Influence of Teacher Discursive Moves on Students' Relational Reasoning in Science Classrooms

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Aim

This study investigates the sequential relations between teachers' discursive moves and students' uses of various relational reasoning in eighth-grade science classes.

Background

- Relational reasoning, the ability to identify meaningful patterns among any informational stream, lies at the heart of critical, analytical, and higher-order thinking (Alexander, Jablansky, Singer, & Dumas, 2016).
- Increasing evidence shows that relational reasoning plays a crucial role in learning and performance in academic domains, such as reading (Alexander & the DRLRL, 2012), mathematics (Richland, Zur, & Holyoak, 2007), science (Murphy, Firetto, & Greene, 2017), and engineering (Dumas & Schmidt, 2015).
- A better understanding of how teachers affect students' relational reasoning during instruction has implications for learning in scientific domains.
- Relational reasoning can manifest in multiple forms, such as analogy (similarity), anomaly (discrepancy), antinomy (exclusivity), and antithesis (opposition; Alexander et al., 2016).
- Previous classroom-based studies have focused primarily on analogical (Lin et al., 2012; Richland et al., 2007) and anomalous reasoning (Chinn & Brewer, 1998).

Research Questions

1. How often do teachers and students use relational reasoning in eighth-grade science classroom discussions?
2. How do teachers' discursive moves affect student utterances of relational reasoning in science classroom discussions?

Methods

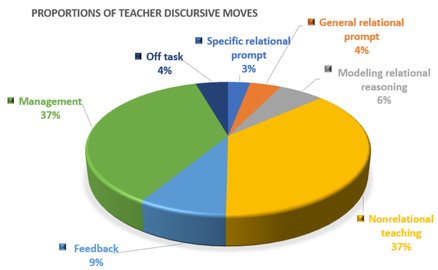
Data Source. Three videotaped science classes randomly selected from the TIMSS 1999 Video Study. Lesson topics included types of rocks (geology), weather (meteorology), and polymer structures (chemistry).
Participants. Three eighth-grade science teachers and their students (30-40 in each class).
Procedure. The transcribed classroom discourse in each lesson was segmented into speech units representing complete expressed thoughts. We coded teacher speech units for the types of instruction move made (*prompting, modeling, feedback, management, nonrelational teaching, and off-task*) and student units for their relational or nonrelational nature of the thoughts expressed (*relational reasoning, task-related, and off-task*). The interrater agreement between two independent coders on 15% of the transcripts was 95.1% for speech unit segmentation and 86.2% for unit coding (κ = .80).

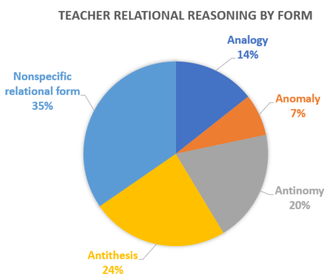
Examples of Teacher Uses of Relational Reasoning

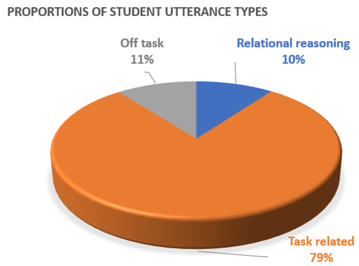
Utterance Type	Example
Prompting	
Specific relational prompt	
Analogical	I have three balloons this time, and they are different color. Red is? (Referring to the analogy that red balloon represents warm air)
Anomalous	How could you explain- since granite cools underground slowly- how in the world can this piece of granite be above the surface?
Antinomous	Now, if I'm standing on the top of a volcano, why am I not standing on sedimentary rock?
Antithetical	Now, why would this magma that came out at the surface cool faster than the magma, let's say, that never made it to the surface?
General relational prompt	
Call for comparison/contrast	What's the difference between the chains here and the chains here?
Activating prior knowledge	Remember the balloon thing?
Modeling	
Analogical reasoning	So if magma cools, it becomes solid, much the same way that when water cools it becomes ice.
Anomalous reasoning	Now, this crystal of quartz, is kind of rare because it has a point on both sides.
Antinomous reasoning	We can't call it lava; we have to call it magma.
Antithetical reasoning	And the magma comes up and freezes much quicker than it does in the air.
Nonspecific relational form	But on the other hand, different parts of the world have different magmas.

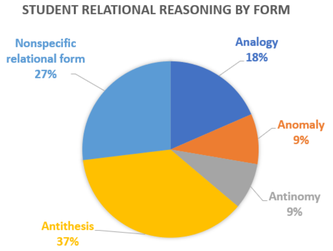
Frequency of Teacher and Student Uses of Relational Reasoning

Among 2,604 total teacher speech units, 349 (13.4%) were relational (prompting or modeling specific or general forms of relational reasoning). Among 1,285 total student speech units, 130 (10.1%) were relational.









Transitional Effects of Teacher Discursive Moves on Student Relational Reasoning

Sequential Analysis: Test whether a type of student utterance followed a certain type of teacher move significantly more or less often than would be expected by chance.

Partial Transition Matrix from Teacher Moves to Student Utterances

		Subsequent Student Utterance (Lag 0)					
		Relational Reasoning		Task Related		Off Task	
		N of transition	*Z* score	N of transition	*Z* score	N of transition	*Z* score
Preceding Teacher Utterance (Lag -1)	Specific Relational Prompt	27	15.53***	12	-2.2*	0	-1.69
	General Relational Prompt	8	2.30*	30	0.20	0	-2.03*
	Modeling Relational Reasoning	1	-1.95	18	-4.40***	0	-2.45*
	Nonrelational Teaching	18	-2.55*	282	-4.01***	6	-5.24***
	Feedback	4	-1.32	51	-1.17	4	-1.41
	Management	15	-3.51***	241	-0.81	13	-4.10***
	Off Task	2	-1.77	39	-1.71	56	20.28***

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

Significant Transition Effects of Teacher Moves on Student Relational Reasoning

			Subsequent Student Utterance of Relational Reasoning (Lag 0)				
			Analogy	Anomaly	Antinomy	Antithesis	Nonspecific form
Preceding Teacher Utterance (Lag -1)	Specific Relational Prompt	Analogical	*Z* = 20.22***				*Z* = 5.31***
		Anomalous		*Z* = 5.53***			
		Antinomous			*Z* = 7.62***		*Z* = 6.19***
		Antithetical				*Z* = 17.34***	*Z* = 3.29**
	General Relational Prompt	Call for comparison/ contrast			*Z* = 2.65**	*Z* = 3.61***	*Z* = 6.13***
	Nonrelational teaching	Request for elaboration/ explanation			*Z* = 6.08***	*Z* = 3.96***	

Note. ** $p < .01$, *** $p < .001$.

Conclusions

- Teachers and students used various forms of relational reasoning in eighth-grade science classrooms.
- When teachers directly elicited a specific form of relational reasoning, students were more likely to reason with the type of relation prompted. More general prompts for comparison/contrast, explanation/elaboration increased the likelihood of subsequent student relational reasoning.
- Modeling relational reasoning without explicitly drawing students' attention to the relation being demonstrated was unlikely to elicit student use of relational reasoning.