

Comparing Calculus Students' Use of Problem-Solving Strategies on Related Rates of Change Problems in a Traditional versus Online Homework Format

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Keywords: problem-solving, related rates, calculus, online-homework

With the advent of many online platforms for assigning and grading homework, more and more of the homework in calculus no longer entails paper-and-pencil homework (Dorko, 2020). As such, with the prevalence of associated scaffolding embedded in these platforms, more needs to be understood about whether this tends to over-proceduralize topics, such as related rates of change (RRC), and undermine roles these topics may have in further developing students' capacity in mathematical problem solving or mathematical reasoning. Engelke (2008) maintains that to successfully solve RRC problems, students require well-developed mathematical problem-solving skills. However, Mkhathshwa (2020) asserts that few studies have explored students' reasoning on solving RRC problems. The purpose of this investigation is to explore how problem-solving strategies (PSS) may differ when solving RRC problems presented in a traditional paper-and-pencil format versus RRC problems presented in an online platform which includes typical options for scaffolding help as well as "view an example" features. In this poster, we address the following research questions: (1) How do students' PSS when working online homework on RRC problems compare with their PSS when working paper-and-pencil homework RRC problems? (2) What influence does the 'view an example' feature in online homework have on a student's PSS when working an online RRC homework problem?

This study takes place at a large, urban research university located in the southwestern United States during a 15-week first-semester calculus course which incorporated the use of an online platform for homework. After scoring 318 participants' written work on a free response RRC common midterm exam problem for the extent to which their work exhibited processes for productive problem solving of RRC problems (Engelke, 2008), participants were invited for task-based interviews using a scheme aimed at ensuring that participants from different score ranges would be included in the interviews. Fourteen participated in task-based interviews. Because we were interested in comparing PSS when working paper-and-pencil versus online homework problems, the task-based interviews included four RRC problems, two sets of paired tasks of a paper-and-pencil format problem and a similar problem on the online platform. Qualitative data analysis software was used to code the data using a priori codes from Álvarez et al. (2019) and Carlson and Bloom (2005). Common themes were identified using thematic analysis (Braun and Clark, 2016).

Data analysis reveals more instances of PSS from the exemplary group (top quartile scorers on midterm RRC problem) when compared to the other groups. In addition, participants used more PSS when solving paper-and-pencil RRC problems than when solving online RRC problems. Further, participant's use of PSS decreased when using the 'view an example' feature in the online format. Three categories emerged on participant use of the 'view an example' feature (1) those who mimic the example (ME), (2) those who use the example to learn the process (LP), and (3) those who refuse to use the feature (RF). Participants using this feature for ME used fewer PSS than those whose use was classified as LP or RF. Findings suggest that the format of and resources for online homework RRC problems may need to change to ensure that students engage in using PSS in a manner comparable to traditional paper-and-pencil homework.

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Introduction

With the advent of many online platforms for assigning and grading homework, more and more of the homework in calculus no longer entails paper-and-pencil homework (Dorko, 2020). As such, with the prevalence of associated scaffolding embedded in these platforms, more needs to be understood about whether this tends to over-proceduralize topics, such as related rates of change (RRC), and undermine roles these topics may have in further developing students' capacity in mathematical problem solving or mathematical reasoning. Engelke (2008) maintains that to successfully solve RRC problems, students require well-developed mathematical problem-solving skills. However, Mkhathswa (2020) asserts that few studies have explored students' reasoning on solving RRC problems.

The purpose of this investigation is to explore how mathematical problem-solving strategies (MPSS) may differ when solving RRC problems presented in a traditional paper-and-pencil format versus RRC problems presented in an online platform which includes typical options for scaffolding help as well as "view an example" features.

Research Questions

- (1) How do students' mathematical problem-solving strategies when working an online homework related-rates of change problems compare with their mathematical problem-solving strategies when working paper-and-pencil related-rates of change homework problems?
- (2) What influence does the 'view an example' feature in online homework have on a student's mathematical problem-solving strategies when working an online related-rates of change homework problem?

Phase 1: Textbook Problem to Online Problem

Frequency of Problem-Solving Strategies Utilized in Phase 1

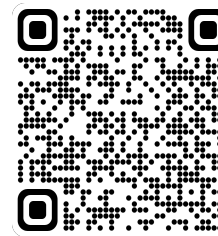
Student	Q1	Q2
Echo	6	4
Eboy	4	3
Earl	22	0
Ed	5	3
Elsa	12	13
Eve	5	3
Pamela	5	0
Paris	8	4
Pat	7	4
Penny	8	8
Percy	5	0
Peter	8	0
David	4	5
Donald	8	2

23. Time-lagged flights An airliner passes over an airport at noon traveling 500 mi/hr due west. At 1:00 p.m., another airliner passes over the same airport at the same elevation traveling due north at 550 mi/hr. Assuming both airliners maintain their (equal) elevations, how fast is the distance between them changing at 2:30 p.m.?

Phase 2: Online Problem to Textbook Problem

Frequency of Problem-Solving Strategies Utilized in Phase 2

Student	Q3	Q4
Echo	8	8
Eboy	3	2
Earl	15	13
Ed	1	6
Elsa	10	11
Eve	3	7
Pamela	1	4
Paris	1	4
Pat	4	5
Penny	8	5
Percy	0	4
Peter	0	1
David	4	4
Donald	0	5



<http://tinyurl.com/4f9s57cc>



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Methods

We used student ($n=338$) departmental midterm performance levels on RRC problems to select participants for task-based interviews. Participants were drawn from three groups, based upon their performance and problem-solving score quartile on the midterm RRC problems.

Of the 14 participants consenting into the study, six came from the fourth quartile, six came from the third quartile, and two came from the second quartile. The task-based interviews entailed solving two pairs of RRC problems (textbook-to-online, online-to-textbook).

Transcripts were coded using thematic analysis techniques (Braun & Clarke, 2006) with a priori codes from Alvarez et al. (2019) and Carlson and Bloom (2005) and also examined for emergent codes.

- The problem-solving codes used included orienting/sense-making, planning, representing and connecting, executing, reviewing, justifying, checking.
- Emergent codes included the use of *view an example* for process, to mimic, or for sense-making.

Findings

Participants appear to use MPS strategies more frequently when solving the traditional paper and pencil-related rates of change of problems.

The findings suggest that students may be using features of online homework platforms on RRC problems in a manner that circumvents the use of MPSS. That is, 'view an example' feature in online homework may be scaffolding the problem-solving process in a manner that leads to students missing opportunities to further develop their MPSS.