Robot Algebra Project (RAP): Integrating declarative knowledge in a cognitive tutor

The designers of the RAP aimed to extend the traditional role of the tutor by integrating declarative knowledge into their tutor system. In so doing, the existing ways of analyzing student learning from the tutor needed elaboration. This study used the Math Task Framework (MTF) in order to afford a more multi-faceted exploration of student learning with these more complex tutor tasks.

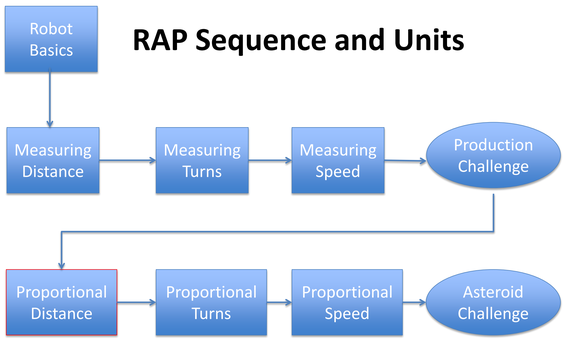
Cognitive Demand (CD) of Task

CODE	Definition	Example
Memorization	Students simple recall previously learned facts, rules, formulae, or definitions	How many cm do you get for each rotation on the REM robot?
Procedure Without connection	Students use previously established instructions to calculate a correct answer; requires no link or explanation to underlying mathematical idea	How did you find the number of unit rate-sized pieces you needed?
Procedure With connection	Students use previously established instructions to calculate a correct answer; requires them to make links or give explanation to underlying mathematical idea	Suppose the robot moves for 4 rotations. How can the rate help you to calculate out how many centimeters it has gone?
Doing Math	Students are required to do complex nonalgorithmic thinking that forces them to explore and understand concepts, processes, or relationships.	Program your robot to travel from point A to point B using only 2 tries and measurements from the practice site.

Defining a "Task" in the RAP

- Each individual question on a page is coded as a task. (n = 52 for Proportional Distance Unit)
- These codes are combined allowing for coding of the whole page. (n =22 for Proportional Distance unit)

RAP Sequence and Units



8 units: 3 focusing on measurement using robot; 3 focusing on teaching proportional skills; 2 Challenges.

Cognitive Demand of Robot Algebra Tutor Tasks: How Students Are Interacting with Tutor Tasks

UNIVERSITY OF PITTSBURGH
LRDC Learning Research & Development Center

By Aaron M. Kessler

Data Collected

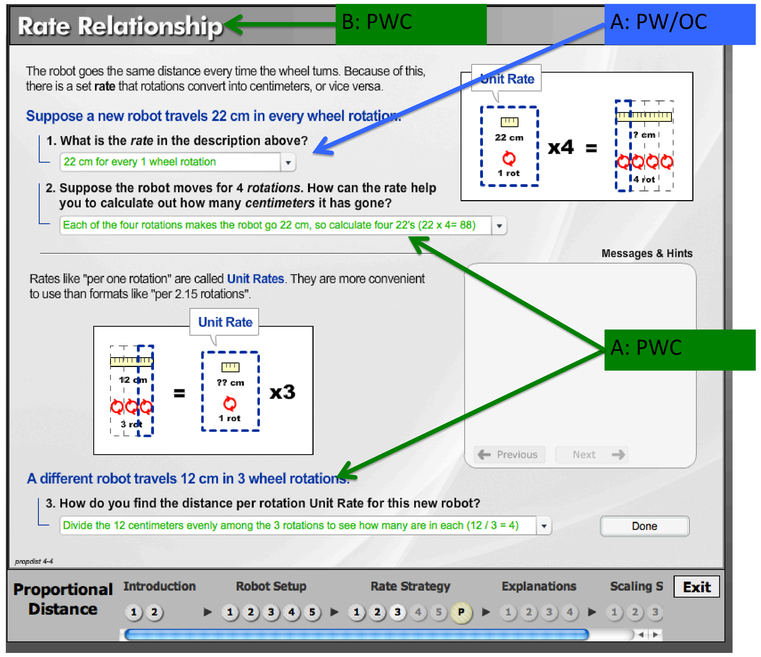
Data	Description	Analysis Method
Screen Shots of All Tutor Pages	Screen shots of every tutor page, including every hint and feedback response, were taken and saved.	Pages from the Proportional Distance Unit were coded for level of designed cognitive demand of tasks.
Talk Aloud Protocol	An individual talk aloud protocol (Ericsson & Simon 1993; Carmel, Crawford, & Chen 1992) around the Proportional Distance Unit. All screen movements and interactions with the cognitive tutor and robot were video taped along with each students' verbalization of what they were thinking about as they worked through the problems.	Qualitatively coded with results used in regression analysis. Transcripts used to build case exemplars for examples of understanding proportional reasoning.

Analysis of the Designed Curriculum:

A. Each question was assigned a CD code, producing a "designed code".
B. Each page was assigned the CD code that appeared the most times on a page.

Analysis of the Enacted Curriculum:

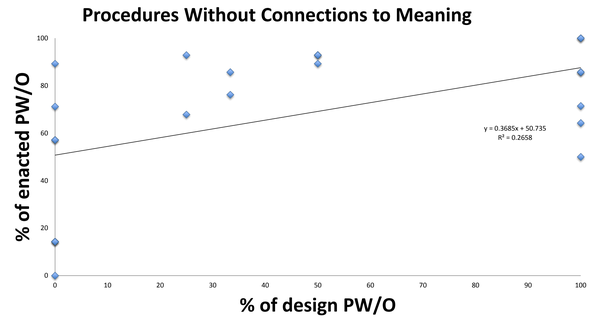
1. Initial pass coded for three types of talk (Reading, Tutor Talk, and Robot Talk)
2. The transcriptions were placed into a matrix.
3. Students' responses to each question on the tutor screen were coded for Cognitive Demand producing an "enacted code".



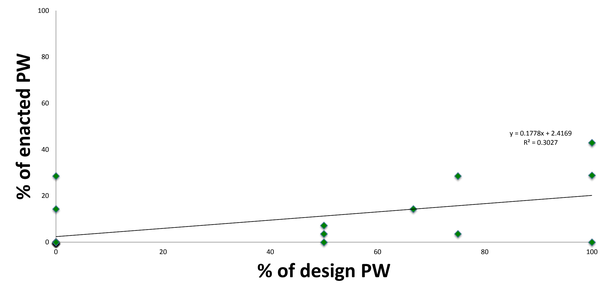
Sample Enacted Data Matrix

Page ID	Transcript	Segment Talk Code	Question CD Code	Page CD Code
Rate Strategy 3	Alright, the robot goes the same dis, the same distance every time the wheels turn. Because of this there is a set rate the rotations convert into centimeters or visa versa.	Reading	PRO/WITH	PRO/WO
	What are you thinking?	RT		
	I just didn't read that right. Uh, the robot goes the same distance every time the wheel turns. Because of this there is a set rate of the rotations convert to centimeters.	Reading		
	So what are you thinking about?	RT		
	Ok, so for every rotation there is going to be a set amount of centimeters that it will go.	TT		
	So, suppose a new robot goes 22, uh, centimeters in every wheel rotation. So. What is the rate in the description above?	Reading	PRO/WO	
	Will be the distance traveled for, ok so this is saying it will go 22 cm for every one wheel rotation. Oh I did not get that right. And so I am going to look in the hint.	TT		
	You got the right idea but your answer is to general. Try to me more specific. So. The distance in the.	Reading		
	Talk it outloud.	RT		
	What is the rate in the description above. Oh its 22cm for every one wheel rotation. I just chose the most generic answer.	TT		

Results



The direction of the correlation was significant and positive, r = 0.52, $p < .05$; as the percentage of PW/OC designed questions increased so did the percentage of student enacted pages at the same level.



The direction of the correlation was significant and positive, r = 0.55, $p < .01$; as the percentage of PWC designed questions increased so did the percentage of student enacted pages at the same level.

Example From The Transcript Data: Failure to explain or properly use unit rate

Problem: Use unit rate strategy to arrive at the answer and then explain your reasoning.

Student Response: "So it needs to go 34.2 and then, in this situation they're similar so I can just move the decimal, point, well. I can multiply it by 10. So if I did 2.9 multiplied by 10 equals 29. Which is how many... I knew that, 34.2 was one tenth of 3.42 so I could multiply 2.9 times ten to get the prediction."

Conclusions

- The CD level of task that was designed into the tutor is significantly related to the CD level that students enact tasks.
- In transcript data, however, we uncovered a lack of the deeper understanding of proportional reasoning that Lobato, Ellis, Charles, and Zbiek (2010) say is crucial for students future mathematical success, while still seeing students be proficient at the procedure of solving problems. This suggests that a gap remains between the procedural and declarative knowledge that the tutor attempted to teach.

Special Thanks to: Mary Kay Stein, Christian Schunn, Ross Higashi, Robin Shoop, Mike McNally, and Jay Moser.