of factories running at a time and monitor the relationship between greenhouse gases and temperature through graphs. Yet, given the complexity of the topic and the range of factors to be studied, students may lose interest or become uninvolved in the investigations. To encourage student participation and interest, we implemented a collaborative jigsaw activity. The “jigsaw method” (Aronson & Patnoe, 2011) allows for students to engage in deep exploration of model features while also supporting student involvement (Lazarowitz et al., 1994) and cooperative integration of new ideas. By allowing students to choose their own investigation and engage in discussions with their peers, students can discover the value of finding answers for themselves and working together with other students to gain new knowledge (Songer, Lee, & Kam, 2002). Yet, whether students benefit equally from listening to their peers and investigating their own topics is an open question.

In order to promote a greater number of ideas around global warming, students chose one of three model-based investigations: meat-eating, albedo (surface reflectivity), or ozone. Following students’ investigations, two students representing each topic met in a small group to discuss their findings. We have two main research questions: 1) Do all students make more conceptual links across all topic areas at posttest compared to pretest? 2) Do students become “experts” in their topic areas?

## Potential significance of work

The work presented here attempts to not only explore methods that successfully teach students about factors related to climate change, but it also seeks to validate a jigsaw activity as a productive way for results of computer simulations to be shared. Specifically, is personally exploring a computer model just as effective as hearing about a model from a peer? By showing gains from pre- to posttest on three assessment items that match the investigation topics, we suggest that jigsaw activities allow students to delve into topics of interest through computer model exploration, while also supporting knowledge gains in areas they did not personally explore.

## Methodological approaches

We tested 273 8<sup>th</sup> grade students from the classrooms of 2 teachers at a middle school in the northwest United States. Students used the web-based inquiry science environment (WISE) unit *What Impacts Global Climate*

*Change?* The unit consisted of a 5-class-period lesson on climate change, with a focus on the chemical reactions that affect global temperatures. Following the main unit, students began a 2-day *challenge* unit extension during which students chose to investigate one of three topic options related to global climate change.

### Independent investigation

During the challenge unit, students had the opportunity to independently investigate the relationship between climate change and one of the following topics: meat-eating, albedo, or ozone. Each student ranked the investigations by preference. The second author made great efforts to ensure that each student was able to investigate either their first or second choice while ensuring that each topic was equally represented.

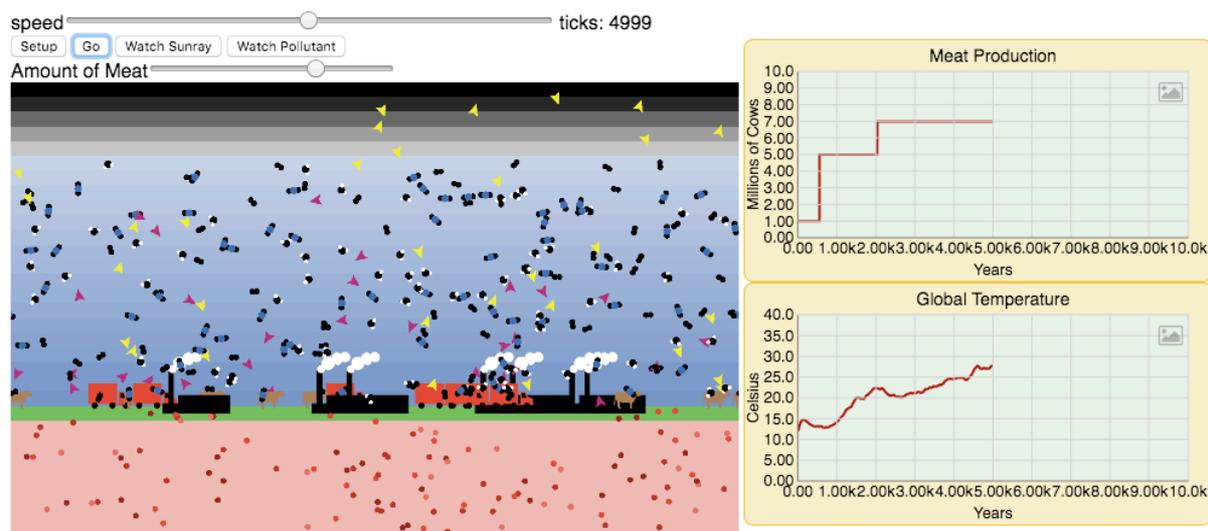


Figure 1. Snapshot of meat-eating investigation model.

To start their investigations, students saw a computer model that matched their topic (see Figure 1 for a snapshot of a meat-eating model). After exploring the model, students generated research questions that could be answered using the model. Once students selected their research question and explained the data they would need to answer their question, students gathered their data using the computer model. Computer model exploration was followed by reflection prompts about their investigation and their findings.

### Collaborative jigsaw activity

After completing their investigations and reporting the results of the findings within WISE, students participated in a jigsaw activity. During the jigsaw activity, students were placed in groups of six (two students from each topic). Students were asked to present the findings of their investigations to their group members.

### Assessments

At pre- and posttest students were asked 3 questions relevant to the challenge (one question for each topic). For meat-eating: *Suppose everyone on earth started eating twice as much meat as they do now. Would that make earth's climate colder, hotter, or have no effect? Explain your reasoning.* For albedo: *Suppose we covered the Earth's land with giant mirrors. Would that make earth's climate colder, hotter, or have no effect? Explain your reasoning.* For ozone: *Does the ozone hole make earth's climate significantly colder, hotter, or have no effect? Explain to [fictional character name] the role of ozone in global warming.*

### Coding

Scoring (1-5) was completed using knowledge integration rubrics (Liu, Lee, & Linn, 2011). Knowledge integration acknowledges the diverse set of ideas that students hold. Without penalizing for alternative ideas, the knowledge integration rubric focuses on the links between two ideas and awards higher scores for not just stating normative ideas but also linking them together. Links for each item can be found in Table 1.

Table 1. Links for each assessment item.

Pre-/Posttest item	Link
Meat-eating	Cows/trucks/factories release greenhouse gases AND this leads to higher temperatures
	Greenhouse gases reflect infrared radiation AND this leads to higher temperatures
Albedo	Mirrors reflect solar radiation AND this leads to lower temperatures
	Mirrors prevent infrared radiation from transforming into heat beneath the earth's surface AND this leads to lower temperatures
Ozone	Ozone protects us from UV rays AND this does not affect temperature
	The amount of ozone can increase or decrease AND this does not affect temperature

## Major findings

### Overall

Students at pretest held, on average, non-normative or incomplete ideas about the effects of meat-eating, albedo, and ozone on global temperatures (meat-eating:  $M=2.21$ ,  $SD=.61$ ; ozone:  $M=2.07$ ,  $SD=.50$ ; albedo:  $M=2.54$ ,  $SD=.90$ ). By posttest, student scores were higher on all items (meat-eating:  $M=3.20$ ,  $SD=.97$ ; ozone:  $M=2.88$ ,  $SD=.94$ ; albedo:  $M=2.94$ ,  $SD=1.11$ ). The differences between pre- and posttest scores were significant for all questions (meat-eating:  $M=.99$ ,  $SD=.99$ ,  $t(247)=15.85$ ,  $p<.001$ ; ozone:  $M=.81$ ,  $SD=1.07$ ,  $t(236)=11.62$ ,  $p<.001$ ; albedo:  $M=.40$ ,  $SD=1.21$ ,  $t(249)=5.35$ ,  $p<.001$ ). See Figure 2 for average assessment scores by question.

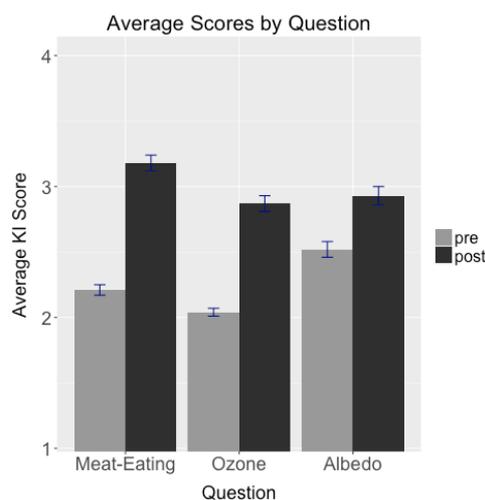


Figure 2. Average scores by question.

### How does the investigation affect student performance?

Recall that students had direct experience with only one of the investigations before learning from their peers and that they were responsible for explaining their findings to their peers. Therefore, we ask: is student performance better for the item matching the investigation the student conducted themselves? In order to answer this question, we conducted a mixed effects regression with random effects for student and fixed effects for pretest score (totalled across all three pretest items), teacher, and dummy variables for whether the investigation the student conducted matched the assessment item. (See Figure 3 for posttest score averages by investigation.) Pretest score significantly predicted posttest performance ( $\beta=.19$ ,  $p<.001$ ), as did teacher (students in teacher A's class performed significantly better than students in teacher B's class:  $\beta=.21$ ,  $p=.01$ ). The effect of the meat-eating investigation was significant ( $\beta=.52$ ,  $p<.001$ ), which suggests that students who chose the meat-eating investigation performed significantly better on the meat-eating posttest item than those students who conducted a different investigation. There were no effects for either of the other two investigations on posttest performance (albedo:  $\beta=-.007$ ,  $p>.1$ ; ozone:  $\beta=.11$ ,  $p>.1$ ).

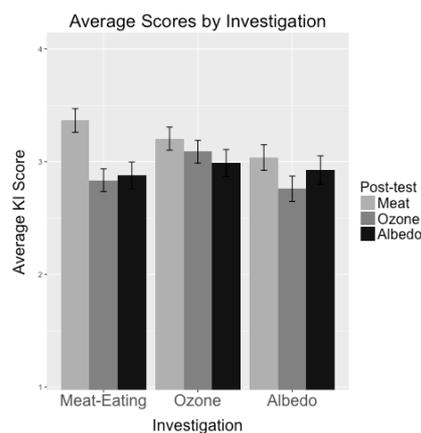


Figure 3. Average posttest item scores by student investigation.

## Conclusions & implications

Study results show that regardless of investigation choice, students made gains on all assessment items. This suggests that the jigsaw activity performed one of its main functions: to help students integrate knowledge from a diverse range of ideas, regardless of their investigation choice. This provides evidence that students learned from their own investigation and from peer descriptions of the other investigations. Interestingly, students in the meat-eating investigation seemed to become “experts.” The advantage for the meat-eating investigation may, in part, be due to differences in relevant prior beliefs. At pretest, students had little prior knowledge regarding meat-eating (e.g., “Why would meat effect the Earth's climate”, “eating meat has nothing to do with temperature”). On the other hand, regarding albedo, students often (correctly) recognized that surface reflectivity decreases temperatures. Conversely, for ozone, students often (incorrectly) implicated ozone depletion in climate change. The extent to which investigations provided evidence that was surprising or conflicted with prior beliefs likely impacted the effectiveness of collaborative groups. For example, it might be the case that having little prior exposure or intuition around the role of meat-eating and temperature made the simulation particularly salient as they discovered something novel, whereas the discovery that ozone does not impact climate change is potentially less striking, and may be equally-well conveyed through discussion.

Overall this study suggests that simulation-based jigsaw activities can confer learning benefits to students who engage with the simulation directly and to students who learn from their peers. These results are promising given the affordances of simulations in modeling complex phenomena such as climate change.

## References

- Aronson, E. & Patnoe, S. (2011). *Cooperation in the classroom: The jigsaw method* (3<sup>rd</sup> ed.). London: Pinter & Martin, Ltd.
- Lazarowitz, R., Hertz-Lazarowitz, R., & Baird, J. H. (1994). Learning science in a cooperative setting: Academic achievement and affective outcomes. *Journal of research in science teaching*, 31(10), 1121-1131.
- Linn, M. C., & Eylon, B. S. (2011). *Science learning and instruction: Taking advantage of technology to promote knowledge integration*. Routledge.
- Liu, O. L., Lee, H. S., & Linn, M. C. (2011). Measuring knowledge integration: Validation of four-year assessments. *Journal of Research in Science Teaching*, 48, 1079–1107.
- Moskowitz, J. M., Malvin, J. H., Schaeffer, G. A., & Schaps, E. (1985). Evaluation of jigsaw, a cooperative learning technique. *Contemporary educational psychology*, 10(2), 104-112.
- Rye, J. A., Rubba, P. A., & Wiesenmayer, R. L. (1997). An investigation of middle school students' alternative conceptions of global warming. *International Journal of Science Education*, 19(5), 527-551.
- Songer, N. B., Lee, H. S., & Kam, R. (2002). Technology-rich inquiry science in urban classrooms: What are the barriers to inquiry pedagogy? *Journal of Research in Science Teaching*, 39(2), 128-150.
- Vitale, J. M., McBride, E., & Linn, M. C. (2016). Distinguishing complex ideas about climate change: Knowledge integration vs. specific guidance. *International Journal of Science Education*, 38(9), 1548-1569.
- Wilensky, U. (1999). *NetLogo (and NetLogo user manual)*. Center for Connected Learning and Computer-Based Modeling, Northwestern University. <http://ccl.northwestern.edu/netlogo>.