Navigating Obstacles to Foster Success in Learning Optimization Problems in First Semester Calculus

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Calculus I serves as either a "gateway" into STEM majors or a "filter" that limits students' career intentions (Ayebo et al., 2017; Baisley & Adams, 2019; Biza, 2022; Bressoud et al., 2015; Rasmussen & Ellis, 2013; Sonnert et al., 2015). Baisley and Adams (2019) asserted that poor performance in calculus I can lead to students dropping out of STEM majors, with significant retention concerns in engineering programs. It is historically documented that many calculus students struggle with solving optimization problems due to its complexity which necessitates quantitative reasoning, modeling, and problem-solving skills (Borgen & Manu, 2002; Brijlall & Ndlovu, 2013; Dominguez, 2013; LaRue, 2016; Mkhatshwa, 2016; Swanagan, 2012; White & Mitchelmore, 1996). Speer and Kung (2016) suggested that further investigation into optimization problems is needed. This poster will highlight aspects of this investigation.

The Pilot Study

Drawing on the social constructivist perspective (Cobb et al., 1997; Confrey, 1990; Noddings, 1990), a qualitative pilot study was conducted to understand how engagement in a collaborative problem-solving activity could reveal evidence of understanding or misconceptions of optimization problems from prior calculus learning. Four students who had recently completed Calculus I in a traditional setting worked together to solve an optimization problem. Student interactions revealed a heavy reliance on procedures and formula recall, with participants exchanging ideas and exploring alternative pathways. Although they referred to calculus strategies like using derivatives and identifying extreme values, these were often applied unsuccessfully or abandoned without thorough consideration. Despite their enthusiasm, gaps in conceptual understanding led to frustration and hindered progress. In exit interviews, students voiced dissatisfaction with traditional calculus instruction and suggested ways to create a more supportive learning environment for future students. The findings of this study highlighted the need to further explore how to support calculus students in developing a deeper understanding of optimization.

Results from the pilot study informed the design of a qualitative teaching experiment aiming to improve the learning of calculus optimization by facilitating the building of knowledge representations among a diverse sample of current calculus students. Guided by Davis's "cognitive science approach to mathematics education," this study investigates: (1) what knowledge representation structures related to optimization do students develop, and (2) how the teaching intervention influences the construction of such a knowledge representation? To deepen students' understanding of calculus optimization, participants worked in pairs on five tasks designed to promote conceptual understanding while connecting optimization to prior knowledge.

Results and Significance

The poster will share brief data from the Fall 2023 pilot study that led to a more extensive teaching intervention in Fall 2024, along with some preliminary findings from the ongoing study.

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