Examining Factors That Influence Biology Student Performance on Quantitative Tasks

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Introduction

Recently, there has been a push among American universities to recognize the substantial interdisciplinary connections between biology and math (Feser et al., 2013). As a result, biology curricula are emphasizing the development of quantitative skills in biology students. Many biology students report low math self-efficacy (Jameson & Fusco, 2014) and according to social cognitive theory, students' self-efficacy can affect their performance (Bandura, 1977). Therefore, it is important to understand how students' confidence in their math abilities may impact their performance on quantitative tasks in biology. We have little understanding of the math concepts commonly used in biology courses that students find challenging. The objective of this study is to provide insight on biology students' math self-efficacy, and their math problem-solving abilities.

Research Questions

1. How does math self-efficacy influence biology student performance on biology-based math problems?
2. What math concepts are challenging for biology students?
3. What aspects of these challenging concepts do biology students find difficult?

Methods

- 10 biology-based math problems were taken from biology textbooks or quantitative biology assessments that covered 5 concepts: exponential growth, exponential decay, logarithms, rates, and unit conversion.
- Cognitive interviews were conducted with 17 introductory biology students. Students were asked about their math self-efficacy and to think aloud as they solved 6 of the 10 biology-based math problems.
- Students were classified into low, medium and high self-efficacy groups; the average percent of problems solved correctly for each group was calculated.
- Questions that <50% of students solved correctly were further analyzed to determine what was challenging about these questions. 6 interview transcripts were independently coded by researchers; consensus was reached. All interviews were coded using the consensus codes.

Results

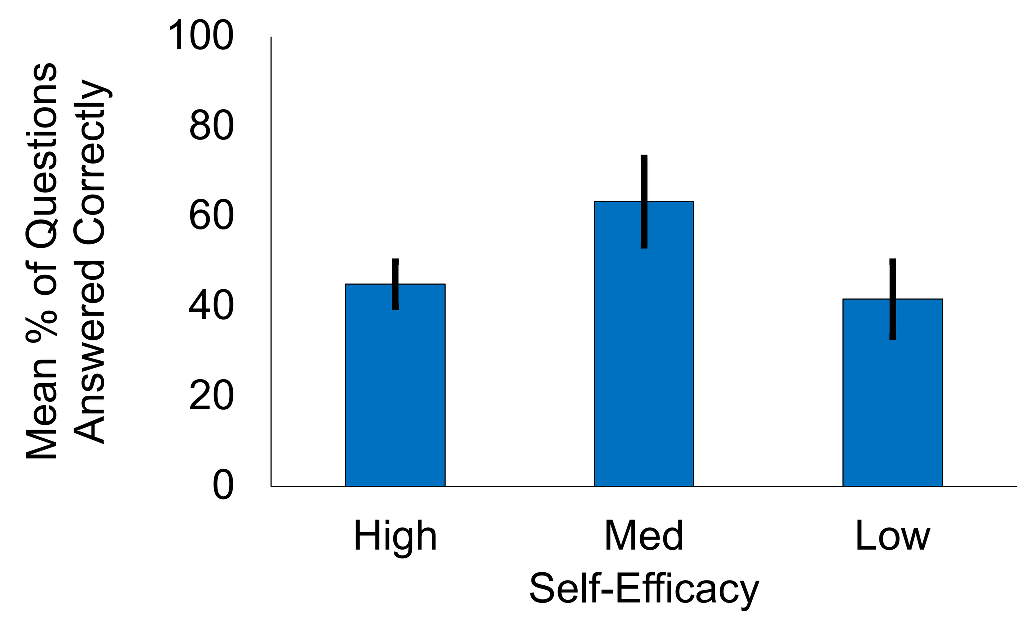

Figure 1. Student performance by self-efficacy. The bars indicate the standard error.

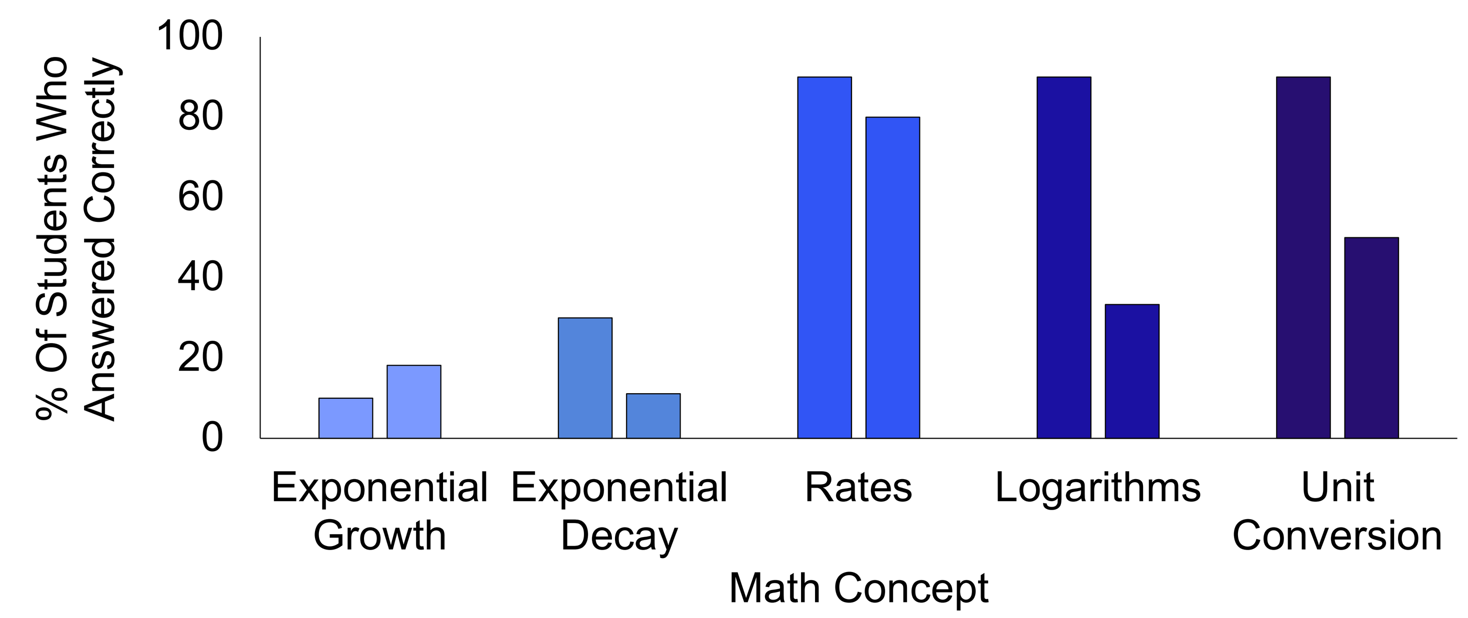

Figure 2. Student performance by question and concept. The line indicates the 50% threshold which was used to identify challenging questions.

A

Abr.	Codes	Definition
TC	Time constraints	Student knew they could solve the problem the long way but did not think they had enough time to do so
MQ	Misread Question	Student did not follow the directions of the problem.
NL	No Log Use	Student did not recognize the need to use logarithms to solve the problem
IL	Inverse log	Student generally knew how to apply the logarithm rules to solve the problem until the final step which required them to use the inverse log to isolate the variable
LR	Log Rules	Student knew they needed to use logarithms but were unsure how; often times they needed to be given the logarithm rules
DR/GR	Decay/Growth Rate	Student used the incorrect rate for an exponential growth or decay question
NE	Need Equation	Student could not derive the equation to solve the exponential growth or decay problem and did not know there was a long-hand way to solve it
SD	Self-Doubt	Student lost confidence in their ability to solve the problem and could not develop a method to solve it

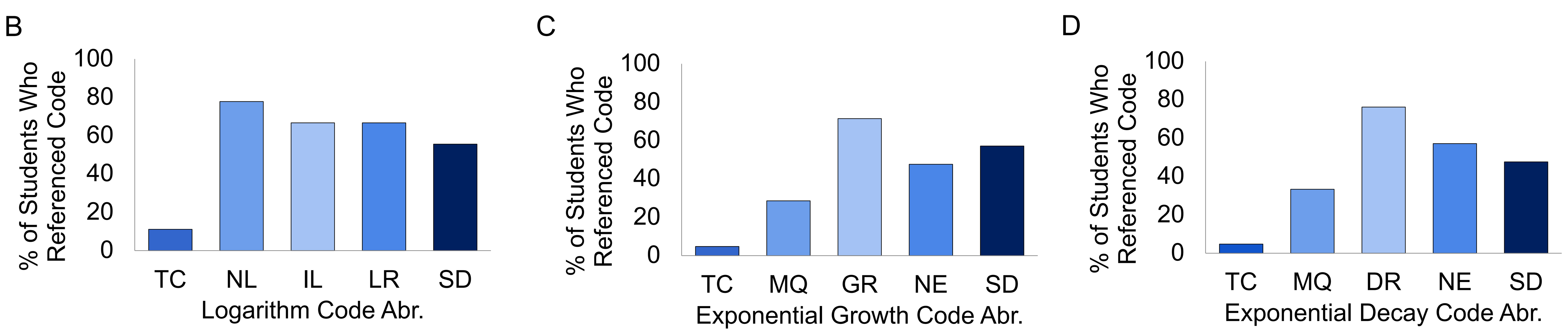

Figure 3. (A) The established codes for the challenging aspects of math concepts and their definitions. The percent of students who referenced a code for (B) logarithm, (C) exponential growth, and (D) exponential decay problems. For the logarithm problem, the top three problems students encountered were knowing that they needed to use logarithms, knowing how to take the inverse logarithm and knowing the logarithm rules. The top three problems students encountered for both exponential growth and decay were using the incorrect decay and growth rate, not knowing the correct equation to solve the problem and losing confidence in their ability to solve the problem.

Conclusions

- Students with high math self-efficacy appeared to overestimate their math abilities, whereas students with moderate self-efficacy appeared to more accurately gauge their math abilities. Literature predicts that students of moderate self-efficacy are accurate in their self-assessment because they tend to pull from multiple sources of self-efficacy (Haddad & Taleb, 2016).
- Exponential decay and growth and logarithms were concepts that less than 50% of students were able to answer correctly.
- One logarithm question had a higher success rate than the other because the harder question required students to derive the logarithm rules whereas the easier question simply had students take the logarithm of a number as part of an equation.
- For exponential growth and decay, the challenges were not knowing the equation to use, converting the growth or decay rate from a percentage to a decimal, and lack of confidence in ability to solve the problem.
- For logarithms, students were challenged by remembering their logarithm rules and knowing how to take the inverse of a logarithm.
- Our data suggest that biology instructors should consider reviewing logarithms and exponential growth and decay equations when integrating these concepts into biology courses. Additionally, self-doubt can impede student performance on quantitative tasks.
- Interview data provided insight into appropriate quantitative biology problems to be used on future surveys to measure student performance on math-based biology problems.

Literature Cited

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