

Active Learning in Undergraduate Precalculus and Single-variable Calculus

Naneh Apakarian
San Diego State University

Dana Kirin
Portland State University

The study presented here examines the active learning strategies currently in place in the Precalculus through single variable calculus sequence. While many lament the lack of active learning in undergraduate mathematics, our work reveals the reality behind that feeling. Results from a national survey of mathematics departments allow us to report the proportion of courses in the mainstream sequence utilizing active learning strategies, what those strategies are, and how those strategies are being implemented.

Key words: Census Survey, Precalculus, Calculus, Active Learning, Instructional Methods

Research suggests experiences in introductory mathematics courses can significantly influence student persistence within the STEM fields (Bressoud, Mesa, & Rasmussen, 2015; PCAST, 2012; Seymour & Hewitt, 1997; Wake, 2011). In the United States, the Precalculus to Calculus 2 (P2C2) sequence often serve as key prerequisite courses for students intending to pursue degrees in STEM fields, and difficulties in these courses often prevent students from continuing on in STEM. One approach that shows great promise for improving student success in the P2C2 sequence is the use of student-centered instruction. Recent studies have highlighted the educational benefits of using active learning strategies in post-secondary mathematics classrooms, including improved STEM retention rates (Ellis, Kelton, & Rasmussen, 2014; Ellis, Rasmussen, & Duncan, 2013; Rasmussen & Kwon, 2007; Seymour, & Hewitt, 1997) and narrowing achievement gaps (Kogan & Laursen, 2014; Laursen, Hassi, Kogan, & Weston, 2014). The use of such practices was also identified as a characteristic of programs with successful Calculus I programs (for a more detailed discussion see Bressoud & Rasmussen, 2015). Despite these educational benefits, Kuh (2008) points out that these instructional practices are currently not the norm in higher education.

The study presented here reports preliminary findings from data collected as part of a larger study, *Progress through Calculus* (PtC). The main research question addressed in this report is *how, and to what extent, are active learning strategies being implemented in the P2C2 sequence?* Narrowing down on this broad question, this presentation addresses the following questions:

1. How prevalent are active learning strategies in the P2C2 sequence?
2. What particular active learning strategies are being used, and how common are they?
3. What (if any) institutional factors relate to the use of active learning strategies?

Methods

The data reported here comes from a census survey undertaken as part of a larger, multi-phase project studying departmental and institutional factors that influence student success through the P2C2 sequence. The survey was administered to the 341 departments across the country that award graduate degrees in mathematics. The survey closed with an impressive overall response rate of 68%. The survey elicited information about many aspects of each department's implementation of the P2C2 sequence as a whole, informed by the results of the CSPCC study (Bressoud, Mesa, & Rasmussen, 2015; Bressoud & Rasmussen, 2015). This presentation reports on a subset of the data wherein participants provided detailed information about the individual courses that make up the mainstream P2C2 sequence.

The details requested about these mainstream courses included questions about course delivery to ascertain the primary format for regular class meetings and recitation sections (when applicable). 201 institutions completed these details, giving us information on 904

P2C2 courses. The following section includes descriptive statistics (frequencies, proportions, etc.) gathered from these responses. Ongoing analysis is examining the relationships between the use of active learning strategies and other factors (e.g., importance of active learning, DFW rates, instructor type).

Results

To frame our findings, we begin by noting that 44% of all mathematics departments responding to this survey reported that active learning strategies are “very important” for successful P2C2 courses, but 75% of those reported that they are not very successful at implementing those strategies. Overall, 14% of institutions report being “very successful” with active learning strategies, 60% report being “somewhat successful,” with the rest marked “not successful” or “not applicable.”

The first question we answer relates to the usage of active learning strategies in introductory undergraduate mathematics courses across the country. Participants were asked to identify the primary instructional format for regular class meetings of each course in their department’s mainstream P2C2 sequence. The proportions that follow in this section refer to the proportion of *courses* taught in a certain way, not the proportion of institutions offering such structures. Perhaps unsurprisingly, over 60% of courses are primarily taught in a lecture format. Of particular interest to us is the discovery that approximately 16% of courses incorporate some active learning techniques, while a further 3% are taught using mainly active learning techniques. Further investigation revealed that these proportions fall off through out the P2C2 sequence. While nearly 26% of precalculus courses incorporated at least some active learning techniques, this drops to 20% in first calculus courses, and drops again to 13% in secondary calculus. These proportions did not vary significantly between MA- and PhD-granting institutions.

Data was also collected regarding the instructional format of recitation sections (or labs) when applicable. Approximately one-third of the reported courses have recitation sections, and 15% of these use active learning strategies (5% of all courses). Overall, we found that 22% of reported courses have some active learning in the instructional approach in regular course meetings, recitation sections, or both.

Our data also allows us to look at what “active learning strategies” mean when usage is reported. Note that the responses to this question were not exclusive, as a course might utilize several different strategies. The most prevalent technique was group work, reported in 78% of courses and 92% of recitations that included active learning. IBL, clicker surveys, and flipped classes were each reported in 15-20% of lectures, and a sizable proportion indicated that they use something other than the options provided. The story is similar in recitation sections, except for the use of clicker surveys (only appeared in 2% of “active” recitations). The patterns of usage do not change across courses in the P2C2 sequence.

Conclusion & Future Directions

Our current quantitative analysis reveals some of the patterns of active learning in the P2C2 sequence. Only 22% of P2C2 courses incorporate at least one active learning component, but we also found that 40% of institutions have an active learning component in at least one mainstream P2C2 course. This suggests that active learning strategies are not being used consistently through the P2C2 sequence, but only in select courses. However, in courses that implement active learning strategies, we see a consistent trend in *the types* of active learning strategies being implemented across the P2C2 sequence. At this time, analysis of our existing data is still ongoing. Further analysis of this data will link active learning strategies and implementation to institutional factors (e.g., understanding of importance, school size) as well as student factors (e.g., DFW rates, target audience), thus providing a more complete picture of the role active learning plays in the P2C2 sequence.

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