Please direct any inquiries to Mariel Halpern
Mariel.halpern@temple.edu

Students' Informal Reasoning, Evaluations, and Plausibility Perceptions About Climate Change

Mariel Halpern, Doug Lombardi, & Janelle M. Bailey
Temple University

Abstract

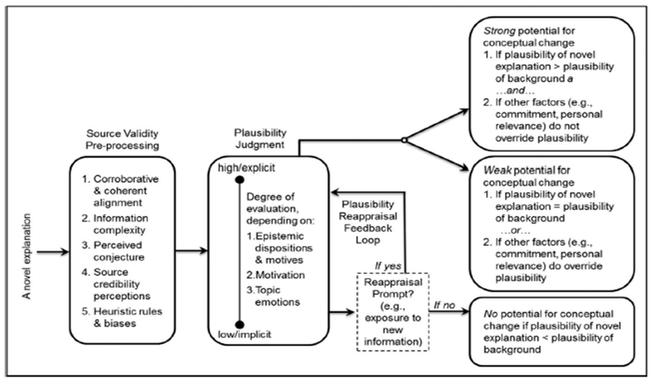
Scientists engage in a wide variety of practices, such as generating ideas, coordinating theories with evidence, and critically evaluating arguments. Current science education reform efforts call for students to be critically evaluative of alternative explanations in a way that reflects scientific practice. The purpose of the present study was to examine students' depth of evaluation while engaging in a MEL activity around the topic of climate change. We analyzed students' Depth of Critical Evaluation (DCE) to identity and track changes in students' scientific thinking. Our findings suggest that participation in the MEL diagram activity instantiates scientific modes of thinking.

Purpose & Research Questions

- The purpose of this study was to examine students' depth of critical evaluation while engaging in a MEL activity around the topic of climate change.
- Two research questions guided our study:
  - What evaluations do students make in a collaborative discourse activity?
  - What evidence of plausible reasoning is present in students' evaluations?

Background

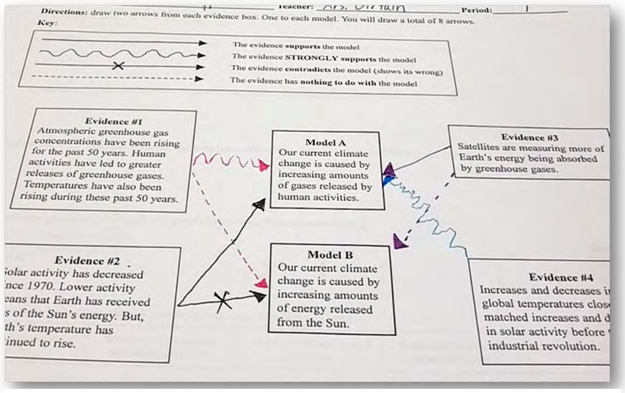
- Scientists use informal reasoning processes, involving building arguments in response to open-ended, ill-structured, and complex societal issues (Çalik & Coll, 2012; Means & Voss, 1996; Sadler, 2004;Wu & Tsai, 2007).
- Informal reasoning skills may be of considerable importance, because students encounter issues that lack clear cut solutions in 'real life,' and also reason with conflicting and abstract information.
- Students struggle with figuring out what is "potentially truthful," or plausible, and what is not when judging competing knowledge claims (Çalik & Coll, 2012, Lombardi, Bickel, Bailey, & Burrell, 2017).
- Lombardi et al. (2016), recently developed a theoretical model on the role of Plausibility Judgements in Conceptual Change (PJCC)



- The next generation of students should be able to navigate relatively ambiguous societal issues for educated citizenry (Sadler, 2004; Sinatra, Kienhues, & Hofer, 2014; Wu, 2013).
- Because learners understanding of science appears to be amenable to change (National Research Council [NRC], 2010), there is reason to suspect that instructional scaffolds may affect student thinking and reasoning.

Model-Evidence Link (MEL) Diagrams

- Model-evidence link (MEL) diagram activities welcome reasoned discourse and evaluation of competing explanations about scientific topics (e.g., climate change) and stimulate students' epistemic growth (Lombardi, Sinatra, & Nussbaum, 2013).
- MELs are easily integrated into the curriculum because they are modular and can be used as a substitute for more traditional, but less effective, instruction.
- The mode and structure of MEL diagrams were originally developed by a team of researchers at Rutgers University (Chinn & Buckland, 2012).



An example of how students complete a model-evidence link (MEL) diagram about explanations of current climate change.

Methods

- High school (grades 9-12) students from a small, northeastern suburban districts (majority White and upper middle class).
- Students participated in the MEL diagram activity around the topic of climate change in small groups of 4
- Participants' discussions were recorded and transcribed

Results

- To capture participants' knowledge construction processes, we examined their Depth of Critical Evaluation (DCE).
- We identified three DCE categories: *DCE-Dimension 1* (*DCE-D1*), *DCE-Dimension 2* (*DCE-D2*), and *DCE-Dimension 3* (*DCE-D3*).
  - *DCE-D1* was comprised of relating lines of evidence only within the purview of the MEL diagram activity
  - *DCE-D2* includes information or sources of knowledge both within and outside of the purview of the MEL diagram activity; with empirical indication of participants' considerations of the consistency of evidence with established models
  - *DCE-D3* builds upon *DCE-D2* but is distinguished by offering alternatives, evaluating others' viewpoints, or broadly applying knowledge.

Results

Descriptive Statistics from the coding analysis

Group	*n* students	Chunk	Total sentences	Off task sentences	Consensus	*n* sentences DCE-D1	*n* sentences DCE-D2	*n* sentences DCE-D3	Plausibilistic Reasoning (E, I, N)
08_G4	4	1	13	1	Yes	6	5	0	N
		2	13	0	Yes	1	1	0	N
08-G5	4	1	12	0	No	5	2	0	E
		2	14	0	No	3	0	0	E
		3	22	0	No	1	0	0	E
		4	18	0	No	1	0	0	E
		5	12	0	Yes	6	1	0	E
		6	11	0	Yes	0	0	0	N
		7	18	0	Yes	1	0	0	N
		8	17	0	NA	5	0	0	N
01_V1	4	1	19	0	Yes	7	0	0	I
		2	9	1	Yes	5	1	0	N
		3	11	0	Yes	1	2	0	I
		4	12	0	No	1	0	0	I
		5	16	0	No	6	3	0	E
		6	14	0	Yes	0	7	0	N
		7	20	0	Yes	0	3	2	N
		8	14	0	Yes	2	4	0	E
		9	18	0	Yes	0	0	9	E
		10	14	0	NA	NA	NA	NA	NA
02_V1	4	1	9	NA	NA	NA	NA	NA	NA
		2	18	0	NA	0	1	0	NA
		3	13	1	NA	0	1	0	NA
		4	12	0	Yes	0	0	0	N
		5	18	9	Yes	0	0	0	N
		6	7	0	NA	0	0	0	NA
		7	14	4	Yes	0	1	0	N
		8	15	7	Yes	1	0	0	E
		9	24	2	0	0	0	0	E
		10	9	1	Yes	1	0	0	N
		11	19	11	Yes	1	0	0	N
		12	16	1	NA	NA	NA	NA	NA
		13	13	4	NA	0	0	0	N
		14	17	17	NA	NA	NA	NA	NA
		15	12	7	No	0	5	0	N
		16	9	3	No	1	0	0	N
		17	13	13	NA	NA	NA	NA	NA
		18	17	17	NA	NA	NA	NA	NA
		19	24	9	No	0	2	0	N
		20	19	14	yes	1	0	0	N
		21	10	6	Yes	4	0	0	N
		22	29	29	NA	NA	NA	NA	NA
		23	13	11	No	0	1	0	N
		24	12	4	Yes	3	1	0	N
		25	10	0	No	2	0	0	E
		26	10	NA	NA	NA	NA	NA	NA

Note. NA = not applicable, where participants mainly read off of the MEL diagram.

Implications

- Our findings show that participation in the MEL encourages collaborative discourse and promotes critical evaluation to reappraise plausibility judgements
- When used as a small group activity, the MEL serves as a resource that potentially contributes to student understanding of the dynamic processes which underlie growth of scientific knowledge

References

Çalik, M. & Coll, R. K. (2012). Investigating socioscientific issues via scientific habits of mind: Development and validation of the scientific habits of mind survey. *International Journal of Science Education, 34(12),* 1909-1930.
Chinn, C. A., & Buckland, L. A. (2012). Model-based instruction: Fostering change in evolutionary conceptions and in epistemic practices. In K. S. Rosengren, E. M. Evans, S.Brem, & G. M. Sinatra (Eds.), Evolution challenges: *Integrating research and practice in teaching and learning about evolution* (pp. 211-232). New York, NY: Oxford University Press.
Erduran, S., & Dagher, Z. R. (2014). Scientific knowledge. *Reconceptualizing the nature of science for science education*. Netherlands: Springer.
Lombardi, D., Bickel, E. S., Bailey, J. M., & Burrell, S. (2017). High school students' evaluations, plausibility (re) appraisals, and knowledge about topics in Earth science. *Science Education.* Manuscript submitted for publication.
Lombardi, D., Danielson, R. W., & Young, N. (2016). A plausible connection: Models examining the relations between evaluation, plausibility, and the refutation text effect. *Learning and Instruction, 44,* 74-86.
Lombardi, D., Sinatra, G.M, & Nussbaum, M. E. (2013). Plausibility reappraisals and shifts in middle school students' climate change conceptions. *Learning and Instruction, 27,* 50-62.
Means, M. L. & Voss, J. F. (1996). Who reasons well? Two studies of informal reasoning among children of different grade, ability, and knowledge levels. *Cognition and Instruction, 14(2),* 139-178.
National Research Council. (2010). *Science teacher readiness for developing 21st century skills.* Washington, DC: National Academies Press.
Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41(5),* 513-536.
Sinatra, G. M., Kienhues, D., & Hofer, B. K. (2014). Addressing challenges to public understanding of science: Epistemic cognition, motivated reasoning, and conceptual change. *Educational Psychologist, 49(2),* 123-138.
Wu, Y. (2013). University students' knowledge structures and informal reasoning on the use of genetically modified foods: Multidimensional analyses. *Research in Science Education, 43,* 1873-1890.
Wu, Y. & Tsai, C. (2007). High school students' informal reasoning on a socio-scientific issue: Qualitative and quantitative analyses. *International Journal of Science Education, 29(9),* 1163-1187.

The material in the poster is based upon work supported by the NSF under Grant No. DRL-1316057. Any opinions, findings, conclusions, or recommendations expressed are those of the authors and do not necessarily reflect the NSF's views.