Promoting College Algebra Instructors' Adoption of Evidence-Based Teaching Practices

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While there is evidence that college students benefit from classroom activities that engage them, a shift in instruction from the lecture style of teaching to methods where students are actively involved in their learning is difficult to generate. This study focuses on providing structure and support for college algebra instructors to implement evidence-based instructional practices. We interviewed participants each semester they were involved with this project to gain insight into their perspectives on their teaching practices. We also video-recorded three lessons each semester when participants were implementing co-constructed in-class materials. Initial results showed how collaboration empowered instructors to implement evidence-based instructional practices in their class. Additionally, even though instructors collaborated to co-create in-class materials, results showed variation in their implementation styles as they moved towards more student-centered practices.

Key words: Professional Development, Active Learning, Instructional Change

College students' learning and conceptual understandings of mathematics benefit from instruction that actively engages students in their learning (e.g., Kogan & Laursen, 2014). Although there have been numerous calls to increase student engagement in college mathematics classrooms (CBMS, 2016; PCAST, 2012), lecture (where instructors present information and students receive it) remains the most prominent form of instruction (Stains et al., 2018). Notably, instructional change is difficult to catalyze, especially amongst college-level instructors (Fairweather, 2008; Henderson & Dancy, 2007). Shadle et al. (2017) identified several barriers to implementing practices that actively engage students and drivers that foster instructional change and support college instructors in adopting evidence based instructional practices (EBIPs). The project described in this report aims to better understand how a particular form of a professional learning community (PLC) can encourage the adoption of EBIPs by college mathematics instructors. We address the research question: In what ways does the structure and goals of the PLC support college algebra instructors in making changes in their teaching?

This study is part of a larger ongoing funded project of collaborative instructional improvement at the university level, aiming to support the implementation of EBIPs that actively engage students with the course content (NSF IUSE: HSI #2116187). The project supports the development of a PLC of instructors of all sections of a university-level college algebra course at a single large, southwestern, Hispanic-serving institution. Before the start of the project, the mathematics department had recently implemented a strong effort of course coordination, including a leadership structure with a coordinator for every multi-section course, weekly or bi-weekly meetings of all the instructors of the course, and aligned assessment procedures, instruments, and structures. Additionally, the college algebra team chose to implement innovative assessment techniques in the semester before this project began.

Theoretical Framework

The theoretical framing that guided the design of this project is the Ethic of Practicality (Doyle & Ponder, 1977), which describes the factors teachers consider when deciding whether innovative curricula is practical or realistic for implementation in the context of an actual classroom. Doyle and Ponder (1977) argue that in order for curriculum to be considered practical, it must: (a) Be compatible with the instructor's classroom, setting, and instructional goals (congruence); (b) Have potential benefits (e.g., student outcomes, student attitudes) that outweigh the effort and other costs of implementation (cost); and (c) Consist of clearly articulated procedures for ease of implementation in the instructor's classroom (instrumentality).

The Continuous Improvement (CI; Berk & Hiebert, 2009) framework began as a roadmap for instructional improvement within courses for preservice teachers, but its alignment with the backwards design principles for lessons are broadly applicable (Wiggins & McTighe, 2005). These principles advocate for planning lessons by first defining the student learning outcomes and the aligned assessment and then designing the in-class task. As part of this project, instructors worked as a group to implement CI cycles (Berk & Hiebert, 2009) to develop and facilitate lessons on particular course topics. In this model, each semester participants isolated specific lessons and implemented the following cycle: 1) *Design a task* that targets a particular student misconception or deepens understanding of a particular mathematical idea based on existing research on student learning about that concept. 2) Develop hypotheses about *anticipated student responses*. 3) *Collect data* in the form of student work and classroom recordings and *analyze the data* for evidence of the desired student learning outcomes. 4) *Record this information* and use it to revise the task for use in subsequent iterations of the course.

Instructors chose to create and use Desmos Classroom activities as a way to incorporate EBIPs in their teaching. Although instructors differed in how they used these activities (with some soliciting and leveraging student thinking more than others), they mostly gave students time to work individually or in small groups before discussing the activities in class. The CI model was a natural fit for a project guided by the Practicality Ethic. The model empowers instructors to make choices about curricular revisions and drive decisions about implementation and the CI framework leverages the knowledge, experience and priorities of instructors to guide these changes; thus, it maximizes congruence. Additionally, in order to maximize instrumentality and minimize cost, we used project funds to secure course releases for college algebra instructors so that they would have time and space to implement the CI cycles and participate in the PLC.

Methods

This report focuses on two participants who were full-time fixed-term faculty participating in the PLC instructional improvement project: Alex and Ivy. While Alex and Ivy were involved in the project, the course coordinators, Nicholas and Shay, also participated in the project. In the final semester of Alex's and Ivy's participation, two more instructors joined. Data were collected over the first three full academic semesters that these instructors were involved, which were also within the first two years they taught the course at this institution. Instructors were interviewed each semester. Interviews were semi-structured and included questions that prompted instructors to describe their teaching practices and participation in the project activities. We also collected class video data. In the first semester one lesson was filmed, and this recording served as a snapshot for what instruction looked like before implementing lessons co-created as part of the project. During the second semester, we filmed three lessons when the instructors taught lessons that were co-created by all the members of the instructional / PLC team.

Interviews were analyzed using thematic analysis (Braun & Clarke, 2006). We focused on coding segments that shed light on instructional practices in the context of the collaboration and coordination within the project. Multiple people from the research team reviewed the interview transcripts and identified representative quotes. Video from the filmed lessons were coded by at least two people from the research team using the College Observation Protocol for Undergraduate STEM (COPUS; Smith et al., 2013). Researchers coded the recordings individually and then met to discuss coding decisions and to reach consensus. After the filmed lessons were coded, we used the collapsed codes of Instructor Presenting, Instructor Guiding, Student Receiving, Student Working, and Students Talking in order to create radar plots of the percentage of class time where students and the instructor were engaged in these activities (Reisner et al., 2020). Collapsed codes grouped together codes that captured similar behaviors. For a detailed description of the codes grouped in these collapsed codes see Smith et al. (2014).

Results

It was clear from the interviews with instructors that the collaboration and support in the context of this project enabled them to try new things in their classes. For example, Alex described how watching other instructors implement different lessons gave him ideas of what to try in his class. He also highlighted how he was motivated to continue trying new things as the semester progressed instead of primarily lecturing. He said:

> Because of the grant I'm refreshing and recycling through different strategies much more than I think I would. I think normally I would just settle into what's easy, which might end up looking like semi-lecture style … But this time I randomly was pushing my students to do more group work. And I wouldn't have been doing that if it wasn't for the grant and seeing all the [other instructors use] group work.

This quote helps illustrate that there was a sense of accountability to keep implementing EBIPs amongst the instructors, as well as support. Alex emphasized, "I don't have to worry if what I'm doing in the classroom is good enough because it's what everyone else is doing and we're all trying it together."

Ivy also commented on how she tried new things because of the collaboration and coordination of the course. She said, "I've always wanted to do the flipped classroom, and I'm getting the benefit of seeing how it works right now." In another part of the interview, Ivy said that "peer pressure" enabled her to try more EBIPs in her classes. She went on to emphasize how having access to the co-created resources was important in her decision to implement more student-centered activities. She said:

> I have … more freedom to - I can explore this stuff. So the fact that Shay and Alex are doing all these activities, and they're amazing, so I've got all these resources. My experience was lecture, and now I get to try the things I've always wanted to try. So I'm loving it. I love the activities, and I'll be honest, at the start of the semester, I was like, 'Oh, we're going to do this now?' because I didn't know how powerful it was. … And yeah, it's just cool to see everything that we can do with [Desmos], and it really helps the students understand.

In addition to instructors discussing how participating in this project enabled them to implement more EBIPs in their teaching, the analysis of what happened in class (as measured by the COPUS; Smith et al., 2013) indicated that there was some instructional change that occurred. Before being involved with this project, Ivy spent most of class time lecturing while students listened and took notes (Instructor Presenting and Student Receiving), see Fall 2021 semester in Figure 1. As Ivy participated in co-creating Desmos activities to use during class time, her instruction shifted to include more time where students were working and she was guiding them, see Spring 2022 and Fall 2022 radar plots for the Algebraic Properties, Fractions, and Factoring lessons in Figure 1. In the following quote Ivy describes how she used the Desmos activities in her class.

> I think Nicholas and I take a more laid-back approach to the Desmos and let the students fight through it and ask us questions. Whereas the other four instructors this semester seem to do the pacing a whole lot more. And especially Shay, Shay is … really talking through every slide … Whereas Nicholas and I, instead of pacing them, … we let them pace themselves. … we take the more passive approach and answer individual questions.

Alex also demonstrated a shift in how he spent class time before and during the project. Before the project, he tended to spend a large percentage of class time presenting material (Instructor Presenting), see Fall 2021 in Figure 2, but then as he taught the lessons with the co-created instructional materials, he spent less time presenting. In the interview, Alex shared how he started to create more space for students to work through problems themselves or share their answers with the class. He said:

> From the interactive style that we would do with … the Desmos [activities], and then talking about it, I think that's how I was able to tie in with my lectures. Like even just having those long pauses to let the students answer I think I got better at doing all of that with the Desmos. And that helps with breaking it up. ... Even though it's like a lecture, I try to have some moments where we just really stop and think about a question.

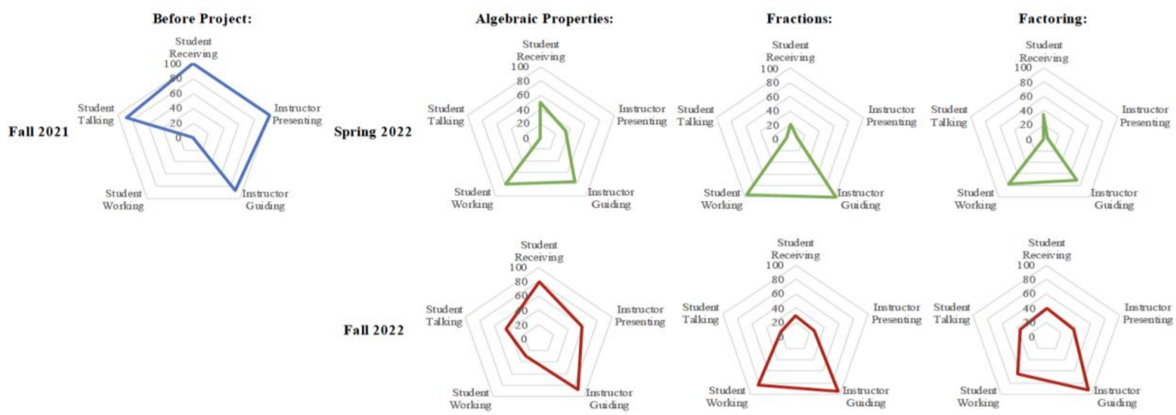

Figure 1. Radar plots by semester / lesson of the percentage of class time spent with Students Receiving, Talking, Working and the Instructor Presenting or Guiding for Ivy's recorded classes.

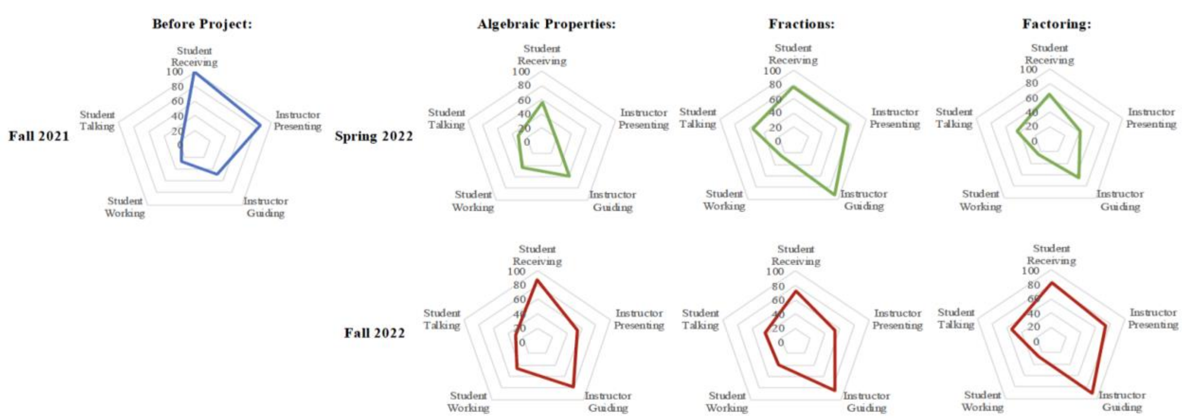

Figure 2. Radar plots by semester / lesson of the percentage of class time spent with Students Receiving, Talking, Working and the Instructor Presenting or Guiding for Alex's recorded classes.

Although the instructors co-created the Desmos materials as part of this project, it is important to notice that their implementation of the lessons varied (see Figures 1 and 2). That is, the analysis video data showed that the instructors (and their students) spent different amounts of class time with the instructor presenting or guiding and the students receiving, talking, or working. Each instructor had their own way of incorporating the materials into their instruction, retaining independence and control over what happened in their section(s). Ivy's quote above also points to these different approaches to implementing the co-created lessons, with her and Nicholas taking a more "passive approach" and Shay providing pacing and leading class discussions on nearly every slide of the Desmos activity.

Discussion

Instructors discussed how the project impacted the activities they did in class and their pedagogical decisions. The analysis of class video shows some differences in instructor and student activities over the course of three semesters. We hypothesize that the course coordination system in place allowed for "coordinated independence" (Rasmussen & Ellis, 2015), where instructors were encouraged to implement more evidence-based and student-centered activities while also retaining independence with their pedagogical and instructional decisions. In an interview that was conducted in the semester after her involvement with the project, Ivy said:

> For me the flipped classroom, it didn't work for my teaching style. … That was one of the reasons actually, that I asked to try to teach something else … so the flipped classroom was just... It just didn't work for me because I preferred to be more 'do it in the moment.'

This quote highlights that while participating in the project and teaching in this coordinated course, Ivy still used this style of teaching even though the "flipped classroom" did not align with her teaching preferences. The coordination and collaboration are also what empowered Alex to try different practices throughout the semester. Often, instructors may be isolated when attempting to adopt EBIPs, but the experiences of Alex and Ivy show how institutionally supported collaboration structures (such as course coordination) can be a powerful force in changing instruction.

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