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Approximating Teaching

A Systematic Review of the Research

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Prospective teachers need opportunities to practice key teaching skills as they begin their work with children. Some of that practice inevitably happens in clinical placements, where teacher candidates (termed “candidates”) learn while working alongside more veteran mentor teachers (Anderson & Stillman, 2013; Ronfeldt, 2015). And yet, clinical practice alone is often not sufficient for developing the knowledge, skills, and beliefs that help teachers feel efficacious about their work, cultivate equity-oriented lenses for teaching, and demonstrate effectiveness in supporting and honoring all students in their classrooms. In clinical placements, the focus and priority is meeting the needs of PreK-12 students, rather than the needs of the candidate. Moreover, mentors are not all equally skilled at demonstrating high-quality teaching, nor are they equally facile at scaffolding candidate learning (Goldhaber et al., 2017; Matsko et al. 2020). They may not be able to describe *why* they are doing what they are doing or detail the equity implications of their work (Kavanagh & Danielson, 2020). How, then, can teacher preparation coursework complement clinical practice to expedite and enhance candidate development?

One response has come in the form of “practice-based teacher education” (PBTE) which centers the “work of teaching” in preparation programs (Ball & Forzani, 2009). Rather than solely use courses to develop disciplinary content or knowledge of educational theory, PBTE offers learning experiences during coursework that help candidates *do* instructional activities, like engaging in an interactive read-aloud or facilitating a discussion about mathematical ideas with support from teacher educators (e.g., Lampert et al., 2013). Because these practice spaces are inherently artificial, teachers educators can pause instructional activities, ask candidates to analyze aspects of the interactions, and press them to consider how their beliefs, values, and visions for educational equity and justice influence what they do in classrooms (Davis et al., 2017; Dutro & Cartun, 2016; Richmond et al., 2017). In this way, PBTE can afford opportunities to underscore the ways in which knowledge, beliefs, and observable skills are intertwined.

Nearly 15 years ago, Grossman and colleagues (2009) delineated the value of such practice opportunities, which they term “approximations of teaching.” They noted prospective teachers had few opportunities to try out teaching activities during courses, while novices in other relational professions like clinical psychology engaged in myriad role-plays, simulations, and other forms of rehearsal. Grossman and colleagues argued there is enormous value to infusing such “pedagogies of practice” into teacher preparation, so candidates can develop skills and justice-oriented beliefs about students, while also creating space for discussion about why and how such skills and beliefs can support students and promote more equitable educational outcomes. They also noted that in other fields, approximations were often preceded by or coupled with “representations,” opportunities to engage with high-quality models of complex teaching tasks, and “decompositions” that break these complex models into their component parts to identify their key features.

Rather than serving as spaces for regimented enactment of prescriptive moves like the micro-teaching research from the 1960’s and ‘70’s (for a review, see Grossman, 2005), approximations can be designed around complex, disciplinary, and justice-oriented practices, allowing candidates to engage in responsive improvisation. They afford opportunities for teacher educators to provide directive coaching, and/or ask the candidate to repeat the practice using a different approach, allowing for collaborative iteration, and refinement. Approximations of teaching can also support candidates in framing the work of teaching around issues of race and power, as teacher educators press them to consider how their own identities and students’ identities influence classroom interactions (Kavanagh & Danielson, 2020; Stroupe et al., 2020).

Though PBTE is not without critics (e.g., Kennedy, 2016; Philip et al., 2019) and is not necessarily a novel idea (Zeichner, 2012), there has been a proliferation of new scholarship around these ideas since the publication of Grossman’s (2009) seminal paper. The goals of this systematic review of that literature are to synthesize what is being approximated, by whom, for what purposes, and in what contexts. We aim to detail what we have learned about candidate development from approximations of teaching, as well as delineate areas where more research is needed. Ultimately, we wanted

to know the contexts, conditions, and corresponding supports that maximize approximations' potential utility. Our central motivation is to support teacher educators in making more empirically-informed decisions about the affordances and constraints of different approaches to approximating teaching, as well as the degree to which different supports before, during, and after an approximation support improved teacher development. Teacher educators will be better able to capitalize on their limited time with candidates with a clearer sense of the arc of candidate development into, through, and beyond approximations. To that end, we answer the following research questions:

1. What practices do researchers and teacher educators approximate? In what contexts are those approximations occurring?
2. What instructional supports do teacher educators provide before and during approximations?
3. To what extent do characteristics of the approximation correspond with development of candidates' knowledge, skills, and beliefs? In what ways does that development transfer to contexts beyond the approximation, including PreK-12 classrooms?

Given our interest in candidate development, we focus on studies for which there are candidate outcomes, collected before and after an approximation or for which there is a clear comparison group (either no approximation or a different form of approximation), as it is difficult to discern evidence of shifts or growth without comparison. This focus parallels other reviews of research that emphasize the outcomes of specific aspects of teacher preparation (e.g., Mancenido, 2023). Though many important studies have provided fine-grained detail about what can happen *during* an approximation (e.g., Davis et al., 2017; Kazemi et al., 2016; Stroupe & Gotwals, 2018), we were interested in collating evidence about the degree to which and ways in which approximations support candidate learning. We define learning here as observable shifts in knowledge, skills, or dispositions in relation to a teacher educator's goals for the approximation.

FRAMEWORK

In framing this review, we draw on Grossman and colleagues' (2009) theory of pedagogies of practice alongside Ericsson and Pool's (2016) theory of the development of professional expertise through deliberate practice. At the outset, we note that we limited our review to research on approximations of teaching that occurred in the absence of real PreK-12 students. Though some study clinical experiences as approximations of teaching (e.g., Roser et al., 2014), we see opportunities for practice as preparing candidates to assume these more complex responsibilities. By practicing with peers (e.g., through rehearsals or role-plays) or actors (e.g., through simulations), candidates independently practice teaching and develop skills or perceptions, with opportunities for support, without incurring risks to real students.

Teacher educators and researchers may benefit from consistent definitions of approximation types, so that we might learn from others' research of approximations. Thus we propose specific definitions that could be used for future research, though we note these definitions are not always used consistently in the studies reviewed here. Role-plays are practice opportunities where a candidate assumes the role of "teacher." They may approximate alone or with someone they know (e.g., peer, teacher educator) who assumes a different role for the purpose of the interaction. Rehearsals are similar to role-plays in that the candidate assumes the role of "teacher" and may approximate alone or with others they know. However, rehearsals also include active engagement by a teacher educator or more knowledgeable expert who can pause the interaction, provide feedback on the candidate's performance, and facilitate discussion and reflection throughout (Kazemi et al., 2016). In a simulation, a candidate interacts with an actor, rather than practicing alone or with a person they know. There are digitally-mediated simulations, like those available through Mursion (e.g., Author, 2020) and TeachLivE™ (e.g., Driver et al., 2018), in which candidates engage with digital "students" or "parents/guardians" who are remotely controlled by live actors trained to administer scenarios in

consistent ways. There are also “standardized student” or live-actor simulations (Self & Stengel, 2002; Shaughnessy et al., 2019) where candidates engage with trained actors.

Approximations as described by Grossman and colleagues (2009) were not conceptualized as standalone learning experiences. Instead, candidates would approximate teaching practices after engaging with representations of those practices (e.g., video examples, written cases) that teacher educators decomposed into key features. In other words, what happens before the approximation is as vital as what happens during it. These approximations should exist alongside—not replace—other pedagogical approaches that convey concepts, frameworks, and principles, as well as foundational courses that convey the history of PreK-12 education in the United States and the ways schools perpetuate systemic racism and structural oppression (Zeichner, 2012). Similarly, approximations should complement robust clinical experiences.

The pedagogies of practice framework (Grossman et al., 2009) and the theory of deliberate practice (Ericsson & Pool, 2016) direct attention to the complexity and authenticity of practice opportunities. An approximation should be sufficiently complex that candidates experience “instructive failure” (Grossman et al., 2009, p. 2078). Along those same lines, the theory of deliberate practice suggests that the quality—rather than the quantity—of practice opportunities predicts learners’ improvements; namely, the practice should be within the learner’s zone of proximal development (Vygotsky & Cole, 1978). While “naive practice” consists of simple repetition, deliberate practice is composed of carefully designed, intentionally sequenced experiences that are just beyond the learner’s comfort zone and coupled with opportunities for feedback. Over the course of teacher preparation, novice teachers should enact approximations that are increasingly proximal to the demands of classroom teaching. A less-advanced novice might read a case study of student formative assessment data and write a script of how they would discuss the data with a student; a more-advanced novice might prepare a brief math lesson and “teach” it to peers before teaching that lesson in a clinical placement.

Theoretically, deliberate practice in an approximation of teaching should build on prior learning by modifying and refining the learner’s existing mental representations of teaching. Candidates likely need to first recognize high-quality instantiation of a practice and have its key features highlighted and discussed before attempting enactment. Teacher educators can support candidates’ development of knowledge, beliefs, and skills through a cyclical process that includes multiple opportunities for candidates to learn, practice, and reflect (e.g., McDonald et al., 2013). Therefore, what, when, and how candidates approximate must be analyzed alongside what precedes and follows practice. To that end, our review analyzes the features of approximations in preservice teacher education to build more nuanced theory and/or research-based hypotheses about the characteristics, timing, and supports associated with growth for novices at different stages or contexts of preparation.

Into, Through, and Beyond

As part of their work in the Core Practice Consortium, Grossman and colleagues (2018) provide guidance for developing and implementing approximations. In particular, we draw on work by Kelley-Petersen and colleagues (2018) that underscores the importance of analyzing candidate learning in approximations using an *into*, *through*, and *beyond* framework. Figure 1 maps the criteria we used to code each study in relation to this framework.

First, we consider how teacher educators or researchers prepared candidates going *into* the studied approximation, as well as their goals for candidates’ practice; that is, what should be approximated. Some studies in this review align their goals for candidate learning with the Council for the Accreditation of Educator Preparation standards (Regalla et al., 2016). Other research has delineated “core” or “high-leverage” teaching practices as useful foci for approximations (for a brief history of this work, see Chapter 1 of Grossman, 2018). These include practices that cross content areas, such as eliciting student thinking and communicating with families (TeachingWorks, 2024), as well sub-

ject-specific instructional practices, such as pressing students for evidence-based explanations in science (Windschitl et al., 2012) or selecting and adapting historical sources in history (Fogo, 2014).

Figure 1

Coding Studies for Learning Into, Through, and Beyond Approximations of Teaching

<p>Into <i>Preparation</i></p>	<p>What do researchers hope candidates will learn conceptually? What do researchers hope candidates will enact? What is the role of the author? List descriptive information about teacher preparation program. Geographic area of teacher preparation program. Public or private teacher preparation program? How many teachers are prepared each year? Who assigned the approximation? Explain details of assignment. When in program did approximation occur? Is there concurrent field placement? Undergraduate, Master's, or licensure-only program? Participant licensure: Elementary or secondary? Sample size Description of candidate demographic characteristics How are candidates prepared for the practice? Does the approximation follow other pedagogies of practice?</p>
<p>Through <i>Enactment</i></p>	<p>Type of approximation (i.e., rehearsal, role play, simulation) Structure of approximation (e.g., individual, small group) Format of approximation (i.e., digitally mediated or in-person) Explain details of approximation Are there repeated opportunities for practice? What type(s) of instructional supports were available? Who provides the support? When is the support provided?</p>
<p>Beyond <i>Outcomes</i></p>	<p>Is there post-approximation support or debrief? Who provides the post-approximation support? Who participates in the post-approximation support? When does the post-approximation support occur? What is measured specific to our research questions? How is it measured (e.g., specific scales) What are the outcomes specific to our research questions? Are tools provided to help candidates connect the approximation to real teaching? Any details of if/how learning transferred to real teaching? Any information of candidates' sensemaking after the practice and post-approximation support?</p>

Members of the Ambitious Science Teaching Project have also considered *what* teachers should teach, the content and tools that should be considered “high-leverage” (Windschitl et al., 2020). Others, like Stroupe and Gotwals (2018) and Stroupe and Christensen (2023), have built on this work and also argued for broadening the goals of approximations to semester-long “macroteaching” rehearsals wherein candidates plan and teach an entire science unit.

Grossman and colleagues’ (2009) assert candidates may experience some modalities of practice as more authentic than others; as such, we note whether practice was digitally mediated and thus designed to feel more realistic and immersive (Dieker et al., 2014) or in-person with other adults playing the roles of PreK-12 students, parents, and educators (Lampert et al., 2013). We also analyze

the type of the approximation (i.e., rehearsal, role-play, and simulation) and practice group size (i.e., individual, small group, and pairs) to understand the design of each approximation and potential for patterns therein.

Though the focus of our review is approximations, we also look for evidence of representations and decompositions as these pedagogies of practice can support enactment in approximations by developing candidates' mental representations, or background knowledge (Grossman et al., 2009). We also looked for evidence of other strategies not explicitly connected to Grossman and colleagues' pedagogies of practice, such as peer collaboration or direct instruction. Preparation *into* an approximation can support the efficiency of practice, as novices can expand and refine existing mental representations as they approximate.

We also analyze how candidates in these studies moved *through* an approximation, with particular attention to the design and supports of each practice opportunity. Ericsson and Pool (2016) assert novices learn more from practice when it includes opportunities for immediate and iterative feedback. Support *through* an approximation can help candidates identify the successes, challenges, and implications of their actions during practice. This should, in turn, help candidates when they subsequently engage with real students.

Finally, we analyze how candidates are supported in extending their learning *beyond* the confines of the approximation. Because the goal of approximations is to prepare candidates for subsequent enactment in real classrooms, we analyze the supports candidates receive after the approximation to connect their learning to work in K-12 contexts. We also identify the degree to which there is evidence of "transfer" into classroom settings.

To the degree we are able, we report on the identities of the learners participating in these approximations and the teacher educators who are facilitating them, but identity is not our focus, because these frames have been used in other synthetic reviews of teacher learning (e.g., Beauchamp & Thomas, 2009; Horn & Garner, 2022). We posit that understanding the features of approximations of teaching that expedite candidates' learning is an important first step in building evidence-based hypotheses to systematically analyze in future work. Future work should also layer hypotheses around identity onto study designs, to help us better understand the degree to which and ways in which candidate and teacher educator identity may influence the enactment and results of different types of approximations.

RESEARCHER POSITIONALITIES

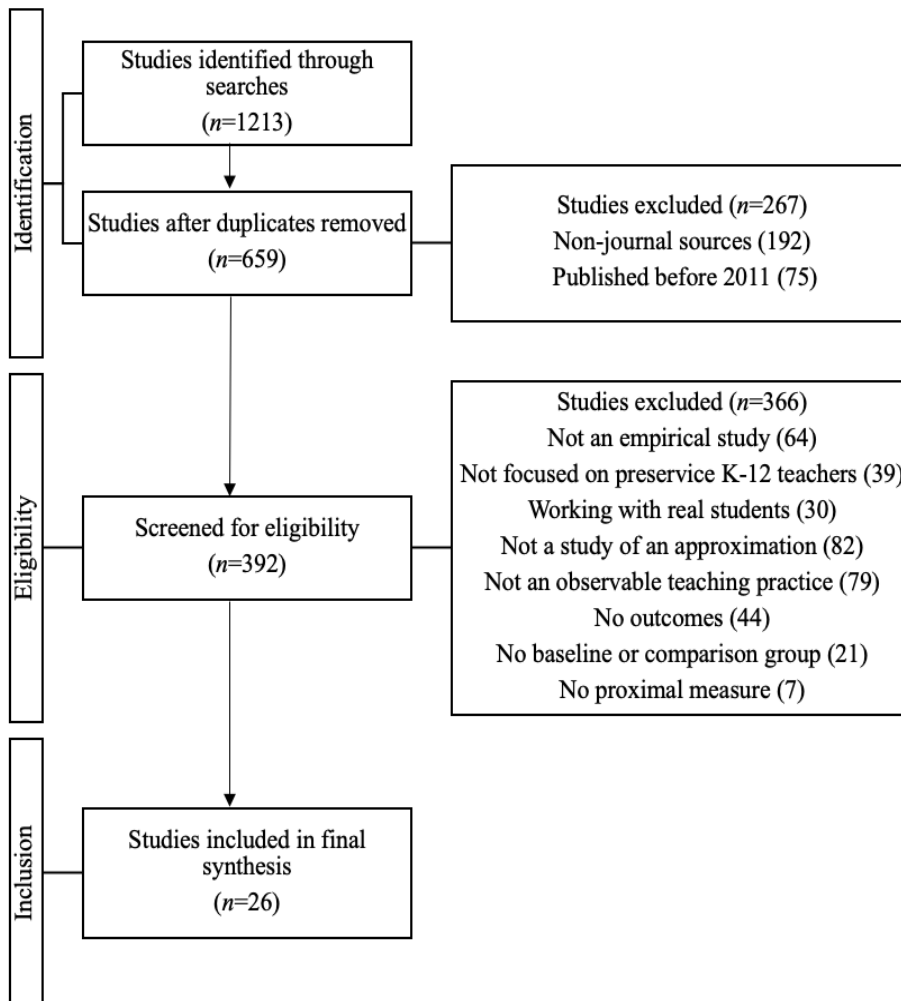
As our identities and experiences as teacher educators inform our research, we describe how we position ourselves in relation to this work prior to describing our methods (Boveda & Ananama, 2023). While all members of the author team identify as cisgender white women, we bring distinct areas of instructional expertise and research paradigms to this work. This team of authors includes an elementary education generalist, a PK-12 education generalist, and a secondary social studies teacher educator. Consequently, we sought studies that reflect both general instructional skills and content-specific practices. Additionally, two authors primarily utilize mixed methods in their research and one is a qualitative researcher, which contributed to our interest in including *all* available empirical research focused on candidates' learning from approximations rather than focus on a specific methodological tradition (e.g., Mancenido, 2023). These identities led to many discussions of how we conceptualize an approximation of teaching and what we consider observable outcomes of candidate learning. These discussions, in turn, informed the inclusion criteria we detail below.

Despite these differences, we shared a common goal of examining levers for candidate learning into, through, and beyond approximations of teaching because we are all teacher educators who have used approximations in our own methods classes. Our ultimate goal with this review is to draw on

the available evidence to implement approximations as effectively as possible to support the candidates with whom we work in learning to teach.

Figure 2

PRISMA flow diagram (Moher et al., 2009)



METHOD

This review examines empirical studies of approximations of teaching used in PreK-12 teacher preparation programs in the United States. Although teacher educators in many countries—including Israel (e.g., Shapira-Lischinsky, 2013), Germany (e.g., Martin et al., 2022), and Hong Kong (e.g., Chan, 2022)—utilize and study approximations of teaching, teaching—and teacher preparation—is a cultural activity that can greatly vary by country. For example, McChesney (2010) argues for additional research of approximations and decompositions of teaching in New Zealand, where initial teacher education programs follow an official, national curriculum that requires practice-based teaching and close collaboration with school communities. Such structures and policies are not nationally mandated in the United States. Thus, like other systematic reviews about teachers, we limited our search to research of teacher preparation in the United States (e.g., Kennedy, 2016; Mancenido, 2023; Matschiner, 2022).

We analyze studies published since 2011 because we conceptualized Grossman and colleagues' (2009) pedagogies of practice framework as a key impetus for the body of literature we synthesize. We conducted a systematic literature review using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol as our foundation (Moher et al., 2015). In Figure 2, we provide an adapted PRISMA flow diagram (Moher et al., 2009) to summarize our source identification, eligibility, and inclusion decisions. We document our search, screening, and analytic strategy below.

Search Methods

We exhaustively searched five databases (i.e., Academic Search Complete, Education Full Text [H. W. Wilson], Education Research Complete, ERIC, Psychology and Behavioral Sciences Collection) for all publications relating to approximations of teaching in teacher preparation; we created two sets of search terms and used permutations of each term shown in Table 1 to search the full text of articles in the databases. Our first set of search terms focused on approximations of teaching that teacher educators use to provide novices with opportunities to “take on a more active, and probably more authentic, teaching role” (Grossman et al., 2009, p. 2081). Our second set of search terms narrowed the focus of the search to preservice teacher preparation, as novices across many professions engage in similar practice opportunities. Each set of terms within a specific category can be joined using the Boolean phrase OR; we joined each category of search terms with the search term AND.

Table 1

Examples of Search Terms Used across Databases

Search term category (joined with AND)	Search terms in text (joined with OR)
Type of practice	Approximation of practice, approximated practice, approximation, practice, pedagogies of practice, practice-based, role-play*, rehears*, simulat*, TeachLivE, SimSchool, Mursion, TeachME, TeachSIM, mixed-reality simulation, micro-teaching, authentic practice, Interactive Virtual Training for Teachers
Teacher education	Preservice teacher, pre-service teacher, teacher education, methods course, practice-based teacher education, enactment, core practices

Note. While all terms listed above were used, these are provided as examples because additional search terms were included in the search. The asterisk “*” represents a truncated search term; for example, simulat* included simulate, simulated, and simulation.

Our database search yielded 1,213 records; we saved the authors, titles, publication info, and abstract of each publication to an Excel spreadsheet. We identified and removed duplicate studies, which resulted in 659 unique articles. We limited our initial review to peer-reviewed articles; we excluded 192 studies published outside of peer-reviewed journals, including unpublished dissertations ($n=52$) and conference papers or records of proceedings ($n=90$). Our focus on peer-reviewed work mirrors previously published reviews of research (e.g., Kennedy, 2016; Mancenido, 2023). In addition, while book chapters and dissertations can also be valuable sources of information, they do not always undergo the same level of rigorous evaluation and peer scrutiny as peer-reviewed research articles. Additionally, while we removed studies published before 2011 ($n=75$), we

acknowledge the importance of some earlier research in informing the later design and implementation of approximations of teaching (e.g., McNaughton, 2008). Ultimately, these procedures led to the identification of 392 articles published between 2011 and June 2022, which we systematically reviewed for inclusion or exclusion.

Screening Methods

To determine if the sources would provide insight into our research questions, we read each article that met the initial inclusion criteria. This process led us to further refine our inclusion and exclusion criteria, as shown in Figure 1. Three hundred and sixty-six sources were subsequently excluded for the following reasons:

1. The study was not an empirical study (n=64). This excluded papers that provided conceptual arguments for practice opportunities (e.g., Windschitl et al., 2012), reviewed research relating to practice-based teacher education (e.g., Bradley & Kendall, 2014), and summarized technological innovations that could be used when designing an approximation (e.g., Tyler-Wood et al., 2015).
2. The study was not focused on preservice PreK-12 candidates (n=39). Studies that reference teacher education but sampled in-service teachers (e.g., Kavanagh et al., 2020) or people who were not training to become PreK-12 teachers (e.g., post-secondary teaching assistants in Chini et al., 2016) were excluded because they do not provide insight into the integration of approximations in teacher preparation programs. Studies that sampled a combination of preservice and in-service teachers (e.g., Pankowski & Walker, 2016) were included because they examine preservice teacher development.
3. The study measured candidates' work with real students (n=30). Studies of candidates' interactions with real students (e.g., Roser et al., 2014) were excluded based on the specific affordances of practice in the absence of students. Such studies provide insight into placement-based practice rather than approximated practice.
4. The study did not examine an approximation of practice (n=82). This excluded papers that referenced approximations used within a teacher preparation program but did not conduct analysis specific to an approximation. This criterion resulted in the largest number of excluded studies because it includes studies that mention approximations but focus analysis on other learning opportunities, such as studies of a rehearsal in conjunction with field experiences and coursework as concurrent levers for improving candidates' agency (e.g., Ticknor, 2015), studies of teacher educators' instruction rather than candidates' practice (e.g., Kavanagh & Danielson, 2020), and studies that mention an approximation of practice but focus analysis on a decomposition or representation of practice (e.g., Tyminski et al., 2014).
5. The approximated practice was not observable (n=79). We define observable teaching practices as those that an outside observer, such as a teacher educator or instructional coach, can see candidates enact. This excluded studies in which candidates write scripted responses for student characters to say (e.g., Amador et al., 2016) and studies in which candidates create a simulation or game for future students to use (e.g., Schrader et al., 2011). This does not exclude studies that analyzed changes in participants' beliefs, so long as what participants approximated was observable (e.g., Regalla et al., 2016).
6. The study did not include any outcomes of teacher candidate learning (n=44). This excluded papers that described the structural design of a practice (e.g., Boerst et al., 2011), teacher educators' actions (e.g., Kazemi et al., 2016; Lampert et al., 2013), and participants' discourse within an approximation (e.g., Alvermann et al., 2011). Studies excluded under this criterion address what candidates did in the approximation but do not provide evidence that the approximation was associated with shifts in participants' skills, beliefs, knowledge, or beliefs (e.g., Walker & Dotger, 2012). Additionally, studies with outcomes of participants' perceptions of the practice or social

validity of an intervention (e.g., Mueller et al., 2019) were excluded unless they also included outcomes for participants' teaching.

7. The study did not utilize consistent measures before and after an approximation or use a comparison group to analyze candidates' development ($n=21$). This excluded studies that detail candidates' actions during and reactions after an approximation of teaching, but lack a baseline measure collected before the approximation (e.g., Shaughnessy et al., 2012; Stroupe & Gotwals, 2018; Stroupe & Christensen, 2023). This also excluded studies that determined outcomes based on measures that did not parallel each other, such as pre- and post- measures of different constructs (e.g., Dalinger et al., 2020; Thompson et al., 2019).
8. The study used distal rather than proximal measures to determine the outcomes of the approximated practice ($n=7$). These studies were excluded because they used outcomes collected at the beginning and end of a course or semester, rather than immediately before and after the approximated practice (e.g., Bautista & Boone, 2015). It was thus not possible to determine the outcomes of the approximated practice, independent from other instructional activities.

After we used these parameters to exclude studies that were not relevant to our research questions, we included 26 studies in our analysis.

Analytic Methods

We coded each study utilizing 37 analytic criteria that we include in Figure 1. Eleven of the 37 criteria offered a binary or forced choice option (e.g., the format of the approximation was digitally mediated, in-person, or multiple modalities). More than 70% of the criteria were open-ended and authors included quotations from each article to respond to the prompt (e.g., explain details of the approximation). Authors entered their codes on a Microsoft Excel spreadsheet, allowing us to include detailed comments and text evidence for each criterion.

Two authors began the coding process by independently coding one article then meeting to discuss and resolve any discrepancies; this allowed coders to establish intercoder agreement (Campbell et al., 2013). For example, when the authors disagreed about codes related to "post-approximation support or debrief," the authors compared the text evidence they selected before agreeing on activities that were post-approximation supports (e.g., feedback, self-reflection, small group discussion, whole-class reflection). Following this meeting, the coding authors coded the entire corpus of articles independently. During this process, the coding authors met again to resolve emerging questions about coding, avoid potential coder drift, and ensure alignment throughout the process. After each coding author completed their analysis of each article in the corpus, codes were compared on the Microsoft Excel workbook; the coders agreed on 84.10% ($n=809$) of the initial codes ($n=962$). The coding authors met to discuss discrepancies, resulting in 100% coder agreement on the final set of codes.

LIMITATIONS

Like any systematic review of research, there are several limitations to our approach. Our inclusion criteria were not as stringent as other recent reviews of teacher education research (Mancenido, 2023), in part because we recognized many teacher education researchers engage in self-study and do not always have access to multiple sections of courses to allow for comparison groups. However, given our focus on observable development of knowledge, skills, and beliefs over time, we do limit our analysis to studies that include either consistent pre- and post- measures *or* a comparison group. As such, our review does not include many interesting and conceptually rigorous design experiments, in which the approximation evolves in coordination with candidates over an extended period of time, often without baseline measures (e.g., Campbell & Elliott, 2015; Stroupe & Christensen, 2023;

Stroupe & Gotwals, 2018) or consistent measures for candidate learning before and after (e.g., Thompson et al., 2019). Moving forward, we hope that more researchers both designing and studying approximations of teaching will develop measurement plans that allow for readier assessments of candidate development and learning (for a detailed discussion of some potential approaches, see Hill et al., 2024).

On the other side of the coin, because our inclusion criteria did not limit us to causal studies, we cannot determine whether candidates “get better” because of approximations or particular aspects of the approximation. Studies in this corpus include a range of designs with varying degrees of detail about candidates’ preparation of learning into and extension of learning beyond approximations. Some included studies use a pre/post design to compare candidates’ changes after an approximation to a baseline measure (e.g., Driver et al., 2018). Other studies compare outcomes for an intervention group who approximated to a control who did not (e.g., Mehlig & Shumow, 2013). Others still compare two groups who approximated similar content in different modalities (e.g., Aguilar & Flores, 2022). Unfortunately, it is often difficult to disentangle how other pedagogical approaches leading up to the approximation may contribute to the cited findings in the comparison group approaches. We hope our framework, which attends to the context in which approximations occur and how they are supported by other pedagogies, is helpful for future research. Ultimately, we encourage ongoing work that allows teacher educators to better parse how approximations are situated in broader programs of candidate development, as well as to empirically disentangle how different aspects contributed to such growth.

RESULTS

In line with our conceptual framework, we analyze the context for each study, candidates’ preparation *into* the approximation, the design and instructional supports for candidate learning *through* the approximation, and candidates’ outcomes and transfer of skills *beyond* the approximation. Across each, we highlight the variety in this corpus of studies and identify relevant themes for teacher educators and education researchers.

Study Characteristics

Characteristics of Teacher Preparation Programs

All studies took place in the context of a postsecondary institution, but studies report inconsistent details about the universities in which candidates are enrolled. Half the studies ($n=13$) provide no details about the university context, such as size or research activity. Eighteen studies did not specify whether candidates were enrolled at a public or private university. Of those that remained, five occurred at public universities and two at private universities; one multi-site study (i.e., Kaka et al., 2021) featured candidates from both public and private institutions. Only two studies (i.e., Edelman & Talbert, 2020; Kaka et al., 2021) included candidates at multiple universities. The plurality of studies ($n=9$) did not specify the geographic region(s) of the university, but many occurred in the northeastern United States ($n=8$).

Most studies detail candidates’ licensure area and enrollment program. These details indicate that this research primarily focuses on a narrow subset of licensure programs. More than half ($n=15$) exclusively studied undergraduate candidates. Eight studies exclusively used elementary and early childhood preservice teachers as their sample, whereas only two studies exclusively studied secondary candidates (i.e., Judge et al., 2013; Kaka et al., 2021). Almost all studies examined traditional

certification programs; only two studies included alternatively certified novices in their sample (i.e., Judge et al., 2013; Pankowski & Walker, 2016).

Characteristics of Candidates

These studies included 1,004 unique candidates; sample sizes were relatively small, ranging from six (Judge et al., 2013) to 113 (Regalla et al., 2016). Only three studies (i.e., Author, 2020; Regalla et al., 2016; Spencer et al., 2019) investigated samples of 90 or more. Due to the small samples, this research is likely not reflective of the broader population of candidates, who typically number more than 160,000 a year (U.S. Department of Education, 2022).

Studies use a range of categories to describe candidate demographics. Some studies provide rich details, such as neurotypicality (Lamb & Etopio, 2010), relevant work experience (Henry et al., 2022), language history (Driver et al., 2018), or socioeconomic background (Author, 2020). Among the studies that report gender identity and age ($n=24$), most candidates identify as female and are between 18-29 years old. Half of the studies ($n=13$) do not report candidates' race or ethnicity. Among those that report race and ethnicity, most sampled candidates identify as white; only one study (Aguilar & Flores, 2022) worked with a population of primarily Hispanic candidates. Few studies include any Black or Indigenous candidates. While these demographics mirror those of teachers in public schools in the United States (National Center for Education Statistics, 2022), they do not reflect those of PreK-12 students that candidates are preparing to teach. As such, we do not disaggregate results by candidates' identity, though we theorize this is an important direction for future research.

Into the Approximation of Practice

Context for Studies

Approximations were frequently assigned as components of specific teacher preparation courses ($n=21$). Six studies examined approximations that were part of courses on special education—the most of any course topic (i.e., Driver et al., 2018; Henry et al., 2022; Hudson et al., 2019; McKown et al., 2021; Robbins et al., 2019; Walters et al., 2021). Three studies were associated with a mathematics methods course (i.e., Aguilar & Flores, 2022; Grant & Ferguson, 2021; Lee et al., 2021). Other studies examined a randomly selected sample of candidates (i.e., Peterson-Ahmad, 2018) or all candidates in a preparation program (i.e., Greif Green et al., 2020).

Candidates participated in approximations at varying stages of their programs. Seven studies do not report candidates' progress through their teacher preparation program at the time of the approximation (i.e., Author, 2020; Greif Green et al., 2020; Judge et al., 2013; Lamb & Etopio, 2020; Lee et al., 2021; Pankowski & Walker, 2016; Peterson-Ahmad, 2018). Fourteen studies described candidates as “upper level,” which seems to include second-to-fifth-year undergraduate students. Half of the studies reported candidates had some clinical teaching experience at the time of practice; one study specified that candidates had not begun student teaching (i.e., Robbins et al., 2019). Four studies drew candidates from multiple stages of preparation. Given the widely ranging contexts in which approximations are occurring, we can infer little about the relationship between context and candidates' outcomes.

Goals for Practice

We categorized researchers' goals for candidate learning in approximations into observable skill development and/or cultivation of knowledge or beliefs. These goals were not mutually exclusive: many studies delineated multiple goals for candidate learning. Nine studies focused on a goal for developing

candidates' knowledge or beliefs, ten studies specified a goal only for skill development, and seven studies specified both types of learning goals.

Of the 16 studies that specified goals for candidates' knowledge and/or beliefs, most targeted confidence and/or perceptions of preparation about a range of teaching practices. Five studies aimed to develop candidates' perceptions of their skills for communicating with other adults, such as families, co-teachers, or paraprofessionals (i.e., Driver et al., 2018; Henry et al., 2022; Mehlig & Shumow, 2013; Robbins et al., 2019; Spencer et al., 2019). Two studies sought to improve candidates' knowledge, including knowledge of reading strategies (i.e., Ely et al., 2018) and knowledge of a system of least prompts (i.e., McKown et al., 2021).

Of the 17 studies that had a goal for candidates' observable skills, the most common goal ($n=4$) was improving candidates' behavioral redirection skills (i.e., Author, 2020; Judge et al., 2013; Pankowski & Walker, 2016; Rosati-Peterson, 2021). The second most common observable skill outcome ($n=3$) was leading a student discussion (i.e., Grant & Ferguson, 2021; Kaka et al., 2021; Lee et al., 2021). Other goals for observable skill development range widely, include improving communication during collaborative partnerships with families and colleagues (i.e., Driver et al., 2018), responding to bullying in the classroom (i.e., Schussler et al., 2017), and improving feedback to students during a music rehearsal (i.e., Edelman & Talbert, 2020).

Preparation for Approximations

The pedagogies of practice framework (Grossman et al., 2009) suggests candidates might prepare for practice by engaging with representations (e.g., video examples, written cases) and decompositions (e.g., analysis of component parts of a skill) of practice; however, teacher educators may provide these opportunities without using these specific terms. Consequently, we analyzed authors' descriptions of preparatory activities. Candidates in six studies prepared by viewing representations of practice, such as videos that model enactment of the practice (i.e., Ely et al., 2018; Grant & Ferguson, 2021; Masters, 2020; Pankowski & Walker, 2016; Walters et al., 2021). Candidates in two studies prepared by first practicing with an additional approximation, such as a role-play or rehearsal (i.e., Aguilar & Flores 2022, Schussler et al., 2017). Candidates in three studies had multi-layered preparation, including opportunities to analyze representations of practice *and* complete an extra role-play or rehearsal before completing the approximation under study (i.e., Judge et al., 2013; Lee et al., 2021; McKown et al., 2021).

Candidates were also prepared through a range of strategies not explicitly connected to pedagogies of practice (Grossman et al., 2009), such as collaborating with peers (e.g., Grant & Ferguson, 2021) and writing lesson plans (e.g., Edelman & Talbert, 2020). A plurality of studies ($n=10$) specified that candidates received specific direct instruction through their coursework to prepare for practice. Direct instruction was often a component of the course in which the approximation occurred and included lectures (i.e., Ely et al., 2018), instructional videos (i.e., Grant & Ferguson, 2021), and content acquisition podcasts (i.e., Kennedy et al., 2015, as cited in Driver et al., 2018) that detailed features of the focal practice. In one study, the authors note candidates did not receive any preparation related to the task of developing nonverbal communication skills; their explicit goal was skill-building through approximated practice and feedback (Rosati-Peterson et al., 2021).

Through the Approximation of Practice

In the following section, we analyze studies in relation to the design of each approximation, including the type, modality, opportunities for iteration through in-the-moment do-overs or repeated practice, and supports available to candidates during practice. The idiosyncratic goals and contexts for practice across these studies makes it difficult to discern patterns in what, how, and for what purposes candidates approximate.

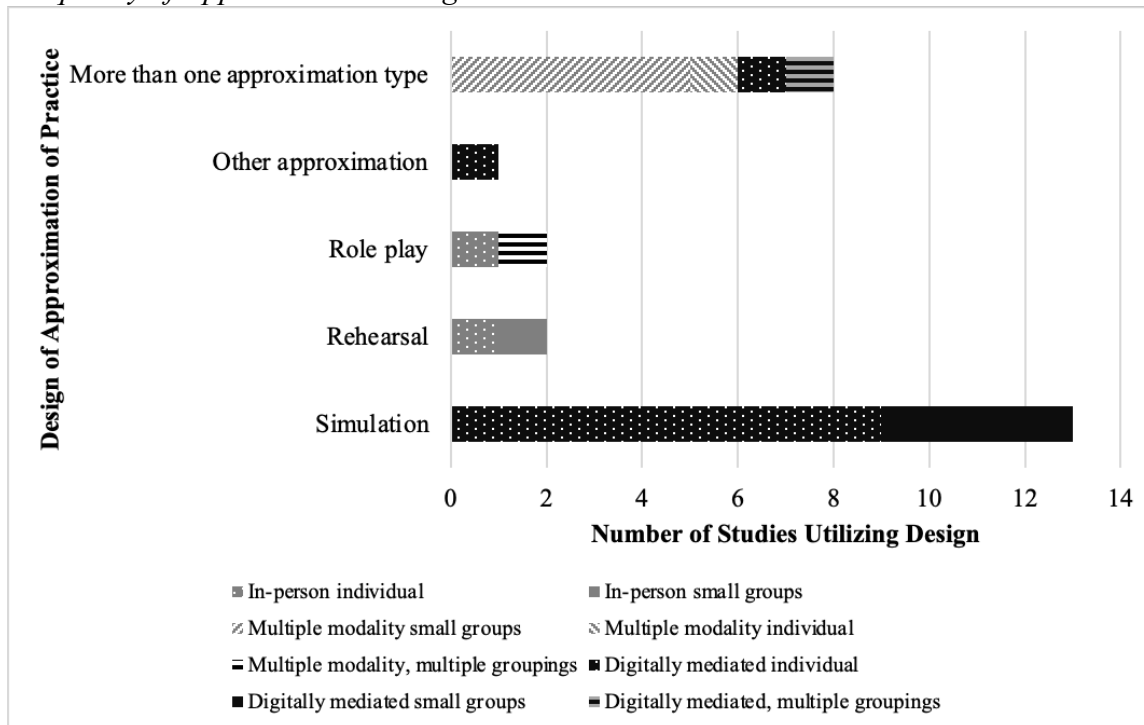
Design of Approximation

Authors use terms to describe the type of approximations—role-play, rehearsal, simulation—interchangeably and inconsistently within and across studies. In the absence of uniform terminology, we studied authors’ descriptions of the type of approximation under study, in conjunction with other details about their design. For example, Greif Green and colleagues (2020) refer to candidates’ practice as a “role-play simulation” (p. 42) whereas Lee et al. (2021) refer to a similar opportunity as a “virtual rehearsal simulation” (p. 298). Henry and colleagues (2022) studied candidates’ learning in three practices that they refer to as “simulation conditions”: a peer-to-peer role-play, a digitally mediated simulation where they interact with a parent avatar remotely controlled by an actor, and an in-person simulation where they interact with an actor playing a parent.

In addition to classifying studies by approximation type, we considered other factors that may impact candidate learning. Because peer collaboration may influence candidates’ learning through approximations, we analyzed the size of groups with which candidates practiced; we found that candidates typically completed practice independently ($n=14$). We also considered the modality: whether the practice was in-person or digitally mediated, such as through a mixed-reality simulation (MRS) interface (e.g., Author, 2020) or an interaction with an AI-driven chatbot (i.e., Schussler et al., 2017). Most of the included studies analyze practice that occurs entirely within a digital interface ($n=16$); additional studies analyze candidates’ practice in both digital and in-person modalities ($n=7$). We provide an overview of these design aspects and how they relate to approximation type in Figure 3.

Figure 3

Frequency of Approximation Designs



We also analyzed with whom candidates interacted during the approximation, with particular attention to whether the approximation occurred with familiar people (i.e., peers or teacher educators) and/or unknown entities (i.e., actors, digital avatars controlled by actors or artificial intelligence). In most studies ($n=15$), at least some participants interacted with trained actors, either in a mixed reality simulation (e.g., Author, 2020) or in-person (e.g., Henry et al., 2022). In three studies, participants communicated with an interface controlled by artificial intelligence (i.e., Kaka et al., 2021; Lamb &

Etopio, 2020; Schussler et al., 2017). One study involved participating exclusively with known persons (Masters, 2020), and one asked participants to approximate alone by recording themselves (Mehlig & Shumow, 2013).

When actors or artificial intelligence were involved in approximations, authors often included details about the logic underlying the script and how actors' responses to candidates were governed. Most of these studies ($n=14$) specified that interactions proceeded according to *If-Then* logics. For example, in Bosch and Ellis' (2021) study, avatar behavior depended on candidates' successful implementation of "classroom management best practices" (p. 22): *if* a candidate used "best practices," *then* avatars responded positively, but *if* the candidates used an "inappropriate strategy," *then* avatars responded negatively. This approach allows teachers to see the potential implications of their instructional choices. Some studies layered additional script logics onto *If-Then*, including standardized planted errors (e.g., McKown et al., 2021; Walters et al., 2021) or increasing complexity or intensity (e.g., Driver et al., 2018). In Hudson and colleagues' (2019) study, the *If-Then* logic was replaced by escalation as candidates proceeded through rounds of approximations. Specifically, in the third round of the simulation, student avatars displayed "disruptive behavior," regardless of candidates' instructional choices.

Authors of half of the studies ($n=13$) analyze candidates' outcomes following simulation-based practice. While simulations do not necessarily always leverage digitally mediated interfaces, nearly all of the included studies examined digitally mediated simulations. Only three studies exclusively studied in-person practice opportunities, which the authors refer to as rehearsals (i.e., Edelman & Talbert, 2020; Masters, 2020) or role-plays (i.e., Mehlig & Shumow, 2013). In initiating this review, we did not intend to focus on simulations more than rehearsals or other forms of approximation. We encourage additional research on the affordances of peer-to-peer role-plays and rehearsals, as it may be cost-prohibitive for teacher preparation programs to hire, train, and compensate actors.

Nine studies featured designs that defied neat classification into "simulation," "role-play," or "rehearsal." Eight studies included analysis of more than one type of approximation, such as a study comparing candidates' performance in peer-to-peer rehearsal with performance in a simulation (Lee et al., 2021, p. 298). One study compared virtual reality practice to real teaching in a clinical placement (i.e., Lamb and Etopio, 2020).

Candidates in most studies ($n=22$) had multiple rounds of practice. In the other four studies, researchers compared candidates' performance across multiple types of approximations (i.e., Spencer et al., 2019), compared candidates' approximated enactment to enactment in a placement (i.e., Lamb & Etopio, 2020; Masters, 2020), or compared candidates' perceptions of their self-efficacy before and after one round of an approximation (i.e., Regalla et al., 2016).

Instructional Supports During the Approximation

In nearly all studies ($n=22$), candidates had access to instructional support during their practice. Across these studies, candidates had 49 distinct supports available, as many studies offered candidates multiple instructional supports. The most common forms of instructional support were coaching between rounds of practice (e.g., Bosch & Ellis, 2021), instructional coaching during practice (e.g., Lee et al., 2021), and self-reflection (e.g., Author, 2020). Some of the identified supports were not available to all candidates or were not utilized by all candidates. For instance, Spencer and colleagues (2019) allowed faculty intervention if students made "a critical error," defined as a "problem that would make the interaction ineffective," but the authors note this support was not utilized (p. 1779). In some studies, particular supports were available to some but not all students, based on their treatment condition (e.g., Edelman & Talbert, 2020; Judge et al., 2013). In others, some candidates were able to observe peers' practice before their own based on the order of individual practice, while others did not benefit from the same sort of previewing (e.g., Robbins et al., 2019).

Most instructional supports were available between iterations of practice rather than during the approximations themselves. Only eight studies (i.e., Edelman & Talbert, 2020; Greif Green et al., 2020; Lee et al., 2021; Masters, 2020; Regalla et al., 2016; Spencer et al., 2019; Walters et al., 2021) exclusively offered supports during practice, including pauses and live coaching. These studies offered a variety of approaches to pausing: candidates determined when to pause practice (e.g., Spencer et al., 2019), researchers determined pauses (e.g., Lee et al., 2021), or either the candidate or researcher could pause (e.g., McKown et al., 2021). Here, too, we are limited in the conclusions we can draw about the utility of different approaches to pausing because of differences in the design and outcomes of these studies.

Beyond the Approximation of Practice

Our analysis of candidates' learning beyond approximations of teaching explores two key questions: did candidates improve after practice and did the improvements “stick” beyond the context of the approximation? The studies in this corpus have divergent designs, goals, approximated tasks, and conclusions about what—or if—candidates learned from approximations. As such, we frame our findings of the outcomes following approximated practice in relation to each study's goal(s) for candidate learning. We define “improvement” as whether practicing candidates improved in their demonstration of the focal skill, cultivated the desired knowledge, developed the targeted perception, or improved relative to a group who did not practice or practiced differently. Given the variation of approximated tasks, we cannot evaluate the degree to which specific tasks, supports, or programmatic contexts are levers for candidate development.

Outcomes for Teacher Candidate Learning

Taken together, the reviewed studies suggest approximations of teaching (largely, in this corpus, in the form of digitally mediated simulations) and corresponding instructional supports *through* approximations can support candidates in learning to teach. In most reviewed studies ($n=23$), candidates demonstrated improvement after approximating relative to a baseline measure or comparison group. Candidates nearly always had access to instructional supports, such as coaching or opportunities to reflect, during approximations; as such, we report how these corresponding supports may contribute to the cited improvements whenever possible. In a smaller subset of studies ($n=3$), candidates did not demonstrate improvements after approximating relative to a baseline measure or comparison group. Nearly all studies rely on small samples and employ designs that do not afford causal claims, so we are unable to report on “effects” or statistical significance for many studies. We also acknowledge the publication bias toward outcomes suggesting growth or change; as result, these studies may not provide an accurate sense of how often or why approximations do *not* contribute to novices' improvement. In the following analysis, we summarize the outcomes of candidates' learning, focusing on specific elements of approximations that may contribute to or impede candidates' learning.

Candidates Demonstrated Improvement Relative to Baseline or Comparison Group.

Candidates who participated in approximations showed some improvements following practice in over three-fourths of the studies ($n=23$). In six of these studies, researchers indicated the improvements were statistically significant (i.e., Driver et al., 2018; Ely et al., 2018; Grant & Ferguson, 2021; Henry et al., 2022; Kaka et al., 2021; Peterson-Ahmad, 2018). Together, these findings suggest approximations can support shifts in candidates' skills, knowledge, or beliefs relating to a variety of teaching practices. We further divide these studies into sub-themes related to each study's claim of why candidates may have improved.

Candidates May Benefit from Practice of a Range of Instructional Tasks.

Across a variety of distinct instructional tasks, candidates who completed approximations of teaching demonstrated improvements. Together, these five studies suggest candidates may benefit from approximating a range of teaching tasks, but do not allow for claims about the ways modality of approximation, candidate characteristics, or instructional supports influence learning.

Candidates in two studies (i.e., Driver et al., 2018; Mehlig & Shumow, 2013) completed approximations of teaching focused on improving communication skills with other stakeholders in students' education and improved following practice. While these studies vary by approximation modality and study design, they similarly conclude approximations of teaching can be a useful strategy to prepare preservice teachers for this skill. Candidates ($n=7$) in Driver and colleagues' (2018) study individually completed four rounds of MRS practice in which they aimed to establish collaborative partnerships during "difficult conversations" with colleagues or families (p. 65). Candidates improved their communication skills and perceptions of preparation for developing collaborative partnerships with paraprofessionals, co-teachers, parents, and administrators in an inclusive education setting to a statistically significant degree. Similarly, Mehlig and Shumow (2013) found candidates' ($n=15$) who were randomly assigned to complete four role-plays speaking to a "parent" reported significantly greater knowledge and skills for communicating with families than candidates in a control group ($n=19$) who did not practice.

Candidates in two studies (i.e., Grant & Ferguson, 2021; Masters, 2020) completed approximations of teaching focused on content-specific instructional practices and subsequently demonstrated improvements towards the researchers' goals for practice. Candidates in Grant and Ferguson's (2021) study ($n=59$) individually completed two rounds of MRS practice in which they led a student-centered discussion to elicit students' thinking about mathematics problem solving; these candidates improved their confidence for leading a mathematics discussion to a statistically significant degree. Candidates in Masters' (2020) study used a Claim, Evidence, Reasoning (CER) framework to help students interpret data and use it to construct a scientific explanation. When subsequently teaching real students, candidates who completed rehearsals ($n=8$) performed better than candidates who did not ($n=8$) at utilizing the CER framework to encourage students' use of evidence to support an argument.

Finally, candidates in Greif Green and colleagues' (2020) study practiced supporting students' mental health; the authors find an approximation of practice improved candidates' performance on some but not all learning outcomes. Candidates were randomly assigned to complete either three virtual role-plays ($n=24$) or an online training module ($n=22$) related to students' mental health. Candidates who completed role-plays reported significantly greater feelings of preparedness and confidence to address students' mental health needs compared to candidates who completed modules. Both groups demonstrated small but statistically significant improvements to mental health stigma related behavior, but there were no differences between groups. The authors offer multiple explanations for the lack of treatment effects on this outcome, including that the measure of mental health stigma they use is not specific to teaching.

Modality of Approximations May Contribute to Candidate Learning.

Seven studies explore candidate learning across multiple modalities of practice, such as digitally mediated simulations and in-person rehearsals or role-plays. In six of these studies, candidates improved more after completing digitally mediated practice compared to in-person practice (i.e., Aguilar & Flores, 2022; Lee et al., 2021; McKown et al., 2021; Schussler et al., 2017; Spencer et al., 2019; Walters et al., 2021); the seventh study reported candidates' learning after three forms of approximation without examining how each contributed to candidates' learning (i.e., Henry et al., 2019). These studies suggest candidates can improve through practice, and some modalities of practice may be more beneficial for candidates than others.

Two studies (i.e., McKown et al., 2021; Walters et al., 2021) examined different outcomes for the same sample of candidates; in both studies, candidates competed either two rounds of MRS practice ($n=12$) or two rounds of live practice with peers ($n=15$). They practiced implementing a behavioral scaffold called a “system of least prompts” (SLP), in which they supported autistic students through a hierarchy of verbal, gestural, physical, or visual prompts. Walters and colleagues (2021) find candidates who were randomly assigned to complete MRS practice ($n=12$) used the SLP more effectively than candidates who completed rehearsals with peers ($n=15$). Though both groups showed statistically significant growth between rounds, the MRS group showed significantly greater gains. McKown and colleagues (2021) found the groups had comparable levels of perceived knowledge of SLP strategies and/or confidence enacting SLP, but the simulation group implemented the strategies more effectively. These analyses suggest candidates can show greater improvements to skills and knowledge after MRS practice compared to peer-to-peer practice.

Three studies of distinct tasks similarly conclude candidates who complete MRS demonstrate greater improvements than candidates who complete peer-to-peer practice. Candidates in Aguilar and Flores’ (2020) study individually completed individual MRS practice leading mathematical discussions ($n=20$) demonstrated more effective use of productive mathematical talk moves than those who completed in-class rehearsals in groups of four or five peers ($n=20$). Candidates in Lee and colleagues’ (2021) study completed two rounds of MRS practice leading number talks with students ($n=38$) and significantly increased their use of some talk moves for eliciting student thinking compared to candidates who completed two peer-to-peer rehearsals ($n=22$). Although candidates in both treatment conditions improved their use of some eliciting strategies between practice sessions, candidates who completed MRS practice increased in their average use of eliciting strategies more than candidates who completed peer-to-peer rehearsals. Candidates in Spencer and colleagues’ (2019) study ($n=48$) who were randomly assigned to complete a practice conversation with a special education co-teacher in MRS showed significantly greater shifts in their opinions about the value of having a co-teacher compared to candidates who completed peer role-plays ($n=42$) (Spencer et al., 2019).

One study compared the impact of different practice opportunities following an in-person role-play (i.e., Schussler et al., 2017). Candidates who completed one in-person role-play with peers followed by virtual role-plays with an AI chatbot ($n=14$) showed more positive changes in their responses to classroom bullying compared to candidates who completed case study analysis after the initial in-person role-play ($n=13$) (Schussler et al., 2017). The statistical significance of these differences was not reported.

Although most studies that include multiple modalities indicate digitally mediated approximations contribute to greater candidate improvements than in-person approximations, not all studies disaggregate findings by modality. Candidates in Henry and colleagues’ study (2022) individually completed three approximations communicating with a student’s family—a rehearsal with peers, a rehearsal with a parent actor, and an MRS. After completing the three types of approximations, candidates ($n=25$) improved their confidence and perception of preparation for communicating with families to a statistically significant degree. Because the authors report the outcomes in aggregate, we are unable to conclude if there is a relationship between outcomes and specific modalities of approximation.

Instructional Supports May Contribute to Candidate Learning.

Eight studies suggest specific supports within approximations that might contribute to or bolster candidates’ development. The authors of these studies examined candidates’ outcomes in relation to a specific treatment or support within the approximation (i.e., Author, 2020; Bosch & Ellis, 2021; Edelman & Talbert, 2020; Ely et al., 2018; Gundel et al., 2019; Judge et al., 2013; Peterson-Ahmad, 2018; Robbins et al., 2019; Rosati-Peterson et al., 2021). We categorize these pedagogical supports that may contribute to candidate learning into three categories: dosage of practice time, opportunities to observe peers, and instructional coaching.

Two studies examined the relationship between the amount of time candidates spend practicing and their learning (i.e., Gundel et al., 2019; Rosati-Peterson et al., 2021). Candidates in Rosati-Peterson and colleagues' (2019) study ($n=15$) completed three MRS sessions in which they practiced eliciting student thinking through nonverbal questioning techniques. Candidates significantly improved their nonverbal immediacy behaviors (e.g., eye contact, proximity) when responding to students, but these improvements occurred between the second and third rounds; changes between the first and second rounds were not significant. Gundel and colleagues (2019) similarly examined candidates' outcomes when assigned to varying dosages of MRS practice time: 30 minutes ($n=20$), 60 minutes ($n=18$), and 90 minutes ($n=15$) practicing varying tasks. On average, candidates ($n=53$) significantly improved their teaching self-efficacy after practice, but the amount of practice time seemed to influence their self-efficacy: participants who practiced for 60 minutes reported a significant decrease in self-efficacy, while candidates who received 30 or 90 minutes of exposure reported significant increases. Candidates in each group were at differing program stages, and the duration and tasks of MRS sessions varied across groups, confounding our ability to attribute differences between groups to dosage. Nevertheless, these studies suggest that future research should examine the relationship between the amount of time candidates practice parallel tasks and their outcomes.

Three studies examined the influence of peer observations on candidates' learning (i.e., Ely et al., 2018; Judge et al., 2013; Robbins et al., 2019). In Ely and colleagues' (2018) study of candidates' knowledge and enactment of collaborative strategic reading strategies (CSR), candidates either practiced using CSR strategies in an MRS ($n=11$) or observed classmates' enactment ($n=11$). Both improved their knowledge and enactment of CSR strategies to a statistically significant degree, and candidates in each condition demonstrated statistically similar scores on their subsequent enactment. These findings indicate that both participating in and observing approximations of teaching may support candidates' development. Relatedly, Robbins and colleagues (2019) found that candidates who observed peers practice co-planning a lesson in an MRS before enacting their own practice performed significantly better than those who practiced twice; all candidates ($n=29$) improved their knowledge of collaboration skills for co-planning after practice. Robbins and colleagues suggest candidates in the observing group may have experienced "vicarious observational learning" (p. 172); in other words, watching peers practice before approximating seems to have supported knowledge development. Finally, Judge and colleagues (2013) examined the influence of peer or instructor feedback on candidates' performance in MRS: candidates who completed three MRS sessions and received feedback ($n=4$) from an instructor and/or peers demonstrated more growth in the use of a behavior management strategy than those who received no feedback ($n=2$), though all groups increased their use of the strategy. The outcomes of these studies suggest observing peers before practicing and/or receiving feedback from peers after practice may bolster candidates' learning.

Although instructional coaching was the most frequent instructional support in these studies, only three studies analyzed the impact of coaching on candidates' learning. Candidates in two studies demonstrated improvements following instructional coaching; these studies also illuminate potential limitations to in-the-moment coaching. Author (2020) studied the impact of self-reflection and two forms of coaching on candidates' behavioral redirection skills, perceptions of student behavior, and ideas about next steps for addressing student off-task behaviors. Candidates who completed a written self-reflection survey between rounds of MRS practice ($n=33$) demonstrated smaller improvements than those who received instructional coaching between rounds of practice ($n=34$) and candidates who received coaching between rounds of practice *and* "bug-in-ear" coaching during the first round ($n=33$). Both coaching groups outperformed the self-reflection group, but there were no differences in performance outcomes for candidates who received different forms of coaching. Edelman and Talbert (2020) similarly studied the impact of in-the-moment coaching: an instructor would raise a red card to provide visual feedback to candidates who provided vague verbal feedback to their orchestral students during rehearsals. Candidates who received in-the-moment visual feedback ($n=9$) significantly increased the amount of time their students made music compared to candidates who were

randomly assigned to rehearse without feedback ($n=9$). However, candidates did not improve on all outcome variables. There was no significant difference in the amount of substantive verbal feedback candidates provided to students following repeated practice and in-the-moment visual feedback.

Not all studies found that instructional coaching improved candidates' outcomes. All candidates in Peterson-Ahmad's (2018) study ($n=8$) improved the frequency with which they provided opportunities to respond during four MRS lessons about responsible work habits and respect (Peterson-Ahmad, 2018). A randomly assigned treatment group received coaching after each session, while a control group ($n=4$) received no coaching; both groups completed self-reflections after each session. Notably, candidates who received instructional coaching showed similar improvements to candidates who did not. The authors do not report on the statistical significance of these results, likely due to the small sample size. These conflicting results on the effectiveness of coaching in approximations suggest a need for further research with larger sample sizes and comparably rigorous designs.

Programmatic Context May Contribute to Candidate Learning from Approximations.

In addition to other factors that can impact candidates' outcomes beyond approximations, candidates' previous or concurrent preparation experiences may influence their learning. Specifically, three studies compare outcomes for candidates in different preparation programs (i.e., Kaka et al., 2021; Pankowski & Walker, 2016) or at various stages within one program (i.e., Bosch & Ellis, 2021). Bosch and Ellis (2021) studied candidates from multiple contexts within one program: candidates in the sample spanned multiple academic years and were enrolled in one of three different courses. Following two rounds of MRS practice, candidates ($n=44$) improved overall teacher self-efficacy (Tschannen-Moran & Woolfolk Hoy, 2001) to a statistically significant degree, as well as their self-efficacy in classroom management, instructional strategies, and student engagement. Results did not vary by candidates' academic year but varied based on student teaching experience: candidates who completed the MRS during their student teaching course ($n=3$) reported decreased self-efficacy for instructional strategies and classroom management after practicing. The authors suggest that teaching experience may influence candidates' development during approximations.

Pankowski and Walker (2016) found that candidates pursuing traditional certification ($n=12$) and alternative certification ($n=14$) significantly improved their beliefs, knowledge, and enactment of classroom management strategies following six rounds of MRS practice motivating students and addressing non-compliance. Candidates pursuing a traditional certification, who were completing field work before student teaching, found the practice more helpful and realistic than alternative certification teachers, who were first-year teachers. Previous teaching experience may be a particularly salient consideration for programs that include multiple certification pathways with varying clinical experience requirements.

Although programmatic context may influence candidates' learning, one study of simulation practice reports findings from three different teacher programs in aggregate (Kaka et al., 2021). Candidates ($n=25$) completed two rounds of a digital simulation called *Discussion Leader* in which they planned and facilitated a student-centered discussion about contemporary controversial topics. Candidates improved their skills and confidence for leading whole-group discussions about controversial issues to a statistically significant degree, but the results are not reported by individual programs. This parallels other studies that report outcome by treatment condition rather than university enrollment (Edelman & Talbert, 2020) or do not report differences by enrollment after baseline (Greif Green et al., 2020), limiting our understanding of the potential relationship between context and participants' outcomes.

Candidates Did Not Demonstrate Improvement Relative to Baseline or Control Group.

While the findings of 23 studies suggest that approximations have the potential to enhance candidates' knowledge, skills, and beliefs, there were three studies where candidates did not improve relative to

a baseline measure or control group on any outcome variable(s) after an approximation (i.e., Hudson et al., 2019; Lamb & Etopio, 2020; Regalla et al., 2016).

Candidates in Hudson and colleagues' (2019) study ($n=29$) individually completed three MRS scenarios in which they practiced behavioral redirections of increasingly intense off-task behaviors. Candidates were able to watch peers' practice but had no other supports available during their individual practice sessions. After three rounds of practice, candidates reported no significant changes in their perception of their classroom management ability; they reported a decrease in their perception of their overall "teaching ability." The authors suggest this decline in self-perceived "ability" may have occurred because "participants were realizing what they still needed to know to be competent teachers," as the MRS experience exposed candidates to the challenges inherent to teaching (Hudson et al., 2019, p. 91).

Candidates ($n=54$) in Lamb and Etopio's (2020) study were randomly assigned to teach a science micro-lesson about matter and energy in either a clinical context or a virtual reality (VR) student teaching context. In both conditions, candidates were monitored for physiological measures, such as hemoglobin oxygenation, heart rate variability, and eye movements; university supervisors also evaluated candidates' instruction on a standardized rubric for both conditions. The authors found no statistical difference for the physiological or instructional rubric measures between the treatment conditions, concluding that candidates' physiological and instructional outcomes after three rounds of virtual reality practice are comparable to those of candidates who practice with real students. The authors suggest that candidates may experience VR the same way they experience classroom teaching, and VR simulations can provide comparable insight into skill development. The authors note that candidates in either condition may have shown improvement following these practice opportunities, but the "lack of baseline data from initial entry into the program prohibited assessment of growth" (Lamb & Etopio, 2020, p. 583).

Candidates in Regalla and colleagues' (2016) study either completed coursework in addition to a MRS with coaching ($n=38$) or completed only coursework ($n=75$) relating to effective communication with English learners. Candidates in both groups reported statistically similar improvements in attitudes and beliefs related to teaching English learners on a survey measure. Their findings suggest completing an approximation of practice did not improve candidates' development more than completing business-as-usual coursework.

Transfer to Practical Teaching

The final element of examining candidate learning "beyond" the practice itself is how candidates transfer their learning from approximated teaching into a real classroom setting. Although the goal of approximations is for candidates to prepare for real teaching (Grossman et al., 2009), very few studies explore the degree to which and way in which shifts in observed development following approximations of teaching "stick" across time and contexts. Two studies (i.e., Pankowski & Walker, 2016; Rosati-Peterson et al., 2021) include candidates' qualitative reflections, suggesting they felt able to utilize the behavior management skills they practiced in a clinical teaching context. However, neither of these studies observe whether candidates' skills are transferred to a context working with real children.

Only two studies (i.e., Lee et al., 2021; Masters, 2020) studied candidates' enactment with real students after an approximation; both found evidence that candidates transferred skills from approximations to classroom teaching. The designs and approximation outcomes for each of these studies are detailed above. In their comparison of candidates' elicitation moves in real classroom settings, Lee and colleagues (2021) found the group that practiced in a virtual simulation increased their use of all nine elicitation moves between their first approximation and classroom enactment; the in-person rehearsal group increased their use of eight of nine elicitation moves. Though both groups improved, the virtual simulation groups' instruction yielded more student-centered and open-ended discussions.

Masters (2020) found candidates who completed in-person rehearsals of instruction on how to construct scientific explanations better supported students in forming claims than a comparison group that did not have practice opportunities. This limited research suggests the need for additional longitudinal research to explore whether and how approximations and corresponding supports can contribute to lasting growth for candidates.

DISCUSSION

One clear implication from existing teacher education research is candidates need chances to practice key skills, develop productive, equitable, asset-oriented dispositions, and consider the implications of their instructional decisions. They also need consistent feedback from more experienced professionals. Practice opportunities in teacher preparation typically happen during student teaching when novices are placed in PreK-12 classrooms to learn from experienced mentor teachers, who might model “best practices” and provide feedback on how to improve (Anderson & Stillman, 2013). Though a great mentor can go a long way, not all student teaching experiences are equally supportive (Ronfeldt et al., 2018). Some mentors teach in ways counter to the methods advocated in teacher preparation coursework; others struggle to provide actionable feedback to candidates (Matsko et al., 2020).

Approximations of teaching can provide an important complement to clinical practice in PreK-12 classrooms by allowing candidates to pause practice sessions and receive feedback from teacher educators. Unlike teaching in a classroom, an approximation can be enacted multiple times, allowing candidates to try out and compare a range of approaches to the same scenario. In theory, these opportunities might enhance candidates’ instructional flexibility, sense of efficacy, and productive dispositions. Perhaps more importantly, approximations avoid risks to real students. Candidates will inevitably fumble during their early attempts at navigating a complex classroom scenario; in an approximation, they can do so without worrying about implications for real children. Unsurprisingly then, there has been a proliferation of research around approximations of teaching in the last 15 years. The goal of this systematic review was to synthesize that literature to provide insight to teacher educators about the contexts and conditions in which approximations were more or less helpful, for which candidates, towards which goals.

The field of teacher education would benefit from knowing more about how candidates’ experiences before, during, and after approximations influence their learning; as such, we used an “into, through, and beyond” framework to analyze the studies (Kelley-Peterson et al., 2018). In initiating this systematic review, we hoped this work would help move the field of teacher education toward one that prepares candidates through the type of deliberately sequenced and supported practice detailed by Ericsson and Pool (2016). However, after careful review of the existing literature, we are left with little such clarity. Rather, we offer a range of hypotheses we argue can and should be tested systematically through a coordinated set of research efforts.

Much of the research we review about approximations of teaching is idiosyncratic to a particular preparation program or specific to the goals of a single course. Many studies in our initial search of approximations did not include outcomes of any sort, and fewer still included measures of focal knowledge, skills, or beliefs before the approximation. This makes it nearly impossible to make claims about how candidate development results from approximated practice. Those studies featured here include either a pre/post design or a comparison group, but very few featured designs allowing for causal claims about the effects of practice opportunities or the corresponding instructional supports. Most studies use distinct outcome measures, making it difficult to aggregate findings across studies. Very few studies explore whether the approximated practice influences candidates’ instruction in real classrooms with real students. Concerningly, no studies explore candidates’ dispositions or skills related to race and equity.

We argue such evidence is imperative and urgent if we, as teacher educators, are to speak to policymakers and licensing agencies about the learning experiences candidates need to begin their teaching careers poised for success. The duration of teacher preparation is quite contracted compared to other professions: we often have less than a year to cultivate the wide range of knowledge, skills, and beliefs needed to support students. Maximizing the effectiveness and efficiency of practice opportunities is vital. Below, we detail the limited conclusions we feel comfortable drawing from the extant research, with a focus on key questions for future research. Though we emphasize that methodological constraints in the studies above limit generalizable or even conclusive claims, we do see a number of potentially generative hypotheses that could be studied to better understand the circumstances and mechanisms contributing to the greatest candidate improvements. To explore the precise circumstances under which those improvements happen, however, additional research is needed where teams systematically vary the type of approximated practice, the duration and modality of practice time, the supports available during the practice, and the sequencing of practice in relation to clinical teaching opportunities.

Who is practicing? What are they practicing, in what modality, and when?

What we can say conclusively is these studies reflect only a tiny fraction of the beginning teachers who enter classrooms each year. Most studies featured here include samples of fewer than 60 candidates, primarily in elementary and special education programs, who are predominantly white undergraduates enrolled in traditional certification programs. Many studies do not include information about the ways in which the approximation(s) under study is situated in a broader programmatic arc of learning to teach. We need far more research on the utility of approximations in contexts that represent the vast diversity of teacher preparation programs including online licensure, residency models, and other alternative licensure routes. We also need more research in minority-serving institutions and with candidates who reflect the diversity we hope to cultivate in the next generation of teachers. This review also makes clear teacher education needs clear and consistent definitions for different types and modalities of approximation. It is hard to disentangle the role of modality in approximating teaching if we do not use shared definitions of terms and their constituent features. What is a rehearsal versus a role-play? How are they different from a simulation?

These findings suggest the modality of the approximation may influence candidate development, making clear and consistent definitions even more vital. A small set of studies (i.e., Aguilar & Flores, 2022; McKown et al., 2021; Lee et al., 2021; Spencer et al., 2019; Walters et al., 2021) contrast development from live rehearsals to mixed-reality simulations and suggest digitally-mediated practice may be more beneficial than in-person practice with peers. There is suggestive evidence candidates find digitally mediated approximations more useful and realistic (Spencer et al., 2019; McKown et al., 2021; Walters et al., 2021), as well as more anxiety-inducing (Lee et al., 2021; McKown et al., 2021; Walters et al., 2021), than face-to-face practice, providing a more authentic approximation of the inevitably stressful experience of first year teaching. However, the mechanisms underlying these differences are not well-understood.

Our findings also suggest design considerations may be contributing to some of these observed differences between modalities. In simulations, candidates interact with an unknown actor, whereas in-person practice often occurred with peers or teacher educators. Interacting with an unknown person—rather than something about the interface itself—may facilitate candidates' suspension of disbelief in ways research suggests support learning (Dieker et al., 2014). It may be harder to embody a "teacher persona" if you are engaging with a classmate or your instructor. Second, the simulations and live actor approximations in this review often included scripting logics to create intentionally instructive opportunities for candidates. Specifically, fourteen studies trained actors to use *If-Then*

logics to respond to candidates' instruction. As such, these simulations may have supported candidates in recognizing the implications of their instructional choices. Additional simulation studies employed other design logics, such as escalating intensity of avatar behavior (Driver et al., 2018; Hudson et al., 2022) or the systematic increasing of task complexity (Gundel et al., 2019). These, too, may have facilitated learning by creating moments of productive struggle (Hiebert & Grouws, 2007). In contrast, role-plays or rehearsals with classmates inherently rely on improvisation and cannot be as predictable in terms of the learning opportunities afforded. In a role-play, a peer may not respond to instruction in ways that K-12 students might or that a teacher educator might want to highlight. Importantly, these design affordances are not unique to digitally mediated formats and might also be implemented in more standardized, live-actor role-plays teacher educators can consistently structure to reinforce their desired learning goals (Henry et al., 2022; for other examples not included here, see Self & Stengel, 2020).

Despite their potential utility, digitally mediated platforms like MRS are resource intensive. Because most teacher preparation contexts are resource-constrained, it is essential to build an evidence base about what modalities of practice are especially helpful for which specific skills. More research is needed to understand the circumstances under which these varying formats and modalities of practice could have implications for candidates' learning, alongside more work to determine *why* and *how* different kinds of practice support teacher development.

There is also enormous variability in terms of what is being approximated, suggesting approximations are a flexible pedagogy with myriad applications. These studies suggest approximations can support development across a range of instructional activities from working with parents or guardians, to content-generic practices (often behaviorally focused), to more discipline-specific practices like pushing students to use scientific evidence. That said, many studies focus on behavior management or dyadic conversations with adults, perhaps because those are more straightforward to approximate, particularly in digitally mediated formats. Much of the research on approximating complex disciplinary skills has been in the context of rehearsals (e.g., Alston et al., 2018; Davis et al., 2017; Lampert et al., 2013) and focused on teacher educators without corresponding assessments of candidate development. Much more research is needed to understand how approximations support shifts in content-specific teaching.

These approximations also target a wide range of outcomes, from observable skills to knowledge of teaching practices to feelings of confidence. Though some studies measure outcomes related to both skills and cultivation of knowledge and beliefs, none provide opportunities to evaluate the alignment between candidates' confidence with or knowledge of a practice and the quality of their enactment of that practice. Both matter for beginning teachers, and we will be well served to generate evidence on both fronts.

Ultimately it will be challenging to build a more coherent evidence base to address these lingering questions without a set of common measures we can use across research efforts. Except for some commonly used survey items, like Tschannen-Moran and Woolfolk Hoy's (2001) Teacher Self-Efficacy Scale (used in Bosch & Ellis, 2021; Gundel et al., 2019; Regalla et al., 2016), virtually every study used a unique set of outcome measures about a study-specific teaching practice. It is worth noting "deliberate practice" as defined by Ericsson and Pool (2016) is predicated on coalescence in a field around *what* should be practiced and how one would *know* someone has developed the requisite skills. Unlike Ericsson and Pool's (2016) research on practice in competitive fields with accepted training methods that have been gradually refined, as in classical music and mathematics, the field of teacher education does not generally agree upon what constitutes "good performance" or how to measure it, making it difficult for teacher education practice to be deliberate.

Teacher education has long faced calls for common language (e.g., McDonald et al., 2013), alongside criticism of such calls (Philip et al., 2019). Without wading into that debate, we argue here that without common language or common measures, it is difficult to build a collective knowledge base about the affordances and constraints of different approaches to approximation for the range of

candidates with whom we work (Grossman, 2008). Efforts like the Annenberg Institute’s (n.d.) collection of education-related instruments are a helpful starting place for identifying existing measures with established technical properties, rather than re-inventing the wheel with each new study. However, we need more research—and more coordinated research—to better understand how different measures can be used in tandem to provide a comprehensive picture of candidate learning. There is a corresponding opportunity for a repository of approximation materials, collated across live-actor simulations (Self & Stengel, 2020; Shaughnessy et al., 2019), MRS (Mikeska & Howell, 2020) and rehearsals of teaching (Lampert et al., 2013; Teacher Education by Design, n.d.). Having a shared space for defined practices with parallel approximations and outcome measures that could be used with different practice modalities would help enormously in moving us towards a clearer understanding of how, when, for whom, and in what contexts approximations promote candidate development.

Into: Work Preceding an Approximation

Grossman and colleagues’ framework (2009) makes clear that “into” supports are vital for developing candidates’ schema around the focal practice and promoting flexible understandings of how the upcoming practice supports PreK-12 students, rather than conveying the approximation as a set of rote procedures to execute without attention to context (Philip et al., 2019). These supports can include representations or examples of the practices alongside decompositions of the key features of that practice. Such preparation can support candidates’ understanding of the necessary malleability of approximated practices by providing theoretical and contextual background for the practices.

However, few studies included here explicitly detail preceding pedagogical supports. Here, too, it would be very helpful to conduct studies that systematically parse the relative advantages of different preceding pedagogical supports. What types of instruction before an approximation support candidate development? Are representations sufficient or does a corresponding decomposition enhance learning? All but one study (i.e., Rosati-Peterson et al., 2021) offered candidates some form of preparation, such as group discussions (e.g., Aguilar & Flores, 2022) or content-acquisition podcasts (e.g., Driver et al., 2018) before they practiced. How do these methods complement those detailed in the pedagogies of practice framework?

Through: Instructional Supports during Practice

The studies included here feature a range of instructional supports during approximations, including pausing the practice to debrief and directive coaching from a teacher educator. Most of these studies feature multiple rounds of practice (e.g., Author, 2020; Kaka et al., 2021), a key affordance of approximations, in contrast to clinical practice where candidates often have only one attempt to enact a lesson plan. Some of this work suggests the amount of time for practice and the number of rounds of practice matters (i.e., Gundel et al., 2019; Rosati-Peterson et al., 2021), though these findings are neither conclusive nor generalizable due to issues of confoundedness and potential maturation threats in the study designs. There is also encouraging suggestive evidence that candidates can benefit from watching peers’ approximations (i.e., Ely et al., 2018; Robbins et al., 2019). Relatedly, we see promising results following practice in group formats, perhaps because working in a group affords additional opportunities to see representations of practice in the form of a peer’s approximation (e.g., Spencer et al., 2019). However, we cannot make claims about the role of group size in candidates’ learning, as it is often confounded with other variables. These are relatively straightforward approaches that require few resources, making them strong candidates for future, systematic investigation.

The variety of tasks and study designs impedes our ability to make claims about the relationship between instructional supports and candidate development. While we can affirm supports are frequently available for candidates during approximations, we cannot conclusively state the degree to which or ways in which supports contribute to the development of focal knowledge, skills, and beliefs. However, there is suggestive evidence that certain supports may be more beneficial than others: for instance, coaching between rounds or after practice may be more beneficial than receiving in-the-moment feedback (Author, 2020; Edelman & Talbert, 2020). While studies have shown the benefits of in-the-moment feedback for more experienced teachers (e.g., Rock et al., 2014; Schaefer & Ottley, 2018), it may be candidates do not yet have sufficiently robust ideas about “good teaching” and/or the facility with classroom interactions to take up and integrate such feedback.

Table 2*Example Variables for Future Systematic Studies of approximations of teaching*

Stage of Candidate Learning	Variables for Future Analysis
Context(s) of Practice	<ul style="list-style-type: none"> – Program(s) (e.g., traditional, alternative, online, residency) – Licensure area(s) (e.g., elementary, secondary, special education) – Candidates’ prior teaching experience, including student teaching – Candidates’ demographics – Diagnostic assessment(s) of candidates’ focal knowledge, skills, or beliefs (e.g., paper & pencil test of knowledge, performance task, survey of beliefs)
Into the Approximation	<ul style="list-style-type: none"> – Formative assessment(s) of candidates’ focal knowledge, skills, or beliefs that parallels diagnostic – How candidates prepared for practice (e.g., pre-coaching, collaboration with peers, instruction in a course) – How practice is introduced and framed (e.g., introduced by instructor or researcher, connected to course or program) – Utilization of other preparatory pedagogies of practice
Through the Approximation	<ul style="list-style-type: none"> – Formative assessment(s) of candidates’ focal knowledge, skills, or beliefs that parallels other assessments – Types of approximation (i.e., role-play, rehearsal, simulation) – Modality of practice (i.e., in-person or digitally mediated) – Structure of approximation (e.g., small group, individual) – Difficulty of approximation – Availability, modality, dosage, and frequency of instructional supports (e.g., pausing, coaching, observe peers) – Dosage and frequency of repeated practice opportunities
Beyond the Approximation	<ul style="list-style-type: none"> – Summative assessment(s) of candidates’ focal knowledge, skills, or beliefs that other assessments – Availability, modality, and dosage of post-practice debrief – Opportunities for self-reflection (e.g., written, reflect on video, class discussion)
Transfer to Real Teaching	<ul style="list-style-type: none"> – Summative assessment of candidates’ focal knowledge, skills, or beliefs that other assessments – Enactment of focal knowledge, skills, or beliefs in student teaching – Enactment of focal knowledge, skills, or beliefs in classroom teaching in subsequent year(s)

We need additional research into the impact of instructional supports on candidates’ learning. For instance, a specific affordance of approximations is the ability to pause practice, but none of the studies in this corpus look systematically at outcomes of pauses. Three studies analyze the impact

of instructional coaching on candidates' knowledge, skills, and beliefs but present conflicting findings on the impact of coaching and offer no clarity on what features of coaching contribute to candidate learning (i.e., Author, 2020; Edelman & Talbert, 2020; Peterson-Ahmad, 2018). Consequently, additional research is needed to explore the impact of instructional supports, including when they are available, their duration, their quality, and alignment with the desired outcome of practice.

Beyond: Outcomes and Transfer

Do certain types of approximations and accompanying supports help candidates develop knowledge, skills, and beliefs that are important for classroom teaching? This question is at the center of this review and is impossible to answer based on the current research. The vast majority of these studies ($n=23$) note candidate improvement, broadly construed, from approximations. That said, there are numerous reasons why null or negative effects from approximations would be underreported in published studies. The results of the few studies that indicate no improvement or evidence of decline ($n=3$) are also confounded with issues around study design. Candidates in Hudson and colleagues' (2019) study, for example, likely would have benefitted from additional practice to overcome the reality shock of the difficulties of teaching (e.g., Gundel et al., 2019; Rosati-Peterson et al., 2019); their decline, therefore, may indicate they need *more* time to approximate teaching, not less. Another study did not include baseline data (i.e., Lamb & Etopio, 2020), making it impossible to compare and assess growth.

It is also worth noting many of these studies indicate evidence of maturation, or skill/belief development, from practice. While this provides support for the common adage that “practice makes perfect,” it obscures the nuanced information the field of teacher education needs to capitalize on our limited time to support candidate development. We argue coordinated research efforts can support greater efficiency in teacher education. In particular, we echo Pankowski and Walker (2016) in identifying the need for more research about transfer. Most studies ($n=24$) do not address how—or if—the outcomes of practice transfer to teaching in clinical placements or subsequent years. The paucity of research on transfer does not allow us to answer questions about the longitudinal impact of approximating teaching. Consequently, our understanding of the outcomes of approximations of teaching for candidates is limited to outcomes that occurred in the context of—and not beyond—the approximations.

This is what we must try to understand as a field: how teacher education pedagogies promote long-term positive outcomes for candidates and, ultimately, the students with whom they will work. While we are unable to make causal claims about the effectiveness of specific supports within approximations of teaching based on the extant research, we find promising evidence that specific supports into, through, and beyond approximations of teaching can promote candidate learning. We draw upon the research reviewed here and the potentially helpful conditions surrounding these approximations to propose a set of variables for teacher educators and researchers to consider when designing and studying approximations of teaching (Table 2). Teacher educators and researchers can use these variables—and increased attention to the supports candidates receive into, through, and beyond approximated practice—to support more systematic and collaborative work around teacher learning. Working together, we can learn far more than an individual teacher educator in the context of an individual program of course. With a common language for approximations, shared variables of study, and systematic supports for candidates, our field can develop a more rigorous research base and better-prepared teachers for future generations.

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