



Learning to teach science during the clinical experience: Agency, opportunity, and struggle

Mark Windschitl¹  | Karin Lohwasser² | Tammy Tasker¹ |
Soo-Yean Shim¹  | Caroline Long¹

¹College of Education, Teaching, Learning and Curriculum, University of Washington, Seattle, Washington, USA

²Teacher Education and Professional Development, University of California Santa Barbara, Santa Barbara, California, USA

Correspondence

Mark Windschitl, College of Education, Teaching, Learning and Curriculum, University of Washington, Seattle, WA 98195, USA.
Email: mwind@uw.edu

Abstract

Agency has been used as a lens to focus on how educators learn through pedagogical risk-taking, advocacy for curricular reform, and resisting policies that are not focused on the needs of students. We explored the role of agency as 65 preservice science teachers created learning opportunities for themselves during their clinical placements. Specifically, we investigated whether the types of agentive episodes varied by the level of congruence novices perceived between the vision of science teaching supported in their university coursework and the prevailing practices and culture of their host classrooms. Interview and survey data of participants from three preparation programs indicate that those in highly congruent placements experienced earlier and more mentor-scaffolded opportunities to take on active roles in teaching, and exercised agency to extend research-informed practices or tools they observed their mentors using. This resulted in participants seeing the richness of students' thinking and how capable they were of challenging work, given strategic supports. Those in low congruence placements had fewer chances to play active roles in teaching, were more likely to draw upon agency to make minor adjustments as they emulated their mentors' instructionally conservative lessons, and expressed concern they were "getting better" at aspects of teaching they viewed as inequitable or less responsive to students. Regardless of congruence, however, even simple acts of



agency such as asking mentors to explain their instructional decisions were remarkably rare.

KEY WORDS

agency, clinical experience, reform teaching, teacher education

1 | INTRODUCTION

A growing number of preservice science teachers are being prepared to enact instruction that foregrounds responsiveness to students' ideas, supports diverse sensemaking opportunities for learners, and maintains educational justice as a core value (see Davis et al., 2019; Stroupe et al., 2020). The assumption is that novices will carry this vision with them into their clinical placements and, under the guidance of experienced mentors, use research-informed practices in their work with children. In reality, this transition to K-12 settings is frequently complicated by mis-alignments between images of good teaching cultivated in university coursework and the prevailing practices and cultures of host classrooms (Kang, 2018; Ronfeldt & Grossman, 2008). For example, it is not uncommon for teachers to simply explain curricular content to students rather than uncovering their existing ideas and engaging them in sense-making dialogue (National Academies of Sciences, Engineering, and Medicine [NASEM], 2015); in many classrooms, students churn through procedural labs rather than use science practices as epistemic tools to test budding theories (Cherbow et al., 2020; NASEM, 2019; Osborne & Dillon, 2008), and discourse is often reduced to recitations around known-answer questions (Weiss, et al., 2003). Opportunities for novices to try out responsive and appropriately challenging instruction in these situations may be different than in classrooms where the pedagogy is both informed by research and congruent with a vision of teaching espoused in their preparation programs (Cohen & Berlin, 2019; Edwards, 2005).

To understand how novices learn in situations where they must constantly negotiate the authority to try out new roles and teaching strategies, it is important to attend to their agency. Opportunities to experiment with pedagogy may present themselves in the form of invitations by their mentors or as required tasks by their preparation program, but novices must also actively *influence* situations that can deepen their understandings of teaching. Unless we include agency as integral to professional learning during the clinical experience, we risk over-emphasizing the influences of situational context and how novices are prepared while paying less attention to individuals' subjectivities, identities, and intentionality (Holland et al., 2003).

To explore this territory we draw on the concept of professional agency, which Eteläpelto et al. (2013, p. 61) describe as "exercised when subjects and/or communities influence, make choices, and take stances on their work and professional identities." This can include opening up spaces to try out new ways of doing things, making suggestions for revising existing work practices, and repurposing common tools for different aims. Professional agency can also manifest itself as resisting structural power or authority, challenging existing assumptions used to guide action, or questioning implicit goals for the work at hand (Fenwick & Somerville, 2006). For experienced teachers this can mean requesting justification of departmental decisions, pushing back on informal curriculum policies, or questioning the dominant language in the work space that defines what is possible in classrooms. These decisions are interwoven with subjects' work-related sense of selfincluding professional commitments, ideals, interests, and goals. For vulnerable preservice teachers, we have less understanding of how agency in these or other forms plays a role in navigating relationships where power asymmetries with mentors can influence what and how they learn. In practical terms, if we want to design teacher preparation experiences for the purpose of supporting productive forms of agency, we must better understand the range of agentic activities that novices already engage in, across a range of clinical settings.



In this study, we investigated how novices draw upon agency to generate opportunities for their own learning and to understand if their efforts vary, depending upon the congruence of their placement with the values and practices featured in their preparation coursework. Preservice secondary science teachers from three universities were studied as they transitioned from coursework to their clinical experiences. We documented the types of opportunities these preservice teachers were afforded to take up active instructional roles and we investigated a wide range of agentic acts that appeared to be motivated by a desire to learn beyond the opportunities that were presented to them or required of them. We asked:

- In what ways does perceived congruence between the vision of science teaching supported at participants' universities versus in their host classrooms relate to their opportunities to take up meaningful teaching roles during their clinical experience?
- How do novices exercise agency to support their own learning in high versus low perceived congruence placements?

2 | LITERATURE REVIEW

2.1 | Congruence between the university and field placements

In an article referring to clinical experiences as “The Holy Grail of Teacher Education,” Darling-Hammond (2014) claims that preservice teachers who have regular opportunities to experiment with research-informed pedagogy and receive useful feedback become more skilled educators than peers who lack such experiences. These opportunities to learn about teaching are thought to be influenced by the instructional practices of mentors and the established routines and norms of classroom activity (Hoffman et al., 2015). There is evidence, for example, that preservice teachers become more instructionally effective when they learn with mentors who are more instructionally effective (Goldhaber et al., 2020; Ronfeldt et al., 2018). This may be because cooperating teachers’ coaching includes learning supports that are similar to those they use with students in their classrooms (Hoffman et al., 2015). Along these lines, Anderson and Stillman (2010) found that more capable mentors viewed novices as possessing varied and useful proto-repertoires of practice, as making meaning of new concepts in relation to prior knowledge and experiences, and requiring chances to engage in guided practice while student teaching.

These clinical relationships are thought to be compromised when mentors’ beliefs and practices contradict principles taught in teacher education programs (see Clift & Brady, 2005). Mentors have been observed guiding novices toward intellectually conservative practices and preventing them from exercising more progressive beliefs or trying instructional strategies learned in their university coursework (Feiman-Nemser & Buchmann, 1985; Ronfeldt & Grossman, 2008; Valencia et al., 2009). LaBoskey and Richert (2002) found that mentors opposed to preparation program principles even resisted engaging in critical discussions about their own approaches or those taught in the program. Conversely, in a study of elementary teachers, Anderson and Stillman (2010) described how “without exception” participants going through their clinical experience with at least one mentor who enacted philosophies and pedagogies similar to those taught in the preparation program, reported learning more during their time together and applied more of what they learned in their work as first-year teachers. Participants claimed that these placements “provided images of ‘what’s possible,’ which in turn anchored them when they faced first-year struggles” (p. 451).

For the purposes of this study, we are interested in the alignment of coursework with the prevailing practices and culture of the host classroom during the culminating clinical experience. We refer to this practice-based alignment as *perceived congruence*. We use this term because it applies to the correspondences between two different activity systems (preparation program and K-12 schools) in terms of how practices and stances toward teaching “map” from university coursework onto the clinical setting. We distinguish congruence from the idea of



coherence which describes the consistency and complementarity among features within a single activity system, such as across a program's courses and assignments (see Hammerness, 2006).

In a placement, if there are similarities between the vision of teaching at the university and in the host classroom, it can mean that particular resources and routines, congruent with a shared conception of competent pedagogy, may already be integrated into the interactional repertoires of the mentor and students. For example, the mentor and students may regularly coconstruct whole class conversations, and because this discourse is situated in familiar ways of being and interacting for students and is mediated by tools tailored for this study (e.g., verbal cues by the teacher, or a graphic organizer guiding different stages of the conversation) the novice can more readily make sense of these practices. The novice can also experiment with tools and routines similar to those used by the teacher and understood by the students (see Windschitl & Calabrese Barton, 2016). On the other hand, research-informed frameworks endorsed at a university may not be perceived as applicable by novices in classrooms where more traditional goals organize the work of teaching. In fact, implementing practices that are incongruent with students' and mentors' ways of knowing or being risks criticism by the mentor, and in some cases can mean fewer opportunities to practice (Braaten, 2019).

2.2 | Common practice in secondary science classrooms

Science teacher preparation is increasingly being shaped by visions of responsive and equitable classroom cultures (Davis et al., 2019; Larkin, 2014; Stroupe et al., 2020). These visions include connecting curriculum to students' interests and lived experiences, using discourse as an everyday tool for sensemaking, involving students in epistemically authentic science activity, and using formative assessment to modify instruction based on all learners' needs. However, finding clinical placements that are congruent with these aims is as difficult now as it was 30 years ago when Feiman-Nemser and Buchmann (1985) wrote about the "two-worlds pitfall"—a reference to the culture shock novices can experience when they transition from the university and its ideals for teaching, to public school classrooms.

A recent report by the National Academies of Sciences, Engineering, and Medicine (NASEM, 2015) questions whether national reform efforts for teaching science have fundamentally impacted classroom practice. Observational studies at all grade levels in the United States have shown only a fraction of lessons to be appropriately high in intellectual rigor (Corcoran & Gerry, 2011; Weiss et al., 2003). Few students experience science as a collective knowledge-building enterprise or have opportunities to use disciplinary practices like argumentation, evidence-based explanation, or modeling. Rather, teachers often substitute tightly controlled and procedural forms of "hands-on" work (Cherbow et al., 2020) and do not help students make connections between these activities and important science ideas (Roth & Garnier, 2007). Nearly all these studies express concern about the lack of sensemaking via linking content to students' lives and more generally the lack of academically productive talk (Braaten, 2019; NASEM, 2015; National Research Council (NRC), 2007). In a study of European science teaching, Osborne & Dillon (2008) echo the same issues reported in American schools—teacher-dominated discourse, the near absence of student-driven science practices, and lab work being written up formulaically. We would add that nearly every aspect of conservative pedagogy described above risks marginalizing students from nondominant backgrounds, disregarding the diverse experiences they bring to the classroom and tolerating lowered expectations (NASEM, 2019).

These ways of conducting business have become so normalized in educational institutions at all levels that researchers refer to them simply as "doing school" (see e.g., Jiménez-Aleixandre et al., 2000). Given that many preservice teachers are invited to work in traditional classrooms, it is important to understand how they might take action to create openings for their own learning and work to resolve tensions between their two worlds.



2.3 | The role of agency in navigating the clinical experience

Agency involves intentional efforts to influence current circumstances or “make a difference” within social-constituted systems of activity—acts which require knowledge or other resources to accomplish some valued end (Hokkä et al., 2017). Intentionality refers to the actor knowing or believing that an action may have a particular outcome, and in which knowledge is utilized by the actor to achieve the outcome. Holland et al. (2003) characterize these acts as improvisations, using whatever is at hand to create some form of change. To understand how agency influences one's opportunities to learn during the clinical experience, we need to understand how it is resourced and constrained by contextual factors, including power relations and discourses, and further by the material conditions and cultures of social interaction in schools. We draw from Eteläpelto et al. (2013) conception of *professional agency* in which subjects influence, make choices, and take stances on their work and work-related identities, “not merely entering into and suggesting new work practices, but also maintaining existing practices, or struggling against suggested changes” (p. 61). Identities represent one's internalized commitments, goals, and ideals that are associated with being or becoming a member of a particular group. Identities emerge from internal conversations which entail discernment of and dedication to our particular concerns. This “internal conversation” is a form of interplay between the social and the individual. We also become recognizable subjects by taking up certain social positions in conversations with others. In learning contexts, identities are at least partially socially constructed through such interactions, using culturally defined forms of language, tools, and representations (Holland et al., 2003). Agentive actions then, are motivated and exercised in the performance of those identities.

Recent conceptions of agency have expanded our view of learning as the movement from peripheral to more central forms of participation within communities of practice (Lave & Wenger, 1991). In this view, newcomers learn by negotiating with knowledgeable others to take on more involved roles within the group. These roles can be generative for learning and more expansive than merely replicating performances. For preservice and early career teachers it stands to reason that, as newcomers, they may take opportunities to challenge the status quo or transform local conditions and relationships. Studies have shown that some preservice (Luft et al., 1999) and early career teachers (Braaten & Sheth, 2017; Larkin, 2020; Milner, 2010) do exercise agency to make their pedagogy more student-centered, critically conscious, and challenging than do their mentors or department peers. However, these educators simultaneously feel pressured to prepare their students with basic skills that will be measured on tests, to ask young learners to reproduce ideas specified in a common curriculum, and to sacrifice authentic and passionate student dialogue for the sake of “orderly” classrooms.

Because of inherent asymmetries in authority between mentor and novice during the clinical experience, generative actions like these often require novices to take calculated risks. If novices find their mentors are open to questioning or experimenting together with new practices, it may facilitate trust building in the dyadic relationship and help them feel safe, even as they make themselves vulnerable. There are, in fact, a number of teacher education programs that intentionally foster such relationships during the clinical experience (see Darling-Hammond & Oakes, 2019). On the other hand, a different sense of vulnerability may develop from feelings of powerlessness and result in anxiety or fear. In these situations, people may feel they have little control over work circumstances, or feel they are being compelled to act in ways that are inconsistent with their core beliefs and values (Lasky, 2005). Rather than opening themselves up in such situations, they may withdraw or conform to the normative expectations of the community.

While there are numerous examples of how agency plays out in work situations, we know little about the specific forms it can take and to what effect in situations where novice educators are learning in classrooms. In a study of 12 novice-mentor dyads in elementary, middle and high schools, researchers found that novices did not perceive themselves as agents in their own learning and relied on mentors to initiate changes in their roles during teaching, hindering their opportunities to develop adaptive expertise (Soslau et al., 2019).



In a decade-long series of studies on preservice teachers and agency, Edwards (2007) found that they rarely interacted with other professionals while in their host schools. Their work was guided by lesson plans, often supplied by the mentor, and feedback focused on their delivery of the lesson as well as the pace at which children moved through the curriculum. Most problematically, adherence to lesson plans meant that novices became increasingly less responsive to children over the year of their training. Edwards found they did not expand the problems they encountered in their teaching and thereby failed to expand their own learning. Agency seems essential for professional learning but it appears that novices, for reasons that are unclear, demonstrate little self-advocacy or propensity to challenge the status quo toward these ends during their clinical experiences.

3 | THEORETICAL FRAMEWORK

Opportunities for novices to take up active teaching roles in a clinical setting can be understood through the lens of situated learning (Greeno & Engeström, 2014) which describes “coming to know” as a process rooted in activity with others that is mediated by tools and culturally defined ways of participating in work together. In classroom communities, tools can be practical, such as written guides for developing units of instruction or templates for students to make their thinking visible through scientific modeling. Tools can also be conceptual, such as a repertoire of discourse moves to support sensemaking dialogue or heuristics for implementing different types of formative assessment. Broader conceptual frames about what is proper and possible to do with students in classrooms and the means to accomplish these goals (i.e., visions for teaching) can shape learning experiences and foster particular kinds of communities in classrooms (Jóhannsdóttir, 2010).

Activities, tools, and understandings are part of a broader system of social relations that are produced by and reproduced within communities. Learning can be considered an evolving form of membership within such communities, and thus, identity, knowing, and social membership entail one another (Holland et al., 2003; Lave & Wenger, 1991). Using this lens, novice educators enter their placements with marginal status: they are beginners in the profession and guests in the classroom. They come with collections of untested tools and nascent practices as well as commitments for supporting students, but they must negotiate what they do in that setting with experienced teachers who are in supervisory relationships with them. In these roles, mentors may invite novices to try out parts of teaching or give permission for them to design and enact instruction as required by their preparation programs. But these are not the only avenues of opportunity for novices to learn. As they attempt to move from peripheral to more central means of participation in the life of the classroom (Lave & Wenger, 1991), they can exercise agency to create new openings for their learning (Figure 1). They can take action aimed at developing deeper understandings of the work of teaching and achieving goals that are meaningful to them or their students (Eteläpelto et al., 2013). Agency in these cases is emergent because it is both resourced and constrained by interactions between social conditions—including cultural and material resources—and individuals with their own professional identities (Biesta et al., 2015; Hokkä et al., 2017). These identities are challenged or reinforced by taking up certain positions in conversations with others. When this kind of dialogue happens, individuals not only internalize messages about themselves but send messages to others; they “place themselves in social fields” in affinity with, opposition to or at a distance from identifiable others (Holland et al., 2003).

Contradictions can arise if novices attempt to use specialized discourses and tools to serve goals that are not in alignment with or are unrecognizable by other members of the community (Stillman, 2011). Agency then, may take different forms depending upon the institutional context, norms of the classroom, students' histories as learners, and the influence of mentors.

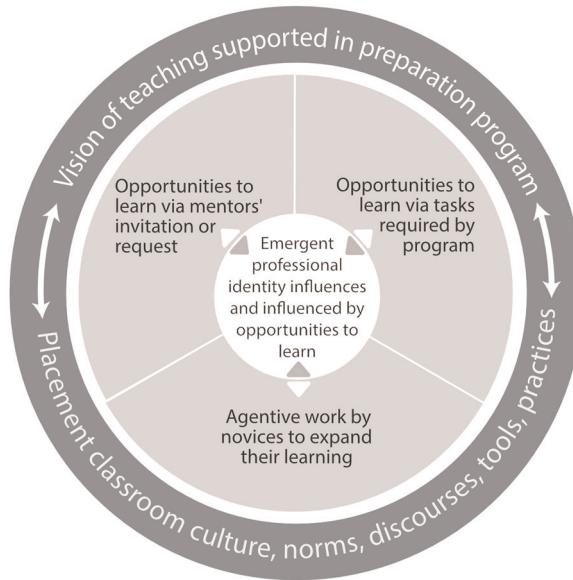


FIGURE 1 The role of congruence and agency in professional learning during the clinical experience

4 | METHODS

4.1 | Participants and context

We employed a mixed-method multicase approach (Creswell, 2012) collecting both survey and interview data from 65 preservice secondary science teachers about their clinical experiences. All members from two cohorts at each of three university-based teacher preparations programs (during academic years 2015–2016 and 2016–2017) were asked to participate. Only two declined and one had to drop out. One program was located in the Northwest United States (U1), another in the Midwest (U2), and the third in the Southwest (U3). These were graduate-level, meaning that candidates entered with a bachelor's degree in an area of science or engineering. Seven participants identified as first-generation college students and 14 as first-generation immigrants. Twenty-two identified as non-White, including four Filipina/o, four Chinese-American, five East Indian, and four Latinx. Forty-eight participants were women.

Each of the programs featured methods and assessment classes designed around recommendations in widely cited consensus documents, with a focus on student sensemaking and equity in science teaching (described later). Instructors drew upon research-based reports such as the *Framework* document (NRC, 2012) for the *Next Generation Science Standards*, *Taking Science to School* (NRC, 2007), and *Science and Engineering for Grades 6–12: Investigation and Design at the Center* (NASEM, 2019). Practices consistent with recommendations in these documents were modeled by methods instructors at the participating institutions, supported with particular tools and conversations during university coursework, and studied in classroom videos. The methods and assessment courses focused on designing instructional units grounded in events and processes young learners find interesting and relevant, eliciting and building upon students' ideas and everyday experiences as foundational to good instruction, and creating opportunities for equitable forms of sensemaking talk as students engage in disciplinary practices to create evidence-based explanations. Formative assessments like diagnostic conversations with students, scientific modeling, and the use of exit slips to improve instruction were also featured in all these programs. At least one course in each program included discussions about professional identity, the need to address value



tensions in placements, and to continually assess how self-advocacy might help them develop into “the kind of teacher they wanted to become.” In two of the programs, participants role-played how to speak up to mentors if classroom conditions appeared to undermine their pedagogical or social justice commitments.

The programs’ durations were 13–15 months and included extensive coursework, observations in local middle or high school classrooms, and student teaching, typically at a different location from the observations. The programs each began their principal clinical experiences at the start of the school year (late August, early September). University 1’s teacher candidates were placed in a middle school or high school in late August and they remained there under the guidance of a mentor until early April. University 2’s teacher candidates started at the same time, observing in a middle school and high school, then transitioned later that fall to another school for approximately 2 months, and by December they were in their final placement classroom until June. University 3’s teacher candidates were placed in a middle or high school at the start of the academic year and continued in that setting until early June.

Candidates were assigned primarily to schools in diverse and high-needs communities. Schools that partnered with University 1 averaged 32% free and reduced-price lunches for students and 15.4% emerging multilingual students in their population. These were located in a large urban area and its surrounding suburbs, serving students from a wide range of social class, racial, and ethnic backgrounds. University 2’s partner schools averaged 25% and 7.8%, respectively, on the same metrics mentioned above, and were distributed across a medium-sized city and its outlying communities. The population of low-income students in the area had doubled in recent years and the larger community was made up of middle class or working class families. University 3’s partner schools averaged 38% and 10.1%, respectively. They were located in a large suburban area and served students from primarily middle-class families.

All institutions used the educative teacher performance assessment (edTPA) as a comprehensive culminating assessment (Stanford Center for Assessment Learning and Equity, 2013). Aspiring preservice teachers were required to demonstrate readiness to teach through lesson plans designed to support their students’ strengths and needs, engage them in disciplinary activity and reasoning, analyze their learning, and modify instruction to serve a broader array of students.

4.2 | Data sources

Participants responded to nine on-line survey logs over the course of their placements. Questions focused on novices’ opportunities to observe instruction, participate in coteaching or to take a lead role in teaching. We felt it was also important to determine whether they were seeing and participating in reform-oriented practices around teaching, so we included more specific questions, asking, for example, if novices observed their mentor “eliciting ideas from a wide range of students” and if they had a chance “to teach lessons allowing students to make choices about how to use scientific practices (e.g. modeling, investigations, and argument) to test ideas?”

At four points during their clinical experiences we also conducted 1-h interviews with participants. We asked them to identify actors, events, and conditions that influenced their thinking or chances to teach. They were asked to describe in detail what a typical day was like for them currently and if or how it had changed in the past few weeks. We used a standard set of questions to find out about their opportunities to teach, but also used their survey responses to probe further into experiences they mentioned as significant to their thinking or their practice.

To understand their uses of agency, we asked who had initiated any opportunities to learn, which could mean observing other teachers, interacting in new ways with students, analyzing student work, trying out new routines or tools while teaching, and so on. More broadly we asked whether their needs been met in this placement, and if not, did they take any action to meet those needs. We asked about self-advocacy: “Were there times since our last interview that you needed to advocate or ask for particular opportunities or support? And, “Since our last interview, have there been any points at which you felt that you took a risk in your placement?”



4.3 | Data analysis

4.3.1 | A focus on opportunities to do the work of teaching

Using survey and interview data we marked opportunities in which the participants took some active role in teaching. These roles could be a form of checking in with students, observing and imitating the mentor's teaching, coteaching with the mentor, or taking the lead in teaching (Table 1). Learning-to-teach opportunities were distinguished from more peripheral or passive episodes which included novices examining the existing curriculum, observing others teach, and talking with mentors about their instructional decisions. We collaboratively defined four active teaching roles that appeared in the data, then for each individual mapped their unique combinations of these onto a timeline (in 2 week increments). We indicated when these roles were taken up and how one type of role transitioned to another.

4.3.2 | Perceived congruence

We created a five-point scale for each of four components of instruction relevant to supporting student learning. The upper anchor descriptions (rating = 5) were synthesized from recommendations in *Taking Science to School* (NRC, 2007), *Science and Engineering for Grades 6-12: Investigation and Design at the Center* (NASEM, 2019), and the *Framework* document for the NextGen Standards (NRC, 2012). The lower anchors (rating = 1) were derived from research cited in these three reports that have documented common and problematic practices in American

TABLE 1 Classifications for opportunities to teach

Category	Description
Chipping in and checking in	Novice "chips in" comments to students, provides directions or questions during teaching in which the mentor has the lead role, and/or novice checks in with groups of students during the lesson to answer questions, monitor progress, keep them on track/focused, etc.
Observe then repeat a lesson or lesson segment	Mentor teaches one or more class sections; novice then teaches a subsequent class section using similar lesson plan, materials, types of activity. OR Mentor teaches one or more class sections, then in a subsequent class section the novice leads an activity that is part of the lesson without modification
Substantive coteaching	Both mentor and novice play intellectually interactive roles with students during the same class period. Novice and mentor may alternate who is in charge of various segments or may share a lead role throughout the class. Either novice or mentor may adjust their activities, scaffolds, or learning goals, based on how students respond to earlier tasks during the lesson. During group work, both mentor and novice are responsible for supporting students' learning within their groups, pressing for sensemaking, scaffolding in the moment, and/or enabling differentiation of the task.
Taking the lead in teaching whole lessons	Novice takes the lead in teaching all parts of a lesson the first time it is taught, at least once per week. These lessons may be planned by the novice or by the mentor; however, the novice may adjust activities, scaffolds, or learning goals, based on how students respond to earlier tasks during the lesson. Nonexample includes doing an "observe and repeat" lesson after watching mentor.



science classrooms, directly related to each of these dimensions. The four components were chosen because the reports cited above prioritized these as foundational for creating learning environments that are equitable, reflective of science as a discipline, and supportive of deep content understandings by students. In addition, these reflect the broader work of teaching: one focuses on the curricular structure of units and lessons (#1), two focus on the nature of instruction (#2 and #3), and one focuses on assessment (#4).

1. *Contextualization and connectedness of lessons.* The upper anchor was defined as: Content is made relevant to K-12 student experiences or interests; lessons are anchored in the press to explain complex phenomena; learning and activity reflect “big ideas” in science; and lessons are connected across units. The lower anchor on this five-point scale was characterized as: Lessons or units not grounded in real-world contexts (not connected to phenomena or big ideas, links to students’ interests not evident); lessons represent isolated bodies of knowledge, information, skills (do not clearly build upon one another).
2. *The degree to which classroom activity is oriented toward students’ sense-making about science ideas.* The upper anchor described instruction as regularly including small or whole-group discourse built into lessons and aimed at unpacking students’ ideas generated by activities. The lower anchor was characterized by little or no opportunity for students to reflect on or discuss what was learned and strict pacing of lessons, regardless of students’ state of interest, needs, or confusion.
3. *Students’ engagement with disciplinary work.* The upper anchor described activities in which students are given the opportunity to coordinate the use of different scientific practices to construct knowledge (e.g., investigations, modeling, and explanation). In the process they have a hand in deciding the specifics of how to take up this study. In the lower anchor, students’ daily tasks are unrelated to authentic disciplinary activity.
4. *Use of classroom assessment practices to improve learning.* In the upper anchor, formative assessments are used regularly to provide feedback to students or modify instruction. Summative assessments focus on challenging intellectual work or performances, and students are offered support and options to show what they know. In the lower anchor, there are no formative assessments evident; quizzes and tests are used for evaluative purposes only and emphasize the reproduction of textbook information.

For each component, we developed initial markers in the data records. As an example, for classroom orientation toward sensemaking (#2), markers included statements about: documenting publicly students’ ideas or pressing students to think deeply during small group work. Statements contradictory to these were marked as well (e.g., references to an emphasis on vocabulary learning or equation cranking, completing lab activities without opportunities to discuss outcomes). We did not use inferences by participants (“I don’t think my students know what exit tickets are”) or evaluative statements (“My mentor is really good at making learning relevant for kids”) to assess congruence.

Three researchers independently reviewed survey and interview data for each case then came together to compare both the passages they had flagged as relevant in regard to each of the four categories and the congruence ratings they had applied. Intercoder reliability for the ratings was approximately 80%, and areas of disagreement were negotiated to produce final ratings. Classroom placements that were labeled as near or at the lower anchors for all four dimensions—1 or 2—we categorized as “low perceived congruence” (using the acronym LPC). Placements that were rated 4 or 5 on each dimension were labeled as “high perceived congruence” (HPC). The remaining placements were “medium perceived congruence” (MPC).

4.3.3 | Agency

We cross-referenced interview transcripts and surveys for evidence of agentic acts by novices while in their clinical setting. Initial codes (see Table 2) were derived from dimensions of professional agency (Eteläpelto et al., 2013) and

**TABLE 2** Codes for agency

Code name	Code description
Self-advocacy	Requests by novice to design tool or learning sequence, enact something, participate in new way, take up new role, request feedback or request a particular kind of opportunity to learn something new.
Extending or elaborating on a normative teaching practice in host classroom	Making adaptations to existing strategies or tools for a purpose related to student learning, equity, participation, well-being, developing classroom community, etc. Can be modifications to any aspect of the work of planning, teaching, assessment, or community-building to solve a problem or experiment with how students respond.
Actively resisting norms or authority	Making choices about lesson design or other practice contrary to the perceived classroom culture, practices, or expectations of students. Novices may stop doing something they feel is unhelpful for student learning, participation, or well-being.
Providing rationale to mentors or asking for justifications	Probing mentors or others in authority why things are done a particular way or are a part of normal practice (or not a part of practice). Novice can also offer her/his rationale for a stance, practice, use of a tool, that may not be common or normative in that classroom.
Studying situations for a purpose	Observing or recording students' interactions with one another, analyzing student work, documenting and analyzing elements of one's own practice or students' responses to elements of mentor's practices.
Seeking out and interacting with others for a professional purpose	<ul style="list-style-type: none"> • Engaging with students: Deciding to interact with them in a new way or to get to know them as individuals as well as learners. Can be done in classroom, outside classroom, at extracurricular events, etc. • Engaging with other faculty, staff, or admin: Can be observing other teachers, consulting with staff, asking for input or information from administrators, other adults in school. • Engaging with parents: Can be done via e-mail, phone, parent nights, other meetings. • Engaging with fellow novices: Communicating for information, advice, comparisons of ideas, emotional support, etc.

relational agency (Edwards, 2005). Examples included instances of *self-advocacy* in which novices requested or negotiated with mentors to design something, take up new role, or ask for specific feedback. We also coded instances of participants *extending a normative teaching practice*, which included making adaptations to existing teaching routines or modifying assessment strategies. Novices' could elaborate on mentor routines that were already effective for supporting learning (as in high congruence classrooms) or they could modify less effective routines (as in low congruence classrooms). "Normative" in this analysis does not refer to the quality of practices, only their prevalence in the host classroom. We also looked for instances in which participants *actively resisted norms or authority* in the context of the classroom or science department. These included making choices about instruction, about interaction with students, or about assessments that were contrary to what they perceived to be normative practice or expectations. This could include introducing a new practice or declining to include a common practice their mentor used. We identified episodes in which participants *requested justification* from mentors for particular pedagogical decisions, or conversely *provided rationale* to mentors for choices they were making about



instruction or student interactions. We developed codes for instances in which participants *studied situations for a purpose*, which included observing students' responses to instruction by the mentor or analyzing student-produced artifacts of learning. All instances of *seeking out and interacting with others for a professional purpose* were coded as agency; these included engaging with students specifically to get to know them as individuals or as learners, deciding to interact with students in a new way, or talking with students outside of classroom, at extracurricular events, and so on. Similarly, novices could seek out interaction with other faculty, staff, or administrators. These agency categories were not mutually exclusive; however, we chose the "best fit" for each example described by participants.

Although each novice reported dozens of instances in which they took action of some kind, we did *not* consider these examples of agency if they: (1) could not describe any intention to learn something relevant to their role as an educator, or to effect change they expressed as meaningful to them or to students, (2) were responding to what someone else (typically the mentor or teacher education program instructors) asked them to try out in the classroom; (3) took up practices or other aspects of the work of teaching that unproblematically emulated their classroom's norms or prevailing practices, even in highly responsive and equitable classroom/school environments; (4) only described the actions they felt they should take, but did not follow through on. As with the analysis of opportunities to do active teaching, the research team developed markers for each type of agency in the survey and interviews, and collaboratively revised these after analyzing a subset of the data.

Finally, the team discussed each case, identifying data that could support or disconfirm emerging hypotheses about relationships between clinical context, agency, and opportunities to teach, and in particular how examples of agency played out across cases that had similar congruence ratings. Final claims were assessed for consistency within and across cases.

5 | FINDINGS

5.1 | Opportunities to take up active teaching roles and how these varied by perceived congruence

Opportunities for participants to take up active teaching roles varied dramatically across placements. Common teaching arrangements fell into four categories, each offering different chances to learn about the face-to-face work of instructing students, and in particular how to adapt lessons as they unfolded to meet the needs of learners. We refer to the least involved role for the novice as *chipping in and checking in*. In these situations, the mentor maintained the lead teaching role while the novice offered occasional comments to students about the content or addressed students' questions about an upcoming activity. If the lesson included group work, the novice consulted with students to monitor progress or keep them focused on the task. Some participants took advantage of these visits to listen to students' ongoing conversations, then practice pressing them to reason further about the science or encourage them to respond to one another's ideas.

The second arrangement was to *observe then repeat a lesson or lesson segment*. In these situations, the mentor would teach one or more class sections, after which the novice would take up a lead role in a subsequent class section using similar or identical lesson plans, materials, and types of activity. Alternatively, a novice might step in to lead an activity that their mentor had used with students earlier that day. In either case, novices did not significantly modify the lesson's structure, intellectual demands, or learning goals.

The third arrangement we refer to as *substantive coteaching*. In these cases, dyad partners alternated who was in charge of various segments of a lesson or shared the lead role throughout the class. Both mentor and novice interacted with students and could make adaptations to the lesson mid-class, adjusting their segments based on how students responded to earlier tasks or to conversations with their dyad partner. During group work, both



mentor and novice were responsible for supporting students' learning, pressing for sensemaking, and/or enabling some differentiation of tasks.

A fourth arrangement was *taking the lead*. This refers to the novice assuming responsibility for teaching all parts of a lesson and how they were taught, at least once per week. These lessons could be planned by the preservice teacher or in collaboration with the mentor. A nonexample would be doing full "observe and repeat" lessons after watching the mentor.

Novices often reported being in one or two of these teaching arrangements for weeks or months at a time. This allowed us to see trends in opportunities that were related to levels of perceived congruence. High perceived congruence classrooms (HPC, with a range of 16–20 for their composite ratings) made up only 17% of all placements. Medium perceived congruence placements (MPC, range of 10–15) made up 23%, of the total, and low perceived congruence (LPC, range of 4–9) comprised the majority at 60%. Congruence was the only measure of the study that had some modest variance by program. The majority of the HPC placements were associated with University 1, however this was a bi-modal distribution as many of the LPC placements were also associated with that program.

In HPC placements, mentors frequently made content relevant to students' experiences or interests, activities reflected "big ideas" in science which were frequently revisited or used by students to help build explanations for complex phenomena. Sense-making discussions were regularly built into small group and whole class work. Novices noted that records of students' ideas, in the form of scientific models or collectively developed ideas about puzzling events, were often written on poster paper and displayed on classroom walls. Mentors did frequent presentations, but they also allowed students to use a variety of different scientific practices to construct knowledge. Exit slips and diagnostic conversations were used formatively to assess student thinking or students' perceptions of instruction.

Novices in most HPC placements began the school year engaging in both substantive coteaching and observe-and-repeat opportunities with their mentors. These teaching arrangements lasted about 3 months and then transitioned into more independent types of instruction, where the novice would often take charge of one or more class sections to make modifications for and teach entire lessons (Table 3). Taking the lead for one or more class sections was sustained, on average, more than 3.5 months. In half of the MPC placements novices also experienced substantive coteaching before taking the lead, but this occurred about 2 months later than in HPC settings.

TABLE 3 Relationships between perceived instructional congruence of placement and active teaching opportunities

	Perceived congruence levels		
	High	Medium	Low
Proportion of participants for which extended experiences with substantive coteaching preceded taking the lead in teaching	8/11 72.72%	8/15 53.33%	4/39 10.25%
Median onset of "taking the lead" in teaching at least one section of a class	Mid-December	Late-December	Mid-January
Average duration of taking the lead in teaching at least one section of a class (range)	3.70 months [1.00–6.00]	3.25 months [0.75–5.75]	2.41 months [0.00–6.25]
Proportion of participants whose lead teaching opportunities ended after their edTPA lesson	2/11 18.18%	1/15 6.66%	15/39 38.46%
Proportion of participants for which edTPA was only time to take the lead or for which there was no opportunity to take lead	0/11 0.00%	2/15 13.33%	8/39 20.51%

Abbreviation: edTPA, educative teacher performance assessment.



In LPC placements, pedagogy was described as dominated by lengthy teacher presentations, vocabulary was front-loaded and definitions were emphasized as learning targets. Lab work was often perceived by novices as procedural and either not recognizable as a scientific practice or given the label of “investigation” regardless of the tasks being done. Modeling, argument, and evidence-based explanation were largely absent from the curriculum. In most classrooms, worksheets were given daily, but sensemaking follow-ups were not part of the classroom culture. Participants reported that they did not see cohesive units being enacted, rather each lesson appeared as a one-off exposure to a set of concepts and only nominally related to a general topic (such as ecosystems). Formative assessment, especially to shape instruction, was not evident to the novices. Rather, they reported pressure by their mentor or the science department to stay on a strict pacing schedule and teach the current curriculum as written.

In only 4 of 39 LCP cases did novices begin by coteaching. They were more likely to start the school year by chipping in information during a lesson their mentors were teaching, circulating among students during small group work, or observing and repeating segments of lessons they had seen their mentor lead. In seven LCP cases, participants had no teaching role at all until January or February, at which point they were required to take the lead in at least one class section over a 3 to 5-day period to complete their edTPA. Participants in LPC placements were more likely than those in HPC or MPC placements to “hand back” all teaching responsibilities to their mentors weeks before their placement ended.

Figure 2 shows the trajectories of all 65 participants, arranged from high (top) to low (bottom) perceived congruence. The figure caption describes all acronyms and symbolism used to indicate the sequence of individuals' teaching opportunities. For example, the eighth participant listed (with triangle at left) attended University 1, and the perceived congruence score for her placement was 16 (in the HPC range). She began substantive coteaching with her mentor in early September, but then her role shifted to observe and repeat from late November until early January. At that point she took the lead teaching until late February, after which she did not play an active instructional role (indicated by the blank space on timeline). Her placement ended in early April (indicated by square symbol at right), as different from participants attending U2 and U3 who finished in late May. Overall, Figure 2 shows the prevalence in HPC and some MPC classrooms of novices' early opportunities to engage in substantive coteaching with their mentors and following this, long periods of taking the lead. Moving down the figure into LPC classroom situations, more of the clinical experiences start with either no opportunities for active instructional roles (indicated by blank stretches of space), or less involved roles like chipping in/checking in or observe and repeat. The opportunities to take the lead (solid lines) tend to begin later and are noticeably shorter in duration.

5.2 | Agency as a way to generate new learning opportunities

All participants, regardless of their placement, took it upon themselves to create additional opportunities to learn about their students, about other educators, and teaching itself. This could take the form of requesting justification from mentors for particular pedagogical decisions, studying classroom situations for the purpose of seeing what strategies engaged students, or seeking out interactions with other faculty, staff, or administrators to learn from their experience. In early interviews, it appeared that nearly all participants used agency to try out research-informed strategies and tools, as well as adapt the curriculum to the needs of students. However, many of these instances were the result of required university course assignments to be carried out in their classrooms, and therefore were not consistent with the volitional premise of agency in which actors take it upon themselves to make decisions to “influence, make choices, and take stances” (Eteläpelto et al., 2013, p. 61). Although many participants described these as opportunities to learn, they were not examples of agency. These assignments were similar across university programs and included teaching a series of lessons that were tailored to students' needs, using formative assessments, and managing whole class sense-making conversations with students. When these were filtered out as not the result of agency, we were left with far fewer examples of self-advocacy and initiative.

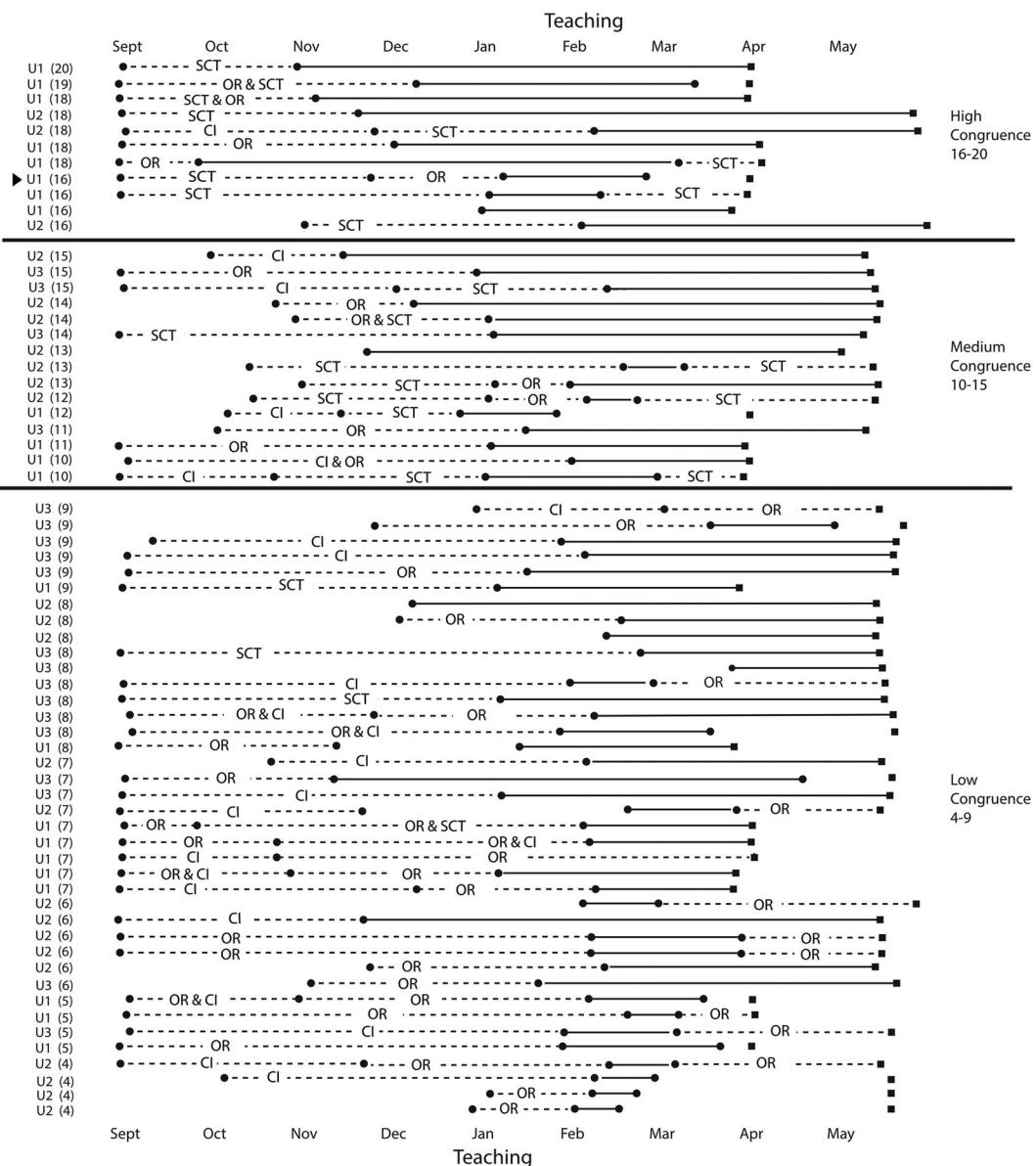


FIGURE 2 Distribution of active opportunities to teach for each participant. Blank spaces = no regular opportunities to play active roles in teaching. CI = chipping in and checking in. OR = observe then repeat a lesson or lesson segment. SCT = substantive coteaching. Solid lines = duration that participants take the lead in teaching. Squares terminating lines at right = end of clinical experience

We tabulated episodes of different types of agency for all participants and found, from a quantitative standpoint, no significant differences between low, medium, and high perceived congruence placements, nor were there shifts in agency over time (Table 4). Across congruence levels, examples of resistance to mentors' practices or classroom norms were almost nonexistent; one of the few instances was a novice rearranging the desks in her classroom so students could work in groups—something her mentor warned would result in chaos (it did not).



TABLE 4 Mean number of instances of participants' agentic action by perceived congruence levels of their host classrooms

Perceived congruence levels	High	Medium	Low
Categories of agency			
Self-advocacy	M = 2.2 SD = 1.8	M = 2.2 SD = 1.6	M = 2.5 SD = 1.8
Extending or elaborating on a normative teaching practice in host classroom	M = 5.8 SD = 2.7	M = 5.3 SD = 2.2	M = 4.9 SD = 2.5
Actively resisting norms or authority	M = 0.2 SD = 0.3	M = 0.6 SD = 0.3	M = 0.6 SD = 1.1
Providing rationale to mentors or asking for justifications	M = 0.3 SD = 0.5	M = 1.1 SD = .6	M = 1.2 SD = 2.1
Studying situations for a purpose	M = 3.3 SD = 1.4	M = 3.4 SD = 1.6	M = 2.0 SD = 2.3
Seeking out and interacting with others for a professional purpose	M = 12.5 SD = 6.6	M = 10.1 SD = 5.2	M = 8.6 SD = 5.3

Similarly, there were few requests by novices for mentors to justify decisions; the occasional disagreements with mentors' decisions came in the area of assessment. Novices, particularly in HPC placements, pointed out to mentors how the standard assessment regime would not allow students to show the most of what they knew or they voiced concerns that the structure of summative assessments might disadvantage emerging multilingual students.

Interestingly, the most frequent type of agency was extending normative practices in the classroom (averaging, across all data sources for each participant, five instances for individuals in LPC classrooms and six for those in HPC classrooms). This included making adaptations to or trying out new instructional strategies for a purpose related to students' learning, well-being, or for developing classroom community. However, extending normative practices as a form of agency differed greatly depending on the congruence of novices' placements. We unpack these differences in the following sections.

5.3 | Extending normative practices in HPC placements

Extending normative practices in HPC placements often involved experimentation with strategies and tools that novices were familiar with from their university coursework. These participants were also more likely than their peers in LPC placements to modify the curriculum in collaboration with their mentors. One novice, Sasha, spoke in terms of "we" (she and her mentor) when describing how they developed three changes to the standard curriculum being used—these included adding a Socratic Seminar to a unit on human body systems, asking students to incorporate information from that discussion into models for how they believed the nervous and endocrine systems worked together, and using a routine for peer commentary on the models. In the second interview she described these modifications:



Well, we did a fish bowl where we asked some questions about the articles they read, and they discussed among themselves in an inner circle and an outer circle, so they asked questions and then they switched. And then from there, they drew their initial models of, "This is how I think the nervous system works." Like they also had to be like, "OK, this is how I think the endocrine system works, but here's how the nervous system works. Here's what's different. Here's what's similar." We hung them up in the classroom or outside the classroom, and then they took post-its, and they go and essentially peer review everybody else's poster and write down questions that they still have about what people put on their poster, or comments, or like, "Did you consider...?"

Extending normative practice frequently meant testing out opportunities for their students to engage with an event or process, then eliciting their ideas. Terrell, who was placed in a middle school classroom, convinced his mentor to start a unit on buoyancy and unbalanced forces by probing what students already knew:

When we did our anchoring event with the little toy boats, I kind of took the lead in that because it was something I had put together and my mentor kind of wanted me to just run it. We had some really fantastic conversations there, and in talking about that lesson afterwards, [my mentor] was saying how a lot of the students that he had had, like he was surprised how much they were talking and contributing.

When asked what he learned from this experience, he described how his design and the students' responses appeared to support his own pedagogical vision:

It wasn't like we were starting off with, "You have to memorize these facts before we can even begin to talk about the content." It's almost that you can provide them with something that is just understandable from an everyday perspective and then when you start adding science content so that it's much more approachable. And students don't feel intimidated because they don't have the science vocabulary yet, or they don't have an understanding of the content yet. It's like everyone can explain that they've seen salt dissolve in water. And it provides an anchor that students can use to feel confident in talking about it, I think.

Other participants in HPC placements also found that they could try out the strategy of eliciting students' ideas early in units, then document changes in their thinking over time. Kammie, for example, who was teaching in a transitional high school for English Language Learners, described this growth during a unit on digestion and biosynthesis that she substantially adapted. She asked students to create initial models about "How a child grows" then had them revise these weeks later (also coded as: studying situations for a purpose):

...and it told me a ton about what students learned. Some students in their initial models, you know, tell me about a child needs love and care to grow. And then, you know, on their final models they're like, "The child eats food and the food gets broken down and then travels through the blood and goes to the cells." So, it was an awesome assessment tool actually because it was low stress and there were a lot of different ways they could explain their thinking.

Several participants in HPC placements exercised agency by studying assessment artifacts from students for the purpose of sharing information with their mentors that could be used to modify instruction (also coded as: studying situations for a purpose). Annika analyzed how 9th graders created "summary tables" in their notebooks—a tool to help them make sense of lab activities and eventually use ideas and evidence from across multiple activities to explain complex phenomena:



I noticed the students that put cognitive work into their summary tables got really high grades on the test, and students that did not put cognitive work in the summary table, or didn't even do it, got low grades. So, there's a clear difference here. Even students that typically underperformed, but they did cognitive work on their summary table, they did really well on the test. There's a definite correlation there. And I told [my mentor] this, and she goes, "So they do work." She had already been using summary tables before me showing her my data, but she's just taken it and gone with it. She's using summary tables for AP with all their units now, and she's doing it as a google docs spreadsheet where students are all adding and collaborating together online.

Some extensions of normative practice were aimed at remediating serious classroom problems that novices, in their new roles, felt responsible to deal with. Jeremy, who was placed in a suburban high school, asked to meet with his mentor about cultivating new relationships with students and among students who were subject to micro-aggressions by peers (also coded as: self-advocacy):

The students had begun to have a more hostile learning environment, where students were more vocally suggesting that other students were less contributory to their group. And so, I thought that that was pretty much something that had to change. So I built into my lesson plans for a whole week, we would start every day with some re-norming activities and some group building activities, community-building activities...And so, during that time I really engaged with individual students to try and build my relationships with them.

He acknowledged that he had made mistakes but was able to learn important lessons:

I think that the most important take-away was that I did see markedly increased participation from the students. But I also noticed that there were some relationships that were not forged early on—and in fact they were very struggling relationships. Those I may have put a little bit too little effort in, too late in the game to improve. But I think that what I learned from that is that it's never too early to forge relationships with the students.

5.4 | Extending normative practices in LPC placements

Participants in LPC classrooms (congruency rated 4–9) were aware of stark differences between the pedagogy they were observing and what they learned to do in their university coursework. They often articulated how this compromised their opportunities to grow. Andrew described the teaching in his high school chemistry classroom: "I would say it's very behaviorist. Sort of like rote memorization. [My mentor] usually starts the unit with a lecture and then we'd have a quiz along the way. And then a review day and a test. And they do a lot of worksheets in class." His frustrated tone suggested that these practices did not reflect his values, nor who he wanted to become as an educator. Two months into his placement, Andrew attempted to elicit students' ideas about electron orbitals and energy by showing videos of fireworks and asking what caused their different colors:

A lot of them were thinking that atoms were exploding...it was just interesting to see their thinking and kind of see if they could connect it back to prior knowledge. But it was just good for getting their prior knowledge and eliciting their ideas. So that if I had been teaching the unit I could sort of plan...and change it based on what they were saying.



When asked why the emphasis on "if he had been teaching the unit," he described how he had planned for his students to build explanations for the fireworks over the next 2 weeks, incorporating ideas about energy transformation, photon emissions, and wavelengths of visible light. He intended for students to learn how to use science practices and argue with evidence from various activities. However, at the end of his eliciting activity in the first class, he watched in disbelief as his mentor stepped to the front of the room and delivered a lecture that explained everything for the students.

Extending normative practices in LPC classrooms often entailed making minor adaptations to prevailing routines that novices felt would benefit students, while not raising the skepticism of their mentors. Frequently they tried out pedagogical moves that preserved the intellectually conservative assumptions of what was legitimate to ask of learners. In his middle school classroom, Winston tried tweaks to "insert some content" into otherwise procedural labs:

We'll usually spend maybe a half hour after school and [my mentor] will give me some ideas. Like, "We're going to be using the microscope to look for paramecium and amoeba." And with that idea I'll go home and develop some sort of work or plan to assess that knowledge and the progress they've been making. So, I try and create... not an anchoring event by any means but try and give it some context. So, I spoke about the mission of a scientist to create a filter that was small enough to filter out a type of microbe that we would be looking at. To prevent people from getting sick from contaminated water.

Similar to other participants in LPC placements, Winston noted how students were not used to developing evidence-based explanations of phenomena, nor being pressed by the teacher, and that this made his work more difficult:

I'll see an opportunity to have a short discussion on scientific reasoning, because we're not really working with anchoring events. But I'll try and jump in and push students for ninety seconds or so in a small group. It goes well but the technique and the line of questioning is really unfamiliar to these students. And they need to be conditioned, I think. That I'm really going to ask them to do some heavy thinking.

In some LPC placements, group work itself was not part of classroom life. Patrice was one of two novices who had to advocate to their mentors about grouping the desks together so that students could talk to each other. She decided to visit another teacher in the building to see how she organized her classroom for discourse (coded as: seeking out and interacting with others for a professional purpose):

So, they always are working in fours or threes and it's much more collaborative—the feel—and she's also taught them how to speak to each other and how to crosstalk and, "I agree with you, because..." sort of thing. And they are very much used to working in groups and that's not the case in our room, because all the desks are facing forward. When I did move the tables in groups and I was like, "OK. We're going to do this differently today," The students were like, "What?" They weren't used to it.

In a high school chemistry classroom, Jenee tried to make small adjustments to lectures that would support student sensemaking, even as she was asked to simply observe and repeat what her mentor did:

So, I have to make sure they get that same content, and I have to give them the worksheet and the same amount of work time that he gives them...So instead of me talking, I'm walking around the room and they're reading it, and we're talking about it a little bit more collectively. And then I put in



a lot of questions that they need to work on with a partner for a minute or two minutes. So, whenever I bring up—where he would say, “Here’s sodium. The electron configuration for sodium is 1s₂, 2s₂, bla bla bla.” Where he would write it, I would say, “We’re going to talk about sodium. Spend a minute with your partner, writing the electron configuration.” So just trying, wherever possible, to make the kids the ones talking, and the kids the ones doing the intellectual work.

Many novices expressed their ambivalence toward improving lecturing in any form. Maria described this tension with her mentor:

She’s helping me work on how to—especially at the beginning of the year, we worked on how to make my PowerPoints or lectures a little bit more comprehensible for some of the ELLs here. I think I kept—I caught myself getting a little anxious about it, because I felt like I was learning to do things better that I don’t want to do anyway. I don’t want to sit there for 45 min and lecture.

Maria was also aware that incongruent visions and practices between her and her mentor negatively impacting the quality of feedback she received: “She’s much more explicit like prep, vocab, lecture-based, labs kind of thing. I felt like we’re kind of just at odds with our styles of teaching. So, for that whole entire time, it was kind of—we just weren’t really on the same page about what was going on.” Nearly all novices in LPC placements expressed disappointment in the inabilities of mentors to provide feedback targeted at practices they valued. One participant described her mentor as caring and generous with his time, but admitted that his routine advice to her was a mantra which was both vague and suggestive that her “problem” was a lack of effort:

“I will try harder next time.” Yes, it comes from The Lord of the Rings. So, that is the thing, and I’m always thinking, “Well, it didn’t work that well, but I will try harder next time,” and it’s over, and over, and over, try, try, try.

5.5 | The role of agency when there are few opportunities to plan or teach

We present the case of Ariel, to show that even wide-ranging, creative, and goal-oriented agentic activity by novices may not be enough to help them move from peripheral to more central instructional roles in classrooms, especially when structural constraints regarding curriculum and mentor reluctance are involved. We also want to trace the progression of how a participant actively responds to lack of expanded learning opportunities over time, and to make visible how apprenticeships can be unproductive.

Ariel came into the program with a degree in the biosciences, field research experiences, and a year of teaching in a community-based environmental learning program. She was assigned to a comprehensive urban high school and the classroom of a mid-career biology teacher. From September through November, Ariel was allowed to lead occasional warm-ups with students, but her primary teaching role was to circulate among groups once they were assigned a task and to check in with them about their understanding of instructions or ask if they had questions. When probed about these responsibilities she replied:

We don’t really co-teach too much. Sometimes I’ll lead the entry tasks. And I taught a mini-lesson Monday, because it was part of a university assignment, but most of what I do with the students is visiting them when they are talking, as opposed to standing in front of the classroom and doing whole group discussions.



She tried to make the most of these table visits by using strategies from her methods course that invited wider student participation and challenged all group members to think more deeply:

And I try to probe and press them and sometimes quieter ones are the students who are not comfortable in their new seats. I'll try to get them started talking to each other and I feel like if a student doesn't particularly get highlighted in the class then I'll try to—try to bring their idea forward to the group and ask the group to think about it. And then I ask them a lot of "why" questions. Or like, "How do you think this happens?" And then sometimes they get really annoyed and they're like, "You know what I'm talking about." [laughs]

Across the four interviews Ariel had described seven instances of requesting justification from her mentor or members of the science department about curriculum decisions. Most of these episodes seemed to be subtle push-backs against assumptions about what students were capable of or would be interested in. She recalled a planning discussion about a scenario to be used for teaching homeostasis (coded as: providing rationale to mentors or asking for justifications):

And then we met with the department chair teacher, who was saying how, "Oh, it'd be really fun if instead of a boy we could put [professional football player] in there. And I was like, "But what about the people who don't like football? And what about me? I can't really...all I know is like his name." And so we sort of talked about the pros and cons of that.

As November passed, Ariel realized her limited role in the classroom was not changing, so she refocused her energies on learning more about her students (coded as: seeking out and interacting with others for a professional purpose):

I made all my students little index card journals. I hole-punched the index cards and I tied them up and I told them that they can write questions, comments, and concerns that they have. Preferably about the class but life in general is okay. And some of the really high achieving ones said that like, "Oh, I did this [science topic] in 6th grade so I really want to learn more information."

Students in one class section compiled a list of things they wanted her to experience (e.g., high school basketball games, bubble tea). She used this information to build a mini-portfolio for each student, including questionnaire responses, messages they'd written her about themselves and maps they created connecting themselves to other students or to ideas they had about science.

By mid-year, Ariel's mentor asked her to start taking on different responsibilities for teaching, however these were all instances of observing what the mentor did and repeating it in a later period. Anne could not substantively modify any of these lessons but simply talked about adding her "style" to the instruction:

I think that she wants me to do the same. And I kind of like to add my own...my own kind of style to it. And some days she receives it better than others. And some days the students receive it better than others. But I think it's just good for me to practice because I feel like that's the whole point of student teaching.

When she tried to insert even modest adjustments to activities that were clearly meant to support student learning, her mentor expressed skepticism and would often disallow them (coded as: extending or elaborating on a normative teaching practice):



One of the edTPA rubrics about student voice is asking students to explain why the learning targets are important and applicable to their lives. And I think students—like I think we should do that every time we have a new learning objective. Not just for the edTPA. And so I've been asking for it, or putting it into the back of a reading or after a test. And then she'll take it out.

By early January, Ariel was expressing some desperation about not having opportunities to teach. When she was required to film herself engaging her students in scientific modeling and whole class sense-making conversations, she decided to “exaggerate” the requirements to her mentor to get more teaching time (coded as: self-advocacy):

Yeah, I taught all the classes. Because I told her—sometimes like—it's not really a lie but sometimes I have to say things like, “Oh, because I'm filming all the classes, I need to do all the classes.” Or last quarter when we had more university assignments, I said, “I need to do this for my assignment, so please just let me do it and try it out.”

She was frustrated at implementing instruction without chances to use strategies she felt were helpful for students' learning and her own improvement:

[My mentor] wants a lot of the control because some of the things I've done were not very successful. Which is very true, but it's like, I have to be able to try it out and then reflect on it and then think about how I'm going to change it to make it better next time. So, if you never let me try something then I can't, you know, I can't just magically pretend I know how it's going to go.

In mid-January, Ariel was required to design or modify lessons for her edTPA and teach those over a 5-day period. Her mentor, however, was again uncomfortable with deviating from the curriculum and asked Ariel to teach what was already planned, with only minor modifications (e.g., allowing students to fill out exit slips at the end of some lessons to inform her teaching). In the final interview Ariel said “I feel like I've not really taken over.” Indeed, she finished the year, having made dozens of attempts at getting to know and support students in different ways, but not having designed or taught a single lesson that was “hers.”

6 | DISCUSSION

This study provides a close look at 65 case studies of the clinical experience, including a rare critical mass of 11 placements in which the pedagogy and classroom culture were perceived as highly congruent with the research-informed visions of science teaching advocated in novices' preparation programs. These cases allowed us to identify similarities in how chances to teach unfolded, the role that agency played in opportunities to learn, and how these contrasted with opportunities and agency in low congruence placements.

Participants in HPC and MPC placements were far more likely to engage in substantive coteaching with their mentors earlier in the school year, they took up lead roles in teaching a full month before peers in LPC placements and taught a month longer. At a more granular level, through a combination of mentors' invitations and their own agency, novices in high and medium congruence placements had far more access to students' thinking, witnessed their collective reasoning about science ideas, and learned to support diverse evidence-based explanations. These experiences are foundational to novice learning if they are to take up teaching that is consistent with reforms and educational justice. Novices in LPC placements had few chances to engage students in tasks that could make their thinking visible or to see how students engage with science practices. These patterns partially explain why novices



paired with exemplary mentors are more likely become ambitious educators themselves (Goldhaber et al., 2020; Hoffman et al., 2015; Ronfeldt et al., 2018).

Some of the differences in opportunity to teach between LPC and HPC placements would have been less apparent, had we not analytically separated more peripheral roles, such as “chipping in/checking in” and “observe and repeat” from more collaborative coteaching. While the less involved roles provided chances for novices to interact with students, the benefits as they described them were limited and faded with time. Based on our findings, we advise against using “co-teaching” as a broad label because it failed to differentiate between substantive learning experiences for novices in this study and playing the role of the teacher’s assistant.

In nearly all LPC classrooms and to a lesser degree MPC classrooms, novices felt pressure to conform to the curriculum, and to move through lessons without pausing to support student needs or take advantage of their interests (see also Cherbow et al., 2020; Edwards, 2007). They witnessed students being asked to do little more than reproduce canonical knowledge, yet were not empowered to improve conditions for learning. For over 20% of those in LPC classrooms, the mandatory edTPA lessons were the *only* time they took the lead in teaching. In some cases, participants did not even design these, but were told to use lessons developed by their mentor or the department. This “policing” of the science curriculum has also been reported by Braaten (2019) who found that “any reorganization of practice or appropriation of science teaching practices different from those of the mentor teacher ran a risk of being so negatively evaluated by the mentor that PSTs did not feel safe experimenting...” (p. 86).

Despite the enormous variation in teaching responsibilities across placements, participants in all classrooms described occasions to experiment pedagogically and to learn about their students. Many of these opportunities came about because of required university assignments and could not be considered as acts of agency. However, it appears as though this structural feature of the preparation program “raised the floor” for novices’ opportunities to try out practices that were consistent with equity, sensemaking, and authentic disciplinary work by K-12 students. Although these teaching roles represented more central forms of professional participation in the classroom community, they were short-lived for most novices and as such, not consistent with the idea of apprenticeship.

In most studies of the clinical experience it is unclear whether examples of agency include novice teaching performances that were expected by their programs (university assignments) or requested by their mentors. Our decision to separate these out analytically from self-initiated opportunities to learn about teaching placed in stark relief the modest role that agency played in novices’ development. Regardless of perceived congruence, it was rare that they took the initiative to advocate for more chances to teach in ways they felt were productive for students, to observe other educators, influence the nature of feedback they received, or take advantage of opportunities to learn more about their students. Half the participants could not recall an instance of seeking justification from mentors for pedagogical decisions they had made.

We also discovered that the ways (not the number of instances) novices extended their mentors’ normative practices varied significantly by congruence and resulted in very different kinds of learning for them. In most HPC and some MPC placements, novices were more likely to request experimenting with instructional strategies to be responsive to students’ ideas, to orchestrate open discourse, or manage students’ engagement with science practices like modeling, argument, or explanation. They were also more likely to volunteer to find ways to get feedback from students on the quality of their instruction. On the whole, these participants exercised agency to access the work involved when equity-minded educators navigate tensions between visions of ideal practice and the realities they encounter in classrooms—a finding consistent with others who have studied congruence and opportunity to learn (Anderson & Stillman, 2010; Kang, 2018).

For novices in LPC settings, extending normative practice meant tweaking traditional lessons by “inserting content” into procedural activities or adding analogies to mentors’ presentations about concepts. Many of them made minor adjustments to lectures and worksheets, occasionally expressing regret that they were getting better at things they didn’t value, and by extension, not serving their students well. There were few indications that these acts of agency resulted in professional learning or the reinforcement of positive professional identities.



It remains unclear why novices in LPC classrooms reported that they were not allowed to deviate from the curriculum as planned, while those in HPC placements were far more likely to be able to modify instruction to be adaptable to students' interests and needs. Several studies have documented clinical educators' inability to "let go" in the classroom or share control with candidates (Glenn, 2006; Soslau et al., 2019). Letting go entails the novice taking up a meaningful role in instruction and being allowed to design lessons that incorporate strategies and tools that may be unfamiliar to the mentor. However, if one member of the dyad believes that acquiring facts and vocabulary is a central goal of science learning, then the pedagogy used to accomplish these aims would likely feel ineffective to a partner who feels students should be making meaning of science ideas and using the epistemic tools of the discipline to do so (Edwards, 2005). These differences in vision, as well as the reluctance of the mentors to share control, would undermine the basic assumptions of apprenticeship and cause tensions around the uptake of teaching roles by the novice. We agree with Putnam and Borko (2000, p. 8) that "If the aim of teacher education is a reformed practice that is not readily available and if there is no reinforcing culture to support such practice, then the basic imagery of apprenticeship seems to break down." Although participation is "always based on situated negotiations of meaning in the world" (Lave & Wenger, 1991, p. 51) we argue that this theoretical stance underplays the role of discordant worldviews among actors and how power can be used to maintain the status quo.

The vulnerability of novices to oppressive forms of authority was exemplified in Ariel's case, in which she went to extraordinary lengths to generate her own learning opportunities while having many teaching ideas rebuffed by her mentor. Her initial frustrations turned to despair in later interviews when she became resigned to the fact that she was expected to remain in curricular lockstep with others in the department and would not be teaching any lessons of her own design. In each conversation with us she alluded to roles and responsibilities that teachers typically take up and how she was not allowed to approximate these, such as helping students understand what might be meaningful to them about an upcoming science topic or supporting sensemaking talk. If we consider our original description of professional agency as "exercised when subjects and/or communities influence, make choices, and take stances on their work and professional identities" (Eteläpelto et al., 2013, p. 61), Ariel and other participants in LPC classrooms exercised agency in many unique ways. However, because of power asymmetries with mentors, these individuals had fewer opportunities than peers in HPC placements to use instructional discretion and take principled pedagogical risks that would allow them to build identities as competent beginning educators.

In this and other LPC cases, institutional (school, department) structures stifled agency for both the mentor and the novice. Among these were curricular policies that prioritized content coverage over the state of student understanding or interests, and an emphasis on summative tests and quizzes over formative assessments that are designed to support learning. Valencia et al. (2009) caution that "When student teachers are not able to experiment and not guided by their mentors to become thoughtfully adaptive, they lose an opportunity to deepen their understanding of pedagogical approaches they have studied in coursework" (p. 319). Edwards (2007) specifically warns that clinical experiences in classrooms featuring rote forms of instruction and strict adherence to curriculum can result in preservice teachers developing weak forms of agency as well as complacency around following procedures. To be clear, we do not believe agency and opportunity "arise" from congruence *per se*. As described in our theoretical framework and exemplified in our findings, agency is emergent—both resourced and constrained in interactions among individuals with their own identities, commitments, tools, and authoritative status within communities that are, at least in name, dedicated to learning.

7 | LIMITATIONS

Novices' perceptions of placement classrooms may have been influenced by factors we did not account for, such as personal relationships with mentors or the type of host school. Classroom observations by researchers may have provided a more accurate picture of the context within which the novices worked. We acknowledge that capturing



all agentic actions during the clinical experience is unlikely and that participants may have reported only memorable or recent episodes. The preparation programs were all graduate level at R1 universities. This limits the applicability of our findings to novices' experiences in other types of institutions or pathways.

7.1 | Implications and conclusions

Models for professional learning during the clinical experience must continue to evolve. The view of gradually releasing responsibility from the mentor to the novice, a passive approach, had shifted to a view of clinical work as apprenticeship, which still positions the mentor as a "demonstrator" and the novice as emulator of routine and unproblematic practice. More recently, coaching or guided practice by the mentor has been considered a core component of novice learning, and this model places the host teacher in a supportive role. What needs to be explicit, however, are the supports needed for novices to develop the agency that can shape their own learning and perhaps change the arc of their development during the clinical experience.

As a result of this study we have since interviewed experienced mentors about the kinds of initial conversations with novices that could help both partners feel comfortable in requesting clarifications of one another, providing and receiving feedback, and taking risks together. Our collaborators referred to this as a "professional roommate conversation" to be held at the start of the clinical experience. Among their recommended questions were: "What are our professional goals for this upcoming year, individually and together? When might we have conversations about our work together (goals, progress, transitions, etc.)? How does each of us prefer to work? (e.g. planning things far in advance vs. plan as you go, experimenting and risk-taking with lessons vs. staying in step with department and other class sections, etc.) How could we support each other in these situations? How do you prefer to give and/or receive feedback?" The mentors reasoned that coming to common ground on ways of being together and learning with one another were helpful, but perhaps more importantly, sets the expectation that these kinds of dialogue should recur in some form during the relationship. We have also created a one-page trajectory of opportunities—around planning, teaching, assessing, and getting to know students—that spans the clinical timetable and breaks down recommended experiences into increasingly independent options for the novice. The trajectory is now used in our programs to help structure conversations between dyad partners about what comes next for the novice in each category and empowers the novice to set goals and ask the mentor for new challenges. We are also writing up diverse cases of how agency, in various forms, can be used safely and productively in placements (see also Soslau et al., 2019).

This study exposes the strengths and weaknesses of a critical part of our educational system—preparing aspiring teachers to take up research-informed practices that prioritize the needs of students from all backgrounds and engage them in appropriately challenging work. From a structural standpoint, teacher education programs would benefit from seeking out mentors who are working toward the kinds of classroom cultures characterized by equitable and responsive pedagogy, consistent with the upper anchors of our four dimensions of congruence. This would require additional resources, but the potential benefits to novices seem substantial.

There is ample research that tells us the clinical experience is an under-supported part of preservice preparation, and in many cases, it falls far short of providing opportunities for novices to practice the kinds of teaching or student relationship-building that lays the necessary foundations for educational justice. Professional learning is not simply a matter of induction into established practices, but should include the capacity for actively seeking opportunities to try out nonnormative forms of instruction, contesting assumptions about what learners can do, and creating one's own learning resources, all for the purpose of serving children's well-being. Without this preparation, it increases the likelihood that novices will simply reproduce the "doing school" culture, and fail to serve students.

**ORCID**

Mark Windschitl  <http://orcid.org/0000-0001-5935-4936>
Soo-Yean Shim  <http://orcid.org/0000-0003-2073-6579>

REFERENCES

Anderson, L., & Stillman, J. (2010). Student teaching for a specialized view of professional practice? Opportunities to learn in and for urban, high-needs schools. *Journal of Teacher Education*, 62(5), 446–464. <https://doi.org/10.1177/0022487111412052>

Author. (2015). *Journal of Teacher Education*.

Biesta, G., Priestley, M., & Robinson, S. (2015). The role of beliefs in teacher agency. *Teachers and Teaching: Theory and Practice*, 21(6), 624–640. <https://doi.org/10.1080/13540602.2015.1044325>

Braaten, M. (2019). Persistence of the two-worlds pitfall: Learning to teach within and across settings. *Science Education*, 103, 61–91. <https://doi.org/10.1002/sce.21460>

Braaten, M., & Sheth, M. (2017). Tensions teaching science for equity: Lessons learned from the case of Ms. Dawson. *Science Education*, 101(1), 134–164. <https://doi.org/10.1002/sce.21254>

Cherbow, K., McKinley, M., McNeill, K., & Lowenhaupt, R. (2020). An analysis of science instruction for the science practices: Examining coherence across system levels and components in current systems of science education in K-8 schools. *Science Education*, 104, 446–478. <https://doi.org/10.1002/sce.21573>

Clift, R. T., & Brady, P. (2005). Research on methods courses and field experiences. In M. Cochran- Smith, & K. Zeichner (Eds.), *Studying teacher education: Report of the AERA Panel on Research and Teacher Education* (pp. 309–424). Lawrence Erlbaum. <https://doi.org/10.5860/choice.43-2338>

Cohen, J., & Berlin, R. (2019). What constitutes an “Opportunity to Learn” in teacher preparation? *Journal of Teacher Education*, 53, 122–133. <https://doi.org/10.1177/0022487119879893>

Corcoran, T., & Gerry, G. (2011). Science instruction in Newark Public Schools. *Consortium for Policy Research in Education. Research report # RR-71*. Teachers College, Columbia University. <https://doi.org/10.12698/cpre.2011.rr71>

Creswell, J. W. (2012). Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4th ed.). Pearson.

Darling-Hammond, L. (2014). Strengthening clinical preparation: The holy grail of teacher education. *Peabody Journal of Education*, 89(4), 547–561. <https://doi.org/10.1080/0161956X.2014.93909>

Darling-Hammond, L., & Oakes, J. (2019). *Preparing teachers for deeper learning*. Harvard Education Press.

Davis, E., Zembal-Saul, C., & Kademian, S. (2019). *Sensemaking in elementary science*. Routledge.

Edwards, A. (2005). Relational agency: Learning to be a resourceful practitioner. *International Journal of Educational Research*, 43(3), 168–182.

Edwards, A. (2007). Relational agency in professional practice: A CHAT analysis. *Actio: An International Journal of Human Activity Theory*, 1, 1–17.

Eteläpelto, A., Vähäsantanen, K., Hökkä, P., & Paloniemi, S. (2013). What is agency? Conceptualizing professional agency at work. *Educational Research Review*, 10, 45–65. <https://doi.org/10.1016/j.edurev.2013.05.001>

Feiman-Nemser, S., & Buchmann, M. (1985). Pitfalls of experience in teacher preparation. *Teachers College Record*, 87, 255–273.

Fenwick, T., & Somerville, M. (2006). Work, subjectivity and learning: Prospects and issues. In S. Billett, T. Fenwick, & M. Somerville (Eds.), *Work, subjectivity and learning. Understanding learning through working life* (pp. 247–265). Springer. https://doi.org/10.1007/1-4020-5360-6_15

Glenn, W. (2006). Model versus mentor: Defining the necessary qualities of the effective cooperating teacher. *Teacher Education Quarterly*, 33(1), 85–95.

Goldhaber, D., Krieg, J., & Theobald, R. (2020). Effective like me? Does having a more productive mentor improve the productivity of mentees? *Labour Economics*, 63, 101792–234. <https://doi.org/10.1016/j.labeco.2019.101792>

Greeno, J., & Engeström, Y. (2014). Learning in activity. In R. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 128–148). Cambridge University Press. <https://doi.org/10.1017/cbo9781139519526.009>

Hamerness, K. (2006). From coherence in theory to coherence in practice. *Teachers College Record Volume*, 108(7), 1241–1265. <https://doi.org/10.1111/j.1467-9620.2006.00692.x>

Hoffman, J. V., Wetzel, M. M., Maloch, B., Greeter, E., Taylor, L., DeJulio, S., & Vlach, S. K. (2015). What can we learn from studying the coaching interactions between cooperating teachers and preservice teachers? A literature review. *Teaching and Teacher Education*, 52, 99–112. <https://doi.org/10.1016/j.tate.2015.09.004>



Hokkä, P., Vähäsantanen, K., & Mahlakaarto, S. (2017). Teacher educators' collective professional agency and identity—transforming marginality to strength. *Teaching and Teacher Education*, 63, 36–46. <https://doi.org/10.1016/j.tate.2016.12.001>

Holland, D., Lachicotte, W., Skinner, D., & Cain, C. (2003). *Identity and agency in cultural worlds*. Harvard University Press.

Jiménez-Aleixandre, M. P., Bugallo Rodríguez, A., & Duschl, R. A. (2000). "Doing the lesson" or "doing science": Argument in high school genetics. *Science Education*, 84(6), 757–792. [https://doi.org/10.1002/1098-237X\(200011\)84:6<757::AID-SCE5>3.0.CO;2-F](https://doi.org/10.1002/1098-237X(200011)84:6<757::AID-SCE5>3.0.CO;2-F)

Jóhannsdóttir, T. (2010). Deviations from the conventional: Contradictions as sources of change in teacher education. In V. Ellis, A. Edwards, & P. Smagorinsky (Eds.), *Cultural-historical perspectives on teacher education and development* (pp. 163–179). Routledge.

Kang, H. (2018). *Where Is the 'Best' Field Placement?* Paper presented at the Annual Conference of the American Educational Research Association. New York, 2018. <https://doi.org/10.4324/9781410600523>

LaBoskey, V. K., & Richert, A. E. (2002). Identifying good student teaching placements: A programmatic perspective. *Teacher Education Quarterly*, 29(2), 7–34.

Larkin, D. B. (2014). Structures and strategies for science teacher education in the 21st century. *Teacher Education & Practice*, 27(2).

Larkin, D. B. (2020). *Teaching science in diverse classrooms: Real science for real students*. Routledge.

Lasky, S. (2005). A sociocultural approach to understanding teacher identity, agency and professional vulnerability in a context of secondary school reform. *Teaching and Teacher Education*, 21, 899–916. <https://doi.org/10.1016/j.tate.2005.06.003>

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Luft, J. A., Bragg, J., & Peters, C. (1999). Learning to teach in a diverse setting: A case study of a multicultural science education enthusiast. *Science Education*, 83(5), 527–544. [https://doi.org/10.1002/\(SICI\)1098-237X\(199909\)83:5%3C527::AID-SCE2%3E3.0.CO;2-T](https://doi.org/10.1002/(SICI)1098-237X(199909)83:5%3C527::AID-SCE2%3E3.0.CO;2-T)

Milner, H. R. (2010). *Start where you are, but don't stay there: Understanding diversity, opportunity gaps, and teaching in today's classrooms*. Harvard Education Press.

National Academies of Sciences, Engineering, and Medicine (NASEM). (2015). *Science teachers' learning: Enhancing opportunities, creating supportive contexts*. The National Academies Press. <https://doi.org/10.17226/21836>

National Academies of Sciences, Engineering, and Medicine (NASEM). (2019). *Science and Engineering for Grades 6–12: Investigation and Design at the Center*. The National Academies Press. <https://doi.org/10.17226/25216>

National Research Council (NRC). (2012). *A Framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. The National Academies Press. <https://doi.org/10.17226/13165>

National Research Council (NRC). (2007). Taking Science to School. In R. A. Duschl, H. A. Schweingruber, & A. W. Shouse (Eds.), *Board on Science Education, Center for Education*. The National Academies Press. <https://doi.org/10.17226/11625>

Osborne, J., & Dillon, J. (2008). *Science education in Europe: Critical reflections*. Kings College London: A Report to the Nuffield Foundation.

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, 29(1), 4–15. <https://doi.org/10.3102/0013189X029001004>

Ronfeldt, M., Brockman, S. L., & Campbell, S. L. (2018). Does cooperating teachers' instructional effectiveness improve preservice teachers' future performance? *Educational Researcher*, 47(7), 405–418. <https://doi.org/10.3102/0013189X18782906>

Ronfeldt, M., & Grossman, P. (2008). Becoming a professional: Experimenting with possible selves in professional preparation. *Teacher Education Quarterly*, 35(3), 41–60.

Roth, K., & Garnier, H. (2007). What science teaching looks like: An international perspective. *Educational Leadership*, 64(4), 16–23.

Soslau, E., Gallo-Fox, J., & Scantlebury, K. (2019). The promises and realities of implementing a coteaching model of student teaching. *Journal of Teacher Education*, 70(3), 265–279. <https://doi.org/10.1177/0022487117750126>

Stanford Center for Assessment, Learning, and Equity. (2013). *Guidelines for supporting candidates completing edTPA*. Stanford University.

Stillman, J. (2011). Teacher learning in an era of high-stakes accountability: Productive tension and critical professional practice. *Teachers College Record*, 113(1), 133–180.

Stroupe, D., Hammerness, K., & McDonald, S. (2020). *Preparing science teachers through practice-based teacher education*. Harvard Ed Press.

Valencia, S., Martin, S., Place, N., & Grossman, P. (2009). Complex interactions in student teaching: Lost opportunities for learning. *Journal of Teacher Education*, 60(3), 304–322. <https://doi.org/10.1177/0022487109336543>



Weiss, I., Pasley, J., Smith, S., Banilower, E., & Heck, D. (2003). *Looking inside the classroom: A study of K-12 mathematics and science education in the United States*. Horizon Research, Inc.

Windschitl, M. & Calabrese Barton, A. (2016). Rigor and equity By design: Seeking a core of practices for the science education community. AERA Handbook of Research on Teaching, 5th Edition. https://doi.org/10.3102/978-0-935302-48-6_18

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