

Exploring Connections between Story Problem Topics and Problem Solving: Is Work Hard and Socializing Easy?

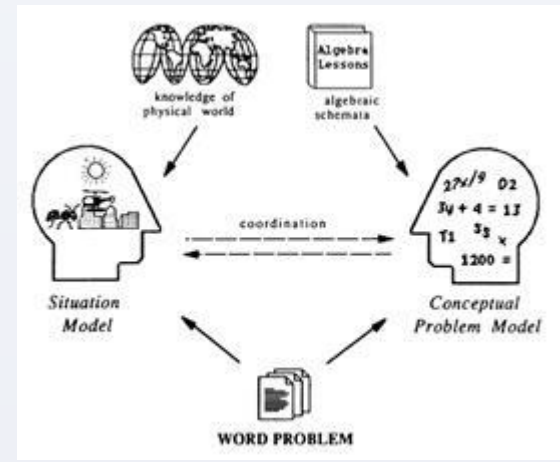
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Background

Story problems are frequently used in algebra classrooms to develop key ideas relating to functions and rate of change (Common Core Standards - Mathematics, 2010).

To solve a story problem, students develop a mental representation of the relationships in the text (i.e., situation model) and a mental representation of the formal mathematics (i.e., a problem model; Nathan, Kintsch, & Young, 1992).



Students are more likely to accurately solve problems with topics that are *personalized* to their interests in areas like sports, music, and movies (Walkington, in press).

Problems with relevant and familiar topics, like personalized stories, may promote situation model construction by allowing new mathematics concepts to be connected to prior experience, with key concepts becoming more *grounded* (Goldstone & Son, 2005).

However, individual-level personalization may not be feasible for a heterogeneous classroom where many students hold diverse interests (Hidi, 1990).

Therefore, it may be helpful to find *story problem topics* which facilitate problem-solving performance across a diverse group of students.

Research Question

How is the *incidence of story problem topics* in algebra story problems associated with students' problem-solving performance (corrects, incorrects, hints, & latency) in Cognitive Tutor Algebra?

Methods

Datasets from 9 high schools and 1 middle school that use Cognitive Tutor Algebra Intelligent Tutoring System for Algebra I were analyzed ($N = 3394$) using mixed effects regression models.



CTA presents students with algebra problems and provides adaptive hints if the student requests them (Morgan & Ritter, 2002).

Cognitive Tutor Interface

Scenario
You have just been promoted to assistant manager at PAT-E-OH Furniture Inc. and have received a raise to \$10.50 per hour.

- How much would you be paid if you worked five hours?
- How much would you be paid if you worked 10 and 1/2 hours? If you have not already done so, please fill in the expression row with an algebraic expression for the total pay. Then use the expression and the Solver to answer questions 3 and 4 below.
- How many hours must you work to make five hundred fifty dollars?
- In order to make \$2,200.00, how many hours must you work?

To write the expression, define a variable for the time worked and use this variable to write a rule for your total pay.

Quantity Name	Unit	Expression
Question 1		
Question 2		
Question 3		
Question 4		

Answer Key:

Quantity Name	the time worked	the money earned
Unit	hour	dollar
Expression	X	10.5X
Question 1	5	52.5
Question 2	10.5	110.25
Question 3	52.381	550
Question 4	209.5238	2200

LIWC Analysis

A software program, LIWC (Linguistic Inquiry and Word Count), was used to conduct a quantitative and objective content analysis of the topics of 151 algebra story problems about linear functions.

LIWC is a dictionary-based computerized text analysis program that counts words in over 70 categories (Pennebaker, Chung, Ireland, Gonzales, & Booth, 2007).

The topic of a story problem was determined by whether it had at least one word that fell in one of the LIWC topic sub-categories.

LIWC Topic Categories	LIWC Topic Sub-Categories
Social processes	family, friends, people
Affective processes	positive emotions and negative emotions
Biological processes	body, health, ingestion
Cognitive processes	insight, causation, discrepancy, tentativeness, certainty, inhibition, inclusive/exclusiveness
Perceptual processes	see, hear, feel
Relativity processes	motion, space, time
Personal concerns	work, achievement, leisure, home, money, religion, death

Results

Pearson Correlation between LIWC topic measures and measures of problem solving performance, for all story problems

	Correct	Incorrect	Hint	Latency
Social Processes (e.g., mate, talk, child)		-.241***		.200*
Humans (e.g., adult, baby, boy)				.214**
Insight (e.g., think, know, consider)			.214**	.249**
Tentative (e.g., maybe, suppose, assume, guess)	-.216**	.186*	.206*	
Inhibition (e.g., safe, save, stop, contain)			.208*	
Inclusive (e.g., and, with, include)		-.179*		
Exclusive (e.g., but, without, exclude)			.181*	
Motion (e.g., arrive, car, go)	-.199*		.249**	
Time (e.g., minute, second, day)	-.184*		.164*	
Work (e.g., job, firm, company)	-.177*		.178*	
Health (e.g., clinic, flu, pill)			.212**	

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

Regression results for using LIWC topic measures to predict problem-solving performance

measures (corrects, incorrects, hints, latency), for all story problems

	% Correct	% Incorrect	% Hint	Latency (sec)
(Intercept)	80.96 (2.39) ***	17.93 (1.52) ***	2.73 (0.81) ***	9464 (4548)
One sentence	(ref.)		(ref.)	
Two sentences	2.86 (1.45)		-0.32 (0.41)	
Three sentences	3.56 (1.52) *		-0.44 (0.45)	
Four or more sentences	-0.84 (1.73)		0.88 (0.50)	
Social		-2.09 (0.85) *		
Work	-1.89 (0.97) *			
Motion	-2.03 (1.00) *			
Health			1.63 (0.51) **	
Inhibition			0.98 (0.36) *	
Insight				11272 (4021) **
Overall improvement in log-likelihood due to predictors	3.25%	0.81%	4.83%	0.75%

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

Topic	Example Problem
Work	You have just been promoted to assistant manager at PAT-E-OH Furniture Inc. and have received a raise to \$10.50 per hour.
Motion	A machine called the Crawler which moves space shuttles travels at the rate of 29 feet per second. The Crawler is currently 100 feet from the hanger moving toward the launching pad.
Social	A bride is making nameplates to put on the tables at her reception. She can make them at the rate of 25 per hour. She works for two hours and quits for the night realizing that she cannot complete this many nameplates herself. The next day she calls her mother and they both work together. Her mother can make 35 nameplates per hour.
Health	According to the American Heart Association approximately 145000 women die every year from smoking-related diseases. In fact lung cancer has become the leading cause of cancer death among women.
Inhibition	During the school year teachers save money for use during the summer when they're not being paid. This year due to some unexpected expenses one teacher was able to save only \$879. He figures he will need \$23 a day for personal spending money.
Insight	A company uses three different servers to manage web site traffic. Visitors are evenly distributed over the three servers to increase speed and performance. The webmaster runs a report and sees that there are currently 100 visitors accessing the web site. Assume that the 100 users continue to access the web site.

Discussion

Overall, performance seemed to be facilitated when stories are about familiar topics like socializing.

Performance seemed to be hindered when stories elicited cognitive processes like insight, and when they were about topics that may be boring or dry to adolescents – work contexts, saving money, physics/motion contexts, and healthcare contexts.

Hint requests were more sensitive to language measures (5% of deviance explained by predictors), with correct answers being slightly less sensitive (3% of deviance explained by predictors).

Future research may illuminate whether this effect is due to increased familiarity with the topic or activated interest in the story problem.

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