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Research Enhances Scientific Literacy

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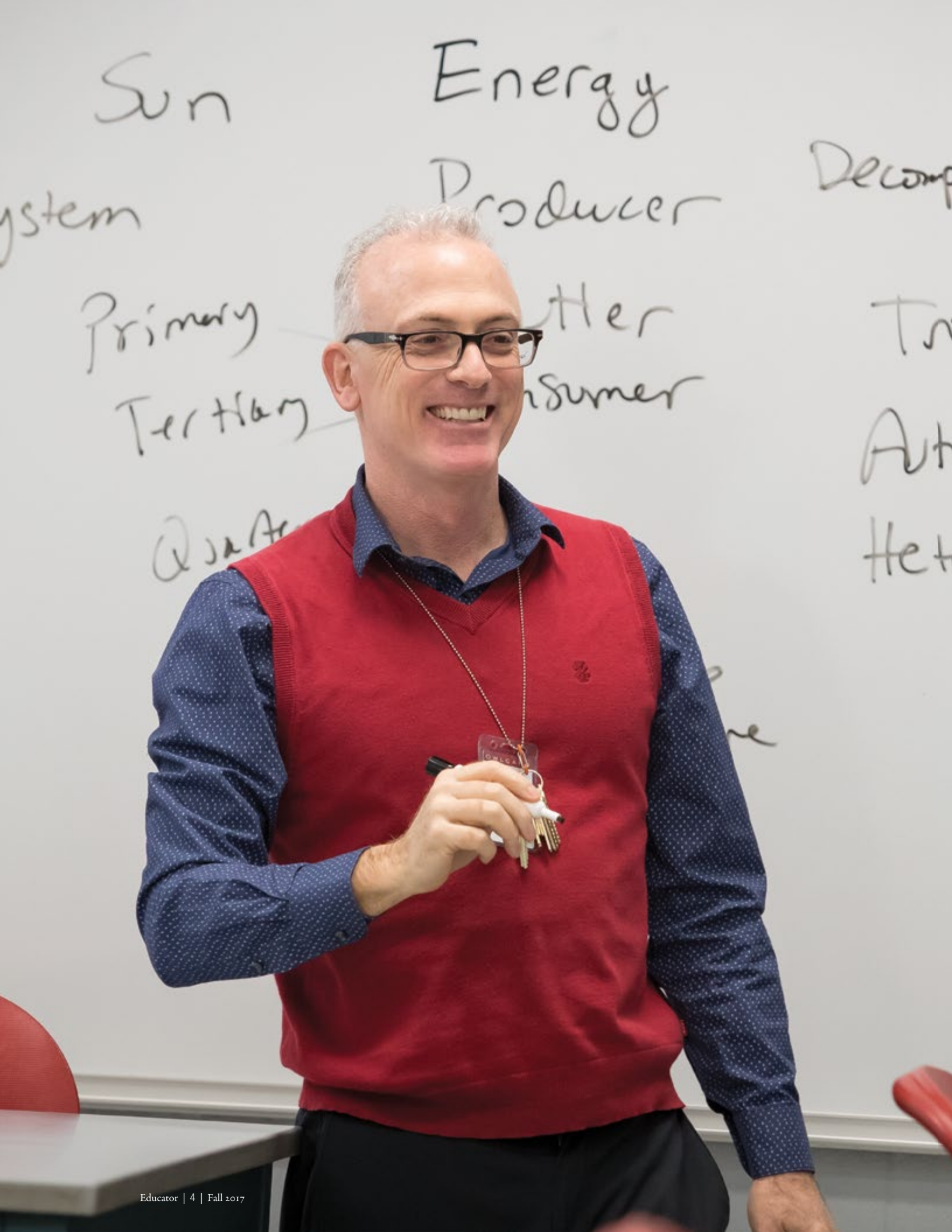
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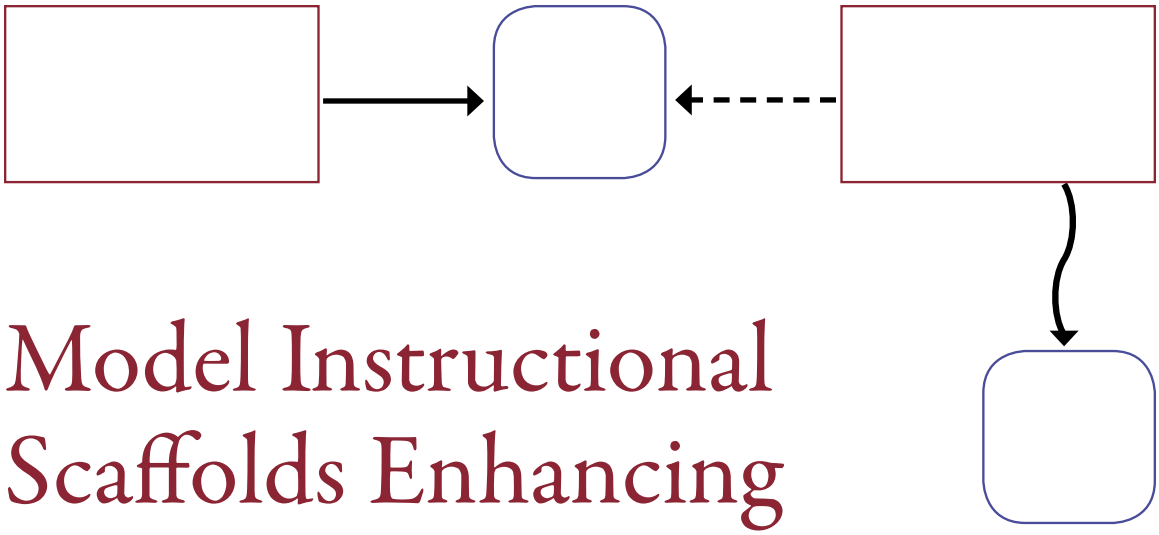


Model Instructional Scaffolds Enhancing Students' Scientific Literacy

Just a week after the last of three powerful hurricanes had devastated Texas, Florida and the Caribbean, a dozen freshmen in an honors environmental earth science class at New Jersey's Toms River High School South were grappling with two possible climate change models:

A: Our current climate change is caused by increasing amounts of gases released by human activities.

or

B: Our current climate change is caused by increasing amounts of energy released from the sun.

To help them judge which explanation is more plausible, teacher Charlene Wallace had given each of them a worksheet developed by Temple researchers that listed the two alternative models, plus some climate change evidence. The students' task: to use variously colored pencils to draw lines that diagrammed and indicated whether they believed each of four pieces of evidence strongly supported, supported, contradicted or had nothing to do with each of the two possible models.

The evidence included:

1. **Atmospheric greenhouse gas concentrations, and temperatures, have risen for the past 50 years; human activities have resulted in greater greenhouse gas releases.**
2. **Since 1970, the Earth has received less of the sun's energy due to decreased solar activity, but temperatures have continued to rise.**
3. **Satellites are measuring more of the Earth's energy being absorbed by greenhouse gases.**
4. **Prior to the Industrial Revolution, increases and decreases in solar activity closely matched increases and decreases in global temperatures.**

After they reviewed the information and made preliminary judgments individually, the students gathered into four-person discussion groups. In one group, a boy said that he felt that the evidence of declining solar activity had nothing to do with the human activity model.

"Actually, I put that as supporting it, because if solar activity is decreasing, that makes it more likely that it's just the greenhouse gases," another boy responded.

"Yeah," conceded the first boy, now understanding the connection he had initially missed.

Addressing the third evidence point, regarding satellites measuring more greenhouse gas absorption, the lone girl in the group felt it only mildly supported human-caused climate change—in part because it gave no indication how much more the greenhouse gases were being absorbed.

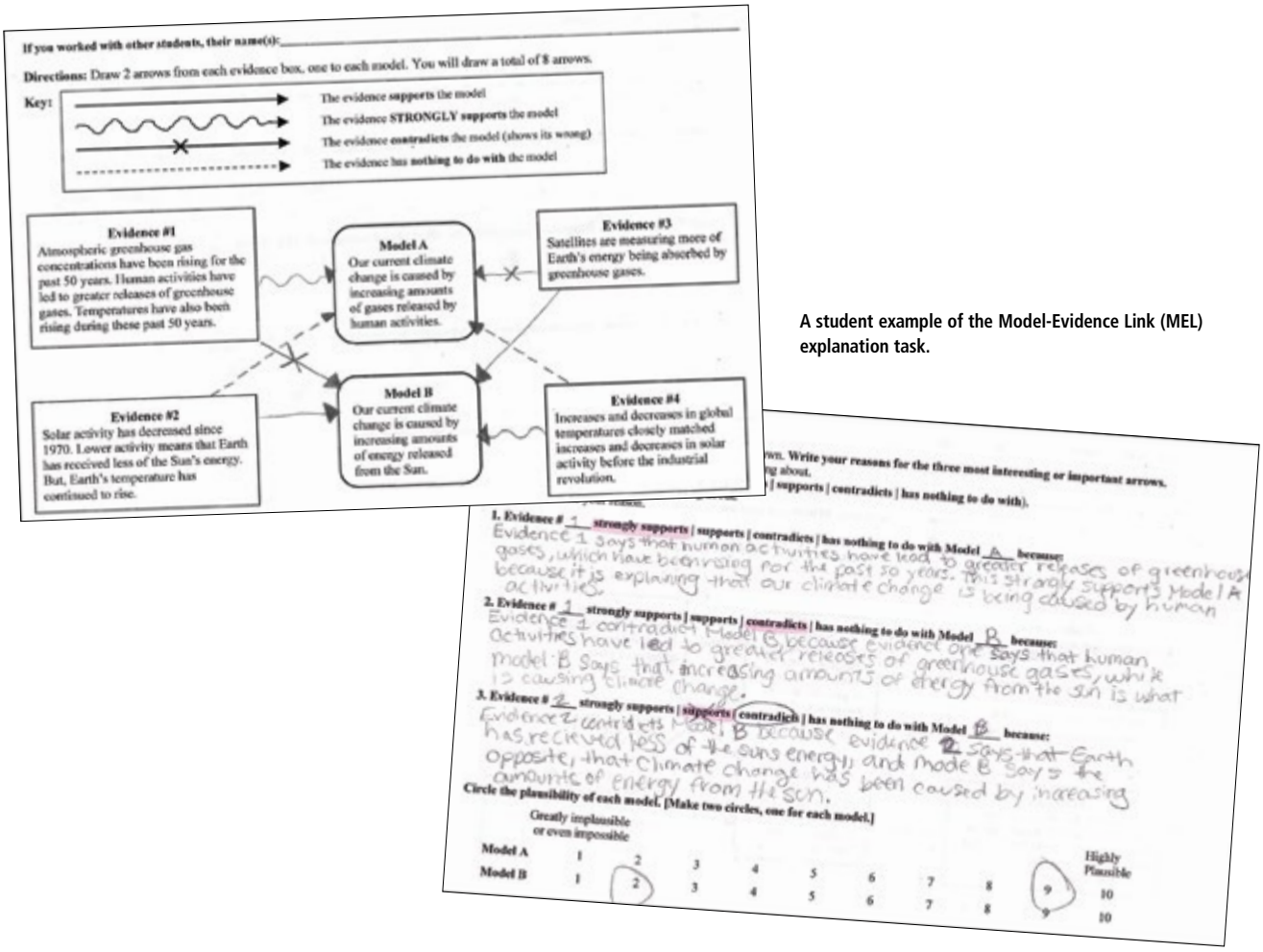
"I think it strongly supports it," countered the second boy, "because it says more of the Earth's energy is being absorbed by greenhouse gases, and Model A talks about how energy is being released by human activity."

When the group moved on to consider Model B, which attributes climate change to changing levels of solar activity, the girl said, "I didn't have anything strongly supporting that."

"Me neither," said the second boy.

"In fact," added the girl, "Model B was contradicted by three of the four evidences."

Their conclusion: on a scale of 1 to 10, the plausibility of human activity causing climate change rated an 8; the sun merited only a 2.



A student example of the Model-Evidence Link (MEL) explanation task.

"Scientific literacy is under siege," says Doug Lombardi, assistant professor of science education. "We live in a country where scientific evidence is not valued, where everybody thinks that any opinion has as much merit and validity as any other.

"We're trying to figure out how to get students scientifically literate, so that when they are in the voting booth or otherwise making decisions about their community, region or the globe, we want them to think in the scientific manner."

Lombardi is a former U.S. Air Force weather officer; engineer/research associate at the Oak Ridge National Laboratory; high school science teacher; and NASA high school astronomy coordinator and education & public outreach manager. In 2013, he and his co-principal investigator and wife, Janelle Bailey, assistant professor of science education, received an exploratory $450,000 grant from the National Science Foundation. They wanted to learn if instructional scaffolds could help students evaluate the merits of scientific explanations compared to plausible, but non-scientific, alternatives.

Building upon concepts first developed by Rutgers University, the Temple researchers created Model-Evidence Links diagrams, or MELs, that helped students explore four socio-scientific topics: climate change, wetlands and land use, fracking and earthquakes and the formation of the Earth's moon.

Wallace was one of seven teachers in New Jersey and Nevada who used these MEL prototypes in their classrooms. The results were so promising that this year the NSF increased its funding five-fold, to nearly $2.4 million over four years, to expand the research. The latest goal: to see how well students can utilize the same steps they are learning in school to think critically about science questions outside of class—for the rest of their lives.

Wallace is a big believer: "In science, students often work with lab partners but not so much with groups, and when I began using the MELs it was the first time I felt I was really approaching student-based learning, where the students really had to work together, talk about it and come up with their own conclusions.

Science teacher Charlene Wallace and Assistant Professor Doug Lombardi speaking about his instructional scaffolds in her Toms River High School South classroom.

"It really opened my eyes to how much students can learn from each other. I think it's incredibly helpful."

Expanding upon the concepts, she was working with her students' English teachers in assigning them to write persuasive essays to newspapers and government officials regarding climate change. She also has created her own MELs for her biology classes, including for evolution.

Missy Holzer, a long-time science teacher at Chatham High School in New Jersey who has participated in both NSF grants, agrees: "It's terrific because it really messes with the students' heads. It forces them to think critically about plausible information and how to decide what's right or wrong when dealing with contradictory material.

"Rather than just reading something in a textbook, which is just a piece of information coming at you, the process is night-and-day in terms of actually getting students involved and talking about the data and evidence."

After observing one of Wallace's classes, Lombardi said, "In terms of actual instruction time, Charlene didn't have to do a lot because she really implemented it so well. It was outstanding."

Last year, Lombardi—along with his two doctorate advisors at the University of Nevada, Las Vegas, Professor E. Michael Nusbaum of the UNLV and Professor Gale Sinatra of the University of Southern California—published the educational theory that underpins the MELs in *Educational Psychologist*, the premier educational psychology journal. "The plausibility judgement that the students are making is a judgment on the explanation or models of what, in this case, is causing climate change. It's not judging the evidence," says Lombardi. "Based on the available evidence, scientists say: 'Is this a plausible explanation?'

"When we have ideas about the world and the way things work that are wrong, it's very difficult to change those concepts," he adds. "Telling people they're wrong doesn't work.

"Instead, based on what we know about cognitive development, we're trying to develop students to become more critical thinkers when evaluating alternative explanations, to activate their scientific thinking when confronted with scientific information.

"It's not a silver bullet, it's just one of the tools you can use to help, in a small but meaningful and important way, to enhance scientific literacy."

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