Resources, Orientations, and Goals Informing Calculus Instructors' Enactment of Equitable Active Learning Teaching Practices Learned Through Approximations of Practice

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We implemented a semester-long professional development workshop series, training Calculus I and II instructors to implement active learning and equitable teaching practices. The workshops actively engaged instructors in approximations of practice (Grossman et al., 2009) in which they learned to enact various teaching practices like designing tasks; eliciting, noticing, and responding to evidence of student thinking; orchestrating class discussions; fostering inclusive social norms; and equitably managing student participation. After they participated in the workshops, we interviewed the instructors about their decisions to implement the teaching practices from the approximations of practice in their teaching. We analyzed the instructors' resources, orientations, and goals that informed their decision to enact those practices.

Keywords: Approximations of Practice, Professional Development, Calculus, Active Learning, Equitable Teaching Practices

Despite the benefits of active learning and equitable teaching practices (Bartell et al., 2017; Freeman et al, 2014; Theobald et al., 2020; Thiry et al., 2019), university faculty have been slow to adopt them (Rasmussen et al., 2019; Stains et al., 2018). There is a need for more professional development (PD) on these teaching practices. At the K-12 level, PD and teacher preparation programs use Approximations of Practice (AoPs; Grossman et al., 2009) to give instructors opportunities to develop and enact specific teaching practices. *AoPs* are activities with a hypothetical teaching scenario in which instructors can simulate a teaching practice without the complexity of being in a real-time classroom. AoPs have been shown to be effective in helping K-12 mathematics teachers develop active learning practices (e.g., Amador et al., 2021; Howell & Mikeska, 2021; Krause et al., 2020; Lai et al., 2021; Roberts & Olarte, 2023; Schack et al., 2013). Their use in PD programs for university faculty has not been commonly documented, however. We propose that such implementation of AoPs in PDs holds promise for the training and professionalization of university mathematics instructors.

In this paper, we investigate how engaging in AoPs can support university instructors in implementing active learning and equitable teaching practices. We report on a study where Calculus I and II instructors participated in a PD program focused on equitable teaching practices and active learning through using AoPs. The instructors' decisions to implement the teaching practices from the AoPs could be informed by their resources, orientations, and goals (Schoenfeld, 2010), so we address the research question: *What are the resources, orientations, and goals that inform instructors' implementation of the teaching practices from the AoPs?*

Literature Review

Active learning is a large umbrella term that captures various pedagogies (e.g., group work, student presentations, class discussions) related to engaging students in class activities beyond passively listening to lectures or taking notes. Although there are numerous benefits associated with active learning in STEM courses (e.g., Freeman et al., 2014; Kogan & Laursen, 2014; Theobald et al., 2020), active learning is not necessarily equitable for students (White et al., 2025; Brown, 2018; Johnson et al., 2020; Reinholz et al., 2022). Thus, it is essential for

instructors who use active learning to attend to equity and inclusion in their courses. There are several teaching practices instructors can use to equitably implement active learning that have been suggested by researchers (e.g., Bartell et al., 2017; Freeman et al., 2014; Gutiérrez, 2010; Kuster et al., 2018; Laursen & Rasmussen, 2019; Reinholz, 2023) and professional organizations (e.g., Mathematical Association of America, MAA, 2018; National Council of Teachers of Mathematics, NCTM, 2014). Serbin et al. (2025) suggested that these practices of varied grain size align with these broader teaching practices: "(i) use meaningful engaging math tasks, (ii) facilitate student collaboration, (iii) elicit, notice, and use evidence of students' mathematical thinking, (iv) orchestrate class discussion on students' mathematical ideas, (v) attend to participatory equity and access in the classroom, (vi) foster an inclusive class community, and (vii) equitably assess student work" (p. 1568). Given the success of active learning and equitable teaching practices in calculus courses (Bressoud & Rasmussen, 2015; Hagman, 2021), mathematics departments in the US have made strides toward institutionally changing their mode of instruction in calculus to active learning (Smith & Rasmussen, 2025; Williams et al., 2022).

It is difficult for instructors to change their instruction, so there is a need for PD on active learning. PD programs for mathematics instructors can be implemented in a variety of formats, like pre-semester workshop days, workshop series, faculty professional learning communities (Stoll et al., 2006), and lesson study (Fernandez & Yoshida, 2012). PD programs can also be informed by various design principles. Soto and Marzocchi (2021) suggested such programs should emphasize building community among faculty participants, create opportunities for faculty to collaborate, encourage faculty reflection and persistence in improving their practices, build faculty's confidence and motivation, and provide a variety of PD formats. These and other researchers have emphasized the importance of actively engaging participants in PD programs to model active learning approaches (e.g., Akin et al., 2023). One such way to actively engage instructors in teaching practices during PDs is to provide opportunities to participate in AoPs, which we describe as follows.

Theoretical Framework

Theoretical Perspective Informing the PD Design

AoPs are productive activities for teachers to engage in during teacher education and PD programs (e.g., González, 2017; Kavanagh et al., 2020; Sapkota & Max, 2024). AoPs are "opportunities to engage in practices that are more or less proximal to the practices of a profession" (Grossman et al., 2009, p. 2056). These activities simulate a teaching scenario or practice, which provides an opportunity for teachers to rehearse and develop teaching practices without the complexity of a real-time class setting or risk of affecting students (Howell & Mikeska, 2021). AoPs can simulate various teaching practices, such as noticing students' mathematical thinking (Jacobs et al., 2010; van Es & Sherin, 2021) or responding to students' ideas in class discussions (Campbell & Elliott, 2015; Howell & Mikeska, 2021; Jackson et al., 2024; Kaka et al., 2021). The design of AoPs can vary by the type of teaching practice approximated, the medium of the scenario (e.g., classroom videos or written artifacts of student work), the degree of authenticity of the approximated teaching practice, and the scenario content.

Theoretical Perspective Informing the Data Analysis

To analyze our data, we drew on Schoenfeld's (2010) decision-making framework, which suggests a teacher's decision-making can be explained by their resources, orientations, and goals.

Resources. In Schoenfeld's (2010) framework, *resources* encompass an instructor's

knowledge inventory (including content and pedagogical knowledge), as well as the material resources available to teachers (e.g., technology, physical classroom spaces). These resources determine what is possible in a classroom at any moment. Resources also include interpersonal skills and practical knowledge that teachers bring into the classroom (Schoenfeld, 2011). What an instructor knows and has access to influences the decisions they make in real-time teaching.

Orientations. *Orientations* refer to a teacher's beliefs, values, preferences, and tastes (Schoenfeld, 2010). These orientations influence how teachers perceive and engage with classroom situations and what goals they consider to be important. Orientations are often implicit and develop over time with experience. They significantly shape teachers' real-time decisions.

Goals. *Goals* are the objectives, either explicit or implicit, that guide a teacher's decisions and actions (Schoenfeld, 2010). They can range in granularity, from broad aims, such as helping students to foster conceptual understanding of a subject, to more specific aims, like maintaining the class pace. Schoenfeld (2011) posited "goals recruit resources" (p. 459); teachers activate and apply their resources in service of the goals they prioritize. Instructors constantly re-evaluate their goals based on evolving classroom dynamics and shift their actions accordingly.

Methods

The 11 participants included part-time lecturers, full-time lecturers, and tenured professors, who taught Calculus I or II. Eight were faculty at a large public university, and three were faculty at a nearby community college in the southern US. Most faculty primarily lectured in their courses but were interested in implementing active learning.

The first author led a PD workshop series on using active learning while attending to equity and inclusion. The program consisted of two full-day sessions before the spring semester, with six two-hour sessions during the semester. The PDs drew on K-12 and undergraduate math education literature and focused on the following evidence-based teaching strategies: fostering inclusive classroom social norms; designing group-worthy mathematical tasks (Lotan, 2003) that require high levels of cognitive demand (Stein & Smith, 1998); eliciting, noticing, and responding to evidence of student thinking (NCTM, 2014); orchestrating class discussions using the 5 practices: anticipating, monitoring, selecting, sequencing, and connecting (Smith & Stein, 2018); and fostering equitable student participation (MAA, 2018). Instructors practiced these strategies through 15 AoPs that used videos of student thinking, scripts of classroom discussions, student quotes, and hypothetical student work to simulate classroom scenarios.

We conducted hour-long semi-structured interviews with each instructor after the PD series. Questions focused on participants' enactment of the teaching practices from the AoPs in their calculus classes. We provided participants a list of topics covered in the PDs and asked them to identify practices they tried implementing and the result. We asked about their experiences in the workshops and what they found helpful about the AoPs. Interviews were conducted over Zoom by the second author and an outside research team member who were not involved in facilitating the AoP workshops. Interviews were transcribed through Zoom and cleaned for analysis.

Our data analysis began by extracting excerpts where participants discussed their experience or decision to enact active learning pedagogies that were highlighted in the PDs. We deductively coded (Miles et al., 2013) these excerpts using the codes, resources, orientations, and goals, while considering Schoenfeld's (2010) descriptions of those. We characterized the types of resources, orientations, and goals discussed via inductive coding (Miles et al., 2013). For each participant, we compared excerpts and created a summary of how their resources, orientations, and goals seemed to influence their decision to enact teaching practices they learned in the AoPs.

Results

For this paper, we present case studies for two participants and describe the resources, orientations, and goals that informed their implementation of the teaching practices from the PD.

Case 1: Sumaya

Overview and What Practices She Implemented from the AoPs. Sumaya had taught university mathematics for 17 years. She primarily taught Calculus I, and during the semester that she participated in the PD, she taught Calculus II. During her interview, Sumaya claimed she implemented these teaching practices from the AoPs: fostering inclusive social norms, designing group-worthy mathematical tasks, eliciting evidence of student thinking, orchestrating class discussions, and fostering equitable student participation. When asked about which of the AoPs impacted her teaching the most, Sumaya brought up the steps of orchestrating class discussions. She remarked, "I wasn't aware that some of the practices that I had would fall into this definition of anticipating, monitoring, selecting, sequencing, and connecting." She went on to say, "After I attended the workshop…I learned that these are actually a sequence of different things that we can do for the class discussions, and so I became more mindful of doing them." Sumaya talked about how, before the workshop, she would anticipate student responses and monitor students during class, but because of "time constraints," she would often just take "the first answer that I would get. I would just say either yes or no and continue with that." But after attending the workshop, Sumaya "was more patient" and would "wait for more responses and then build upon those responses." Sumaya discussed how her participation in the AoPs helped her reflect on her teaching and find areas to improve upon. She said,

> I participated in this program because I wanted to better myself. But then some of the things, for example, the anticipation and selecting and sequencing, when I heard it, my first reaction was, "Oh, yeah, I'm doing this." But then when…we talked about it, and then when I went to the class, and I reflected on it, I realized that there is a lot of improvement that I can make...I became more mindful of everything.

Participating in the AoP helped Sumaya become more aware of the steps in orchestrating class discussions, which led her to be more intentional about selecting, sequencing, and connecting student responses. Below, we discuss our claim that Sumaya's resources, orientations, and goals informed her implementation of the teaching practices from the AoPs.

Goals and Orientations. A central focus of Sumaya's interview was her goals to *grow as an educator* and *engage students in their learning*. These goals were closely linked to Sumaya's orientation that *active learning is important*. Sumaya discussed how she had been committed to using active learning teaching strategies even before participating in the AoPs. She explained that at the beginning of her teaching career, she was very "lecture-based" because that is how she had been taught. However, over time, she "became interested in the teaching practices that best involve students and engage students in their own learning," attending conferences and workshops to learn more about active learning. Sumaya discussed the value of PD, saying they help with "becoming very mindful of our practices, reflecting on what we're doing, so that we can make adjustments." She went on to say that "if the focus goes into learning and what we can do for the students to engage them through active learning, how to be a truly equitable educator, then we can reach more students and help them with learning." These goals and orientation seemed to support Sumaya's decision to use active teaching practices from the AoPs in her class.

Another one of Sumaya's goals was to *provide students with appropriate scaffolding* so that they could engage with material and continue to work in small groups without needing constant assistance. Sumaya linked this to the teaching practice of designing group-worthy mathematical

tasks, which had been the primary focus of one of AoPs. She discussed how facilitating group work in a large class of 56 students in an auditorium classroom without the help of a TA was challenging. However, by carefully scaffolding group activities, Sumaya felt that the students "had some guidance to go through it [the worksheet]" and that providing "questions that would guide them to go to the next step, not necessarily making it too easy...would be one of the better ways to manage the large classroom." This goal seemed to influence Sumaya's decision to implement group-worthy tasks in her class, despite the challenges hindering her implementation.

Sumaya also exhibited the orientation of the *importance of valuing student contributions* and discussed her goal to *have students feel comfortable sharing their ideas* in class. She talked about how Calculus II "has difficult topics, so not all students are comfortable sharing their answers." Sumaya went on to say, "It's really important for them to engage without putting them in a position that would embarrass them. So, that was something that I tried to give value to all answers that I was receiving from the students." She concluded by saying, "I would always try to bring positive remarks to all sorts of answers, so that they feel more comfortable. Building trust with 56 students wasn't easy...But I think I was successful in that." Helping students feel comfortable directly connects to the teaching practices of fostering an inclusive classroom social norms and equitable participation from the AoPs. Sumaya commented that her participation in the AoPs "validated...how I want to approach my students, making sure everyone is included, making sure everyone's opinion does matter, that they have ownership over their learning, that I give credit for their effort, and not necessarily correctness of their answers." Her orientation and goal here supported her enactment of productively responding to student thinking and fostering an inclusive classroom social norms and equitable participation, which she practiced in the AoPs.

Resources. In terms of resources, Sumaya discussed how her *awareness of student backgrounds* and *knowledge of common student struggles* informed the way she structured class and designed tasks. Sumaya discussed the steps in orchestrating her class discussions, saying,

> Anticipating students' answers, that's always been in my mind the way that I make the worksheets or the way that I create those review sessions at the beginning of each class...So that I knew that, okay, this part seems a little bit difficult,...students are going to get caught...[or] make a mistake in this part.

She also described the challenge of supporting students with various mathematical backgrounds and trying to "balance" meeting the needs of different students. Sumaya remarked how she had "math majors in the class who are ready to learn more, and they want to go more in depth with the proofs," while also teaching "students who are really struggling with derivative, anti-derivative, very basic rules. So, how to balance that and be still equitable and inclusive. That was a challenge." Sumaya's resources here seemed to influence her implementation of equitable and inclusive teaching practices, which were addressed in the AoPs.

When discussing how she had implemented the practices of fostering equitable participation and inclusive social norms in her class, Sumaya brought up the cultural context of the institution. She talked about how during group work time, she would "make sure that everything is clear to the students, especially because we are a Hispanic Serving Institution, and some of the students, English is their second language." She went on: "I was very mindful of that...if the language is clear for the students...I let the students know that as I'm walking around, if something is unclear, make sure that you ask me, so I can clarify for you." By drawing on the resource of her *knowledge of students' backgrounds*, Sumaya could attend to equity and inclusion in her class.

Case 2: Richard

Overview and What Practices He Implemented from the AoPs. Richard taught university mathematics for 35 years. He taught a variety of courses, primarily Calculus II, which he taught during his participation in the PD. Richard claimed he implemented the practices of: eliciting evidence of student thinking during class, noticing and responding to evidence of student thinking, fostering inclusive social norms, and some of the five practices for orchestrating class discussions. Richard discussed how the AoP on responding to student thinking "made me more aware of how I need to be interacting with the students in certain areas." The AoP prompted participants to discuss what an instructor should have done differently. Richard recalled the scenario where a student asked about a computation, "From an instructor point of view, it was trivial, but the student was not understanding… the instructor had simply replied, 'You're supposed to already know that.' Of course, that puts the students down." He remarked,

> That scenario reinforced how, when a student asks a question, it's important to take it seriously…Not get frustrated that they didn't understand something trivial…That's important in teaching and interacting with students…to answer them as if they're serious mathematical questions and dig in to see where their misunderstanding was coming from.

Richard exemplified how he implemented the approximated practice while simplifying the expression x^{n+1}/x^n: "The first time that an expression comes up, I usually do it in slow motion and say, from now on, we'll just go to this." When a student asked about the simplification,

> Instead of saying, 'we talked about this earlier'…I tried to explain it in a different way... That's when that connection with the scenario in the PD came in…Just be patient, treat the question as a serious question, and let's see if we can figure out where the misunderstanding is and how to get him over that."

The AoP helped Richard intentionally respond to students in non-dismissive ways and elicit further evidence about their thinking. We posit that Richard's goals, orientations, and resources informed his implementation of these teaching practices that he learned in the AoP.

Goals and Orientations. Richard provided evidence of the goal of *helping students feel comfortable sharing answers and asking questions* and the related orientation that *it is important for students to feel comfortable and confident in class*. Richard described an instance of a student asking a question in class and being "more interested in just learning why, rather than is somebody gonna think I'm dumb." Richard claimed the student "felt comfortable in asking, and so to me, that meant that I maybe was partially successful in having an environment where they could ask questions like that…I found students were very open in offering up their mistakes." Richard perceived value in having a positive class environment where students felt comfortable and confident sharing answers, making mistakes, and asking questions during class. This goal and orientation seemed to support Richard's decision to enact teaching practices of fostering inclusion and productively responding to student thinking, which he learned about in the AoPs.

Another goal and orientation salient in Richard's interview were to *respond to students in productive, non-disparaging ways* and *it is important to value student contributions*. Richard claimed to "try to create a classroom environment where questions are taken seriously and with enthusiasm, and…that the failures are celebrated. So that we can learn a lot more by making mistakes and learning how to fix something than just by getting something right the first time." He valued students' questions, answering them with enthusiasm, and responded to students' mistakes in positive ways. This goal and orientation seemed to support Richard's implementation of responding to evidence of student thinking because he was intentional in responding to students' questions and contributions in ways that did not disparage the students. He described trying to productively respond to students in class by celebrating their mistakes, eliciting further

evidence of their thinking, and providing more explanations without embarrassing the student.

Resources. Richard's knowledge and experiences served as resources that seemed to influence his decision to enact the teaching practices from the AoP, like responding to student thinking in productive ways. He discussed how the AoPs contributed to his *knowledge and awareness of student interactions*, a resource that helped him consider different ways to respond to students. He stated, "That activity stuck with me. There were some discussions that made me more aware of how I need to be interacting with students." This *experience engaging in the AoP* and *learning about specific teaching practices regarding student interactions* served as resources he could draw on while responding to student thinking. His prior *knowledge of how to respond to students* was also a resource informing his decision to implement the teaching practices from the AoPs. He referred to an AoP scenario where an instructor "put a student down," explaining, "I think I'm pretty good about not responding to students that way. That particular scenario... reinforced how when a student asks a question, it's important to take it seriously." Richard had prior knowledge of how to interact with students based on his years of experience teaching, and the AoP helped reinforce that knowledge to use as a resource in his teaching.

Discussion and Conclusion

Given the calls to implement active learning and equitable teaching practices in calculus courses, we led PDs, training Calculus I and II instructors to use these pedagogies. The PDs were designed to actively engage instructors in AoPs to enact various active learning and equitable teaching practices. After participating in the PD, we interviewed instructors about their implementation of the teaching practices they learned in the AoPs. We focused on two case studies, Sumaya and Richard, for this investigation. Both instructors were able to describe how their experience engaging with the AoPs informed their implementation of the approximated teaching practices in their own classrooms. We investigated how their resources, orientations, and goals informed their decision-making while enacting teaching practices from AoPs.

Both instructors had goals and orientations related to engaging students, helping students feel comfortable in class, and valuing student contributions. We posit that having these goals and orientations influenced the instructors' decisions to enact active learning and equitable teaching practices like eliciting and responding to evidence of student thinking, fostering inclusive social norms, and fostering equitable student participation. Furthermore, an instructor's resources (e.g., knowledge, experiences) influence the decisions they make in their teaching (Schoenfeld, 2010), particularly whether to enact the practices they learned in the PD. For Richard, the AoPs served as a resource, reinforcing his goals and prior knowledge of how to respond to students, which seemed to influence how he responded to student thinking in class. For Sumaya, her knowledge and awareness of student backgrounds informed how she implemented practices from the AoPs, such as fostering inclusive social norms and equitable participation. Overall, our case studies exhibit how instructors' resources, orientations, and goals could influence the instructors' decisions to enact the teaching practices learned in the AoPs.

Our findings contribute to the literature on PD for university mathematics faculty and provide implications for PD designers. The AoPs in our PD served as a resource that supported instructors in deciding to implement active learning and equitable teaching practices. AoPs have great potential to train university instructors to implement active learning. They provide a low-stakes environment for instructors to develop new teaching practices. Our case studies showed how engaging in AoPs allowed instructors to reflect on their teaching practice, be more mindful of how they interact with students, and reinforce their pedagogical knowledge. Thus, we suggest that designers of PD programs for university faculty actively engage their participants in AoPs.

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