Shhh! Context is Sensitive: Understanding Student's Graphical Knowledge in Biology and Physics

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Introduction

Many professors expect students within Life Science programs to have a mastery of graphical knowledge with the ability to extract and interpret data from graphs. However, many students in college struggle with graphical interpretation skills, such as evaluating the instantaneous slope of a line at a point. This project attempts to evaluate the extent to which students in physics and biology classes can interpret graphical knowledge based on the context of a question and demographic data. Previously collected data suggests that question context matters significantly; however, new data shows question context is not significantly important to all classes.

Research Question

How does the context of a question in a physics or biology class influence a students' ability to analyze a graph and to what extent do demographic factors affect student performance?

Theoretical Framework

- Difficulties stem from flawed patterns of reasoning
- Students struggle to implement mathematical concepts across disciplines
- Student difficulties are identified through analysis of student work, are categorized and become targets for instruction

Methodology

The population of interest were students in an algebra-based physics class (PHYS 211) and three sections of an introductory biology class (BIO 151), broken into two sections: (BIO 151 A) (BIO 151 B)

- PHYS 211 focuses on principles of motion and mechanics, particularly interpreting speeds of objects from position vs. time curves
- BIO 151 focuses on living organisms and their environment, particularly interpreting growth curves and predicting population growths in the future

Two isomorphic prompts were given within each course; Prompts were handed out randomly and each student only answered one prompt

PHYS 211: Car Prompt, Pop Prompt

BIO 151: Car Prompt, Pop Prompt

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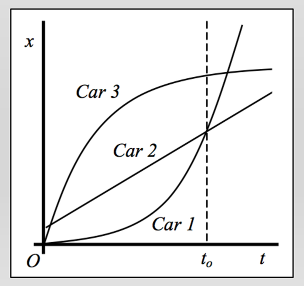
Isomorphic Prompts

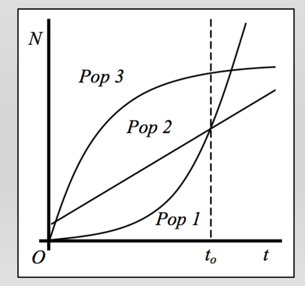
- The bio-context prompt asks about the population growth of three different populations of grasshoppers (Pop Question) and physics-context prompt asks about the speed of three different cars (Car Question), but are otherwise identical (see below)
- Each prompt consists of two parts, both using the same set of skills and requiring minimal content knowledge

Car Graph



Part a) Order the cars/population growth at time t_0 from fastest to slowest

Pop Graph



Part b) Carefully explain why you ordered the cars' speeds/ population growth the way you did. How did you determine this order?

Coding Responses

Responses were coded by four people

- Two people coded the car prompts
- Two people coded the population prompts

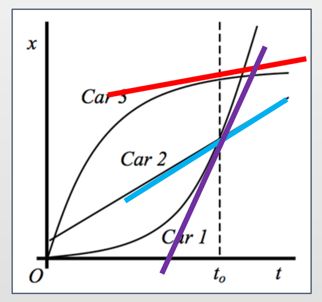
Coding Part A

- The correct order for the cars or populations from slowest to fastest is 3<2<1

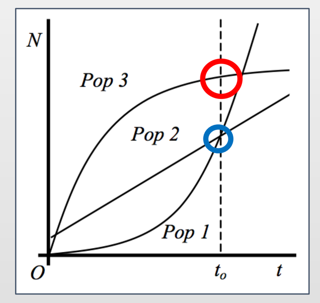
Coding Part B

- Student responses were coded to match categories that were organically developed. The categories include Slope, Explanation, Trend line, Value, Average, and Other

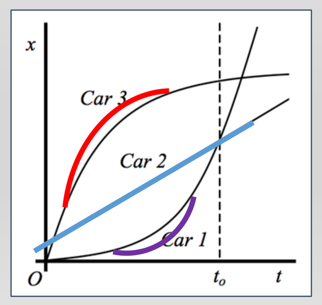
S/E - Slope



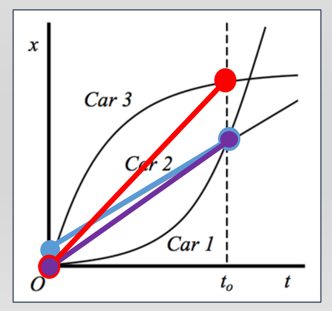
V - Value

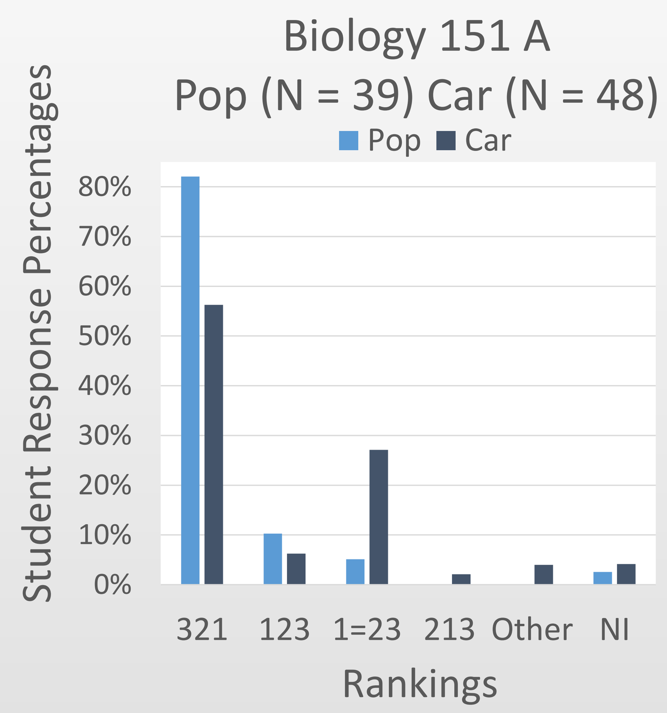


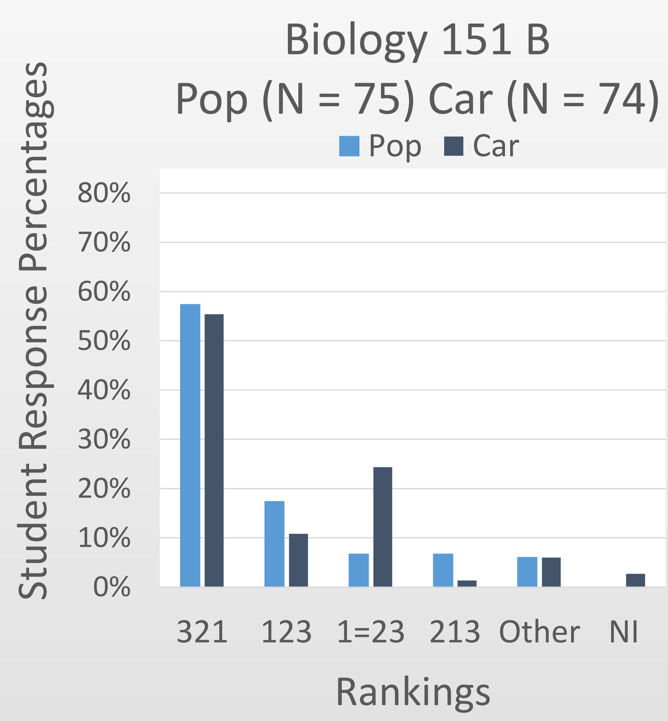
T - Trend Line

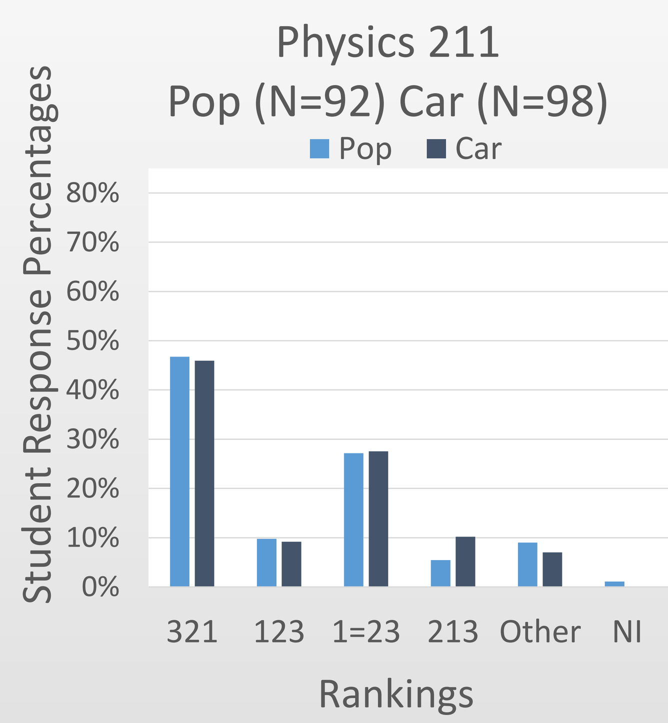


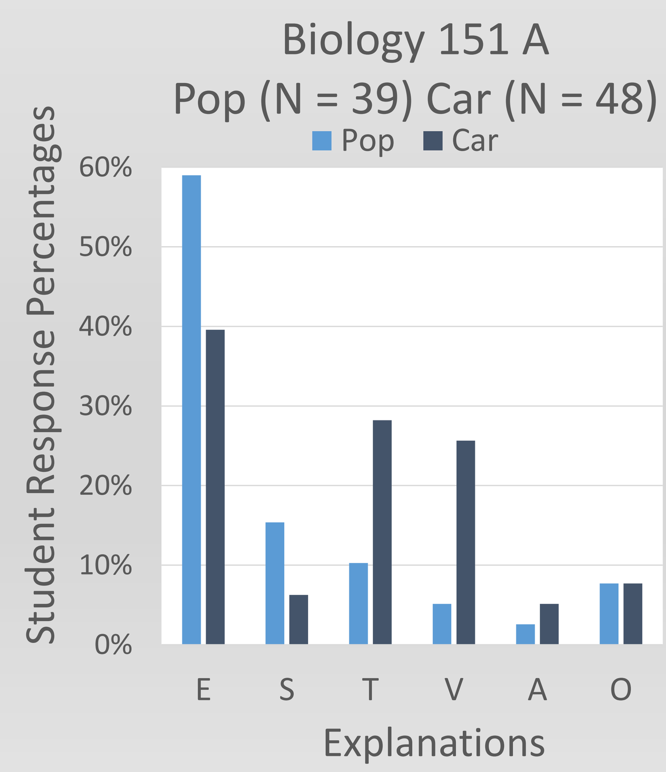
A - Average

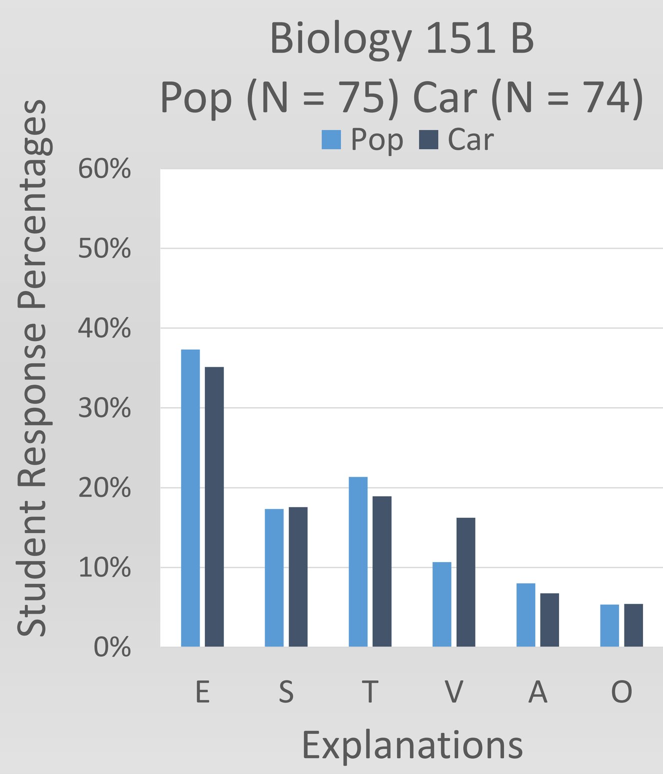


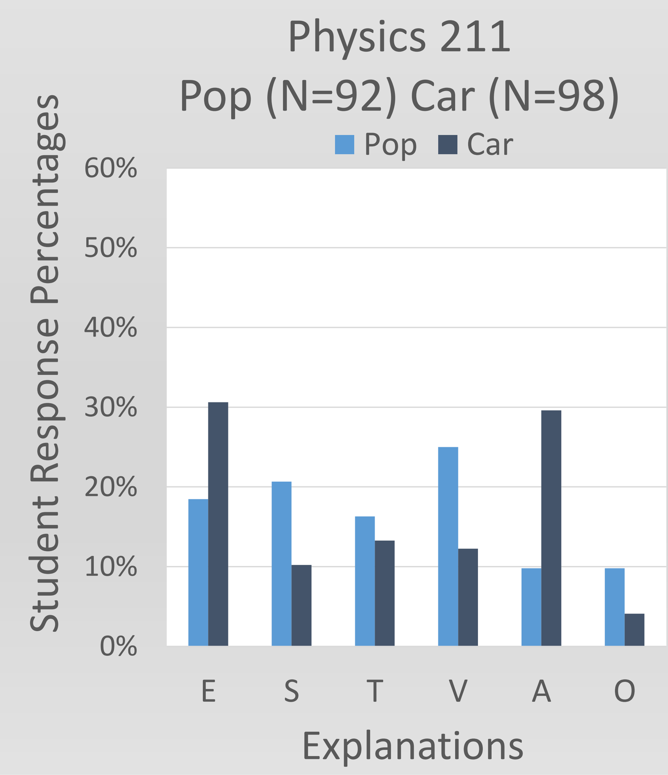












Logistic Regression Analysis

A logistic regression is used when there are two outcomes, correct or incorrect. For our research, students either ordered the slopes correctly or incorrectly. Below shows both statistically significant (blue) and statistically nonsignificant (white) odds ratios for the parameters included in the model. Significant parameters were selected based on p-values less than 0.05.

Significant Coefficients with Explanation Included

	Math.ACT	GPA	GenderM	QuestionPOP	VAT	O
Phys 211	0.22256	-0.77019	-0.02721	-0.46742	-4.36237	N/A
Bio 151 A	0.00564	-0.01109	0.92944	0.92912	-3.62683	-2.70763
Bio 151 B	0.14207	-0.69727	0.55186	0.41876	-2.58523	-3.44391

Significant Coefficients with Explanation Not Included

	Math.ACT	GPA	GenderM	QuestionPOP
Phys 211	0.22047	-0.06744	0.88746	-0.25397
Bio 151 A	0.05506	0.41572	0.10299	1.31751
Bio 151 B	0.15592	-0.47401	0.37474	0.35196

Results

For all samples, students were significantly less likely to answer with the correct order if they had explanations of Value, Average, Trend Line, or Other.

PHYS 211

- The question context had little affect on a student's ability to answer with the correct order
- The model shows male students or students with strong Math ACT scores have improved odds of giving the correct order

BIO 151 A

- Students performed significantly better on the population question when compared to the car question

BIO 151 B

- The question context had little affect on a student's ability to answer with the correct order
- Students with strong Math ACT scores were more likely to order the slopes correctly

Conclusion and Discussion

Data collected previous to this academic year showed that students performed better when given a question relating to the context of the class in which they were enrolled. However, question context was only shown to be a predictor of correct order in only one section of one course. Without this sensitivity to context, other factors such as Math ACT scores seems to become a more significant predictor of success. Two possible contributing factors:

- Changes in the ranking portion of the physics course prompts
- Previous data was collected in BIO 150, and the present data was collected in BIO 151 which focuses more on graphical interpretation

References

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