First-year Mathematics Students' View of Helpful Teaching Practices

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Research in undergraduate mathematics education has identified various research-based instructional practices to support students' learning. However, little is known about how students experience those practices or how helpful they perceive those practices to be for their learning. As part of a larger national project of first-year mathematics, this study focused on classroom experiences in the Precalculus to Calculus 2 (P2C2) sequence. Using survey data from 4,969 students, we considered how helpful students find various teaching practices and then compared student and instructor reports of how characteristic these practices are of their P2C2 class. Here we report students' ratings of twelve different teaching practices in terms of helpfulness for their learning in and descriptiveness of their P2C2 experience.

Keywords: Precalculus, Calculus, Instructional approaches, Survey

The national study of *Characteristics of Successful Programs in College Calculus* (CSPCC) distinguished between aspects of good and ambitious teaching (Sonnert & Sadler, 2015). In that work, *good teaching* is characterized as instruction that is traditionally accepted as good teaching practices, regardless of pedagogical approach (e.g., being available, grading fairly). *Ambitious teaching* refers to instruction that incorporates more innovative or novel approaches to instruction, including more student-centered strategies (e.g., working with peers in class). The CSPCC study showed that both good and ambitious teaching are beneficial for students' learning in Calculus 1 (Bressoud, Mesa, & Rasmussen, 2015). In this study, we extend that previous work to explore levels of usage of particular good and ambitious teaching strategies and provide insight into students' perception of the helpfulness of those strategies.

Ellis, Kelton, and Rasmussen (2014) laid a foundation for understanding Calculus 1 instruction from both student and instructor perspectives, comparing student and instructor reports of the frequency of specific instructional practices. They found that, on average, students and instructors agree on the frequency of various instructional practices in the classroom, though instructors were more likely to over-report practices identified as part of ambitious teaching. They also noted the presence of more variation among students' responses to items related to ambitious teaching constructs than to items related to good teaching. That is, students in the same course reported a wider range of frequencies for activities like "whole class discussion" than for "lecture." Furthermore, students who reported a lower frequency of ambitious teaching strategies were more likely to switch out of the calculus sequence, suggesting an association between students' perception of instruction and interest in continuing in STEM. This leads us to believe that documenting students' perspectives on not only what happens in class, but how helpful they find it, is important for understanding why students do or do not continue through the calculus sequence.

The undergraduate mathematics and science education research communities have identified many pedagogical practices that have been shown to support student learning. However, there is literature to suggest that students' experiences of those practices are not uniform and their view of these practices is not always aligned with that of an external observer (Ellis, Kelton, & Rasmussen 2014; Rogowsky, Calhoun, & Tallal, 2015; Willingham, Hughes, & Dobolyi, 2015). Additionally, students' perceptions of their learning and the helpfulness of the instructor's actions have an effect on their experience of a course. We suggest that the utility of our work is not to identify what teaching practices *should* be used because students believe they are helpful, but rather to identify where there are discrepancies between students' perceptions and education research literature, either in general or disaggregated based on other student factors. That knowledge may help instructors recognize where to build buy-in, what practices are perceived differently, and address students' concerns about their teaching style in a timely fashion. Implementing ambitious teaching practices in ways that students believe are helpful to their learning should not only improve students' learning of content but also improve their overall experience.

In this study, we identify instructional practices that students find most helpful and identify how characteristic these practices are of their Precalculus to Calculus 2 (P2C2) classes, considering both the instructor and student perspectives. In this report we aim to answer: (1) What teaching practices do students regard as helpful for their learning?, and (2) Do students and teachers describe their class with practices that students deem helpful?

Methods

The data for this study comes from surveys designed for a larger, multiphase national project aimed to examine current P2C2 programs. During the first phase of the project, a large census survey was administered to all universities across the country whose math department offered a graduate degree. Census survey responses were considered to select 12 mathematics departments for in-depth case study sites during the second phase of the project. Specifically, the chosen departments were interesting in regards to the seven features of successful programs identified in the CSPCC study (Bressoud et al., 2015) as well as an eighth characteristic: diversity, equity, and inclusion (Hagman, under review).

The study presented here reports on instructor and student survey data that were administered to all instructors of P2C2 classes and their students. The surveys included 12 parallel items regarding classroom experiences (e.g., 'I guide students through major topics as they listen' and 'I listen as the instructor guides me through major topics'). Instructors and students were asked to indicate whether the statements were descriptive of their P2C2 class. Both surveys used a 5-point Likert scale ranging various levels of descriptiveness of the classroom (5=very descriptive, 4=mostly descriptive, 3=somewhat descriptive, 2=minimally descriptive, 1=does not occur/not at all descriptive). For each item which a student responded with 2 or higher (i.e., indicated the item occurs in their class), they were asked to report how much that aspect of the course helped their learning. The helpfulness item was measured on a 3-point scale (3=very helpful, 2=somewhat helpful, and 1=not helpful).

For this study, we reduced our data to responses from courses with an instructor response and at least five student responses, following the methods of Ellis, Kelton, and Rasmussen (2014). These restrictions resulted in a total of 4,969 student responses from 173 P2C2 classes. More specifically, this includes 1,789 student responses from 55 precalculus classes, 1,806 student responses from 74 Calculus 1 classes, and 1,374 student responses from 44 Calculus 2 classes. We considered descriptive statistics for all of the items as well as conducted a paired samples t-test comparing the student and instructor responses for the classroom experience items. The following section presents sample results to highlight findings regarding how helpful students

rate certain teaching practices and students' perspective of how characteristic the teaching practices are of their P2C2 class.

Table 1 offers the student version of the helpful and descriptive items. We coded the items based on Sonnert and Sadler's (2015) factor analysis categories: ambitious and good teaching. Specifically, we coded items that related to traditionally accepted good teaching practices regardless of pedagogical approach as *good* and practices related to student-centered strategies as *ambitious*. Item 1 is reverse coded as ambitious, meaning that more of this practice indicates a less ambitious approach. The items not highlighted as good or ambitious remain uncategorized because there is ambiguity in the terminology which admits many possibilities. Specifically, the nature of feedback, questions, and individual work can support both student-centered and instructor-centered classrooms.

	Ambitious		Good		<u>Other</u>
1.	(reverse association) I listen as	6.	The class activities connect	10.	I receive immediate
	the instructor guides me through major topics		course content to my life and future work		feedback on my work during class
2.	I talk with other students about course topics during class	7.	The instructor knows my name	11.	I am asked to respond to questions during class time
3.	I constructively criticize other students' ideas during class	8.	I receive feedback from my instructor on homework,	12.	I work on problems individually during class
4.	I work with other students in		exams, quizzes, etc.		time
	small groups during class	9.	My instructor uses		
5.	Class is structured to encourage peer-to-peer support among students		strategies to encourage participation from a wide range of students		

Table 1. Helpfulness and descriptiveness items on student survey.

Sample Results

In what follows, we will focus on the students' perspective and draw on the helpfulness and descriptiveness items on the student survey. Students were asked to rate the items listed in Table 1 regarding how helpful they were for their learning and how descriptive they were of their class. We focus on what students find to be (un)helpful, and then discuss the extent to which the strategies that we categorize as "ambitious" are being implemented.

We will begin by focusing on the helpfulness items. Figure 1 depicts the percent of students that rated each item as not helpful, somewhat helpful, or very helpful. More than half of the students that responded to the first, seventh, eighth, and tenth items indicated that these instructional practices were very helpful for their learning. Specifically, 73.2% of students reported listening to their instructor guide them through topics was very helpful for their learning, 64.6% of students indicated that receiving feedback on assignments was very helpful, 52.7% of students reported that the instructor knowing their name was very helpful, and 51.6% of the students said that receiving immediate feedback in class was very helpful.

At least 90% of the students indicated that the following are either somewhat helpful or very helpful for their learning: listening to the instructor guide them through topics (Item 1), receiving feedback immediately in-class (Item 10) as well as on assignments (Item 8), talking with students during class (Item 2), and working individually on problems during class (Item 12). On the other hand, 16.5% of the students indicated that being asked to respond to questions in class

was not helpful for their learning (Item 11) and 23.3% of the students said that constructively criticizing other student's ideas during class was not helpful for their learning (Item 3).



Figure 1. Summary of helpfulness item in percentages.

We further investigated if certain teaching practices were more helpful for students in different courses (Precalculus, Calculus 1, or Calculus 2). Data from several teaching practices were significantly different (p<0.05) in terms of helpfulness across courses (i.e., Item 1, Item 5, Item 7, Item 8, Item 9, Item 11, Item 12). For instance, we found that a greater percentage of Calculus 2 students (77.6%) found listening to their instructor guide them through major topics was very helpful compared to Calculus 1 students (70.2%) and Precalculus students (72.8%). Additionally, more Precalculus students (41.5%) than Calculus 1 (36.9%) and Calculus 2 (38.4%) students found class structures that allowed peer-to-peer support very helpful.

Next, we considered students' perspective of how characteristic the helpful teaching practices are of their P2C2 class. Here, we offer the descriptive rating from the students that rated items classified under ambitious as helpful for their learning (either somewhat or very helpful). See Figure 2. We found that 86.3% of the students that indicated listening to their instructor was helpful for their learning (Item 1, N=4655) also said that it was very or mostly descriptive of their class. Additionally, 53.4% of the students that indicated that talking with students during class was helpful (Item 2, N=2431) said that it was mostly or very descriptive of their class. Of the students that found constructively criticizing other student's ideas during class helpful for their learning (Item 3, N=1937), only 11.3% of them reported it was very descriptive of their class, while 35.1% of them said it was minimally descriptive.



Figure 2. Summary of descriptiveness of ambitious items from students that deemed them helpful.

Alternatively, Figure 3 considers the descriptive rating from the students that reported the ambitious items as *not* helpful for their learning. Comparing Figure 2 to Figure 3, there appears to be a connection between how helpful students report an item and how descriptive it is of their class. Students who deemed Item 2, Item 3, Item 4, and Item 5 as unhelpful more commonly report them as minimally descriptive of their class compared to students who report them as helpful. This suggests that students who experience any amount of these ambitious teaching practices and who think they are helpful for their learning tend to report them more regularly in their class.



Figure 3. Summary of descriptiveness of ambitious items from students that deemed them not helpful.

Implications

Careful attention needs to be given to the implications of our research, especially for findings that suggest that many students find a particular teaching practice helpful (or unhelpful) for their learning. One might think that the "fix" is to either increase (or decrease) that specific teaching practice; however, the solution may not be so simple. For instance, we found that an overwhelming amount of students think listening to their instructor lecture about major topics is helpful for their learning. Moreover, less than 5% of the students indicated that it was not helpful. Although this finding does not indicate that the same students do not find a more active approach also helpful, it is clear that students value a passive experience. However, it is well documented in the literature that a more active approach is far more productive for students' learning (e.g., Freeman et al., 2014). Thus, it seems more useful to focus on student buy-in for certain practices (ones that are known for being beneficial for students) than to increase the presence of, for example, lecture.

In addition to information similar to what is reported here, in the presentation we will consider the instructors' perspective of how descriptive the items are of their class. We will present subsequent analyses to compare the students' perspective to their instructor's view of how characteristic the teaching practices are of their P2C2 class. The preliminary report and subsequent analyses will contribute to research on how students experience research-based instructional practices in the P2C2 sequence.

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