CLEARING THE WAY FOR MINDSET CHANGES THROUGH FORMATIVE ASSESSMENT

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One of the reasons for the exodus in STEM majors is the introductory calculus curriculum. Although there is evidence that curricula like CLEAR calculus promoted significant gains in students' growth mindset, it is unclear how this curriculum promotes mindset changes. The purpose of this case study was to investigate which features of CLEAR Calculus promoted positive changes in students' mindsets. After administering the Patterns of Adaptive Learning Scale to assess students' initial mindset in one section of calculus, four students were selected for interviews. Although participants were selected for maximal variation in their mindset at the beginning of the course, there were a lot of similar themes in their interviews. Students cited that CLEAR Calculus curriculum challenges them in ways that facilitates deeper comprehensive learning than that of a traditional calculus course.

Key words: Calculus, formative assessment, mindsets

Prospective STEM majors who declare a non-STEM major are most likely to do so after introductory calculus (Bressoud, Rasmussen, Carlson, & Mesa, 2014); students cite their lack of a perceived relationship with their instructor and the inability to seek help as primary reasons for switching (Ellis & Rasmussen, 2014). One possible solution is the use of formative assessments such as exit tickets; such assignments show promise in helping students to perceive their instructor as more approachable and caring about their success (Black & Wiliam 1998, 2009; Author 2, 2014).

However, the number formative assessments completed are a far stronger predictor of students' success than their weight in the course grade would indicate (Author 2, 2015). One possible explanation for this effect was that students who completed more post-labs had different mindsets about learning mathematics than those that did not. It has been noticed that mindsets play a significant role in the overall success of calculus students. Dweck (2006) defines mindset in two different ways: fixed mindset and growth mindset. Students classified under the fixed mindset, if not immediately successful in introductory calculus often leave the STEM field. However, growth mindset students can persist and succeed, even after failures as severe as failing a course (Dweck, 2007).

We examined how CLEAR Calculus supports positive mindset changes in students through a case study of four students enrolled in an introductory calculus class taught using CLEAR Calculus. This research will be guided by the question: What are the features of CLEAR Calculus that promote positive changes in students' mindsets? By understanding what makes this curriculum effective, interested practitioners who are not implementing CLEAR Calculus can learn what components to add to their classes if they would like to see a positive increase in their students' mindsets. We argue CLEAR Calculus supports positive changes in students' mindsets because the labs make challenge and conceptual understanding central components of the course, while the set routine of the class and the use of formative assessments helped to prevent students from feeling overwhelmed.

The theoretical perspective for this case study (Patton, 2002) was Dweck's (2006) mindsets. Participants attended a midsized rural regional university in the South, and were recruited from an introductory calculus course taught using CLEAR Calculus labs. These labs are built upon developing systematic reasoning about conceptually accessible approximations and error analyses but mirroring the rigorous structure of formal limit definitions and arguments (Oehrtman, 2008, 2009).

Students in the course took the Patterns of Adaptive Learning Scale (PALS) during the second week of the semester. Four participants participated in semi-structured interviews (Patton, 2002) to obtain a sample with maximum variation according to their mindset (Table 1). Author 1 observed the class and consulted with the instructor of the course for triangulation of the interview data. After the interviews were transcribed, the data was analyzed using standards of evidence derived from the literature.

Table 1

Participants

Pseudonym	**Year**	**Major**	**Mindset**
Ian	Junior	Math	Strong Growth
Roland	Freshmen	Biology	Weak Growth
Penelope	Sophomore	Biology	Weak Fixed
Steven	Freshmen	Math	Strong Fixed

Overall, participants found the feature of the CLEAR calculus that caused them to become more growth mindset-orientated was the presence of safe challenges. Although the labs were always challenging for students, the labs were also seen as the central feature in the course and the main difference between their current calculus experience and their previous mathematics classes, particularly those taken in high school. While the labs provided the challenge needed to help students begin to examine their belief systems, the formative assessments were also seen as a key feature of the course. Even though postlabs required little time, they were aware that questions on the postlab would be answered by the instructor. For students with a more fixed mindset, this help was available with minimal effort and without admitting the need for help in front of peers, which made seeking aid more palatable.

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