Assessing Conceptual Learning in Calculus I: Preliminary Results and Future Ideas

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Our initial project focused on assessing conceptual understanding of key topics in Calculus I, specifically measuring changes in the achievement gap between underprepared and prepared students in Active and Traditional classrooms. However, a main hurdle is the lack of instrument for assessing Calculus readiness. In this poster, we present results of student understanding of continuity in Active vs. Traditional settings from 16 sections of Calculus I. We present ideas for refining this study to be able to better assess student growth by creating and validating questions regarding students' initial understanding of Calculus topics: continuity, differentiability, limits, and area. We present our study design and initial findings; we look forward to feedback as we enter the latter half of our project.

Keywords: Calculus, Active Learning, Assessment, Task Design

Calculus I is a crucial benchmark in the path to a STEM education; however, many students rely heavily on memorization and repetition as paths to success in mathematics. These techniques fail when they are asked to explore the abstract concepts *of limits, continuity of functions, differentiability,* and *area*. One pedagogical approach to increasing student understanding and mastery is active learning. Active learning activities provide a setting for students to learn in cooperation with others, thus placing them in an excellent environment to construct complex mental frameworks (Bransford et al., 1999; Vygotsky, 1978). Existing literature supports the idea that active learning techniques can increase student learning outcomes significantly (Freeman et. al, 2014; Bressoud, 2011; Haak et. al, 2011; Boaler & Greeno, 2000). In this project, we study active learning specific to the calculus classroom.

In the initial phases of our project, we targeted the population of students who enter calculus with deficiencies in algebra, trigonometry, and/or pre-calculus. One question we attempted to explore was the following: Does the performance gap between underprepared and calculus-ready students change to a different extent in an active classroom as compared to a traditional classroom? We compared student-learning outcomes in four classrooms employing active techniques to outcomes in four traditional lecture-based classrooms in each of Fall 2017 and Spring 2018. Due to a lack of instrument for assessing calculus readiness, we chose to use the Precalculus Concepts Assessment (PCA) (Carlson, Oehrtman, & Engelke, 2010) to identify students with weak preparation. During both semesters, the active sections discussed each of our target concepts: limits, continuity, differentiability, and area, using a common exploratory activity, discussion, and follow-up assignment. The traditional sections covered the same content, but from a lecture approach. We assessed learning outcomes by scoring performance on in-class exams and again administered the PCA as a post-test. Unfortunately, the PCA was not adequate for distinguishing between prepared and underprepared students or for answering our research question. However, our preliminary analysis of final exam data involving continuity revealed that students in the active sections performed better than their traditional counterparts on the continuity exam questions. Our next plan is to refine our study to be better able to assess student growth by creating and validating questions regarding students' initial understanding of our four target calculus concepts, and we look forward to feedback.

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