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Publication Date

2026-06-14

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA

Santa Barbara

Deeper Learning in Teacher Education: From Teacher Educators to Preservice Teachers

A dissertation submitted in partial satisfaction of the requirements for the degree

Doctor of Philosophy

in

Education

by

Matthew David Bennett

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Deeper Learning in Teacher Education: From Teacher Educators to Preservice Teachers

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by

Matthew David Bennett

For John and Ellie; Bob and Sue

Acknowledgements

Over the last few years, I have kept a paper planner. In it, next to the various things I set out to accomplish that day, I have taken note of a few things which I am thankful for that day. If I were to look back at every note of thanksgiving, I would find a few themes: I am thankful for my friends; I am thankful for my family; I am thankful for this mythical place called Santa Barbara, which we call home; I am thankful for seemingly mundane things such as coffee, riding bikes, and when the fog breaks into sunshine. Today, I am grateful to so many:

To my committee, Danielle Harlow, Julie Bianchini, Karin Lohwasser, and Beth van Es: throughout my time at UCSB you have supported me, challenged me, encouraged me, and mentored me. I am grateful also to Tine Sloan and Mian Wang, for providing me with opportunities to learn and grow as a researcher which I would never have expected when I started at UCSB. And I am particularly grateful to my advisor, Danielle Harlow, for constantly reminding me of the direction I initially set out on.

To Mom, for always reminding me what Papa would have said. To Dad, for always supporting me and simply reminding me to do my best. And to all my family, for being present in every season—thank you for always encouraging me and laughing with me.

To my friends, whether from UCSB, from Westmont, from church and home group, from the golf course, from Handlebar Coffee (where much of this dissertation was written), or from growing up (and now growing older). If I were to name you all, I might miss the filing deadline. You have all blessed me simply by being my friends. Thank you.

To Amy Armstrong, for always reminding me to do good work. I do not know what is ahead of us, but I know that I will always be grateful for your presence here at the end of this dissertation process. I will see you in less than two weeks.

Finally, to my grandparents, John and Ellie, Bob and Sue. I am not sure where I would be without you.

This research was supported by a grant from the William and Flora Hewlett Foundation.

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Abstract

Deeper Learning in Teacher Education: From Teacher Educators to Preservice Teachers

by

Matthew David Bennett

“Deeper learning” is a confusing term. Depending on who you ask, it could mean processes that happen in the brain, processes that happen in the classroom, or various learning outcomes. Despite a lack of consensus on what the term “deeper learning” means, scholars and teacher educators agree that deeper learning and *teaching for* deeper learning are both important for ensuring that students are able to apply their knowledge (NRC, 2018). This means we must also understand how to teach K12 teachers to teach their students for deeper learning in teacher education programs. This qualitative research study focuses on deeper learning in teacher education: focusing both on teacher educators and preservice math and science teachers.

It is well understood that how teachers conceive of teaching influences their practice (Kang & Wallace, 2004; Butcher et al., 2022). We also know that teachers develop mental models for teaching (Greca & Moreira, 2000; Jones et al., 2011; Leinhardt & Greeno, 1986, Schoenfeld, 2000). Thus, it is important to understand how teachers and teacher educators conceive of deeper learning and teaching for deeper learning. This qualitative research study examines how teacher educators and preservice conceive of deeper learning and how they teach for deeper learning in their respective contexts (teacher education programs and K12 schools, respectively).

The findings of this study show that teacher educators frequently think of deeper learning in combination with other educational constructs, while preservice teachers often think of deeper learning in contrast to what they call “surface learning.” In terms of teaching practice,

teacher educators frequently take thoughtful action to integrate deeper learning into their existing practice in order to meet the needs of their students, while (perhaps unsurprisingly) preservice teachers are still developing their teaching repertoire. This study has practical implications for teacher educators which includes the potential for deeper learning to serve as a helpful framework for organizing and guiding how they teach preservice teachers. In addition, this research suggests that education researchers need to work to better define “deeper learning” and related terms to provide actionable guidance for teachers and teacher educators.

Keywords: deeper learning, teacher education, preservice teachers, teacher educators

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Chapter 1: Introduction

Imagine you are back in your high school science class. Your teacher has given you and your classmates a test which asks you to design a plant which could survive on a different planet (Mayer, 2005). Your teacher has never given you a task quite like this. You take a deep breath, sit back, and smile before spinning your pen around your finger. You start asking yourself: *What kind of light is on this planet? Should the plant have a few big leaves? Plenty of small leaves? What about nutrients? Will this plant need to dig deep into the soil, or will surface level roots be advantageous?* You ask all these questions because your teacher has given you learning opportunities over the past few weeks which specifically focus on different aspects of how plants thrive in different environmental conditions, from light to carbon dioxide in the air to nitrates in the soil. Over time, you have learned a little here and a little there, consciously working to integrate these disparate pieces of information into something that makes sense, something that you can use (Mayer, 2011; NRC, 2018, p. 93). Sure, maybe you will not get to see this hypothetical plant on another planet in your lifetime, but you are about to crush this test.

This example helps us think about various aspects of learning. I will start with this interplanetary plant test and work backwards. Traditionally, this test would be called a “*transfer* test” or a “*transfer* task.” *Transfer* can be a tricky word to define. However, if we stay focused on the plant test, we see that students are being tested on their ability to apply what they have previously learned about plants to a new scenario (remember, “your teacher has never assigned a task quite like this”). In this sense, *transfer* is an outcome. Specifically, *transfer* is when the learner “becomes capable of taking what was learned in one situation and applying it to new situations” (NRC, 2012, p. 5). Successfully applying information learned about terrestrial plants to thinking about interplanetary plant growth demonstrates the *transfer* of learning about specific science

content related to plants to a new context. In this sense, researchers and committees (NRC, 2012) alike consider *transfer* a highly regarded outcome for learning.

Next, we need to consider the cognitive processes which lead to *transfer*. For starters, we know that something is happening inside students' brains when learning. Not only that, but something has been happening inside students' brains during all the various learning episodes on plants leading up to this plant test. Scholars of learning have termed this process "deeper learning" (NRC, 2012, 2018). Indeed, being able to transfer knowledge is how they identify deeper learning. In other words, they claim that "deeper learning" is evidenced by transfer (Mayer, 2011; NRC, 2012, p. 5). Unfortunately, the term *deeper learning* is used by other scholars to talk about not what is happening *in the brain*, but rather the learning opportunities that happen in the classroom that allow such cognitive processes to occur. Thus, to avoid confusion between these two meanings of deeper learning, I use the term *deeper cognitive processing* to mean the sort of thinking that goes on *in the brain* to allow for transfer. I will use the term "deeper learning" only to refer to the learning environment and the things that students and teachers do that facilitate this sort of thinking. To reframe the statement that deeper learning is evidenced by transfer, we can say that *deeper cognitive processing* is evidenced by transfer. In other words, if we see evidence of *transfer*, then *deeper cognitive processing* has occurred. Researchers of *deeper cognitive processing* have also identified various underlying sub-processes which I will address later (consider, as an analogy, how cellular respiration is a process which has various sub-processes, such as glycolysis).

Next, we should address whatever processes happened in the classroom. Learning, especially classroom learning, happens within a specific context (Lave & Wenger, 1991). Perhaps, in the lead up to the plant test, students engaged in activities such as drawing, self-explaining, or enacting (Fiorella & Mayer, 2016). Perhaps students dialogued with classmates to

work through various misunderstandings (Chen & Techawitthayachinda, 2021; Davidson et al., 2020). Perhaps students engaged in an inquiry activity (Butcher et al., 2023). Either way, as a part of learning about plants and ecosystems in the classroom, students engaged in learning activities which promoted *deeper cognitive processing*. Importantly, notice how in these brief examples of learning activities students did something actively; students actively engaged in the learning process in some way. For the purposes of this dissertation, the term *deeper learning* refers to these sorts of classroom-based activities, behaviors, and/or processes. While some of these activities, behaviors, and processes can be done on an individual level, many times it involves learners interacting with one another as a part of the learning process. Engaging in *deeper learning* in the classroom facilitates *deeper cognitive processing*. I am not sure I can stress enough that both cases require active effort on the learner's part; neither *deeper learning* nor *deeper cognitive processing* are things that just happen spontaneously. In other words, learners actively engage in the processes of *deeper learning* and *deeper cognitive processing*.

Finally, we should consider the teacher's role in the sorts of learning activities and teaching strategies which facilitate *deeper learning*, which I refer to as *teaching for deeper learning*. The opportunities to engage in deeper learning described above are created through deliberate choices and actions to provide students with opportunities to engage in the process of *deeper learning*. Engaging in these learning opportunities led students to engage in *deeper cognitive processing*, which then resulted in them completing a *transfer* test. Following the chain backwards, the successful completion of the plant test indicates that students engaged in both *deeper cognitive processing* and, more importantly for the purposes of this dissertation, *deeper learning*. Again, the various learning activities and teaching strategies the teacher used are a part of *teaching for deeper learning*, which refers to teaching actions which facilitate the process of *deeper learning*.

Rationale for This Study

Unfortunately, literature on deeper learning and teaching for deeper learning can be self-contradictory or unclear on the meaning of those terms, hence the need for clarification. For this dissertation, *deeper learning* refers to contextualized learning processes and behaviors which learners actively engage in, which can provide opportunities for learners to actively engage in *deeper cognitive processing*. *Teaching for deeper learning* refers to teaching actions which engage students in *deeper learning*. These actions can range from specific instructional strategies to shaping and orienting classroom culture. These two ideas, *deeper learning* and *teaching for deeper learning* in teacher education programs, are the focus of this study.

While there is a general agreement that deeper learning and teaching for deeper learning are important aspects of education and teacher education (Darling-Hammond & Oakes, 2019; NRC, 2012, 2018), there remains minimal research on how teachers and, in particular, preservice teachers (PSTs) learn about and implement opportunities for their K-12 students to engage explicitly in deeper learning. Additionally, there is minimal research on how teachers and preservice teachers conceive of and develop an understanding of deeper learning, and an understanding of how to teach for deeper learning in ways that might impact their teaching practice.

One example of research on how preservice teachers learn about deeper learning is Darling-Hammond and Oakes's (2019) work, *Preparing Teachers for Deeper Learning*, which uses data from seven exemplar programs that seek to prepare preservice teachers for engaging their K-12 students in deeper learning. These seven programs are considered exemplars because of their track record in preparing preservice teachers to teach for deeper learning. Darling-Hammond and Oakes drew on these programs to outline the need for preparing teachers to teach for deeper learning, explored how these programs seek to address that need, and provided

suggestions for next steps in both research and practice. Further, Darling-Hammond and Oakes used data from the seven exemplar programs to identify and outline a framework for preparing teachers for deeper learning. In doing so, they outlined five general dimensions of learning experiences that prepare teachers for deeper learning: (1) learning that is developmentally grounded and personalized, (2) learning that is contextualized, (3) learning that is applied and transferred (recalling that *transfer* is the outcome of *deeper cognitive processing*), (4) learning that occurs in productive communities of practice, and (5) learning that is equitable and oriented to social justice. Note that four of these five dimensions (1, 2, 4, and 5) are about learning happening in the classroom, what I refer to as *deeper learning*, and one dimension (3) is about learning happening in the brain, what I refer to as *deeper cognitive processing*. Darling-Hammond and Oakes clarified that these are characteristics that should typify learning experiences for K-12 students *and* preservice teachers, each in their respective contexts. In order to be adequately prepared to engage K-12 students in deeper learning, preservice teachers must also engage in deeper learning as a part of their teacher education program. Thus, while teachers have the responsibility to provide learning environments and opportunities that engage K-12 students in deeper learning, teacher educators have the responsibility to provide learning environments and opportunities that engage PSTs in deeper learning.

We know that teacher educators work in various capacities and contexts to prepare teachers for deeper learning (Aina & Aina, 2023; Darling-Hammond & Oakes, 2019; McDonald et al., 2020; Rayner & Corkill, 2015; Thompson & Larkin, 2020). We also know that teachers' conceptions of teaching and learning directly influence their practice (Butcher et al., 2022; Kang & Wallace, 2004). Despite this, there seems to be a lack of research exploring how teacher educators conceive of deeper learning *and* how they teach for deeper learning. Similarly, there

seems to be a lack of research exploring how preservice science and math teachers conceive of deeper learning *and* how they teach for deeper learning.

I briefly note here that I found only one study which addresses conceptions of deeper learning and teaching for deeper learning, which was a quantitative survey-based study on nine English teachers in Indonesia (Wahyuni & Noor, 2025). Their study uses a predetermined framework for deeper learning and measures how teachers' understandings of deeper learning align with that framework. Wahyuni and Noor also provided relevant discussion on some of the barriers that these nine English teachers experienced in implementing opportunities for deeper learning to their students, which I will revisit in the discussion section. In contrast, this dissertation focuses on teacher educators and science and math preservice teachers and uses a different approach to identifying conceptions of deeper learning.

In the literature review, I highlight several studies which exemplify strategies for teaching for deeper learning in both teacher education and K-12 science and math contexts. Understandably, not all these studies explicitly use deeper learning as a part of their framework. Further, among those studies which do mention deeper learning, few give clear and operational definitions of deeper learning outside of mentioning the term (or other related terms such as “transfer” or “deeper understanding”). I found no research which focuses on how teacher educators conceive of deeper learning or teaching for deeper learning. In a similar pattern, research on teaching in K-12 science and math contexts tends to avoid providing clear and operational definitions of deeper learning (for one exception, see Ottmar, 2019). Further, there is scant research focused on how preservice teachers conceive of teaching for deeper learning. One exception to this is McGinnis et al. (2006) which explored how a science methods course impacted perceptions and rationale for making explicit connections between math and science in elementary science teaching. They compared preservice teachers who were in a science methods

course focused on making connections between math and science with those who were in a traditional course. They found the preservice teachers in the math and science connections methods course expressed more positive views of integrating math and science content in elementary science and more thoughtful rationales for doing so. Interestingly, McGinnis et al. posited that one potential reason for this difference was that the preservice teachers in the math and science connections methods course experienced the kind of learning environment in their program which afforded opportunities to integrate math and science teaching and learning and reflect on their teaching and learning. While McGinnis et al.'s work does not explore how these perceptions of teaching connections between math and science may or may not impact teaching practice, the structure of the intervention points to an important aspect of Darling-Hammond and Oakes's five dimensions for teaching for deeper learning noted above: that these dimensions should characterize the learning of both preservice teachers and K-12 students.

Learning Chain of Teaching for Deeper Learning

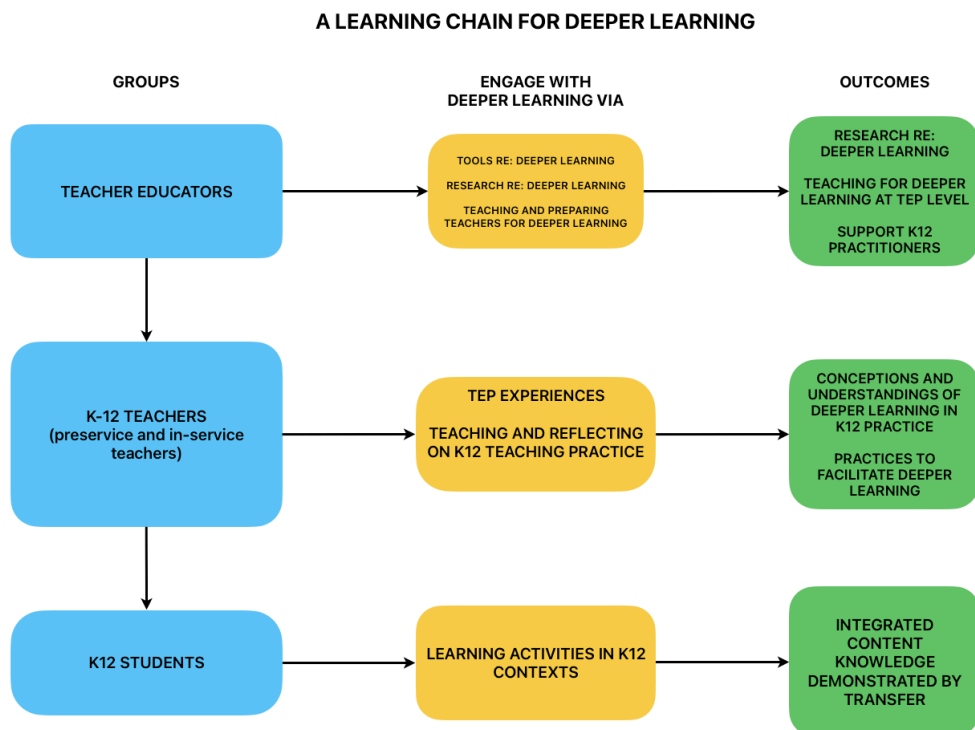
The notion that the five dimensions of teaching for deeper learning characterize learning opportunities provided to both PSTs and K-12 students highlights the fact that teacher educators are working to influence teaching opportunities at both of these levels of education. In fact, this is perhaps the chief aim of teacher education: to adequately prepare future teachers to teach K-12 students. When it comes to communicating regarding deeper learning in teacher education context, this can be confusing, since there are multiple populations which are teachers and multiple populations which are students.

To visualize this, I use a depiction which I call a "learning chain of teaching for deeper learning". This model aims to outline, in broad strokes, how various members engage in the process of deeper learning and how it fits into a larger context of preparing PSTs to teach K-12 students for deeper learning.

At each level of the learning chain, people are engaging in deeper learning for the content which they are learning. For example, I consider the preservice teachers in my study to be learning to teach *through* deeper learning. That is, they are learning to teach by engaging in deeper learning. At the same time, they are learning *about* deeper learning and *about* how to enact these same principles in their own teaching so that future students learn *through* deeper learning. I attempt to illustrate this through the learning chain model. As shown in Figure 1.1, the learning chain has three main groups of participants: K-12 students, K-12 practitioners, and those working within teacher education. Students, positioned at the base of the chain, should be considered the foundation of this learning chain, the ones for whom the entire learning chain aims, or should aim, to serve.

Figure 1.1

A Learning Chain Model of Teaching for Deeper Learning



Briefly, I describe various aspects of the learning chain in order to clarify some of the wide range of actions and interactions that take place within the learning chain. The first population, K-12 students, should be engaging in deeper learning in their coursework, as they progress through school and as they generally learn and grow interpersonally, intrapersonally, and intellectually. For example, students in K-12 classrooms learn to make connections across the content areas. They learn that the slope-intercept form of a linear equation they learned in their math class can be helpful when determining the acceleration of an object as it moves down a ramp in their physics class; they learn that the type of both history and science require claims to be supported by evidence, despite using different sources of evidence.

Moving up the model, K-12 teachers generally engage in deeper learning as it relates to their specific subject areas as well as teaching as a content area of its own (e.g., pedagogical content knowledge, see Shulman, 1986). Physics teachers hopefully will have engaged in deeper learning in their physics coursework and possess an understanding of physics content which is both flexible and integrated. For example, they are likely to view physics problems not so much by the specific visual features present in the problem (e.g., a block on a ramp) but by the underlying physics principles which can be used to solve the given problem (e.g., conservation of energy or dynamics; Chi et al., 1981). Future K-12 physics teachers need to engage in deeper learning not just as it relates to physics, but also as it relates to teaching physics. One way to frame these experiences is outlined by Darling-Hammond and Oakes (2019), specifically in the sense that the five dimensions of deeper learning are meant to characterize learning experiences for *both* K-12 students and future teachers. The learning chain depicts *who* is engaging in deeper learning, *what* they are engaging with, and the corresponding *outcomes*.

Finally, by describing the learning chain in this way, we can visually highlight specific areas for research. For example, consider the first set of research questions, which focuses on

the conceptions and practices of teacher educators as they relate to deeper learning. This set of research questions is situated along the top row of the learning chain. Contrast this with the second set of questions, which focuses on those same concepts and constructs but for preservice teachers. This set of research questions is situated along the middle row of the learning chain.

Overview of This Study

This study focuses on teacher educators' and PSTs' actions and conceptions related to teaching for deeper learning. This study is contained within a larger, mixed methods study funded by the William and Flora Hewlett Foundation and conducted from 2023 to 2025. In the first phase of the study, the SCALE Group (formerly the Stanford Center for Assessment, Learning, and Equity; 2024, see also Appendix A) developed six deeper learning modules (DLMs) for teacher educators to incorporate into their coursework. In the second phase, we researched how teacher educators implemented these modules in their teacher education courses. The goal of these modules is to engage beginning teachers in practices that can help facilitate deeper learning in their future K-12 students. These modules are based in Canvas (a web-based learning management system) and cover various strategies related to teaching for deeper learning that can be integrated into teacher education courses as standalone modules or in combination with others. For example, teacher educators can incorporate the module on “facilitating effective discussions to promote deeper learning and equitable engagement” into their courses. In addition to facilitating discussions, these modules cover other topics such as supporting productive struggle, developing a critical lens, supporting student collaboration, creating responsive learning spaces, and providing equitable and effective feedback. The modules provide examples, activities, discussion prompts, worksheets, and other opportunities for preservice teachers to engage in those topics. Teacher educators can use any of the modules

in part or in whole (in fact, many chose to adopt portions of the modules in order to best fit their course and meet the needs of their students). In the second phase, researchers (including myself) investigated module implementation, understandings of deeper learning and teaching for deeper learning, potential changes to teaching practices related to deeper learning, and how participants engaged in communities of practice related to deeper learning, among a wide range of other research questions. More detail on the modules themselves and how they were implemented by various participating programs is included in the Methods section.

For this dissertation, I ask two sets of research questions focused on two of the populations in this learning chain. The first set focuses on teacher educators, and the second set on preservice teachers.

Teacher Educators

- 1.1 How did teacher educators conceive of deeper learning?
- 1.2 How did teacher educators work to prepare preservice teachers for teaching for deeper learning? How did teacher educators use various deeper learning modules in order to provide preservice teachers with opportunities to learn to teach for deeper learning?
- 1.3 In the findings to the above questions, what differences were present between those who developed modules and those who did not?

Preservice Teachers

- 2.1 How did preservice science and math teachers conceive of deeper learning?
- 2.2 How did preservice teachers describe their teaching practices in relation to, or in the context of, teaching for deeper learning? How did preservice secondary science and math teachers describe their experiences in being prepared to teach for deeper learning?

- 2.3 In the findings to the above questions, what differences were present between those taught by teacher educators who developed modules and those taught by other teacher educators?

This dissertation is structured in the following way. In Chapter 2, I review literature on deeper learning and other related terms and literature which exemplifies various aspects of teaching for deeper learning. In Chapter 3, I describe how this research fits within the larger research project, and I describe the methods used for collecting and analyzing data. In Chapters 4 and 5, I share findings for each of the two question sets, treating each question set separately. Finally, Chapter 6, I discuss the implications of this research, consider relevant limitations, and propose future directions for research.

Chapter 2: Literature Review and Conceptual Framework

This chapter is organized as follows. I first discuss how the literature defines key terms used in this paper. Specifically, I draw distinctions between my conception of deeper learning and the ways that other scholars use the term across the literature. Second, I provide more detail on teaching for deeper learning in both teacher education and K-12 contexts. Finally, I outline the conceptual framework for this study.

Defining Terms: What is Deeper Learning?

As introduced in the previous chapter, the literature on deeper learning uses the term “deeper learning” in multiple ways. In some cases, deeper learning refers to the cognitive processes that take place *inside the brain* during learning which lead to transfer (Mayer, 2011; NRC, 2000, 2012, 2018). In other cases, deeper learning is extended to include the actions that learners engage in to facilitate such cognitive processes (in these cases, “generative learning” is the more common term) (Mayer, 2011, 2014; Wittrock, 1974, 1989). In still other cases, deeper learning includes those cognitive processes *and also* includes the activities and behaviors which learners do while engaging in deeper learning in educational settings (Darling-Hammond & Oakes, 2019). Further complicating this, the term deeper learning has also been used to refer to learning *outcomes* as opposed to learning processes, often citing cognitive-based outcomes such as well-organized schema in addition to transfer of learning (Fries et al., 2021). Finally, deeper learning has been used to refer to a set of competencies which learners develop over time which prepare them for 21st century life and work (Hewlett Foundation, 2013).

In the following few subsections, I consider how various scholars view deeper learning and other, related concepts in an effort to draw clearer distinctions among competing uses of “deeper learning,” while also situating those definitions within the larger body of literature related to deeper learning.

Deeper Learning as a Process (Internal)

First, I consider the conception of deeper learning which focuses on internal, cognitive processes, for which I use the term *deeper cognitive processing*. In this understanding, deeper learning is defined as a process through which an individual becomes capable of taking what was learned in one situation and applying it to new situations (i.e., transfer) (Mayer, 2011; NRC, 2012, 2018).

This process involves several subprocesses. The Committee on How People Learn II noted that “learners put together different sorts of information and experiences, identifying and establishing relationships and expanding frameworks for connecting them” (NRC, 2018, p. 86). They went further to identify three critical aspects of this process: “accumulating information (in part by noticing what matters in a situation and is therefore worth attending to); tagging this information as relevant or not; and integrating it across separate episodes” (NRC, 2018, p. 93). These three aspects align directly with Mayer’s select-organize-integrate (SOI) model and Wittrock’s model of generative learning (Mayer, 2011, 2014; Wittrock, 1974, 1989). These two models state that learners select or direct their attention to the most relevant incoming information, organize information into coherent mental representations and build connections between different elements, and integrate new knowledge with existing knowledge, schemas, or principles. In these models, what the NRC referred to as deeper learning is often referred to as generative learning (Note that while “deeper learning” is generally the preferred term in education [see Darling-Hammond & Oakes, 2019; Mehta & Fine, 2019; NRC, 2012, 2018], “generative learning” tends to be used more in the cognitive sciences [Fiorella & Mayer, 2016; Lawson & Mayer, 2021]). Mayer (2011) further described that deeper cognitive processing requires developing and connecting five different types of knowledge: facts, concepts, procedures, strategies, and beliefs about one’s own learning. This highlights the various kinds of information that learners are attending to during this process.

Deeper Learning as a Processes (External)

At this point, especially for learners in most K-12 and teacher education contexts, I note that this process of integrating different types of disciplinary knowledge occurs in classrooms. For most classroom learners, the cognitive process of selecting, organizing, and integrating different types of knowledge is facilitated by an instructor, whether through various instructional strategies or learning activities. These strategies or activities include group discussions (Cherbow & McNeill, 2022), notetaking (Boyle, 2013; Kiewra, 1985), inquiry-based activities (Butcher et al., 2023), and more (see NRC, 2018, chapter 7). Accordingly, some scholars describe *deeper learning* as the visible process of engaging in these various classroom-based activities (Darling-Hammond & Oakes, 2019). By engaging in deeper learning in a classroom, the learner is also engaging in the types of cognitive processing described in the section above.

Deeper Learning as Outcomes

Other scholars focus on deeper learning as a means to specific outcomes without explicitly defining whether deeper learning is something that is going on externally or in the brain. First, I draw on what Fries et al. referred to as “deep understanding” (2021). Similar to notions of deeper learning which focus on the cognitive processes, according to Fries et al. (2021), key evidence of deep understanding is transfer. In addition to transfer, deep understanding is characterized by well-organized and highly interconnected schemas (Biliac & Campitelli, 2018; Carbonell et al., 2014). So, for these authors, deep understanding is an internal state (well-organized mental schemas) which is characterized by an external outcome (transfer).

In other words, we can say the types of cognitive processing associated with deeper learning lead to *both* transfer and deep understanding, where transfer is an external, demonstrable outcome and deep understanding is an internal, cognitive one. It seems that Fries et al. (2021) agreed with this, as they “equate[d] deep understanding with the transferable knowledge of

adaptive expertise” and further characterized deep understanding as “the ability to make explicit the underlying structure of a domain, its connections and relations in the form of coherent mental schemas” (Chi et al., 1981; Fries et al., 2021, p. 743).

Deeper Learning in Terms of Competencies

Finally, I want to consider the Hewlett Foundation’s understanding of deeper learning, namely that deeper learning is “an umbrella term for the skills and knowledge that students must possess to succeed in 21st century jobs and civic life” (2013). Under this umbrella, the Hewlett Foundation identifies six core competencies which learners should engage in: (1) master core academic content, (2) think critically and solve complex problems, (3) work collaboratively, (4) communicate effectively, (5) learn how to learn, and (6) develop academic mindsets. These core competencies are written with K-12 students in mind, and each of the six core competencies has a number of corresponding aspects which outline what students should be able to do. For example, “students communicate complex concepts to others in both written and oral presentations” is one component of the deeper learning competency to *think critically and solve complex problems* (for more detail on the six competencies see “Deeper Learning Competencies”, Hewlett Foundation, 2013).

Here, I note that despite positioning the deeper learning competencies as things in which students engage, many of the underlying aspects of the competencies are outcome-oriented (e.g., “students understand key principles and relationships in a content area and organize information in a conceptual framework”). On one hand, some of these aspects align directly with the outcomes of deeper cognitive processing outlined above (e.g., understanding key principles). On the other hand, some of these aspects are geared more specifically towards preparing students to be high achievers in the working world beyond school, rather than facilitating deeper learning or deeper cognitive processing (e.g., “students communicate complex

concepts to others in both written and oral presentations”). While these sorts of skills are important for engaging in today’s world, including them in a framework for deeper learning blurs the lines around what deeper learning is. This ultimately creates confusion around how we teach for deeper learning both at the teacher education level and the K-12 level. Briefly, to clarify, communicating complex ideas to others (i.e., teaching) is one way for learners to engage in deeper learning (see Fiorella & Mayer, 2015), and it may be a good indicator that a learner is developing a deep understanding of some topic (see Fries et al., 2021), but it is not itself deeper learning.

Defining Terms

The different conceptions of deeper learning I have discussed so far are each useful. Yet, referring to all of them as “deeper learning” creates confusion. For clarity, I use the following terms in the following ways in my dissertation:

- *Deeper learning*: refers to learning processes and behaviors which learners actively engage in that can provide opportunities for learners to actively engage in *deeper cognitive processing*.
- *Deeper cognitive processing*: refers to processes happening inside the learner’s brain while engaging in deeper learning behaviors.
- *Deeper learning outcomes*: refers to various outcomes of engaging in deeper learning, which include things such as transfer of knowledge and *deep understanding*.
- *Deep understanding*: an internal, cognitive state which is evidenced by “the ability to make explicit the underlying structure of a domain, its connections and relations in the form of coherent mental schemas” (Fries et al., 2021, p. 743).

From Deeper Learning to Teaching for Deeper Learning

The Hewlett Foundation’s deeper learning competencies do not clearly define deeper learning, but they do help us to move from deeper learning to *teaching for deeper learning*. And they

can help us connect deeper cognitive processing with deeper learning and, subsequently, with teaching actions that facilitate deeper learning (i.e., teaching for deeper learning). For example, the second Hewlett deeper learning competency is that students will *think critically and solve complex problems*. However, saying “students should think critically and solve complex problems” does not provide actionable guidance for teachers. The various components within each of the six deeper learning competencies, on the other hand, start to move us in that direction. As noted previously, one of the components of *think critically and solve complex problems* is “students evaluate, integrate, and critically analyze multiple sources of information”. For teachers, I believe this component is more actionable, as they can actively provide students with multiple sources of information which they can use in evaluating, integrating, and critically analyzing. If teachers can provide that sort of learning opportunity, students may be able to “put together different sorts of information and experiences, [identify] and [establish] relationships and [expand] frameworks for connecting them” (NRC, 2018, p. 86). Further, students will have the opportunity to engage in the cognitive process associated with the process of deeper learning: “accumulating information (in part by noticing what matters in a situation and is therefore worth attending to); tagging this information as relevant or not; and integrating it across separate episodes” (NRC, 2018, p. 93).

Conceptions of deeper learning such as the Hewlett Foundation’s deeper learning competencies (2013), while not explicitly oriented around the notion of deeper learning as a process that leads to transfer, can be helpful for clarifying what the process of deeper learning *looks like* in a classroom and how we can consider questions of teaching for deeper learning.

Five Dimensions of Teaching for Deeper Learning

For the purposes of this study, there are two shortcomings in adopting the Hewlett Foundation’s Deeper Learning Competencies as a guide for describing *teaching for* deeper

learning. First, as noted previously, the competencies do not clearly define deeper learning. Second, and perhaps more critically, they are written primarily with K-12 learners in mind. In contrast, Darling-Hammond and Oakes outlined five dimensions of teaching for deeper learning which are explicitly meant to characterize learning in *both* K-12 and teacher education contexts. As such, in this study, I adopt Darling-Hammond and Oakes's (2019) five dimensions of teaching for deeper learning.

Again, these five dimensions can be understood to characterize *both* the learning opportunities afforded to K-12 students and the learning opportunities afforded to beginning teachers. These five dimensions are: (1) learning that is developmentally grounded and personalized, (2) learning that is contextualized, (3) learning that is applied and transferred, (4) learning that occurs in productive communities of practice, and (5) learning that is equitable and oriented to social justice. These five dimensions came out of their intensive study of seven exemplary teacher education programs, chosen for their work and reputation in teacher education. Darling-Hammond and Oakes used a wide range of data (e.g., interviews, observations, course catalogs, and artifacts) to develop detailed case study reports of these programs. From these case studies, they identified five dimensions of teaching for deeper learning that these programs taught the K-12 teachers that graduated from these programs. Thus, the first part of their work was empirically deriving these five dimensions of teaching for deeper learning. Darling-Hammond and Oakes then went on to demonstrate how these five dimensions of teaching for deeper learning could be a valuable framework for both teacher education and K-12 contexts (for more detail, see the discussion in their chapter "Organizing the Knowledge Base", pp. 53-98), reinforcing the potential value of these five dimensions for both teacher educators and beginning K-12 teachers.

I consider Darling-Hammond and Oakes's dimensions of teaching for deeper learning as including my definition of deeper learning outlined above (as a process which leads to transfer), but they build upon it to include the larger contexts in which schooling takes place (at both the K-12 and teacher education levels). Consider, for example, that Fries et al. (2021) proposed a framework for guiding instruction which emphasizes making connections between concepts within a given domain. Making such connections is one example of engaging in deeper learning. Fries et al. offered three different types of connections to be made: contexts and practices of the world, core concepts that organize the domain, and key representations for thinking and communicating. They also offered three ways for instructors to support students in practicing making connections: by making connections explicit, by engaging students in productive struggle, and by providing opportunities for deliberate practice. These general approaches for engaging students in deeper learning align with what Darling-Hammond and Oakes referred to as engaging students in learning that is contextualized and in learning that is applied and transferred. Teaching for deeper learning as described by Darling-Hammond and Oakes might look similar to how it is described by Fries et al., but such learning opportunities will also extend to include aspects of learning and learning environments that go beyond the cognitive components of deeper learning (e.g., learning that is equitable and oriented to social justice).

These five dimensions describe critical aspects of learning which engage learners in the process of deeper learning. Again, Darling-Hammond and Oakes clarified that these are dimensions of learning which should mark the learning opportunities provided to K-12 students *as well as* the learning opportunities provided to preservice teachers. In other words, in order for PSTs to engage their K-12 students in these types of learning opportunities, they need to engage in the same types of learning in their teacher education experiences.

I organized the next part of my literature review around these five dimensions of teaching for deeper learning for three reasons. First, this dissertation asks questions about teaching for deeper learning in both teacher education and K-12 contexts. One of the key features of this framework is that these dimensions of teaching for deeper learning describe the learning opportunities provided to both beginning teachers and K-12 students. Second, these dimensions of teaching for deeper learning influenced the development of the deeper learning modules which were implemented by teacher educators in this study. And third, in searching for research related to deeper learning and teaching for deeper learning, I found that, while there is literature which fits into each of these five dimensions (and research which fits into more than one dimension at one time), I have found no research which is deliberately oriented around these five dimensions (except, of course, Darling-Hammond and Oakes's work). By organizing the literature review around these dimensions, I attempt to take literature which speaks to specific dimensions of teaching for deeper learning and draw it into a larger guiding framework of teaching for deeper learning. As a caveat, the articles discussed below are not exhaustive of the types of teaching strategies that can exemplify any given dimension but are meant to highlight some of the work that has been done which falls into each dimension.

In each of the following subsections, I first include a brief quote from Darling-Hammond and Oakes (2019) that describes the learning characterized by that dimension. Then, I discuss literature which exemplifies *teaching for deeper learning* in the contexts of teacher education and K-12 science and/or math education as it relates to that dimension. Where relevant, I also note how articles relate to other dimensions.

Dimension One: Learning That Is Developmentally Grounded and Personalized

Learning experiences that are developmentally grounded and personalized build on prior knowledge and experience, and account for learners' active construction of new

knowledge. Learning connects to who students are as well as to what they already know, attending to both cognitive and socioemotional realms, and school tasks are designed to be scaffolded according to students' needs, intrinsically interesting based on their experiences, and appropriate to their level of development. (Darling-Hammond & Oakes, 2019, p. 13)

Scholars have looked at multiple ways of providing learning opportunities that are developmentally grounded and personalized. These include, but are not limited to, providing opportunities for self-reflection as a part of the learning sequence (Aina & Aina, 2023; Kleinknecht & Gröscher, 2016), considering the relevance of learners' emotions during learning experiences (Davidson et al., 2020; Hernández-Barco et al., 2021; Pierson et al., 2022), and the use of modeling activities with learners from kindergarten through to preservice teachers (Carpenter et al., 2018; Carroll & Park, 2024; Malone, 2023; Son et al., 2021; Zangori et al., 2020). Each of these instructional strategies explicitly build on prior knowledge and facilitate learners' active construction of new knowledge or attend to socioemotional development along with cognitive development.

Self-Reflection During Learning.

In providing developmentally grounded and personalized educational opportunities for prospective teachers, some teacher education programs have used instructional strategies such as classroom cases, video-based self-reflections and feedback, and multimedia-based learning experiences grounded in principles of multimedia learning (see discussion in Aina & Aina, 2023, pp. 972-3; Mayer, 2009). For example, Kleinknecht and Gröscher (2016) engaged preservice teachers in video-based self-reflections and feedback as a part of their teacher education program. Preservice teachers who used videos for reflections and feedback showed deeper reflections on positive and negative evaluations compared with those who did not use videos of

teaching for reflections and feedback. Aina and Aina (2023) argued that these video-based reflections rely on PSTs engaging in various cognitive processes centered around their own teaching experiences. These experiences require learners to engage in the process of deeper learning by noticing relevant details and interpreting or responding to them based on prior knowledge, which include aspects of teaching that preservice teachers are trying to learn or develop expertise in (e.g., classroom management, curriculum portrayal, etc.).

Attending to Socioemotional Needs.

As noted above, learning which is personalized also entails attending to socioemotional realms. Responding to calls to engage students (and teachers) in the actions of scientists, Davidson et al. (2020) explored teachers' "epistemic affect". Essentially, epistemic affect refers to the emotions which learners experience during learning episodes, in this case a 6-week research experience for teachers. They argued that enabling teachers to feel and navigate their emotions while "doing science" serves a critical role in equipping them to better meet the needs of their students who also experience a range of emotions while doing science. At the K-12 level, Pierson et al. (2022) explored how one case study teacher attended to the emotions of sixth grade students during a 9-week unit on guppies, their survival needs, and ecosystems. They found that by attending to students' emotions, it created new opportunities for science learning, increased student engagement during the unit, and even influenced the direction of student investigations.

Modeling.

Modeling is one example of learning opportunities which can be adjusted to meet the developmental needs of learners at various stages in their education. For example, Zangori et al. (2020) explored how model-based reasoning supports 3rd-grade students' understanding of causal interactions in ecosystems. Both the topic under study (Monarch butterfly populations) and the models used during the unit were developmentally appropriate for the students

participating in the study. They found that students who explicitly engaged in model-based reasoning during the unit tended to express causal reasoning that became more complex, demonstrating both a deeper understanding of the content relevant to Monarch butterfly populations and of the mechanisms surrounding the changes in those populations. In a larger review on modeling instruction in K-12 STEM contexts, Carroll and Park (2024) explored how modeling practices have shifted towards considering not just scientific “correctness” but also meaningfulness, multidimensionality (i.e., using multiple “dimensions” of modeling such as conceptual, social, and epistemic), and equity. Modeling is just one of many instructional practices in K-12 STEM contexts which can facilitate opportunities for deeper learning, but I include Carroll and Park’s review here to highlight the fact that by attending to other aspects, such as equity, K-12 educators are already working to create learning opportunities that are both developmentally grounded and personalized and oriented to social justice.

Dimension Two: Learning That Is Contextualized

Learning experiences that are contextualized recognize that people develop as they use the tools and symbols of their cultural contexts to make sense of the world and their experiences in it. Learning builds on students’ personal, cultural, and linguistic knowledge, and is embedded in meaningful contexts and applications. Learning is connected to students’ experiences and is based on a deep understanding of these contexts for development as well as ongoing communication and connection with parents, caregivers, communities, and the world beyond school. (Darling-Hammond & Oakes, 2019, p. 13)

The notion of contextualizing learning and drawing on learners’ assets as a key aspect of education and teacher education is not new (Lave & Wenger, 1991; Moll, 1992; Putnam & Borko, 2000). Researchers have considered multiple ways to contextualize learning in both

teacher education and K-12 science and math contexts, including literally situating learning in a specific context (Allen & Heredia, 2021; McDonald et al., 2020), engaging students in local science issues (Morales-Doyle, 2017), deliberately incorporating student interests (Penuel et al., 2022), and drawing on students' funds of knowledge and linguistic resources (Moll, 1992; Tolbert & Knox, 2016).

First, I discuss literature in which researchers and practitioners have contextualized learning in teacher education, followed by literature focused on contextualized science and math learning.

Allen and Heredia (2021) explored contextualizing science teacher education within both teachers' local context and the overall context of reform-based science education in the United States. For example, teachers may be excited about implementing reform-based science teaching in their classroom while also experiencing external barriers to implementing those frameworks for teaching. These external barriers could include the same contexts described above such as schools, districts, or communities. To equip science teachers to work successfully in these contexts, the authors suggested providing sensemaking opportunities surrounding the organizational contexts in which teachers work. This entails asking questions around topics like assessment, curriculum implementation, standards, and the structure and dynamics of the organization itself.

However, it may not always be feasible to directly embed teacher education into the local context in this way. Levin (2024) explored in-person simulations of different teacher interactions (teacher-student, teacher-parent, teacher-principal) as a context for deep learning in teacher education. They considered how simulation-based learning could influence deep learning in three specific dimensions of teacher learning: the cognitive, interpersonal, and intrapersonal. In general, they found that simulation-based learning opportunities have the potential to impact

(both positively and negatively) deep learning in these three domains. In terms of positive impacts, they found that simulation-based learning in teacher education has the potential to provide teachers with opportunities to engage in constructing new knowledge and critical thinking. However, they also found that acting in a simulation brings about its own anxieties, since teachers are acting as teachers, students, or principals, and they noted that this could inhibit participants' willingness to fully engage in the simulation.

As noted above, contextualizing learning also means connecting learning to the learners' personal, cultural, and linguistic knowledge. Here I briefly touch on two examples of this type of contextualized learning. First, Penuel et al. (2022) explored how project-based storylines served as a vehicle for deliberately incorporating student interests and questions into science learning (storylines refer to instructional approaches which emphasize how different lessons fit together). Researchers collaborated with science teachers to develop and implement a lesson sequence rooted in an anchoring phenomenon (declining antibiotic effectiveness) which was influenced by student interests in "superbugs" (antibiotic-resistant pathogens). In addition to rooting the lesson sequence in the fact that these students were interested in superbugs, the teachers and researchers also encouraged students to routinely ask and record questions so that they could connect what they learned along the storyline back to those questions. Second, Tolbert and Knox (2016) explored how preservice science teachers contextualize science learning in multilingual classrooms and how different groups of preservice science teachers viewed learners' science funds of knowledge. They found that preservice teachers who were seeking bilingual certification (as compared to those seeking traditional certification) tended to view students with a more asset-based orientation, considering their language, culture, families, and communities as producers of science knowledge, whereas preservice teachers seeking traditional certification

tended to view science knowledge as coming more directly from the science classroom with less emphasis on knowledge that comes from students' experiences, families, or communities.

Dimension Three: Learning That Is Applied and Transferred

Learning experiences that are applied and transferred enable students to apply and transfer content knowledge to novel and complex problem, with abstract and theoretical ideas tightly connected to real-world problems and settings through challenging, authentic activities that promote mastery learning and critical thinking. Clear standards and performance feedback, including the use of both formative and summative performance-based assessments, promote complex cognitive development. (Darling-Hammond & Oakes, 2019, p. 14)

Scholars have explored how learning can be applied and transferred through a variety of specific learning strategies (Fiorella & Mayer, 2016) such as guided or strategic notetaking (Boyle, 2013; Reed et al., 2016), writing explanations (Lawson & Mayer, 2019; Wang et al., 2023); sketching and verbalized self-explanations (Miller-Cotto et al., 2022). Scholars have also explored how more general approaches for guiding instruction can facilitate opportunities for learners to engage with challenging, authentic activities while also connecting their work to real-world problems (King et al., 2007; Son et al., 2021). Some researchers have also worked to situate learning within storylines or “big ideas” (Cherbow & McNeill, 2022; Shemwell et al., 2023), which provides students with opportunities to develop highly integrated schema. Below, I focus on some examples in teacher education before moving to some examples in K-12 science and math education.

This third dimension also relates to previous discussion about deeper learning leading to transfer of learning. In a teacher education context, facilitating transfer might look like embedding a science methods course within a local school context as we saw in McDonald et al.

(2020) above. It could also mean providing PSTs with opportunities to work directly with various stakeholders in local communities through rich partnerships (Thompson & Larkin, 2020). Transfer (for preservice teachers) might look like taking what was learned in a science methods course and applying it in placements and vice versa (McDonald et al., 2020). On the other hand, it might look more iterative in scope as in Thompson and Larkin (2020), in which teachers (both preservice and in-service) and researchers worked iteratively in ways that, over time, bolstered subject-specific pedagogical knowledge as well as the implementation of those pedagogies.

Interestingly, these studies were not explicitly focused on facilitating transfer. Rather, they were focused on situating teacher education experiences directly within a local education context. Nonetheless, they serve as strong examples of approaches to teacher education which can facilitate transfer. In contrast, Orrill and Kittleson (2014) discussed a professional development experience which unsuccessfully promoted transfer among participating math teachers. Specifically, they found that a professional development experience focused on mirroring the instructor's practice (termed "look-at-my-practice," citing Adler & Davis, 2011) did little to bolster math teachers' conceptual understanding of relevant content, nor did it improve the ways in which teachers engaged their students in that content. By considering this example, it reinforces the notion that teacher education programs can support PSTs by providing educational opportunities which engage PSTs in cognitive processes that lead to deeper learning. In other words, teacher education opportunities need to go significantly beyond "look-at-my-practice" type learning, and engage PSTs in cognitive processes such as selecting, organizing, and integrating, in order to facilitate transfer.

Considering K-12 learners, in a study about incorporating writing into non-English classes, Carter and Townsend (2022) offered an example of providing opportunities for K-12

students to engage in learning that is applied and transferred. The science teacher in the study described how by integrating daily writing throughout the quarter, students showed increased biology knowledge, better content comprehension, and “engaged in thoroughly analyzing concepts and processes and making connections between them” (p. 343). Interestingly, the goals specified by this teacher were not necessarily for students to engage in specific cognitive processes or even to engage in deeper learning, but rather to “increase the amount of writing students do regularly and increasing the depth of their writing” (p. 338). This involved students applying what they had learned in various projects through writing and images and having students apply content knowledge to unfamiliar situations through writing. Applying content knowledge was just one of a number of desired educational outcomes. Ottmar (2019) demonstrated the value of specific types of learning opportunities in improving critical thinking within and across subject areas. Ottmar found that providing students with cognitive and interpersonal opportunities as a part of their learning led to growth in critical thinking in math, science, and reading. Interestingly, cognitive opportunities alone did not seem to directly improve academic outcomes, but rather indirectly did so through interpersonal opportunities (e.g., via collaboration).

Some researchers also focus on structuring learning around “big ideas” (Shemwell et al., 2023). Shemwell et al. explored the use of “big ideas” in science instruction, with the goal of trying to teach 9th-grade biology students about glycolysis. Drawing from *How People Learn* (NRC, 2000), they describe how big ideas should express both relationships and facts (recall the importance of instruction which can make clear the underlying structure of the domain [Fries et al., 2021]). They randomly assigned students into two instructional conditions, with one group receiving instruction utilizing energy transfer structures as an underlying big idea. Further, they sought to identify how utilizing integrative analysis—where students use a big idea to

“interconnect isolated scenarios and enrich their meanings” (Shemwell et al., 2023, p. 510)—as an instructional concept could support and enhance student learning of glycolysis compared to more traditional memorization strategies used to teach glycolysis. They found that students who were a part of the integrative analysis group performed better on a posttest, which supports the value of utilizing big ideas as a means of contextualizing learning within the domain.

Finally, I consider an example which uses storyline-based instruction and discussions to contextualize both student and teacher learning. Cherbow and McNeill (2022) explored how one science teacher engaged in curricular sensemaking (i.e., making sense of teaching a given topic to a given group of students) while his students engaged in scientific sensemaking (regarding magnets and forces at a distance). At the teacher level, the authors contextualized sensemaking within a discussion planning cycle (a team-based method for planning in-class discussions); at the K-12 student level, the authors contextualized sensemaking within the forces at a distance unit. Cherbow and McNeill highlighted that, despite the fact that the teacher and students were engaging in different types of sensemaking, the teacher’s curricular sensemaking directly incorporated their students’ sensemaking and influenced their teaching actions as the unit progressed. This example also highlights one parallel way in which both K-12 teachers and students engage in deeper learning within their respective contexts and by considering different “content”. Further, it causes us to consider how K-12 students engaging in the process of deeper learning can influence how their teachers engage in deeper learning and vice versa, regardless of the context.

Dimension Four: Learning That Occurs in Productive Communities

Learning that occurs in productive communities is an active, interactive, constructive, and iterative process. Well-designed and well-tended social interactions allow students to support or scaffold one another’s learning, combining their different knowledge and

experiences into the collective knowledge and experience of the learning community, and helping students to move from peripheral to core participation in subject-matter learning connected to real-world activities. School and classroom communities are built on an ethic of caring, offering supports for social/emotional development, trusting relationships, and restorative practices to create suitable environments for student learning. (Darling-Hammond & Oakes, 2019, p. 14)

In short, learning experiences that facilitate deeper learning should occur in rich learning communities. Researchers have explored such communities which are centered in schools and classrooms (Reiser et al., 2021; Ríordáin et al., 2015; Sølvik & Glenna, 2022) as well as communities which are established as partnerships between different schools, universities, and organizations (Rayner & Corkill, 2015; Ríordáin et al., 2015; Morales-Doyle, 2017; Varelas et al., 2017).

First considering teacher education contexts, Rayner and Corkill (2015) found positive impacts from a research-practice partnership between a secondary science school and a research university. Rayner and Corkill envisioned and described a partnership which extended beyond the common goal of supporting preservice teachers. They situated teacher education within the context of the partnership, which had aims in teacher education, supporting and improving K-12 education, and in conducting research. When teaching and learning is situated in a context which heavily emphasizes the interactive nature of the university-school partnership, it can produce deeper learning experiences for all members of the partnership, from K-12 learners to preservice teachers to university researchers.

Ríordáin et al. (2015) focused their study on teachers who worked to integrate science and math teaching in their classrooms. They explored how these teachers implemented such learning opportunities in their classrooms and how they collaborated with other teachers in the

study. Not only were the teaching practices aligned with facilitating deeper learning (e.g., teaching for understanding and providing students with opportunities to apply and transfer that knowledge), but they demonstrated the benefit of providing teachers with opportunities to engage in communities of practice.

Considering K-12 contexts, productive communities can look like those which use students' sensemaking processes in whole-class settings (Chen & Techawitthayachinda, 2021; Sølvik & Glenna, 2022), support students' epistemic agency (Reiser et al., 2021), or use local issues to teach scientific concepts and skills (Morales-Doyle, 2017, discussed in more detail in the following subsection). Briefly, I consider two of these articles focused on epistemic uncertainty and epistemic agency in using storyline units for K-12 science contexts (Reiser et al., 2021; Chen & Techawitthayachinda, 2021). While both of these studies could also be considered examples of learning that is developmentally grounded and personalized, the focus on epistemic uncertainty and epistemic agency positions students as collaborators in addressing a problem or misunderstanding that is particularly interesting to them. Chen and Techawitthayachinda's (2021) study was designed in collaboration with grades 3 through 8 science teachers, and they developed storyline talks which teachers would use to help manage "epistemic uncertainty" in their classrooms (epistemic uncertainty refers to "students' subjective awareness of their incomplete abilities to explain a phenomenon). Reiser et al. (2021) also used storyline units, but with a focus on supporting coherence from the students' perspective. While the precise focus of these studies varies slightly, they share a few key similarities: student questions and interests are highly regarded in the classroom, students are routinely given opportunities to ask and answer questions posed by their classmates, and students are encouraged to collaborate with others to critique and hone one another's thinking and reasoning. Further, both articles highlight the importance of a community of practice as an integral part of successful science learning, arguing

that as students engage productively in a community of practice the classroom community benefits, which then enables and encourages students to continue to engage productively in that classroom community.

Dimension Five: Learning That Is Equitable and Oriented to Social Justice

Learning experiences that are equitable and oriented to social justice are designed to meet diverse students' needs, to reach all students, and to teach them well. All students have access to rich, supportive curriculum experiences that acknowledge and incorporate their social locations and "status" in the larger society, and that are constructed with an awareness of race, class, gender, and other social characteristics that shape student experience. Teachers consider students' unique identities as strengths and resources; they link social justice values to principles of learning and development by working explicitly to ensure that all students are supported, taking a critical stance, and avoiding deficit thinking. (Darling-Hammond & Oakes, 2019, p. 14)

Learning opportunities that are equitable and oriented to social justice can look like promoting equitable education within a local community (see examples from Darling-Hammond & Oakes, 2019, described below), highlighting local subject-specific social justice issues (Morales-Doyle, 2017), positioning students and teachers as transformative agents within their schools or classrooms (Patterson & Gray, 2019), and providing alternative frameworks and approaches by which educators can teach (Boveda & Weinberg, 2020; Murray et al., 2020; Tolbert et al., 2022).

In teacher education, Darling-Hammond and Oakes (2019) described a number of different ways through which programs prepare teachers to teach at the intersection of deeper learning, equity, and social justice. They highlighted the following: explicit commitment to equity and deeper learning, intentional candidate recruitment, coursework linking education and social

inequality, field experiences in settings struggling with the burdens of inequality, deeper learning about identity and social location, and equitable teaching across differences. For example, Darling-Hammond and Oakes (2019) highlighted that the San Francisco Teacher Residency Program was explicit in preparing teachers “who seek to promote equitable education in the city of San Francisco” (p. 272). Alternatively, they also highlighted High Tech High’s internship program which linked coursework about pedagogical practices to the social and cultural realities of that community.

Also in teacher education (although more focused on in-service teachers), Boveda and Weinberg (2020) outlined their protocol for Intersectionally Conscious Collaboration for physics educators, with the goal of providing a tool for physics educators “who seek to disrupt the long-standing inequities in their field” (p. 480). The protocol is one potential tool that faculty can use in collaborating within physics education, specifically pertaining to centering student identities within physics education.

In K-12 science education, teaching for deeper learning by cultivating productive communities (dimension 3) can also highlight the value of orienting instruction towards equity and social justice. In K-12 science education, this can look like using science as a transformative agent among minoritized student groups (Patterson & Gray, 2019), orienting instruction around queer or feminist pedagogies to teach science for social justice in K-12 settings (Murray et al., 2020; Tolbert et al., 2022), or positioning students as change agents within their local and school communities (Morales-Doyle, 2017).

Focusing briefly on Morales-Doyle’s work, he used “justice-centered science pedagogy” to position students as “transformative intellectuals”. By focusing on social justice science issues, the students in this study were challenged to engage with both specific science content and impacts and potential applications within their community and other communities. For example,

one participating student opted to work on a soil project after school “because he wondered whether the coal power plant was to blame for his asthma” (p. 1044). Like other examples of science educators engaging K-12 students in opportunities for deeper learning, Morales-Doyle’s work did not exclusively demonstrate one dimension of teaching for deeper learning. This approach to leveraging localized environmental issues to engage students in deeper learning in science also demonstrates opportunities for learning that are developmentally grounded and personalized, contextualized, and occur in productive communities.

Gaps in the Literature: Conceptions of Deeper Learning and Teaching for Deeper Learning

Darling-Hammond and Oakes (2019) noted that deeper learning “is not a new type of learning” (p. 6). Rather, it is part of a larger conversation about what constitutes *good teaching* and the type of learning that good teaching facilitates. My intent for the structure of this literature review was, in part, to highlight this conversation and the connections between good teaching and its potential learning outcomes. The other part of my intent for the structure of this literature review was to demonstrate how deeper learning might serve as a potential framework for how we talk about what constitutes *good teaching* and the type of learning it facilitates.

Despite the array of research on teaching practices that facilitate deeper learning, there is a lack of research which asks questions about how teachers themselves conceive of deeper learning. Very few researchers ask teacher educators or preservice teachers about what they think of deeper learning, or to describe how they implement deeper learning in their classrooms. Indeed, I found only one case in which researchers asked teachers for their perceptions of deeper learning and teaching for deeper learning, which was done through a quantitative survey-based study of only nine English teachers in Indonesia (Wahyuni & Noor, 2025). They found

that the teachers in this study generally understood deeper learning in the same way that the study outlines it: Their teaching practices for deeper learning were somewhat limited.

While this dissertation does ask questions related to how teachers facilitate opportunities for deeper learning, it is distinct from any of the above studies in that it asks both teacher educators and preservice science and math teachers to describe how *they* conceive of deeper learning. This dissertation study asks participants for their conceptions of deeper learning in terms of how they think of deeper learning and how they would define deeper learning, as opposed to evaluating their understanding of deeper learning relative to a given framework (Wahyuni & Noor, 2025).

Further, both this dissertation study and the larger study which it comes from are based around the development and implementation of open-sourced modules designed to support teacher educators in providing preservice teachers with opportunities to develop their capacity to teach for deeper learning in K-12 classrooms. Research on this sort of resource is also new.

In summary, this dissertation research aims to fill a gap in the literature by asking both teacher educators and preservice science and math teachers what they think of deeper learning and to describe how they implement deeper learning in their respective contexts. It also serves as new research on resources designed for supporting teaching for deeper learning.

Conceptual Framework

My conceptual framework for this dissertation includes two components. The first component is conceptions of deeper learning based on the literature reviewed above. This part of my conceptual framework includes the various conceptions of deeper learning outlined in the literature described above. These include conceptions of deeper learning as both an internal and external process, outcomes of engaging in deeper learning, and deeper learning as a state which includes deep understanding. This first component directly informs aspects of the analytical

method, which is discussed in detail in the following chapter. In short, the initial coding scheme for conceptions of deeper learning are derived from this aspect of my conceptual framework.

The second component of my conceptual framework is rooted in research on mental models (also often called schemas) for teaching (Greca & Moreira, 2000; Jones et al., 2011; Leinhardt & Greeno, 1986, Schoenfeld, 2000). I consider that the teacher educators and preservice teachers in this study have, and are actively developing, various mental models for teaching for deeper learning, and I am interpreting my data from this assumption.

Chapter 3: Methods

In this chapter I discuss the methods used in designing and implementing this study. First, I describe how this study fits into a larger study. Second, I describe how participants were recruited, the set of deeper learning modules used by teacher educators in the project, the data collection methods, and the data that was collected. Finally, I describe the analytical methods used.

In this qualitative interview study (Kvale & Brinkmann, 2016), I asked two sets of research questions in this dissertation. The first set focuses on teacher educators, and the second set on preservice teachers.

Teacher Educators

- 1.1 How did teacher educators conceive of deeper learning? How did teacher educators work to prepare preservice teachers for teaching for deeper learning?
- 1.2 How did teacher educators use various deeper learning modules in order to provide preservice teachers with opportunities to learn to teach for deeper learning?
- 1.3 In the findings to the above questions, what differences were present between those who developed modules and those who did not?

Preservice Teachers

- 2.1 How did preservice science and math teachers conceive of deeper learning? How did preservice teachers describe their teaching practices in relation to, or in the context of, teaching for deeper learning?
- 2.2 How did preservice secondary science and math teachers describe their experiences in being prepared to teach for deeper learning?

- 2.3 In the findings to the above questions, what differences were present between those taught by teacher educators who developed modules and those taught by other teacher educators?

Context and Participants

This study took place within a larger study conducted from Fall 2023 to Spring 2025. The larger study included participants from across the United States from 10 participating teacher education programs. Participants in the larger study included both teacher educators and preservice teachers. The data used in this dissertation were a subset of the overall data set. Specifically, I used interview data from all the participating teacher educators, while only drawing on interview and focus group data from preservice science and math teachers. A more detailed overview of the data used in this dissertation is provided later in this chapter. First, I outline some relevant details of the teacher education programs before moving to information on the teacher educators and preservice teachers involved in this dissertation study.

Some of teacher education programs in this study primarily served undergraduate preservice teachers (PSTs) who were earning a bachelor's degree in teaching or education, or other subject specific majors (e.g., history, physics, math) in addition to a teaching credential. Other programs primarily served PSTs in a postbaccalaureate context, where they worked towards a relevant teaching credential and, in some cases, a master's degree. Finally, some programs served both of these teacher education populations, although typically not within the same classes or cohorts, but as separate programs within the school. These schools served a wide range of populations of students, many in urban areas, but some also in rural and suburban areas. Table 3.1 gives a brief overview of the programs involved in the larger study, the education level of the PSTs in those programs, the credential objective(s) of those PSTs, and

their placement subject area(s) (if single subject). While the participating programs supported PSTs who were pursuing a wide range of credentials, I only report on the credential areas for those participating in the study. For example, although State University Nettlebrook supported PSTs pursuing all single subject credentials in that state, only history/social studies PSTs were represented in the larger study, so I only include that credential in Table 3.1. Other demographic information was not collected (e.g., race, ethnicity, gender, etc.). All program and participant names are pseudonyms assigned by members of the research team.

Table 3.1

Teacher Education Programs Participating in Larger Study

Program	Preservice Teacher Education Level	Preservice Teacher Credential Type(s)	Single-Subject Credential and Placement Area(s)
Alderwood College	Undergraduate, Graduate	Multiple Subject, Special Education	n/a
Evergreen University	Undergraduate, Graduate	Multiple Subject, Special Education	n/a
Juniper University	Undergraduate	Multiple Subject	n/a
New Cypress State University	Undergraduate	Multiple Subject, Single Subject	Agriculture, Math, Science (middle grades), English/Language Arts, Social Studies
Silver Maple College	Undergraduate	Multiple Subject, Single Subject	Math, English/Language Arts
State University Nettlebrook	Undergraduate	Single Subject	History/Social Studies
State University South Dogwood	Graduate	<i>No preservice teacher data collected from this program</i>	
State University Sycamore	Graduate	Single Subject	History/Social Studies, Home Econ, Chemistry
University of South Boxelder	Graduate	Single Subject	Math
Violet Grove University	Undergraduate, Graduate	Single Subject	Math

Recruitment of Teacher Educators

Teacher educator participants in this dissertation study were initially recruited as part of the larger project which took place prior to the start of this study. Each program in Table 3.1 had both teacher educators and preservice teachers involved in the study (except one program which did not have any PST participants). The teacher educators in the study held a variety of positions, some as full-time professors, some as site supervisors, others as departmental chairs, and one as a graduate teaching assistant. While most programs only had one teacher educator participating in the study, one program (Alderwood College) had multiple teacher educators participating. All 14 teacher educators who participated in the larger study are a part of this dissertation study.

Recruitment of Preservice Teachers

Recruitment of participating PSTs was done in collaboration with the participating teacher educators. In some cases, a member of the research team visited the class via Zoom and recruited participants for the research project; in other cases, the participating faculty connected the research team with students who expressed interest in the project. Some faculty opted to make participation in the research project a portion of the class itself, whether for credit or as a part of in-class time. Participating faculty submitted artifacts on behalf of their preservice teachers. PSTs who participated in either an individual interview or a focus group were given a \$15 gift card.

In the larger research study, there were 18 individual interviews with PSTs and 12 focus groups (including PSTs from all credential areas). I selected only students from the original study who were pursuing math or science credentials. This included nine PSTs who participated in individual interviews and eight PSTs who participated in two different focus groups of four

participants each. In total, there were 17 math or science PSTs involved in this dissertation study.

Table 3.2 below lists the teacher educators and preservice teachers who participated in this dissertation study. Where available, preservice teacher credential areas are also listed.

Program and interview participant names are pseudonyms assigned by a member of the research team. Of the nine individual interview participants, six were PSTs in math and three, in science. Four of these nine PSTs were undergraduate students and the other five were graduate students. Of the three science PSTs, two were pursuing middle grades science credentials and so did not specify a specific science discipline. All other math and science PSTs were pursuing credentials for teaching at the high school level. As noted, eight of the 17 PSTs in this study participated in a focus group. There were two focus groups, and both focus groups had four undergraduate participants from the same university (New Cypress State University). All eight focus group participants were either seeking math or science credentials, but individual data on who was pursuing which credential was not collected as a part of those focus groups.

Table 3.2*Participant Pseudonyms and PST Credential Areas*

Teacher Educators	Preservice Teachers (<i>Note: ug or g denotes undergraduate or graduate level</i>)	PST Credential Area	Program
Mary Oliver Usha Aziz Tamera Marion Sue Eastern	n/a	n/a	Alderwood College
Layla Brussels	n/a	n/a	Evergreen University
Bryn Knight	n/a	n/a	Juniper University
Sophia Cardinal Lewis Ford (graduate TA)	Hope Lee (ug) Ruby Shaw (ug) Miley Jones (ug) Focus Group 1 (ug) Focus Group 2 (ug)	Math Science Science Science and Math Science and Math	New Cypress State University
Tiffany Ryan	n/a	n/a	Silver Maple College
Ryan Snow	n/a	n/a	State University Nettlebrook
Caroline Grey	n/a	n/a	State University South Dogwood
Miriam O'Connor	Carey Kochen (g)	Home economics and chemistry	State University Sycamore
Melissa Stone	Cheng Han (g) Gemma Bailey (g)	Math Math	University of South Boxelder
Emily Riemann	Dylan Stewart (g) Elsa Henley (g) Rose Johnson (ug)	Math Math Math	Violet Grove University

Deeper Learning Modules

The six deeper learning modules (DLMs) used in this study were developed by the SCALE Group (formerly the Stanford Center for Assessment, Learning, and Equity), and the module development and research were funded by the Hewlett Foundation (SCALE Group,

2024, see Appendix A). The DLMs were designed specifically for teacher educators to use in their coursework to provide opportunities for PSTs to build capacity to foster deeper learning for all students. The three overarching goals of the modules are (1) develop PSTs' dispositions towards integrating deeper learning competencies (Hewlett Foundation, 2013), (2) engage PSTs as "adaptive experts" to make equitable and intentional adjustments to teaching practices, and (3) require analysis and reflection of PSTs' own teaching through the lens of deeper learning. The six modules are titled: (1) Facilitating Effective Discussions to Promote Deeper Learning and Equitable Engagement, (2) Supporting Students' Mindset Development as They Navigate Challenges, (3) Developing a Critical Lens to Promote Socially-Just Narratives and Represent Diverse Identities, (4) Supporting Student Collaboration Within Performance Assessments, (5) Creating Responsive Learning Spaces: Leveraging Students' Voices and Assets, and (6) Equitable and Effective Feedback.

In designing the modules, the SCALE Group considered both the Hewlett Foundation's (2013) deeper learning competencies and the five dimensions of teaching for deeper learning outlined by Darling-Hammond and Oakes (2019). Each of the six modules are connected with one or more of the deeper learning competencies. For example, the module on "Supporting Students' Mindset Development as They Navigate Challenges" focuses on the deeper learning competency of developing "academic mindsets." However, the six modules do not correlate directly with the five dimensions of teaching for deeper learning.

The modules were delivered as open education resources in Canvas and were designed so that teacher educators can adopt the content to meet the needs of their students. While some teacher educators implemented one or more of the modules in full, others chose to adopt portions of the modules to best fit their course and meet the needs of their students. An at-a-glance view of which programs implemented which modules is shown in Table 3.3. By the time

initial data collection efforts began in the larger project, only the first four modules had been published, with the final two modules published later. Only one program implemented the fifth module, and no programs implemented the sixth module, so it is omitted from Table 3.3 (following page).

Faculty Participation with Modules.

The participating teacher educators were introduced to a set of four deeper learning modules and asked to implement one or more modules in their course(s). As noted, two additional modules were later developed and made available for teacher educators to use.

In addition to implementing one or more of the modules in their coursework, some participating faculty members worked alongside the SCALE Group in initially designing the modules starting in 2020. Some programs had one faculty member participate in this initial module development while another faculty member implemented the modules and participated in the larger research project. In at least one case, the faculty member who participated in module development retired before handing off the opportunity to implement the modules to another faculty member within their department. Table 3.4 below lists the teacher educators who participated in this study and groups them based on their participation in the module development process (module developers are also indicated via bolded text in Table 3.3 below). Comparisons between teacher educators who did and did not participate in module development is the focus of the third research question of each question set.

Table 3.3*Deeper Learning Module Implementation by Teacher Educator*

Teacher Educator	Deeper Learning Module Implemented				
	Facilitating Effective Discussions	Supporting Student Mindset Development	Developing a Critical Lens	Supporting Student Collaboration within Performance Assessment	Creating Responsive Learning Spaces
Bryn Knight		✓			
Caroline Grey				✓	
Emily Riemann			✓	✓	
Layla Brussels		✓			
Lewis Ford (graduate TA)	✓				
Mary Oliver		✓			
Melissa Stone	✓				
Miriam O'Connor	✓	✓			
Ryan Snow	✓			✓	
Sophia Cardinal	✓			✓	
Sue Eastern	✓				
Tamera Marion		✓			
Tiffany Ryan			✓		
Usha Aziz					✓

Note. Checkmarks indicate that module was used by that teacher educator in some way, whether in full or in an adjusted manner. Teacher educators who participated in both the initial module development and the larger research project are **bolded**.

Table 3.4*Teacher Educators Grouped by Participation or Non-Participation in Module Development*

Module Developers	Not Module Developers
Usha Aziz	Mary Oliver
Sophia Cardinal	Tamera Marion
Tiffany Ryan	Sue Eastern
Ryan Snow	Layla Brussels
Miriam O'Connor	Bryn Knight
Caroline Grey	Lewis Ford
	Melissa Stone
	Emily Riemann

Following from Table 3.4, and to provide additional context, I have included a list of all participating PSTs along with their corresponding teacher educators in Table 3.5 below. I also note that linking these PSTs to their professors' role as module developers comes at the risk of making faulty causal connections between a professor's experiences and their PSTs' learning outcomes. In other words, in this study, grouping and comparing based on a teacher educator's role in module development may provide illustrative insight, but it cannot provide causal insight.

Table 3.5*List of Preservice Teachers Grouped by Teacher Educator Participation in Module Development*

Module Developer?	Teacher Educators	Preservice Teachers (<i>Note: ug or g denotes undergraduate or graduate level</i>)	PST Credential Area	Program
Module Developer	Sophia Cardinal	Hope Lee (ug) Ruby Shaw (ug) Miley Jones (ug) Focus Group 1 (ug) Focus Group 2 (ug)	Math Science Science Science and Math Science and Math	New Cypress State University
	Miriam O'Connor	Carey Kochen (g)	Home economics and chemistry	State University Sycamore
Not Module Developer	Melissa Stone	Cheng Han (g) Gemma Bailey (g)	Math Math	University of South Boxelder
	Emily Riemann	Dylan Stewart (g) Elsa Henley (g) Rose Johnson (ug)	Math Math Math	Violet Grove University

Note. Lewis Ford was a graduate TA at New Cypress State University. He did not participate in module development, and none of the PST participants from New Cypress were from his class. As such, I have omitted him from this table.

Data Collection

Data for both the larger project and this dissertation study include qualitative interviews, focus groups, and artifacts. Members of the research team conducted qualitative, semi-structured interviews (Gubrium & Holstein, 2012) with PSTs and teacher educators. These lasted 30-90 minutes. In addition, the research team conducted focus groups between Fall 2023 and Spring 2025 with PSTs only. These focus groups lasted 45 minutes. Interviews and focus groups covered topics such as their conceptions of deeper learning, experiences using the various DLMs, experiences teaching for deeper learning, and general reflections on deeper learning and

teaching for deeper learning within a teacher education context. Sample interview and focus group protocols are provided in Appendix B. Interviews and focus groups were conducted remotely via Zoom, transcribed initially using AI-based transcription software (e.g., Otter), cleaned by a member of the research team, and then checked by a second member of the research team. Artifacts were submitted by email or uploaded to Box by the participating faculty. These artifacts include materials produced by both teacher educators and PSTs. Artifacts produced by teacher educators include course syllabi, class Canvas sites, learning activities, and lecture/discussion slides. Artifacts produced by PSTs include module-specific worksheets and activities, planning guides, discussion guides, essential questions and discussion maps, and curriculum analysis activities.

In total, the research team collected 15 interviews with teacher educators (1 teacher educator participated in two interviews), 18 interviews with PSTs, 12 focus groups with PSTs (which included 61 total participants), and a wide range of teaching artifacts from all programs except one. Research on the full data set is the subject of additional ongoing research and has been the subject of various conference presentations (Bennett et al., 2026; Su et al., 2026). Table 3.6 below provides an inventory of data collected for this dissertation project.

Table 3.6*Inventory of Data Collected, Grouped by Program*

Program	Teacher Educator Interviews	PST Interviews	PST Focus Groups	Artifacts
Alderwood College	4	-	-	Module discussion prompt responses, in-class posters, module worksheets
State University Nettlebrook	1	-	-	Module worksheets, planning guides
State University Sycamore	1	1	-	Talk moves assignments, essential questions assignments
Evergreen University	1	-	-	None
Juniper University	2	-	-	Assessment guides/tools
New Cypress State University	2	3	2	Lesson plan, discussion guide
State University South Dogwood	1	-	-	Teaching slides, guided notes, student reflections
Silver Maple College	1	-	-	PST notes
University of South Boxelder	1	2	-	Teaching slides, PST feedback, discussion maps
Violet Grove University	1	3	-	Curriculum analysis tool, module discussion responses
<i>Total</i>	15	9	2	

Note. Programs which had faculty members participate in both the initial module development and the larger research project are **bolded**.

Since the second question set for this study focuses on science and math preservice teachers, the data used for that part of the study includes only nine of the 18 PST interviews and two of the 12 focus groups (the remaining 10 focus groups did not have any participating math or science PSTs). As a result, while teacher educators from all 10 programs are included in the data used for question set 1 (on teacher educators), preservice teachers from only four programs

are included in the data set for question 2 (on preservice teachers). These four programs are State University Sycamore, New Cypress State University, University of South Boxelder, and Violet Grove University.

Data Analysis

In this section, I describe which data were used to answer the two question sets and then describe the analytical methods. For the first question set on teacher educators, I primarily used the 15 teacher educator interviews, supplemented by teaching artifacts submitted from participating teacher educators. These 14 teacher educators represent all 10 programs in the larger research project. Artifacts which speak to teaching strategies used by these teacher educators are also included in Table 3.6 and include discussion prompts from the deeper learning modules (DLMs), worksheets from the DLMs, talk moves and essential questions assignments, discussion guides, teaching slides, in-class posters and notes, and curriculum analysis tools.

For the second question set on preservice teachers, I primarily used interviews and focus groups conducted with preservice teachers (PSTs) from the four participating programs that included math and science PSTs. Artifacts which speak to preservice teacher conceptions and practices related to deeper learning include lesson plans, discussion guides, modules discussion responses, and discussion maps.

Data were analyzed in three phases using the qualitative analysis software MAXQDA. In the first phase, I used a combination of deductive and inductive coding schemes, and in the second phase, I used only a deductive coding scheme (Yin, 2016). In the third phase, I analyzed and interpreted the data that had been coded. Here, I first describe the two coding phases and then describe how I interpreted this data after the coding process.

Phase 1: Development of Codebooks

From my conceptual framework, I incorporated four a priori codes for *conceptions of deeper learning* into both codebooks (one for each question set). Additionally, through the data collection process, I identified a number of commonly occurring patterns for how the participants talked about deeper learning. These are shown in Table 3.7 below, which highlights a priori codes for the first question set on teacher educators. Codes for the second question set are given in Appendix D.

Table 3.7

A Priori Codes for Question Set 1 on Teacher Educators

Parent Code	Subcode
Conceptions of Deeper Learning (DL)	Deeper learning as a process Deeper learning as a state Outcomes of engaging in deeper learning Associations with other education-related frameworks
Actions for Preparing Teachers for Deeper Learning	General Use of Hewlett Deeper Learning Modules (DLMs) Adjusted use of Hewlett DLMs Specific instructional strategy for teaching for DL

When considering additional codes for the two question sets, I identified which aspects of the research questions were similar and could use similar codes (such as *conceptions of deeper learning*), and which aspects of the research questions were different and required different codes (such as codes capturing how preservice teachers describe their teacher education program experiences related to deeper learning). I then expanded the initial codebook beyond the a priori codes given in Table 3.7 into the following broad categories: (1) conceptions of deeper learning, (2) actions for teaching for deeper learning, (3) teacher education experiences related to deeper learning, and (4) context.

I determined initial subcodes based on a combination of the literature regarding deeper learning and memos and reflections written shortly after conducting interviews and focus groups. For example, “deeper learning as a process” and “deeper learning as a state” are two conceptions of deeper learning which exist in the literature discussed previously (see Fries et al., 2021 and NRC, 2018, as discussed in the literature review). Because of their presence in the literature, I included both as subcodes within the larger category for conceptions of deeper learning. Alternatively, after conducting many of the interviews, it became clear that participants often associated deeper learning with other concepts within education such as Bloom’s Taxonomy or Webb’s Depth of Knowledge. Despite not appearing in the literature treated previously, this conception of deeper learning was clearly present in the data and so was included in the initial codebook.

Using two initial codebooks, I coded approximately 60% of the interviews while also looking for ways in which the codebook should be expanded or collapsed in order to accurately capture the constructs under study. In order to identify how the codebooks should change before the second phase of coding, I coded any instance of the parent codes which did not clearly or cleanly fit within any of the predetermined subcodes as “other” and wrote analytic memos (Saldaña, 2013) describing how the contents of that excerpt could change the codebook. These memos also served as a tool for documenting my initial impressions of various trends within the data, which would later guide my findings.

Throughout this process, some existing codes were merged while some new codes emerged from the data. Further, a new category of codes emerged—*conceptions of teaching for deeper learning*—as it became apparent that teacher educators held such conceptions, and that in some cases these conceptions were distinct from their conceptions of deeper learning. Another emergent code was *math- and science-specific conception of deeper learning*, which emerged as it became

apparent that many preservice teachers used math or science content and language to describe their understandings of deeper learning and teaching for deeper learning. After coding and reviewing approximately 60% of the data, additional coding did not continue to result in changes to the codebooks, and I considered the codebooks stable. An overview of the codebook for the first question set is given in Table 3.8 below. Table 3.8 lists only the parent codes and corresponding subcodes. Definitions and examples for each code in question set 1 are included in Appendix C and in Appendix D for question set 2.

Table 3.8*Final Codebook for Question Set 1*

Parent Code	Subcode
1. Conceptions of Deeper Learning (DL)	1a. Deeper learning as a process 1b. Deeper learning as a state 1c. Outcomes of engaging in deeper learning 1d. Associations with other education-related frameworks 1e. Limitation or confusion about DL; developing understanding of DL 1f. Deeper learning as framework or resource 1g. Deeper learning in contrast to surface learning 1z. Other (note in annotation)
2. Conceptions of Teaching for Deeper Learning	2a. DL in terms of teaching (general) 2b. Learning chain of teaching for DL 2c. Teaching for DL as process 2d. Limitation/developing understanding of teaching for DL 2z. Other (note in annotation)
3. Actions for Preparing Teachers for Deeper Learning	3a. General Use of Hewlett Deeper Learning Modules (DLMs) 3b. Adjusted use of Hewlett DLMs 3c. Specific instructional strategy for teaching for DL 3d. Reasoning/motivation 3e. Planning/reflection 3f. Using modules as resource/tool for PSTs 3g. Limitation or confusion re: teaching for DL 3z. Other (note in annotation)
4. Context	4a. Undergraduate TEP 4b. Graduate TEP 4c. Teacher educator designed modules
5. Math- and Science-Specific Conception of Deeper Learning	<i>(no corresponding subcodes)</i>

Phase 2: Coding

After finalizing the codebooks, I selected approximately 20% of the interviews and focus groups and worked with a collaborator to ensure the applicability of the codebook and establish

interrater reliability. We used MAXQDA's "intercoder agreement" and a kappa calculation, κ_n , from Brennan and Prediger (1981).

We first reviewed and coded an interview together to ensure the collaborator was familiar with the codebook. We then independently coded a second interview and reviewed the coding together to discuss any additional clarifications to the codebook. Once this was completed, we separately coded approximately 20% of interviews and focus groups using the revised codebook. Interviews and focus groups were coded by turns of talk, and more than one code could be applied to each turn of talk. I then ran the intercoder agreement analysis in MAXQDA using this subset of the overall data set. The initial Brennan-Prediger kappa value for this round of coding was $\kappa_n = 0.23$, which indicated fair, but insufficient agreement between the two coders.

After this, we met and coded two separate interviews for consensus. During this process we identified a few cultural and linguistic challenges to coding education-specific data which we had not anticipated and which did not come up in the initial calibration process (the two coders come from different cultural and educational backgrounds). After this, we separately re-coded a subset of ~20% of the interview and focus group data. Running the intercoder agreement calculation in MAXQDA after this round of individual coding resulted in a new Brennan-Prediger kappa value of $\kappa_n = 0.54$, which indicated moderate agreement. Aiming for a kappa value of $\kappa_n \geq 0.60$, we repeated this process once more, reviewing code assignments together to identify where we agreed that certain codes were present or not present. After a third round of separately coding the subset, we achieved a Brennan-Prediger kappa value of $\kappa_n = 0.63$.

I then coded the remaining interviews and focus groups and reviewed artifacts submitted by the participants. As noted previously, these artifacts include materials such as course syllabi,

class Canvas sites, learning activities, lecture/discussion slides, module-specific worksheets and activities, planning guides, discussion guides, essential questions and discussion maps, and curriculum analysis activities. Artifacts were used as a secondary data source to triangulate findings (Creswell, 2013; Stake, 1995). These artifacts provided both confirming and disconfirming evidence when identifying how faculty members and PSTs implemented opportunities for deeper learning in their respective teaching contexts. For example, artifacts such as the curriculum analysis activity provide a view into how participating faculty members adjusted module delivery in order to engage PSTs in deeper learning. Additionally, artifacts provided clarity into the different approaches used by different faculty members or into the different types of activities used in different educational contexts (e.g., undergraduate versus graduate coursework).

Phase 3: Interpretation

After the coding process was complete, data within each of the two question sets were analyzed using the same overall method, with slight variations appropriate to the different contexts which are discussed below.

First, I analyzed the data to look for trends in frequency counts within each parent code. Using these high-level trends as an initial guide, I looked for more detailed patterns within those trends. For example, many teacher educators in this study described deeper learning in relation to other education-related constructs, but the actual constructs they referenced differed. Looking at all instances of that code allowed me to identify which education-related constructs were most commonly related to deeper learning for the teacher educators in this study. For another example, multiple teacher educators described teaching for deeper learning as being a useful or powerful framework for teaching in general. Through this finer grained analysis, I identified that many of the teacher educators in this study also hold conceptions of teaching for deeper

learning, not just conceptions of deeper learning. After identifying these general trends, I selected illustrative examples which allowed me to highlight both trends and differences within the data set.

Next, I considered cooccurrences of specific codes and subcodes (Saldaña, 2013). When working to identify these cooccurrences, I looked primarily for instances where codes overlapped within the same segment. These cooccurrences looked slightly different at the teacher educator and PST levels. At the teacher educator level, I focused on the following cooccurrences of codes: (1) conceptions of deeper learning with other conceptions of deeper learning (2) conceptions of deeper learning and conceptions of teaching for deeper learning, and (3) conceptions of deeper learning and teaching practices for deeper learning (in teacher education contexts). At the PST level, I focused on the following cooccurrences of codes: (1) conceptions of deeper learning with math- and science-specific conceptions of deeper learning, (2) conceptions of teaching for deeper learning with math- and science-specific conceptions of deeper learning, and (3) actions for teaching for deeper learning in K-12 contexts and teacher education program experiences related to deeper learning.

After both phases of the coding process were complete, and during the data interpretation phase, I began to notice the potential for an additional coding category which could apply to the math and science PSTs in this study. Specifically, I noticed that some of the math and science PSTs used math and science concepts in their descriptions of deeper learning. Some also used math and science concepts in their descriptions of teaching for deeper learning. In order to capture these instances and consider them more fully, I added a code: *math- and science-specific conceptions of deeper learning*. This is included at the bottom of Table 3.8. I defined a *math- or science-specific conception of deeper learning* as one in which the participants explicitly used math or science concepts in describing deeper learning or teaching for deeper learning.

Finally, after identifying relevant trends across codes and subcodes and trends in cooccurrences, I again identified illustrative examples to represent some of these trends. Artifacts served a useful role in developing illustrative examples by providing concrete examples of how both teacher educators and preservice teachers implemented or experienced opportunities for deeper learning. These examples were selected based on their ability to demonstrate overall trends across the data, their ability to highlight trends of relevant connections between codes and subcodes, and their ability to demonstrate unique contrasts within or across groups. Consider, for example, the third research question in each question set which considers differences between those involved in module development and those who were not involved in module development.

Chapter 4: Findings, Part 1: Teacher Educators

I discuss findings in two separate parts, treating the two question sets separately. This chapter focuses exclusively on the question set about teacher educators, while chapter 5 focuses on the second question set about preservice teachers. The question set about teacher educators is reproduced below.

- 1.1. How did teacher educators conceive of deeper learning?
- 1.2. How did teacher educators work to prepare preservice teachers for teaching for deeper learning? How did teacher educators use various deeper learning modules in order to provide preservice teachers with opportunities to learn to teach for deeper learning?
- 1.3. In the findings to the above questions, what differences were present between those who developed modules and those who did not?

1.1. Conceptions of Deeper Learning

For research question 1.1, there were eight different ways in which I categorized how teacher educators in this study conceptualized deeper learning. First, considering the most common occurrences for codes for *conceptions of deeper learning*, the four most common ways were: (1) deeper learning in relation to other educational constructs (such as Webb's Depth of Knowledge or Bloom's Taxonomy), (2) deeper learning in relation to various outcomes related to deeper learning, (3) deeper learning as a process, and (4) deeper learning as a framework which can inform and guide teaching and learning. I highlight these four codes because, of the eight codes for *conceptions of deeper learning*, these four were all mentioned by over half the participants. Of the 14 teacher educators in this study, all 14 described deeper learning in relation to other educational constructs, 13 described deeper learning in relation to various outcomes related to deeper learning, and nine described deeper learning as a process or as a framework for

guiding teaching and learning. A table displaying counts for each subcode, organized by participant, is provided in Appendix E (see Table E4.1). Below, I discuss these general trends and include specific examples. I then share findings of a conception of deeper learning that emerged from the data, which is that for many of these teacher educators deeper learning is directly linked to *teaching for deeper learning*.

Deeper Learning in Terms of Other Educational Constructs

The most common trend in how teacher educators conceived of deeper learning is by relating it to other educational constructs. There were 44 such occurrences from all 14 of 14 teacher educator interviews. Teacher educators commonly referred to Webb’s Depth of Knowledge and/or Bloom’s Taxonomy, various theories/theorists of child development (e.g., Dweck, Piaget, Vygotsky), and frameworks for teaching and learning such as 21st Century Learning, Understanding by Design, and socioemotional learning (see Table E4.2 in Appendix E for additional quotes which exemplify the various education-related constructs which these teacher educators connected to deeper learning).

Within the occurrences of deeper learning in terms of other education-related constructs, there were three general trends. First, that some of the teacher educators thought of these education-related constructs as similar to, or related to, deeper learning. In most of these examples, the connection between deeper learning and the specific educational construct is stated but rarely elaborated upon. For example, Miriam O’Connor said, “The quickest translation I have is 21st Century Skills. Beyond that, there’s an emphasis on transferable skills, real world applications, project-based learning—those are kind of the cluster of things in my brain that I associate with deeper learning” (para. 25).

Second, some teacher educators viewed deeper learning as related to more general approaches to teaching. For example, Bryn Knight described how she viewed deeper learning content as connected to constructivist approaches to teaching:

One thing I've loved about these modules is talking about deeper learning in an elementary context. It's kind of transformative for some of them, because I think we can associate deeper learning with middle and high school curriculum. So, I think of a lot of hands-on learning. I also dig pretty deeply into constructivism in this child development class, so I tie it in with the constructivist methods of teaching and being very hands on, very participatory. (para. 28)

In this case, the more general approach to teaching is constructivism. Other such approaches include Understanding by Design, applying Bloom's Taxonomy, and applying Webb's Depth of Knowledge. We can also see in this instance that Bryn connected deeper learning to the educational constructs she taught in her coursework. Other such examples are provided in Appendix E (see Table E4.2, quotes from Tamera Marion and Tiffany Ryan).

Finally, the third trend is that some of these teacher educators related deeper learning to other education-related constructs by explicitly referencing their past experiences. For two examples, Caroline Grey described her experiences as a school administrator and special education teacher, and Sophia Cardinal made connections to her own experiences as a preservice teacher. We might consider these types of responses as historical or experiential connections to education-related constructs.

One teacher educator, however, took this line of thinking significantly further. When asked about what comes to mind when hearing the term deeper learning, Ryan Snow started to situate deeper learning within the larger, historical context of academic research regarding deeper learning. His response included references to a wide range of prior scholarship including work

done by and in collaboration with the SCALE Group (Stanford Center for Assessment, Learning, and Equity), the edTPA and PACT (two teaching performance assessment tools), and work done by Linda Darling-Hammond and Jeannie Oakes as people on the forefront of work regarding deeper learning. After citing these organizations, tools, and people associated with deeper learning, Ryan Snow stated, “When I think of deeper learning, I think of a decade of work with the wonderful SCALE team that I’ve been involved with and the rich discussions there” (para. 29). I highlight this example because Ryan Snow was the only teacher educator in this study to describe deeper learning in this kind of larger historical/academic context.

Deeper Learning in Terms of Outcomes

The second most common trend in how teacher educators conceived of deeper learning is by describing specific outcomes that result from engaging in deeper learning. There were 37 occurrences of this code across 13 of 14 teacher educators. These outcomes were often phrased in terms of abilities that learners or teachers acquire, such as being able to engage in relevant teaching practices or to make situationally aware teaching decisions. Some teacher educators also described outcomes which resemble transfer of learning, although they may not have used that term. While some of the teacher educators in this study described these outcomes specifically as it pertained to preservice teachers, other teacher educators described these outcomes as it pertained to learners more generally, including K-12 students.

Consider the following quote from Usha Aziz where she deliberately put the definition of deeper learning within the context of teacher candidates and their teaching abilities:

Deeper learning is, for teacher candidates, the ability to make decisions on their own feet based on specific situations that they are facing. Deeper learning is about their ability to, in the moment, as they are facing a specific situation, to make that decision of what works best in this case and be able to implement it quickly. (para. 128)

For a second example, we can consider a quote from Mary Oliver:

Deeper learning is getting to know and understand your students on a deep level so that you're able to scaffold your instruction to best support their learning goals and needs, so that they can really reach that in-depth knowledge. (para. 58)

We can see similarities between these two examples, specifically that they consider deeper learning from the perspective of the teacher. However, Mary, took this a step further to move from the teacher to the student, stating that this type of teaching allows students to “really reach that in-depth knowledge” (para. 58). While Mary was a teacher educator in this study, it is not clear from her quote if she referred to teacher educators, preservice teachers, or just teachers in general. Regardless, these two quotes exemplify the pattern that the teacher educators in this study often viewed deeper learning in relation to both teaching and learning outcomes.

The second main trend for examples of outcomes was more akin to descriptions of transfer of learning. Consider Caroline Grey's quote, shown below, which explicitly cited the application of skills and experiences to other contexts:

What comes to mind for me when I think of deeper learning is the skills, the concepts, the experiences that we would be giving students in our schools that really transcend education, transcend the classroom into lifelong learning, lifelong application of being able to use those experiences and skills in other contexts. (para. 43)

Her response connects to the notion of transfer since she cites that learners will be “able to use those experiences and skills in other contexts.” When talking about deeper learning, other teacher educators also used language which evoked the idea of transfer of learning. These included phrases such as “developing skills that they can use across academic disciplines or potential careers” (Sophia Cardinal, para. 189) and “to be able to apply that content knowledge across multiple situations” (Sue Eastern, para. 29). The full text of these quotes and other quotes

which illustrate how these teacher educators viewed deeper learning in terms of outcomes is given in Appendix E (Table E4.3).

Deeper Learning as a Process

The third most common trend in how teacher educators conceived of deeper learning was as a process. There were 19 such occurrences from nine of 14 teacher educators. When describing deeper learning in terms of processes, many of these teacher educators described processes more related to teaching and learning than in terms of cognitive processes. For example, Bryn Knight described deeper learning as “taking the content that you are presented as a teacher and the standards and teaching that in a way that allows the student to make connections and think critically and collaborate with one another” (para. 137). In this case, the process has to do with teaching which results in learning opportunities for students. Throughout the analysis, it became apparent that many of the teacher educators in this study viewed deeper learning in terms of *both* processes and the outcomes of those processes. As such, it was a challenge to identify instances of conceptions of deeper learning as a process without identifying outcomes of deeper learning. We can see one example of this challenge in a quote from Caroline Grey, who described engaging in deeper learning in terms of engaging in various practices (or processes):

I think you can develop it the more practice you have—I think it’s like with any complex skill that you do. Let’s say you’re playing the piano or working with a symphony or something. It’s not just the skill of playing the instrument, it’s also the tone, the rhythm, the integration with the other instruments. And I think you get better at it the more you do it, and the more you think about it. I think it’s slightly dependent on what deeper learning practice you’re doing, but it’s not one practice. One practice might be the collaboration piece; one practice might be the perseverance piece of looking at

productive struggle. So, there are multiple practices. So, I would say, you can get better and apply it and integrate it. (para. 190)

Here, by drawing an analogy to practicing an instrument, Caroline attempted to separate the outcome, or the skill, from the process of acquiring that skill. In this quote, we can see that deeper learning consists of various practices which learners can engage in. However, it remains difficult to fully separate the process of deeper learning from various outcomes of engaging in deeper learning. Further, in this example, we see that by engaging in various processes related to deeper learning, Caroline described that learners can, in fact, get better at engaging in those processes (which is an outcome). While we might be able to cognitively separate deeper learning as a process from its corresponding outcomes, these interviews demonstrate that, at least for these teacher educators, this remains practically challenging. I treat this overlap in more detail later in this chapter when considering specific cooccurrences of codes.

Deeper Learning as a Framework

Viewing deeper learning as a framework for teaching and learning was the fourth most common trend (18 instances across nine of 14 teacher educators). Some teacher educators described deeper learning as a framework which directly informed instructional decisions; other teacher educators described deeper learning as a framework which enabled them to organize various teaching constructs. For the latter, in some cases, this seemed to influence instruction, while in other cases it was unclear how it might have done so.

First, I consider an example in which deeper learning influences or guides instructional decisions by reviewing a quote in which a teacher educator described how his views of deeper learning changed through engaging in the modules:

In my job, we try to connect everything to real-life situations and real-life concerns or problems or real-life experiences of the students, and so I think that was kind of more

where I was at with deeper learning. I thought that deeper learning was making sure that students had that connection. After the deeper learning modules, I see it was a lot more of the discussions and facilitation and making sure that little things were attended to. So, the deeper learning modules kind of went into the X's and O's of how to execute it as well, not just a mindset. I had the mindset where it's like, let's talk, let's discuss, let's ask. But the deeper discussion modules went into really on the execution of it as well, not just why? (Lewis Ford, para. 25)

Here, we can see that, for Lewis Ford, deeper learning initially served as a generalized approach which influenced instruction (ensuring that students could make connections to real life).

However, he described that by engaging with the modules, this framework was filled in with specific details which not only guided general approaches to instruction but also guided the specific approaches—the X's and O's—of teaching for deeper learning.

Second, I consider a few examples which highlight how deeper learning served to organize other frameworks. Sophia Cardinal stated: “So, we have equity, we have social emotional learning, we have collaboration, right? Deeper learning gives a framework for these different mindsets and a way to connect them”. In this case, Sophia Cardinal viewed deeper learning as a framework which can help organize a number of other educational constructs—or, in her terms, “mindsets” (equity, social emotional learning, collaboration)—within a larger umbrella.

Sophia was not the only teacher educator who described deeper learning in this way. Two other teacher educators in this study described deeper learning as a framework in the sense that it provided them with specific language. When describing deeper learning in general, Bryn Knight said, “I know that I included it in my teaching without really knowing it, but it's given me

the language. And I think in that way it's helped because I call it out more than I did before.”

Similarly, Sue Eastern said:

I had a general sense about what was meant by deeper learning before engaging with these modules. So, I knew that there were several areas in which students could engage in specific skills that would actually allow them to incorporate content knowledge at a deeper level to be able to apply that content knowledge across multiple situations. So, I knew things like collaboration. I knew things like critical thinking and problem solving. I knew things like communication, but I didn't have the specific language from the deeper learning framework that you all sent to us. (para. 29)

In these two examples, deeper learning seems to serve as a framework for guiding how these teacher educators mentally organized and labeled other education-related constructs in relation to one another. In Bryn Knight's example, she further described that the language allowed her to “call it out more”, indicating that the organizing language from seeing deeper learning as a framework allowed her to use those terms in her teacher education coursework.

Conceptions of Teaching for Deeper Learning

Conceptions of teaching for deeper learning was one emergent coding category for this research. In brief, the teacher educators in this study also held conceptions of *teaching for* deeper learning, which in some cases overlapped with their *conceptions of deeper learning* and in other cases were clearly distinct. Here, I share here some examples which demonstrate how these two concepts were often directly connected in how teacher educators described deeper learning. Additionally, I find it worth noting that the interviewers did not explicitly ask teacher educators for their thoughts on teaching for deeper learning. Rather, questions were oriented around their conceptions of deeper learning. In some of the examples discussed previously (Usha Aziz, Mary Oliver), we saw teacher educators describe deeper learning in terms of outcomes. However,

more specifically, some of these outcomes were *teaching* outcomes. In addition to these example, some of the teacher educators in this study viewed deeper learning in terms of *teaching for* deeper learning.

There were a few differences in how participants incorporated teaching for deeper learning into their responses. First, consider Mary Oliver's response: "Deeper learning is getting to know and understand your students on a deep level so that you're able to scaffold your instruction to best support their learning goals and needs, so that they can really reach that in depth knowledge" (para. 58). As noted previously, in this case, deeper learning is directly viewed from the perspective of the teacher. We can also begin to see how Mary might have a mental model for teaching for deeper learning and how it goes beyond the teacher education context. Starting with her position as a teacher, her conception of deeper learning included both understanding (in this case, understanding of students) and teaching ability (scaffolding instruction) in working towards a particular teaching outcome (to best support their learning goals and needs), which leads to a particular learning outcome (so that they can really reach that in depth knowledge).

For a second example, we can consider Caroline Grey's description of what came to mind when she thought of deeper learning: "the skills, the concepts, the experiences that we would be giving students in our schools that really transcend education, transcend the classroom into lifelong learning, lifelong application of being able to use those experiences and skills in other contexts" (para. 43). This response is also directly oriented around teaching in that she refers to skills, concepts, and experiences "that we would be giving students", as well as described a specific learning outcome, which is "being able to use those experiences and skills in other contexts" (e.g., transfer).

Finally, I highlight Emily Riemann's quote, which aptly demonstrates that teaching teachers for deeper learning implies they are learning about teaching as its own field of study and practice. As such, it becomes about more than theory and more than practice, but about weaving those things together in ways that support preservice teacher learning of teaching and preservice teacher classroom practices.

I always think about how we, as a field, we're trying to help them understand theoretically how learning happens. And I also think about how that exists in practice, and I feel like deeper learning means bringing those together as much as possible. So not being like, first we're going to tell you all the theory, and now you're going to go do it; or, and now we're going to show it to you in a video, but how can we, as much as possible, weave those two things together, which, to me, supports the deeper learning of teaching itself. (para. 49)

Looking across these quotes (additional quotes are provided in Table E4.4, Appendix E), we see examples of an overall trend: that the teacher educators in this study do not exclusively describe deeper learning from the learner's perspective, but also from the teacher's perspective. Throughout the analysis, a few additional ways in which teacher educators described deeper learning in relation to teaching for deeper learning came to the surface. These sub-categories are outlined in Appendix C where I provide full definitions and example quotes. Counts of occurrences of those codes are provided in Table E4.5 in Appendix E.

Overall, there were 116 occurrences of codes for *conceptions of teaching for deeper learning*. The two most common descriptions of teaching for deeper learning were coded as *learning chain of teaching for deeper learning* and *deeper learning in terms of teaching (general)*. The quotes described above demonstrate some examples of deeper learning in terms of teaching more generally, while I discuss examples of how the learning chain showed up in this data in the following subsection.

Learning Chain of Teaching for Deeper Learning.

In Chapter 1 (Introduction), I used a learning chain of teaching for deeper learning as a conceptual model to outline and describe some of the participants and interactions taking place within different levels of education, specifically as it relates to deeper learning. Using a learning chain as a conceptual model highlights the wider scope of this area of research and pinpoints where this research focuses in on within that chain. The teacher educators in this study did not use the term “learning chain”, but here I share a few quotes which highlight that many of the teacher educators in this study viewed their work within a larger educational context. As such, they viewed their work related to teaching for deeper learning within that larger context, and that larger context can be visualized, at least in part, by the conceptual model of a learning chain of teaching for deeper learning.

In communicating how their work fit within this larger context of preparing teachers for deeper learning, some of the teacher educators in this study referred to others involved within a given teacher education program (e.g., supervisors, mentor teachers, faculty colleagues), others referred to K-12 learners and their learning goals (see again the quote from Mary Oliver, discussed above), and still others seemed to make connections to a context beyond the teacher education program (e.g., university-district partnerships, historical context for teaching for deeper learning). For an example of the first, we can consider a quote from Bryn Knight, where she described the relationship between university-based teacher educators and site supervisors or cooperating teachers, specifically as it pertained to teaching for deeper learning: “I feel like if the supervisors had a better understanding of what we’re teaching in class with the deeper learning, then maybe they could follow through on that with what they’re seeing them do in their practicum” (para. 160). In this quote, we can see that Bryn expressed a desire for better alignment between teacher educators and supervisors specifically as it pertained to teaching for

deeper learning. In terms of a location on the learning chain, we can say that Bryn referenced others (supervisors) within the same level as herself (teacher educators), but who have their own relationship with their students (PSTs).

For a second example, we can consider a quote from Ryan Snow, who situates the work of preparing PSTs to teach for deeper learning within a historical and academic context:

I had already been involved with the with the edTPA and PACT teaching event before that. And those, those efforts from the same unit, from SCALE, those efforts were the ones that that really deepened the work that we were doing in teacher ed, particularly in my discipline and history social science, they had already taken us in the direction of new and better ways of teaching history that involved serious critical thinking skills and departing from students just reading a textbook and answering the questions at the end of the chapter, or at the bottom of the page, they had taken us in directions of contesting history and asking harder questions. (para. 61)

Similar to Bryn, Ryan referenced others that would be placed on the level of teacher educators. However, in contrast, he highlighted those whose impact is more targeted to directly supporting teacher educators in their efforts to support PSTs.

These are just two examples which highlight the breadth of contexts in which these teacher educators viewed the work of teaching for deeper learning, and which align with the conceptual model of a learning chain of teaching for deeper learning. For other examples, see Table E4.6 in Appendix E.

Code Cooccurrences: Conceptions of Deeper Learning x Conceptions of Deeper Learning

In addition to code frequencies, I also consider cooccurrences of certain coding categories. I identified these cooccurrences by looking at where specific codes overlapped in the transcripts in MAXQDA. These cooccurrences provide more detail into how these teacher

educators held conceptions of deeper learning which were better described by multiple codes, rather than just one code.

The first set of cooccurrences I considered was *conceptions of deeper learning* overlapping with other *conceptions of deeper learning*. A full table outlining the total counts of various cooccurrences is given in Table E4.7 in Appendix E. The most commonly cooccurring code pair was *deeper learning as a process* with *outcomes of engaging in deeper learning*. This co-occurrence occurred in 15 of the 19 occurrences of the code *deeper learning as a process*. This indicates that the teacher educators in this study frequently related the process of deeper learning with outcomes of engaging in deeper learning. Consider, for example, Sophia Cardinal's statement: "Deeper learning is, I think, moving students away from lower levels of Bloom's Taxonomy to higher levels of Bloom's Taxonomy, while, at the same time, developing skills that they can use across academic disciplines or potential careers that they may have" (para. 189). She noted that deeper learning includes students "developing skills," which would indicate a process. She then noted the outcome: that students can use those skills across academic disciplines or potential careers.

The overlap of *deeper learning as a process* with *outcomes of engaging in deeper learning* also highlights how processes and outcomes related to deeper learning can be difficult to parse out. For example, Emily Riemann stated, "I would define deeper learning as becoming able to engage in practices that are supported by relevant theory and recent research on a moment-to-moment basis in practice, which for my population is the practice of secondary teaching" (para. 85). By using the term "becoming able," it indicates some sort of process which the learner engages in to acquire the ability to engage in research-based practices. While the words may indicate a process for deeper learning, there seems to be more clarity in how Emily described the outcomes of engaging in deeper learning.

Code Cooccurrences: Conceptions of Deeper Learning x Conceptions of Teaching for Deeper Learning

The second set of cooccurrences of codes I considered was *conceptions of deeper learning* and codes for *conceptions of teaching for deeper learning*. A full table outlining the total counts of various cooccurrences is given in Table E4.8 in Appendix E. Of 116 total occurrences of codes for *conceptions of teaching for deeper learning*, 87 instances overlapped with at least one occurrence of a code for *conceptions of deeper learning*. The most common cooccurrences were between *associations with other education-related constructs* and *deeper learning in terms of teaching*. In short, I found that despite being asked questions about their conceptions of deeper learning, the teacher educators in this study tended to share descriptions which were also aligned with conceptions of teaching for deeper learning. These cooccurrences provide a window into how *teaching for deeper learning* is a common, and perhaps integral, part of how these teacher educators conceived of deeper learning in general. In other words, if the cooccurrences discussed in the previous subsection highlight how these teacher educators have mental models for understanding deeper learning, the cooccurrences in this subsection highlight how their understandings of *teaching for deeper learning* are a part of those mental models.

Consider the following quote from Layla Brussels, which highlights how teacher educators often have conceptions of deeper learning *and* conceptions of teaching for deeper learning, and that these conceptions are often highly intertwined:

Well, for me, in teacher education, it's going deeper with content acquisition and application. So, thinking about what we're exploring together as learners, and instead of doing it at a base level we're doing more with it and with the application across areas and across contexts. So, asking what can we do together? What can my students do in various contexts versus, like, call and response sort of traditional teaching. I don't think I

said this earlier, but I think it's not traditional, it's not what we often see. It's not textbook, it's not sitting in rows, it's not questions in the back of the book, and it's not lecture. (para. 81)

Here, we see Layla directly placing deeper learning within the context of teacher education. She maintained a sense of deeper learning as a process of learning which results in particular outcomes, but this is directly situated within the relationship between herself (as an educator) and her students (as future educators). She then positioned this approach to teaching against specific teaching strategies typically associated with “traditional” teaching. At least for Layla (and for other teacher educators in this study), we see that deeper learning and teaching for deeper learning were intertwined. Not only that, but she actively considered what sorts of specific instructional strategies are and are not associated with deeper learning. This leads us to our next set of findings, on actions that teacher educators took to prepare PSTs for teaching for deeper learning.

1.2. Actions for Preparing Preservice Teachers for Teaching for Deeper Learning

Here, I consider codes for research question 1.2, focusing on how these teacher educators taught PSTs. Overall, there were 380 total occurrences of codes for *actions for preparing preservice teachers for deeper learning*. The three most common codes were *planning/reflection*, *specific instructional strategy*, and *general DLM use*. A table displaying the counts of code occurrences for *actions for preparing preservice teachers for deeper learning* is provided in Table E4.9 in Appendix E. Notably, *planning/reflection* was not a part of the initial codebook, but was added to the codebook during the coding process as it became apparent that the teacher educators in this study frequently spoke of their planning processes as well as reflected on their experiences implementing the DLMs in considering how they might adjust instruction in the future. In addition to these codes, these teacher educators frequently described adjusting DLM delivery to

better meet the needs of their students and so used a wide range of specific instructional strategies. Some of these instructional strategies came from the modules themselves while others were used in addition to the modules.

In the following subsections, I discuss trends I found when considering the different ways in which the teacher educators in this study worked to prepare PSTs for teaching for deeper learning.

Planning/Reflection

For all 14 of the teacher educators in this study, planning or reflection was a key part of how they approached using the DLMs to prepare PSTs to teach for deeper learning. Their reflections also indicate a breadth of factors outside of the DLMs that the teacher educators in this study considered in making teaching decisions. Examples of planning and reflection included reflecting on past experiences to inform future teaching practice, reflecting on the goals and needs of preservice teachers, planning in collaboration with other teacher education colleagues, and becoming familiarized with the various DLMs before implementing them in their coursework.

Consider an example from Bryn Knight, who reflected on prior implementation of the modules in a way that informed how she intended to use the modules differently in the future:

I had my PSTs look back at their lesson plans, and said, ‘Okay, now that you know about this, where can you add some more and again?’ I did that towards the end of the semester when they were so done. So, I’m going to try to move that up next semester. But I really would love to do that again, because I think having them work on something and then say, “Now, let’s go back to your lesson plans now and let’s add to it practically.” And they didn’t take it super seriously in their written assignment, but in the

class discussions it was clear that it was good that they were able to say, “Oh, yeah, I could add something here or add something there to make it more critical.” (para. 124)

She described an activity in which she had PSTs create a lesson plan before engaging with a module, then, after using the module, PSTs were asked to take their learning from the module and use it to reassess, critique, and edit their lesson plans. She noted that this activity took place at the end of the semester, at a time when PSTs “were so done” (meaning they were exhausted). Reflecting on this, she noted that next semester she would try to move that activity, including the module usage, up to earlier in the term.

For a second example, consider the following quote from Usha Aziz, where she described collaborating with her colleagues at Alderwood College during the summer (before implementing the modules in their courses):

We kind of individually looked at different modules and the description to select a module that we felt was the best fit for our classes. We decided to meet as a team and discuss which modules we were selecting, and which class we would like to implement the module in. We talked about the idea of selecting one module and all of us implement the same one, or selecting different modules and each one of us select a different one. But we immediately came to the idea like, “Oh, no, it has to be different. Because we share a lot of students.” (para. 51)

Both of these quotes show examples of teacher educators reflecting and planning, with one looking backward (Bryn) and one looking forward (Usha). The other examples of planning and reflection from the teacher educators in this study have similar, slight differences. However, taken together, these two examples exemplify a larger trend, that the teacher educators in this study routinely described their planning processes and reflected on their teaching practices in

ways that allowed them to specifically meet the needs of their students. For more examples, see Table E4.10 in Appendix E.

Specific Instructional Strategies and Use of DLMs in General

As noted, the next two most common codes in this category were *specific instructional strategy* and *general DLM use*. Neither of these codes alone provide a clear picture of how these teacher educators used the DLMs, and so I do not discuss them individually. However, we can gain a clearer picture by looking at these two codes together. *Specific instructional strategy* was intended to capture instances where participants described any strategy they used in relation to deeper learning within their teacher education courses. *General DLM use* was used primarily to capture instances where participants described using the DLMs generally and was meant to capture descriptions of DLM usage that did not clearly fall into *adjusted DLM use*. There were 22 instances of these two codes cooccurring, and trends within these 22 instances are the focus of this subsection.

In some instances, the specific instructional strategy that was described was simply a part of the module that was being implemented. For example, an activity within the *Developing a Critical Lens* module focuses on analyzing curriculum. Emily Riemann was one of two teacher educators who used this module, and in her interview, she described specific instructional strategies such as having PSTs bring in specific math curricula to analyze. She also described exposing her PSTs to specific instructional strategies they could use to facilitate more student-centered instruction in their K-12 math classes such as collaboration logs and work logs.

In other instances, teacher educators combined module-specific activities with other instructional strategies that they normally incorporated in their classes. We can see one such example in the following quote from Bryn Knight:

With my classes, I give them what we call a course pack. In their packet, I actually made one section that is all about the modules. And they've mentioned that they like having something on paper, and I've done some screenshots of some of the things in the modules, and then leave some space for them to reflect on it. We also did a class activity—I mentioned a video with a fifth-grade math class. I have them watch that video for homework, and then we do a lot of small group work with that video and then actually create some math lessons after that. (para. 64)

Here, Bryn used module content (screenshots and videos) and incorporated them with specific instructional strategies that she used to get students to engage with that content (reflection, small group work, creating math lessons).

The teacher educators in this study described using an exceedingly wide range of specific instructional strategies. Here is an inexhaustive list of the specific instructional strategies which were either cited in interviews or collected as artifacts: worksheets, reflection question responses, collaborative posters within gallery walks, small group discussions, whole group discussions, think-pair-share, developing lesson plans or unit plans, analyzing curricula, discussion boards, video recordings, lecture with slide decks, anchor charts, and assessment plans,. Some examples of teaching artifacts which demonstrate the various instructional strategies used as a part of DLM implementation are included in Appendix F.

Adjusted Use of DLMs To Meet Student Needs

Despite not being one of the three most common occurrences of codes within this category, I share some key findings for how the teacher educators in this study adjusted module delivery within their courses because I believe these findings could prove insightful for both the module development team and teacher educators who may wish to adopt these modules in the future.

Out of all 14 teacher educators in this study, 12 of them described adjusting their use of the DLMS in some way. Following the trend highlighted in the previous discussion of examples of planning and reflection, many of the teacher educators in this study adjusted the delivery of the modules in order to meet the needs of their students. The other trend was that some of these adjustments were more contextual, meaning they used or adjusted the modules when the course met in a hybrid or remote context. Of these two main adjustments, nine teacher educators in this study described adjusting module delivery to better meet the needs of their students and five teacher educators described adjusting module delivery based on contextual considerations. Two of the teacher educators described making both student-centered and contextual adjustments.

Consider an example from Emily Riemann, who first described part of her reasoning behind a specific adjustment: “I’m just thinking about how to make it small and bite-sized enough for them to still get something out of it, but actually be able to engage with everything that I share with them” (para. 106). She then went on to describe both the specific adjustment (making module-based videos optional) and further reasoning for that specific adjustment (the need for something to be deeply connected to a classroom practice):

I looked at the videos introducing things, and I included these videos but I’m going to say these are optional things for you to do on your own time if you want more information, because I do think I have some students who will want to do that. But I’m not going to require that of all of my students, because I think that if they’re not using something that’s deeply connected to a classroom practice, I see them on their computers lesson planning for the next day, which I understand. (para. 110)

For a second, and potentially powerful example, we can consider again a familiar quote from Bryn Knight, where she integrated the module into the course structure and sequence.

Bryn implemented the *Supporting Student Mindsets* module in her teacher education courses and described how she incorporated the module as a part of a larger assignment where PSTs developed and later critiqued and edited their own lesson plans for teaching in K-12 contexts.

Bryn Knight stated:

I had my PSTs look back at their lesson plans, and said, “Okay, now that you know about this, where can you add some more and again?” I did that towards the end of the semester when they were so done. So, I’m going to try to move that up next semester. But I really would love to do that again, because I think having them work on something and then say, “Now, let’s go back to your lesson plans now and let’s add to it practically.” And they didn’t take it super seriously in their written assignment, but in the class discussions it was clear that it was good that they were able to say, “Oh, yeah, I could add something here or add something there to make it more critical.” (para. 124)

First, the PSTs in her class wrote lesson plans for their respective K-12 contexts. After having students engage with the DLM, she had students use deeper learning content as tool for reviewing and revising their lesson plans. In other words, Bryn’s PSTs adjusted their lesson plans based on where they could incorporate more opportunities for deeper learning. Unfortunately, the lesson plans from this activity were not among the artifacts collected from that program.

While these two quotes exemplify how teacher educators adjusted module delivery to meet the needs of their students, some teacher educators also described ways in which they attempted to adjust module delivery because of misalignment between content areas and the content areas used as examples in the modules. For example, Melissa Stone, who taught math PSTs, said, “I would have loved if the video would have been subject specific. It was a social studies lesson in fifth grade, so it wasn’t really applicable to the students that I teach” (para. 133).

Regardless of the specific type of adjustment made to module delivery, every teacher educator who described adjusting the module described doing so to meet the needs of their students in some way. Whether this had to do with student capacity, available time, course or program structure, or content relevancy, the vast majority of teacher educators in this study described working to use the DLMs in such a way that directly met the needs of their students. Table E4.11 in Appendix E gives an array of quotes which demonstrate these two main types of adjustments.

1.3. Differences Between Groups

Finally, in this subsection, I consider research question 1.3, which focuses on differences in conceptions of and teaching practices for deeper learning between two groups: teacher educators who engaged in module development and those who did not. Of the 14 teacher educators in this study, six of them participated in the module development process which took place starting in 2020, prior to any research efforts regarding module implementation. A list of all participating teacher educators, grouped by their participation in module development, is given in the Methods section (Table 3.4).

When considering differences between the two groups, I identified two subcodes as being potentially insightful: *deeper learning as a framework/resource* and *limitations or developing practice regarding preparing teachers for deeper learning*. First, participants in the non-development group cited *deeper learning as a framework/resource* more frequently (14 times) than those in the development group (4 times). Second, participants in the development group cited *limitations or developing practice regarding preparing teachers for deeper learning* more frequently (31 times) than those in the non-development group (22 times). For counts of all relevant codes, separated for the two groups, see Table E4.12 in Appendix E. Here, I focus on these two subcodes: *deeper learning as a framework/resource* and *limitations or developing practice regarding preparing teachers for deeper learning*.

Regarding *deeper learning as a framework*, some teacher educators who had not been previously exposed to the modules described seeing deeper learning as a framework more in terms of guiding their own learning than in terms of guiding their teaching. Consider a quote from Sue Eastern:

I had a general sense about what was meant by deeper learning before engaging with these modules. So, I knew that there were several areas in which students could engage in specific skills that would actually allow them to incorporate content knowledge at a deeper level to be able to apply that content knowledge across multiple situations. So, I knew things like collaboration. I knew things like critical thinking and problem solving. I knew things like communication, but I didn't have the specific language from the deeper learning framework that you all sent to us.

Again, this quote does not seem to highlight how Sue viewed *teaching for* deeper learning. Rather, it seems to highlight how she used the concept of deeper learning as a framework to reorganize or restructure her own mental model of teaching for deeper learning. In another example, we can see how Bryn Knight seemed to position deeper learning as a framework for enabling her PSTs to connect ideas together, specifically between deeper learning and child development:

I would say most like, I've been most excited about how it does connect with kind of the dry material of child development. We have to cover about 10 theorists, and it can be very dry. So it's exciting for me when they say, 'Wow, the theorists actually make sense now.' So, I think I was just surprised by those connections. It's always fun to hear students like the material that you know can be dry. (para. 44)

Given that both of these examples come from teacher educators who were not in the module development group, it may be that seeing deeper learning as a framework is a relatively novel way for integrating ideas about teaching together.

Second, when considering how the teacher educators in this study described *limitations or developing practice regarding preparing teachers for deeper learning*, one key trend is that the teacher educators in the module development group tended to describe limitations that considered a larger perspective on teacher education and teaching for deeper learning. In some cases, this had to do with limitations caused by the demands placed on preservice teachers such as with performance assessments such as the edTPA (e.g., Ryan Snow, Melissa Stone). In one case, this had to do with other teacher educators within the program not having the capacity to incorporate deeper learning (Ryan Snow). And in one case, challenges to module implementation were tied into the overall sense that deeper learning is “non-existent in the curriculum” (Tiffany Ryan). These connections to a larger context for teaching for deeper learning and preparing teachers for deeper learning are discussed in more detail in the discussion.

Beyond these two specific differences, I noted no major differences in trends between those who developed the modules and those who did not. However, there were two participants (both module developers), Ryan Snow and Tiffany Ryan, who expressed a view of deeper learning that differed considerably from the other participants. Specifically, their views seemed to extend to a larger context for teacher education and teaching for deeper learning, which highlighted some of the external influences that have limited the relevance of teaching for deeper learning in teacher education.

First, we consider Tiffany Ryan. When asked for a description of what comes to mind when she hears the term deeper learning, she first described her views of deeper learning prior to involvement in the modules before considering some of the challenges that teacher educators face when working to incorporate deeper learning:

What would come to mind prior to my involvement is just that, as education preparation programs, not enough time is focused or spent on deeper learning. And then also when

we originally thought about this concept the challenge is how to incorporate it in the education preparation program and get buy-in from all faculty, because deeper learning is something that needs to have multiple—you need multiple attempts, multiple applications across content areas. So there has to be buy-in. I would say, there's a lot of challenges that I could think about as far as implementation, practice, and then how is deeper learning applied in clinical experiences? In order to have really true transformation, all of those pieces are really important. Deeper learning was pretty much non-existent in the curriculum. And I would just say not just Silver Maple, but I would almost say every education prep—or, very few education preparation programs have or are going deep into deeper learning such that it's something that novice teachers are doing well by the time they get in their classroom. (para. 24)

Here, Tiffany Ryan described a larger context and vision for preparing PSTs. In particular, she did this by invoking the trajectory that PSTs are ostensibly on, which is becoming novice teachers in their own classrooms. While other teacher educators also considered that their PSTs will have their own classrooms one day, Tiffany was one of the few participants who integrated a description of deeper learning and a reflection on the past and current state of teacher education into their discussion of deeper learning. Within that consideration of the general state of teacher education, Tiffany described how teaching for deeper learning is something that cannot simply happen at the classroom or teacher level, but requires input from other key contributors (e.g., other teacher educators) or in other relevant contexts (e.g., clinical experiences). In a sense, Tiffany considered deeper learning both as a concept and as the systems and experiences that enable beginning teachers to become the types of teachers who successfully teach for deeper learning.

Second, we consider Ryan Snow. When asked various questions about his conceptions of deeper learning and for a formalized definition of deeper learning, he described a larger, historical and academic context for the work of deeper learning and preparing teachers to teach for deeper learning. The original quote is particularly lengthy, so I include only an excerpt here:

Deeper learning is about increasing the intellectual rigor of the education that we provide students. A higher, deeper level of rigor than the field has seen for several decades, and I think it was in some ways a natural outgrowth of the standards-based movement that began in the late in the late 80s and early 90s, when the academic standards were raised for young students. Eventually, that meant that the standards for the teaching profession needed to be raised. It wasn't just a simple matter of saying, as I believe President [H.W.] Bush did, that we were going to get to 100% high school graduation rate, or that our SAT scores were going to go up, or that students' grades were going to go up. For that to happen, the field had to recognize that means teachers need to do a better job of teaching, and schools need to do a better job of teaching students. And what Jeannie Oakes and many other people were also pointing out that we needed to de-track schools, and teach not just to the AP or honors classes, but to everyone, to the regular students, too. So deeper learning, I think, is the result of decades of work. We can say it's Jeannie Oakes and Linda Darling-Hammond, but it's the hundreds of their disciples and students and doctoral students that agreed and said, "Yes, we do need to teach in better ways, more rigorously challenging ways." And that for me, is what the deeper learning modules have done, to just show very specific ways in which we can improve practice. As noted, in this example, Ryan Snow provided a uniquely historical and academic perspective on deeper learning and teaching for deeper learning. Among all teacher educators in this study, this was the only instance where a participant described viewing deeper learning in either

historical context (e.g., education reform efforts in the United States) or academic context (e.g., the work of Jeannie Oakes, Linda Darling-Hammond, and others).

Chapter 5: Findings, Part 2: Preservice Science and Mathematics Teachers

In this chapter I discuss findings for the second question set focused on preservice science and mathematics teachers (PSTs). The research questions are reproduced below.

- 2.1 How did preservice science and math teachers conceive of deeper learning?
- 2.2 How did preservice teachers describe their teaching practices in relation to, or in the context of, teaching for deeper learning? How did preservice secondary science and math teachers describe their experiences in being prepared to teach for deeper learning?
- 2.3 In the findings to the above questions, what differences were present between those taught by teacher educators who developed modules and those taught by other teacher educators?

2.1. Conceptions of Deeper Learning

For research question 2.1, there were eight different ways in which I categorized how PSTs in this study conceptualized deeper learning. First, considering the most common occurrences for codes for *conceptions of deeper learning*, the three most common ways were: (1) deeper learning as contrasted with surface learning, (2) as self-identifying as having a limited or developing understanding of deeper learning, or (3) deeper learning in terms of outcomes related to deeper learning. I highlight these three codes because occurred the most frequently across all nine interviews and two focus groups and were mentioned by the majority of participants. Of the 17 participants in this study, 14 described deeper learning as contrasted with surface learning, seven described having a limited or developing understanding of deeper learning, and 11 described deeper learning in relation to various outcomes. A table displaying counts for each subcode, organized by participant and focus group, is provided in Appendix E (see Table E5.1). Below, I discuss these general trends and include specific examples. I then share findings of a

conception of deeper learning that emerged from the data, which is that for many of these preservice teachers connect their understanding of math and/or science to their understanding of deeper learning.

Deeper Learning in Contrast to Surface Learning

The most common way PSTs in this study described their conceptions of deeper learning was by directly contrasting it with surface learning. There were 18 such occurrences which came from 14 participants (between interviews and focus groups combined). Many of the PSTs explicitly used the term “surface” in contrasting deeper learning with surface learning. These responses also had a range of specificity in them. Some examples of contrasting deeper learning with surface learning were relatively vague on how that looks in practice, such as in this example from Hope Lee: “Deeper learning to me is like learning more than just like the surface information, like really going in-depth about everything, and kind of pulling real-life experiences in there” (para. 35). She clearly noted a distinction between deeper and surface learning, but beyond “pulling real-life experiences in”, it remained unclear how deeper learning and surface learning are functionally different.

In contrast, other examples incorporated identifiable outcomes of surface learning as compared to deeper learning, such as in this example from Dylan Stewart:

When I think about deeper learning, it’s sort of hinting at that idea of there’s a surface level memorization that students can do in order to, you know, pass the class or do well on a test. And then there’s the higher level like meta thinking of these concepts, and being able to apply critical thinking to a problem that they haven’t quite seen yet. (para. 35)

In this case, Dylan referred to a specific outcome that would indicate surface level learning (memorization) and contrasted that with a specific outcome that would indicate deeper learning (applying critical thinking to a new problem, i.e., transfer).

These two quotes briefly exemplify the pattern within the responses overall, that while many of the PSTs in this study viewed deeper learning in contrast to surface learning, some PSTs took this description further and provided insight into how, specifically, this might look for them. As for how these two kinds of learning might look, multiple PSTs in this study described surface learning by referencing memorization, while deeper learning often had to do with application. Further, by looking at the language within these examples, we can also see that for these PSTs deeper learning may also entail taking an active position in learning. We see this in phrases such as “going in-depth” (Hope Lee) and “apply critical thinking to a problem” (Dylan Stewart). This is not to say that memorizing something does not take active effort. Rather, that it seems the effort and outcomes involved in deeper learning are different than in surface learning. Other quotes which exemplify this trend are given in Table E5.2 of Appendix E.

“I feel like I’m just saying buzzwords”: Limitations and Developing Understanding Regarding Deeper Learning

The second most common trend in how the PSTs in this study described deeper learning was by describing how they were, in essence, still learning about deeper learning. There were 17 instances of *limitation/developing understanding of deeper learning*, which came from eight of the nine interviews (no occurrences from focus groups).

Two important methodological notes apply to findings within this subsection. First, in order for a segment to be coded as being an instance of *limitation/developing understanding of deeper learning*, the participant themselves had to indicate that explicitly in some way. My coding

collaborator and I were not to judge the participants understanding of deeper learning relative to a particular definition or understand and deem it “limited” in that way. In other words, participants needed to self-describe their understanding of deeper learning as limited or in terms of an understanding that was ongoing or developing. In some cases, participants compared or contrasted their understanding of deeper learning at the time of the interview with their understanding of deeper learning before engaging in the modules or before studying in their teacher education program. In other cases, participants simply stated, “I don’t know.” Second, while limited understandings and developing understandings are distinct concepts, it proved practically difficult to determine where a limited understanding ended and a developing understanding started. As a result, we kept these two codes together within the same category.

Here, I highlight a few quotes which exemplify trends within this category. Additional quotes are included in Table E5.3 in Appendix E. Looking across examples where PSTs described their understanding of deeper learning as being limited or developing, there were three notable trends. The first trend was that some PSTs were not able to communicate a clear definition of deeper learning. For example, Hope Lee said:

I don’t think I could say a lot about deeper learning, but I guess learning more or realizing that there’s so many things that are in education, and like there’s so many things going on, and so many things to learn about. That’s about it. (para. 85)

The second trend was that these PSTs described developing understandings of teaching for deeper learning and the specifics around that. For example, Gemma Bailey described how her understanding of deeper learning and teaching for deeper learning changed as result of her teacher education program:

I would say I wasn’t really sure before doing this program, like, how to start with doing deeper learning. Like, I don’t know what kind of activity would help with that, or what I

should even do as a teacher elicit that. And I feel like through to my different classes and placements, I've kind of realized it doesn't always have to be a big activity. Sometimes even just doing class discussions using certain type of questioning and getting students to respond to each other, or even just explain, can do it in small ways. (para. 87).

Specifically, Gemma mentioned that her perspective changed in that teaching for deeper learning can sometimes be done through smaller teaching acts rather than through "a big activity."

Finally, the third trend was that some of the PSTs described changing views on the value of deeper learning and teaching for deeper learning. Elsa Henley, for example, contrasted her view of deeper learning at the time of the interview with her view of deeper learning before starting her teacher education program. She said:

What was my understanding of deeper learning before? I never heard that word before. Nobody cared. You either have it or you don't, move on. So, before all of this, I wouldn't say it was someone else's responsibility. I didn't think that another person could care about your own learning. I didn't think that it was another person's responsibility to care about how to help you learn. So no, I knew nothing about deeper learning." (para. 53)

Here, we see that Elsa is not only describing that her view of learning has changed, but that her view of responsibility within teaching and learning has changed.

Briefly, I highlight two less common trends within these examples, but I include them because they might help inform how teacher educators can support PSTs as they develop their own mental models of teaching for deeper learning. Specifically, that PSTs might be looking, so to speak, for ways to connect various education-related constructs together into actionable mental models. Across these examples where PSTs described having a limited or developing understanding of deeper learning, I also found that the PSTs in this study had a sense that there

was more to know. Ruby Shaw, for example, described having had guidance on how to make deeper learning happen, but also clearly expressed a desire for more opportunities and practice for taking that knowledge and applying it in her classroom teaching. As a more straightforward example, while Hope Lee described not being able to say much about deeper learning, she followed it up with a note that there are a lot of things going on within education and many things still to learn.

Finally, Rose Johnson offered a definition of deeper learning which directly aligned with transfer. And yet, she seemed to indicate that her own understanding of deeper learning was limited. By the book, she seemed to understand the concept. But by saying “I feel like I’m just saying buzzwords”, she indicated that something was lacking in her understanding of deeper learning. This sense of her limited understanding may have to do with teaching for deeper, applying this definition of deeper learning in her own learning, or something else—we do not know. Nonetheless, it is a reminder that PSTs were still developing their understandings of deeper learning and teaching for deeper learning.

Outcomes of Engaging in Deeper Learning

The third most common trend in how the PSTs in this study described deeper learning was by identifying various *outcomes of engaging in deeper learning*. There were 11 instances of this code which came from 11 participants (from five of the nine interviews and both of the focus groups). Some of these outcomes referred to transfer of learning, while other outcomes had to do with developing understanding.

Similar to some of the teacher educators in this study, some of the PSTs in this study did not explicitly use the term “transfer,” but rather described outcomes which align with transfer. We first saw this in the example from Dylan Stewart described above, which he extends:

And I think that is a big point in deeper learning is that you're teaching them not the exact concept, but you're teaching them how to use these concepts and apply them into different areas within your subject. I think that's a big thing in math and science, especially. (para. 35)

In this case, teaching students to be able to transfer their learning is not only a part of deeper learning but is an important aspect of math and science (which is the topic of the following subsection).

Second, I found that multiple PSTs described deeper learning in terms of having or developing a deeper understanding of a given topic. In some cases, this deeper understanding was directly connected to the outcome of transfer. For example, a focus group participant stated, "You gain a deeper understanding of whatever that subject is and you're able to go out and use that" (New Cypress FG2 participant, para. 40). Here, they described that learners first gained a deeper understanding of that subject matter which then enabled them to transfer that knowledge. While this focus group participant described subject matter more generally, some PSTs in this study also thought about deeper learning explicitly in terms of their subject areas (as in the example from Dylan Stewart discussed above), which moves us to the next subsection.

"Procedural versus conceptual math": Math- and Science-Specific Conceptions of Deeper Learning

One pattern that emerged from the data was that some of these PSTs described deeper learning in relation to their subject areas, specifically, math and science. I found 16 instances of such math- and science-specific conceptions of deeper learning. Participants from both focus groups used math or science in some way as a part of their descriptions of deeper learning or teaching for deeper learning. Considering the interviews, seven of the nine PSTs in this study used math or science in some way as a part of their descriptions of deeper learning or teaching

for deeper learning. Five of those seven were math PSTs; the other two were science PSTs. Math- and science-specific conceptions of deeper learning also appeared in both focus groups. For this dissertation, I did not try to separate math-specific conceptions of deeper learning from science-specific conceptions. The main reason for this is that the math and science PSTs in this study did not exclusively use examples from their own subject area. For example, one of the math PSTs referenced both math and science (see the quote from Dylan Stewart in Table E5.4, Appendix E), and one of the science PSTs (Miley Jones) used math-specific examples in their description of deeper learning, which I discuss in more detail below.

In terms of specific math or science constructs, these PSTs referenced things such as negative exponents, the importance of transfer within math and science, indigenous mathematics, hands-on math tools (e.g., Lénart sphere), area and volume problems within calculus, soil and dirt, how human hearts work, and the difference between procedural and conceptual math.

This last notion, the difference between procedural and conceptual math, was mentioned by two different PSTs. I highlight it by considering a quote Miley Jones, a science PSTs, where she considered the difference between procedural and conceptual math:

I keep going back to this idea of procedural versus conceptual math. In procedural math, there's no real connection to it. It's just like, you do these three steps and then you get your answer. And I think part of that conceptual understanding is building in the background knowledge and building in cultural responses. And making sure that your students are represented in whatever word problem you're doing, and it's not just 'Do 1 through 10 for homework.' It's like, here's a real-life example of this bicyclist and he's like riding down a hill in a certain area—just giving more context to a math problem,

than having kids do randomness. I think that has become a lot more important to me, too. Also, procedural it's just like, so bad because the kids don't learn anything (para. 77)

In attempting to make sense of this quote, we can first consider Miley's description of procedural math: "Procedural is very much like there's no real connection to it. It's just like, you do these three steps and then you get your answer." Later in the quote, she critiqued procedural math by asserting that "the kids don't learn anything." In contrast, she described conceptual understanding and math problems which work to build conceptual understanding as "building in that background knowledge, those cultural responses, and making sure that your students are represented in whatever word problem you're doing. It's like here's this real-life example of this bicyclist and he's like riding down a hill in your area." It seems that for Miley one critical difference between procedural and conceptual math related to the corresponding outcomes. In procedural math, a student does three steps, gets their answer, and moves on; there are no connections to be made for learners engaging in procedural math. It might be that connections (internal or external) are one of the corresponding outcomes for engaging in conceptual math, but she did not make that explicit within her quote. A second critical difference, it seems, has to do with teaching approaches. In engaging students in procedural math, Miley essentially described traditional bookwork-style practice as the main teaching strategy ("Do 1 through 10 for homework"). To contrast, in engaging students in conceptual math, Miley described a few different approaches to teaching which, for her, went beyond doing problems "1 through 10." Specifically, she described drawing on students' background knowledge, incorporating cultural responses, using real-life examples, and contextualizing problems by incorporating local context ("a hill in a certain area").

Regardless of the specific math or science concept they used, this example (and those included in Table E5.5 of Appendix E) exemplifies that many of the PSTs in this study used their prior knowledge in math and science to help them make sense of deeper learning and teaching for deeper learning. In looking for additional trends for how these PSTs used math and science to make sense of deeper learning and teaching for deeper learning I considered various cooccurrences of codes, which is the focus of the following subsections.

Code Cooccurrences: Conceptions of Deeper Learning x Math- and Science-Specific Conceptions of Deeper Learning

After identifying that the math and science PSTs in this study used both math and science to describe their understandings of deeper learning and teaching for deeper learning, I looked at various cooccurrences of codes with these *math- and science-specific conceptions of deeper learning*. The first set of cooccurrences I considered was *conceptions of deeper learning* with *math- and science-specific conceptions of deeper learning*. Of these cooccurrences, the most common cooccurrence was with *deeper learning in contrast with surface learning* (8 total cooccurrences). Considering this was one of the most common ways in which the PSTs in this study described deeper learning, this is perhaps somewhat unsurprising. (However, since *limitations/ developing understanding* was the second most common code from conceptions of deeper learning, we might then also expect that cooccurrences with *limitation/ developing understanding of deeper learning* to be the second most frequent cooccurrence. It turns out that is not the case, which I treat in the discussion.) Here, I focus only on cooccurrences between *math- and science-specific understandings of deeper learning* and *deeper learning in contrast with surface learning*, of which there were eight occurrences across six interviews and two focus group participants.

There is one example, in particular, which provides insight into how PSTs in this study used math and science to describe their understandings of deeper learning and teaching for deeper learning:

When it comes to math, my understanding of deeper learning is always making sure that the students are understanding it conceptually, and not just procedurally. I guess an example of this would be something with exponents. Procedurally, if you have negative exponents, most students would know, “Oh, you just flip it or you do the inverse of it, and then change the negative exponent to be a positive.” But I guess conceptually, I’d like students—deeper learning, to me, would be students knowing that actually with negative exponents you’re just dividing by that number. (Cheng Han, interview, para. 21)

This example is somewhat similar to the example from Miley Jones discussed earlier in that Cheng contrasted surface learning and deeper learning by highlighting procedural versus conceptual knowledge in math. However, in this example, Cheng viewed this both from the learner’s perspective and from her own perspective as a teacher. From the learner’s perspective, she considered what they might *do* procedurally and what they might *know* conceptually. However, she seemed to situate her example in a *math teacher-specific* context. First, she highlighted, “when it comes to math,” and second, she noted that deeper learning has to do with “making sure that the students are understanding”. From this example, Cheng not only made sense of deeper learning in terms of different types of knowledge (procedural and conceptual) but actively considered deeper learning in terms of what the learner is doing or knowing and in terms of what her approach and expectations might be as a teacher.

Conceptions of Teaching for Deeper Learning

In the first part of my findings, focused on teacher educators (Chapter 4), I described examples of one emergent code category: *conceptions of teaching for deeper learning*. This code

category emerged from reviewing data from teacher educators, but it is reasonable to consider that PSTs also had conceptions of teaching for deeper learning. As such, I also coded PST data for occurrences of teaching for deeper learning.

There were 64 occurrences of codes for conceptions of teaching for deeper learning across the two focus groups and nine interviews (for full counts, see Table E5.6 in Appendix E). The most common occurrence of conceptions of teaching for deeper learning among these PSTs were *limitation or developing understanding of teaching for deeper learning* (30 occurrences across seven of nine interviews). Below, I discuss several examples of how these PSTs described these limitations and developing understandings. Then, in order to highlight subject-specific findings as they relate to teaching for deeper learning, I consider cooccurrences of *conceptions of teaching for deeper learning* with *math- and science-specific conceptions of deeper learning*.

Limitations or Developing Understandings of Teaching for Deeper Learning.

I have previously discussed how the PSTs in this study described their conceptions of deeper learning as being limited or developing in some way. My coding collaborator and I followed the same rule for coding these types of limitations, namely, that participants had to make it explicit in some way and we were not to interpret their understandings as limited. Here, I discuss a few quotes which exemplify some of the limitations or developing understandings that these PSTs expressed in their interviews or focus groups. A wider range of example quotes is provided in Table E5.7 of Appendix E.

There were two common types of limitations or developing understandings that these PSTs expressed. First, many PSTs in this study expressed a desire to learn more about teaching for deeper learning while also referencing something specific which they connected to teaching for deeper learning. Carey Kochen, for one example, when asked what he would like to learn

more about as it pertains to teaching for deeper learning described wanting to learn more about Universal Design for Learning (UDL):

I would like to learn more about critical education. I understand that critical thinking is one part of critical education. I would like to learn more about UDL, but not online. I would like to learn it in person so that way I can actually absorb it, rather than just have it go in one ear and out the other. (para. 139)

For Carey, “critical education” is an important aspect of teaching for deeper learning, and it seems that UDL is one component of critical education that he would like to learn more about.

The second trend is demonstrated by the following two quotes from Elsa Henley and Miley Jones. First, the quote from Elsa Henley:

When I first came here, I hated those open-ended questions. I thought, ‘Ugh, can you just give me multiple choice so we can move on?’ But now, I ask open-ended questions all the time. It’s even helped my relationship with my husband. I’m always like, ‘Let’s ponder and let’s kind of talk through this. And let’s think about it.’ I’ve even changed my vocabulary. It sounds kind of cheesy, but saying things like, ‘I wonder if we could do this,’ and ‘I wonder if we could do that,’ and ‘I invite you to try this out.’ Just kind of changing the way that I communicate with people, not thinking that I have to be blunt all the time and direct all the time. But being able to connect, wanting to connect, with the person that you are learning with and teaching with, and just being patient. I feel like the classes we’ve taken have really allowed for that. There was a lot of self-reflection, and looking at your own education, and looking at how you were brought up and considering what you’re trying to bring to your future learners or future students. (para. 57)

And, next, the quote from Miley Jones:

I definitely think deeper learning is more important than I thought it was. Especially the idea of incorporating everyone's background knowledge and different cultural backgrounds. I have a little bit of personal experience with that, because I went to a very small school. I was the only Jewish girl in my whole grade for as long as I can remember. And we would do activities that were related to Christian things, and I was just like, "Okay, I don't care, good to know." And I think having that personal experience and then watching the modules and being like, "Oh, other people are going through this, too," and "Here are ways that I can make it better for those students in my classroom." (para. 73)

In general, these two quotes follow a similar pattern of identifying some specific limitation in their own learning experiences and then connect that to their future teaching practice. To illustrate this more clearly, first, we see that Elsa described being frustrated with teaching strategies they experienced at Violet Grove University (open-ended questions); Miley described her experiences as a Jewish student in a predominately Christian culture. From there, Elsa described that over time they began to see the value in it and in practicing it (such that it even helped her relationship with her husband!); Miley described that experiencing this as a student might influence how she incorporates different cultural backgrounds for her future students. Both of these PSTs ended with the idea that their experiences might influence how they teach their future students. Just considering Elsa's quote, she described how reflecting on this, along with other experiences she has had as a learner, might impact her future students, noting there was "a lot self-reflection and looking at your own education, and looking at how you were brought up and considering what you're trying to bring to your future learners or future students" (para. 57).

Code Cooccurrences: Conceptions of Teaching for Deeper Learning x Math- and Science-Specific Conceptions of Deeper Learning.

Earlier, I provided examples which illustrate how the PSTs in this study used math and science in describing their understandings of deeper learning. There were also instances which highlight how these PSTs used math and science in describing their understandings of *teaching for deeper learning*. The second set of cooccurrences of codes I consider are those between *conceptions of teaching for deeper learning* and *math- and science-specific conceptions of deeper learning*. Out of all the interviews and focus groups there were only a total of nine cooccurrences of these codes.

Considering that there were 16 occurrences of *math- and science-specific conceptions of teaching for deeper learning* and 64 occurrences of *conceptions of teaching for deeper learning*, I found it somewhat surprising that there are only nine cooccurrences of these two codes. As such, there may be implications here for teacher educators which I treat in the discussion.

Looking across these examples, I identified a few trends in how these PSTs use math or science in describing their understanding of teaching for deeper learning. First, in some cases, math or science is simply used as an example. For example, a participant from Focus Group 1 stated: “So, if you’re teaching cell organelles, giving students the resources to help research for themselves and get more information” (para. 54). They used teaching cell organelles as an example of something they might be teaching, but the following approach to teaching is not necessarily science-specific. In other words, they mentioned the science content but provided a teaching strategy that could reasonably be used in other subjects. Some explanations are even more generalized. Rose Johnson described how one teacher education course allowed her to see different ways of creating math lessons. She did not describe any of the specific ways in which she would create a math lesson that facilitates opportunities for deeper learning. Instead, she described what she would *not* do in creating such a lesson: “Here’s how you do it, and then here

are these practice problems” (para. 71) (demonstrating a procedure and assigning practice problems).

A second trend within these responses takes a more explicitly subject-specific view of teaching for deeper learning. Gemma Bailey, for example, explicitly brought in a teaching approach used to facilitate productive discussions in math classes (Smith & Stein, 2011):

We’ve been talking a lot about the five practices. It’s like creating open-ended tasks, where you have the five core mathematical principles. So, anticipating, monitoring—it’s anticipating student challenges when you create a task and then monitoring students as they work on them in groups. Then selecting students to share in such a way that whatever you select for them to share and show some sort of deeper learning that you then can make connections between. So, there’s selecting and then sequencing it so it’s in an order that the kids can make sense of the connections happening. And then you have the actual class discussion where you make connections between students work and whatever your learning objective is. (para. 95)

In this case, she connected content related to math teaching to *both* teacher and students’ actions for engaging in deeper learning. In terms of teaching for deeper learning, she noted actions such as “selecting and then sequencing” (which come from the five principles from Smith and Stein, 2011) and “the actual class discussion where you make connections”. In terms of what the learner does, she noted that students work to “make sense of the connections happening”. Additionally, it seems that those teaching actions (selecting and sequencing) provide an opportunity for students to engage in sensemaking. Additional quotes which exemplify these trends while making reference to other aspects of math or science teaching and learning are included in Table E5.8 of Appendix E. As noted in the previous treatment of how these PSTs use math and science to describe deeper learning and teaching for deeper learning, it seems that

they were drawing on their content knowledge to help them actively develop mental models for teaching math or science for deeper learning.

2.2. Teaching Practices and Preparation Experiences Regarding Deeper Learning

Research question 2.2 has two parts. The first focuses on how the PSTs in this study described their teaching practices for deeper learning in K-12 contexts, and the second focuses on how they described their teacher education program experiences regarding teaching for deeper learning. First, I discuss findings for each of these two parts. Then, I consider relevant cooccurrences of codes.

Preservice Teacher Teaching Practices for Deeper Learning in K-12 Contexts

There were 125 occurrences of various teaching practices for deeper learning across the nine interviews and two focus groups. These occurrences are detailed in Table E5.9 (see Appendix E). In describing how they approached teaching for deeper learning in K-12 contexts, the PSTs in this study most frequently described their *planning/reflection* and *specific instructional strategies*. There were 39 occurrences of *planning/reflection* across eight of the nine interviews and both focus groups, and 36 occurrences of *specific instructional strategy* across seven of the nine interviews and both focus groups. Below, I highlight a few examples from each and discuss trends within those examples.

PSTs' Planning and Reflections for Teaching for Deeper Learning in K-12 Contexts.

Planning and reflection are two distinct constructs, but it became difficult in practice to clearly separate the two since in many of the instances where PSTs described planning, they also reflected on various ideas and experiences related to teaching for deeper learning. However, I also believe that when treated together, planning and reflection provide insight into how PSTs started to approach teaching for deeper learning. I say *started to approach* teaching for deeper

learning because, at the time of these interviews, some of the PSTs in this study had not yet had opportunities to be the lead classroom teacher (whether through classroom takeovers, substitute teaching, or some other means). Because some PSTs had not yet been the lead classroom teacher, many of those reflections are oriented around how engaging in the modules *would* change their practice as future teachers. As such, these quotes can provide insight into the thoughts and considerations future teachers made in anticipation of their future teaching practice. One example of this can be seen in a quote from Hope Lee:

We had an assignment where we could make kind of like an icebreaker activity to allow students to be able to share their community, personality, and culture. We didn't have to present to any students, but we presented it like to everyone else in the class. I thought that was really fun. I think a lot of those activities I could really implement in my classroom in the future. We have been doing them in class, and I hope that our future students would also really enjoy that. (paras. 97-101)

Other PSTs reflected on their experiences in the classroom. Consider the next example from Elsa Henley:

I was talking with this 12th-grader, and his entire career in school has been just learning how to be a calculator and not really seeing the connection between math and the real world. So, I think that being in a math classroom and working really hard to incorporate real-life experience with math, and showing the students how we can use math as a tool to solve our real-life issues, but also use math to understand our real-life issues—I feel like that's where you can make a strong case for deeper learning in a math classroom. (para. 149)

In this example, rather than describing a highly specific teaching practice (e.g., an icebreaker activity), Elsa reflected on a conversation with a 12th-grade student used that as a springboard to reflect on a more general teaching practice (connecting math to real-life issues).

Other PSTs described their experiences in their teacher education program as providing the necessary context for reflection and planning. Here I consider only one quote which specifically exemplifies the trend that some of these PSTs engaged in collaborative planning practices, but others can be seen in Table E5.10 of Appendix E. The following quote comes from one of the focus group participants from New Cypress:

We also have PLC groups, professional learning community groups. And that's who we planned with and do some of our work with. And that's who we do our lesson with at the end of observation—that's who we plan and execute that with. When we write that lesson plan, and we actually put the plan into action, there's a lot of incorporating standards and thinking about the types of students that we're teaching and what kind of activities would fit best for them. For example, we're teaching about plate tectonics, and asking, like, what does this activity represent? And are they going to understand that? Just really digging deep into the student population that we have and what would fit best for them. (para. 99)

In addition to demonstrating how these PSTs engaged in collaborative planning practices (via PLCs), this quote also exemplifies the types of opportunities afforded to some of these PSTs as it pertained to planning to teach for deeper learning, which is the focus of the second part of this research question.

PSTs' Teaching Practices for Deeper Learning in K-12 Contexts.

At the time of these interviews, while some of the PSTs had yet not actively taught K-12 students, other PSTs had had such opportunities. In at least one case (Riley Sherwood), they

described what seems to be a collaborative teaching episode. These instructional strategies are in no way meant to be an exhaustive representation of the specific instructional strategies PSTs use for teaching for deeper learning in K-12 teaching. Rather, they illustrate a range of teaching strategies which PSTs described as being relevant to teaching for deeper learning. These teaching strategies may or may not align with our understandings of deeper learning and teaching for deeper learning. Yet they are relevant to these PSTs. By gaining insight into what sorts of teaching strategies PSTs viewed as appropriate for teaching for deeper learning, we gain insight into how, as teacher educators, we can position certain teaching strategies as being relevant or not relevant for deeper learning.

Similar to the teacher educators in this study, there was a wide range of specific instructional strategies which these PSTs described using. Table E5.11 in Appendix E displays an array of quotes which illustrates these strategies. These specific instructional strategies include discussions in math (Cheng Han, Gemma Bailey), incorporating student interests (Miley Jones), and hands-on activities (Riley Sherwood). Some of these instructional strategies are relatively intensive and time consuming, such as a hands-on activity in which students recreate the Solar System to scale. Other strategies are ones which teachers could use at any moment, such as a think, pair, share. Other PSTs in this study described things like having students make a model of the digestive system (FG2), having students communicate and defend their thinking (FG2), using statistics to talk about drug testing (Elsa Henley), and doing a project where students think about wealth distribution in the United States (Elsa Henley). This list is not meant to be exhaustive, but looking across the examples in this study, I think there are two distinct patterns. First, these PSTs described teaching strategies that are oriented around making thinking visible, typically through discussions. We can see this in two examples, one from Cheng Han and

another from Gemma Bailey. Cheng described incorporating essential questions as a part of facilitating discussions:

For our second placement, we had to do a two-week takeover with us leading the class. And what I've done with the modules, I've looked over the lessons a week in advance, and I tried to think about what were the essential questions of each like day, or the notes for that day, and based off what I could see with the worksheet, try to come up with those essential questions and try to facilitate those discussions with the students more often. Whereas prior to the modules, I think what I did was I kind of just asked questions that I thought would help students understand the question, like, "Does that make sense?" (para. 113)

Not only does Cheng highlight using essential questions to facilitate discussions, she contrasts this with her question asking prior to engaging in the modules (in her case, the Discussion module), namely, that she her question asking was limited to asking students if something made sense. Gemma Bailey (who was from the same university as Cheng), also described facilitating discussions as a way of making students thinking visible:

Some of the strategies from the modules I've done in my own classroom, like, "think, pair, share," things like that. Or even, like, four corners—I've done that with my kids. They love that. But some of the other strategies, I just couldn't really picture how it would work in a math classroom. (para. 54)

In both of these cases, these PSTs explicitly make connections to the modules and the strategies gained from the modules. It is worth noting that in Gemma's case, she also seemed to see that other strategies from the module as less relevant than others (although which specific strategies is not included in the quote).

Second, these PSTs described teaching strategies which are rooted in real-world scenarios and student interests. We can see this in a quote from Riley Sherwood (as well as in quotes from Elsa Henley and Miley Jones, see Table E5.11, Appendix E):

One day, the students went to the art room. And they figured out how many kilometers would equal how many inches so they could make the planets to scale. So, they measure the diameter, and then they've cut out the planet so you could really see how little how tiny Mercury is compared to Jupiter. Yeah, you can tell them that stuff. And it might just go over their head. But if they're really thinking about it, and they're actually in the process of making it, and then they put them on the wall, and they see how little their planet is compared to their classmates. (para. 101)

In this example, Riley described an activity where students worked together to build the Solar System to scale. The activity included real-world content, opportunities for hands-on learning, and opportunities for students to collaborate with one another and see one another's work.

Again, these examples are not exhaustive of the types of specific instructional strategies which these PSTs described as being associated with teaching for deeper learning. However, they can provide a window into the types of activities which are beginning to be incorporated into their mental models of teaching for deeper learning.

Preservice Teacher Education Program Experiences for Teaching for Deeper Learning

Across the nine interviews and two focus groups, there were 260 occurrences of PSTs describing their teacher education program (TEP) experiences related to teaching for deeper learning (a full count is provided in Table E5.12 of Appendix E). The three most common TEP experiences these PSTs described were *general TEP experiences regarding deeper learning* (73 instances from all 17 participants), *specific instructional strategies* (56 instances from all 17 participants), and *general engagement in the deeper learning modules* (54 instances from 15 of 17 participants). Having

previously discussed some of the specific instructional strategies used by teacher educators in preparing these preservice teachers (see Chapter 4: Findings, Part 1), I choose not to focus on that here. Rather, I focus on how these PSTs described their TEP experiences in general and how they described engaging in the various DLMs. As a note, “general” TEP experiences does not include their fieldwork experiences even if that fieldwork was a part of the requirements for their program. These “general” TEP experiences predominantly consisted of their coursework, which included courses on math and science methods, instructional design, critical pedagogies, introduction to teaching, and more. Here, I chose to focus on examples in which these PSTs described their TEP experiences that explicitly fell outside of engaging in the modules, which I treat in the next subsection. Looking across these quotes, I found two main trends that help clarify what these TEP experiences provided to these PSTs. First, these experiences provided PSTs with “opportunities for deliberate practice” (see again Fries et al., 2019). Second, PSTs actively worked to connect their various TEP experiences together. Below, I discuss some examples of each, and a wider array of quotes is provided in Table E5.13 of Appendix E.

To highlight the first trend, as one example, Cheng noted teaching a math lesson within their math methods course and the ensuing discussion:

There was another class where it was deeper learning-adjacent, secondary math methods. In that course, we talked about how when we have students practice, we have students cooperate and present their work. And we try to facilitate those discussions. (para 53)

In math methods, our professor for that has us teach a topic of whatever we choose, and then he wants us to keep in mind these deeper learning things. He wants us to essentially keep in mind deeper learning as we are teaching the subject, the topic of the day. And at the end of that, he kind of reviews how we did our lesson. (para. 57)

Here, the opportunities for deliberate practice are incorporated into a math methods course, where PSTs are able to practice and receive feedback from their peers.

In another example from Elsa Henley, she noted collaborating on interdisciplinary lesson plans with other PSTs in her earlier coursework:

I think one of the things I gained from being in a space with undergrads and younger people, it's helping me get ready for the younger people I'm going to be working with in a classroom. But like I said, we've worked on group projects together, and we've collaborated. Usually, it's in class. I think it was my first my first year that I had projects where we met outside of the classroom. But for the most part, the collaboration is done in the classroom, where we can create lesson plans together. We did some interdisciplinary lesson plans where we merged music and math and came up with a lesson plan and gave a mini lesson in class. (para. 109)

Like the last example, this example also highlights that, when asked about their TEP experience related to deeper learning, some of the PSTs in this study focused on experiences which allowed them to explicitly practice teaching. While it is unclear if these opportunities allowed them to develop teaching practices specifically targeted at deeper learning, it seems that these TEP experiences could allow PSTs to engage in their own process of deeper learning. In other words, whether or not they were practicing teaching for deeper learning, it seems they were engaged in the process of deeper learning as it pertained to teaching. Other examples (not included Table E5.13 of Appendix E) where PSTs described opportunities for deliberate practice included interaction with analyzing in-service teachers' lesson plans (Riley Sherwood), completing teaching performance assessments such as the edTPA (Elsa Henley), and collaborating within a cohort (Cheng Han).

Regarding the second trend, where PSTs are actively working to connect their education experiences together (including both TEP and non-TEP educational experiences), consider first the following quote from Carey Kochen:

Deeper learning is something that I've always had in mind. Just because in my undergrad, I had to take a critical analysis class, but it was like an English prerequisite class. And that really opened up my mind when I was doing my undergraduate work at Sycamore State. But the graduate work in the teaching credential program really solidified that. And really made it to where I was like, "Okay, yeah, I've had the foundation, and now I'm building the scaffolding." (para. 39)

Here, Carey described an experience in their undergraduate education coursework which they connected to their TEP coursework, specifically as it pertained to deeper learning. Further, it seems that their TEP coursework reinforced the importance of deeper learning in their mental model of teaching ("the graduate work in the teaching credential program really solidified that").

For one more example, consider the following quote from Dylan Stewart:

The class I'm in now with Dr. Riemann is called Math Visualization. Basically, the entire class is focused around creating this exploratory math pedagogy, where we're bringing in math concepts but in a way that the students discover the important pieces. So, the students will discover these pieces of math and then be able to apply them onto the problems that you give them in the future. It creates this foundation for them because they're the ones actively finding the information and not just being told. It creates these deeper roots within their brain that they can hold on to this information. (para. 51)

Here, Dylan described a TEP experience which exposed him to a math-specific pedagogical approach apparently rooted in cognitive science ("it creates deeper roots within their brain")

while also providing guidance on how to approach instruction (providing students with opportunities to discover aspects of math rather than simply telling them).

These examples, among others (see Table E5.13, Appendix E) exemplify how PSTs considered their specific TEP experiences as having shaped their understanding of teaching for deeper learning. Other PSTs also described experiences from their TEP or undergraduate studies (outside of those courses which implemented the DLMs) which they connected to deeper learning in some way. These include describing experiences from math methods coursework and working alongside fellow cohort members (Cheng Han, Gemma Bailey) and from introduction to education courses (Rose Johnson, Riley Sherwood). Interestingly, in many of these examples, deeper learning was not necessarily the focus of those courses. And yet, it seems that these PSTs used concepts related to deeper learning to help them integrate prior learning with their current learning regarding deeper learning and teaching for deeper learning.

Cooccurrences of Codes: Teaching Actions for Deeper Learning in K-12 Contexts x TEP Experiences for Deeper Learning and Teaching for Deeper Learning

Here, I consider cooccurrences of the two coding categories: *teaching actions for deeper learning in K-12 contexts* with *TEP experiences for deeper learning and teaching for deeper learning*. If PSTs were, in fact, working to connect or integrate their various TEP experiences together into mental models, cooccurrences of these two codes would be insightful. Specifically, they would provide insight into how these PSTs were actively taking what they had been learning across their TEP experiences and trying to incorporate that into their K-12 teaching practice.

Across all occurrences within these two coding categories, the two most common cooccurrences of codes were *planning/ reflection* with *fieldwork experiences related to deeper learning* (14 instances) and *specific instructional strategy* with *fieldwork experiences related to deeper learning* (13 instances) (counts of all cooccurrences between these two coding categories is provided in Table

E5.14 of Appendix E). On the one hand, this makes sense as PSTs can use their fieldwork experiences to practice different aspects of teaching including, but certainly not limited to, planning, reflecting, and using various instructional strategies for deeper learning. On the other hand, looking into these interview excerpts still provides insight into how these PSTs were both learning and teaching *specifically* as it related to deeper learning.

There are a few distinct ways in which the PSTs in this study described their teaching practices for K-12 students in their fieldwork experiences. First, they engaged their students in activities which exposed students to both math or science concepts and real-world scenarios, such as in this quote from Elsa Henley:

In my first placement, I got a chance to work in a classroom where there was no test at the end of the class, so we were free to do any and all the things. We were working on a project where I was showing them wealth distribution in the US. There's a part where we count beans, and there's a mat on the floor where we distribute the beans to show how things are, or how things should be divided up. And then I show them the actual distribution of wealth. And you just heard all the kids like, "This is so unfair, how come all the rich people get all the beans?" And like, immediately went straight into, "what can we do to fix this?" So, I'd given them like little journals to write about what they were experiencing in class. And I got to read some of their notes, and it was just this whole mixed bag of different opinions. I didn't get a chance for us to have a whole group discussion afterwards but it would have been great to see how we would all come together and see if we could all agree that there were some disparities, and then begin to come up with a plan on how to make things a bit more equitable. (para. 85)

Here, Elsa described engaging her students in an activity that exposes them to math concepts connected to distribution of wealth in the United States. She also described some of the specific

instructional strategies she used, or would have used given more time, which included hands-on manipulation, journaling, and whole class discussion. On a potentially relevant contextual note, she noted an important feature of her placement, that students did not have to take a test at the end of the class, which she connected to having the freedom to engage students in that activity.

Second, some of these PSTs described using open-ended activities, such as described in the following quotes from Gemma Bailey:

When I'm designing activities, like warm-ups, especially—I'm trying to get the kids comfortable talking or explaining their thinking by creating warm-ups where there's not necessarily a right answer and it's more open-ended, and getting them to practice explaining their thinking. (para. 91)

Later in the interview she provided more detail on how she developed this warm-up routine, and she specifically cited collaborating with her cohort:

At one point, I had struggles with getting students to participate in the discussion, so we brainstormed ways to get them going and just talking. And that's how I came up with the whole warm-up routine. As I was talking with my cohort about ways to get student to talk and not have them be a stressed out about having the "wrong answer." (para. 121)

Taken together, these quotes show us that Gemma described a type of open-ended warm-up activity that she developed through collaboration with members of her cohort. In this case, we see that Gemma was experiencing a specific teaching problem in her fieldwork (getting students to participate in discussions), and she enlisted the help of her cohort to help find potential solutions. She described that, through that collaborative process, she developed the idea of using warm-up questions which were deliberately open-ended with no "wrong answer." Interestingly, in this case, it does not seem that the goal was, say hypothetically, "engaging students in deeper learning". Rather, the goal was to increase student engagement in class discussions. So, in this

example, we see one specific instance of a teaching strategy which Gemma connected to teaching for deeper learning (open-ended warm-up questions which help facilitate discussion amongst students), and two instances of relevant teacher education program experiences which helped her to use that strategy in her classroom (the fieldwork placement and collaboration with her math PST cohort).

Finally, I highlight an example from the New Cypress focus group participants because they explicitly connected the teaching strategy with one of the deeper learning modules:

During one of the lessons that I was teaching this past semester, we did an informal assessment of student learning where they worked in a group. They had to create a model of a digestive system, and each student would be assigned a different part of the digestive system. So, one student may be working on the stomach, one student may be working on the small intestine, and so on. Each student was responsible for a part of it. And then at the end they came together and put it all together and attached everything. And that sort allowed them to have a sense of responsibility over it, and I think that's something we saw in the modules that we went through. (para. 70)

They described a specific modeling activity (students co-constructing a model of the digestive system) and specifically cited one potential benefit for students engaging in that type of activity (having a sense of responsibility). According to that PST, providing students with a sense of responsibility in their learning is one aspect related to teaching for deeper learning which was part of the module (in this case, the performance assessment module).

2.3. Differences Between Groups

Recalling from the first question set, in the third research question, I focused on differences in the conceptions of and teaching actions for deeper learning between two different groups: teacher educators who participated in the initial module development and those who did

not. The purpose of this research question (2.3) is to consider the various PSTs using this same distinction.

To make better sense of this data, I recall some of the larger context for this dissertation. There were 14 participating teacher educators, six of whom participated in the module development process. Only two of those six taught math or science PSTs who participated in this study (Sophia Cardinal and Miriam O'Connor, see again Table 3.5 in Chapter 3: Methods). Of the eight teacher educators who did not participate in module development, only two taught math or science PSTs who participated in this study (Melissa Stone and Emily Riemann). There were 12 total PSTs in this study who were taught by teacher educators who engaged in module development (four PSTs in interviews and eight in the two focus groups) and five PSTs who were taught by teacher educators who did *not* engage in module development.

To get an initial glimpse into any differences between PSTs who were taught by module developers and those who were not, I first just considered counts of codes across the various coding categories which applied to PSTs. These four coding categories include: *conceptions of deeper learning*, *conceptions of teaching for deeper learning*, *actions for teaching for deeper learning in K-12 contexts*, and *TEP experiences for deeper learning and teaching for deeper learning*. Table E5.15 in Appendix E shows counts for all the subcodes within those four categories. However, one challenge in simply comparing counts is that the module development group includes both interview and focus group participants. This would mean that we might expect most counts to be higher for the module development group than the non-module development group. In fact, for most of the coding categories noted above, the opposite is true: there are more occurrences of various codes for the non-module development group than the module development group. This is especially true for subcodes of *actions for teaching for deeper learning in K-12 contexts* and *TEP experiences related to deeper learning*. First, and more briefly, I consider the first two coding categories (*conceptions of deeper*

learning and conceptions of teaching for deeper learning) before spending more time on the latter two coding categories (*actions for teaching for deeper learning in K-12 contexts* and *TEP experiences related to deeper learning*).

When considering both *conceptions of deeper learning* and *conceptions of teaching for deeper learning*, I did not find any examples which would compellingly indicate that conceptions of deeper learning and teaching for deeper learning are different between the two groups. For example, the most common conception of deeper learning was in contrast to surface learning. Unsurprisingly, participants from each groups described this in similar ways. For example, Carey Kochen, whose professor was a module developer, described deeper learning as “going beyond the surface, and really figuring out the why—why is this happening? Rather than just what’s happening?” (para. 43). Hope Lee, whose professor was not a module developer, described deeper learning as “like learning more than just like the surface information, like really going in-depth about everything, and kind of pulling real-life experiences in there” (para. 35). Perhaps it is the nature of the subcodes, but, at least when it comes to conceptions of deeper learning and teaching for deeper learning, I found no discernible difference between how PSTs in these two groups described their conceptions of deeper learning or their conceptions of teaching for deeper learning.

However, when considering *actions for teaching for deeper learning in K-12 contexts* and *TEP experiences related to deeper learning*, there were a few examples which might implicate the value of future study in this area.

First, when considering various *actions for teaching for deeper learning in K-12 contexts*, there were more instances where the PSTs in the non-development group described using teaching strategies for deeper learning in K-12 contexts. To illustrate some potential differences across responses, I highlight three examples of PSTs using *specific actions for teaching for deeper learning*, all

four of which I have previously discussed. Rather than reproduce the entire quotes here, in Table 5.1, I provide a summary of the teaching actions. I also include the participant's grade level and whether or not their professors were in the module development group.

Table 5.1

Examples of PSTs Specific Actions for Teaching for Deeper Learning

Summary of Teaching Actions	Participant Pseudonym (Credential Area)	Grade Level for Target Credential	PST Grade Level	Module Development Group?
Moving students from “what” to “why” when baking bread; incorporating cultural aspects of food	Carey Kochen (Science)	Secondary	Graduate	Yes
Incorporating student interests (e.g., baking cookies, pizza) into fraction worksheets	Miley Jones (Science)	Middle Grades (6-9)	Undergraduate	Yes
Using essential questions to guide classroom discussions over two-week takeover	Cheng Han (Math)	Secondary	Graduate	No
Using beans as a manipulative to engage students in math concepts and dialogue surrounding wealth distributions in the United States	Elsa Henley (Math)	Secondary	Graduate	No

Any of these four teaching strategies are reasonably appropriate for teaching for deeper learning in various K-12 math or science contexts. While incorporating cookies and pizza into a worksheet on fractions might not seem particularly rigorous, it might be adequate for generating interest for 6th-grade math students. On the other hand, engaging 6th-graders in a math-based discussion on wealth distribution in the United States might not be as developmentally appropriate as it would be for 12th-grade statistics students. Further considering these examples, incorporating cultural aspects of food production into a food science course could orient students toward deeper understandings of other cultures, and using essential questions to guide

discussions over a two-week period could serve as a powerful tool for providing students with opportunities to express their ideas. In short, any of these strategies might be appropriate for teaching for deeper learning in K-12 contexts. Why, then, would the counts for *teaching actions for deeper learning in K-12 contexts* be much higher for those PSTs in the non-module development group than the module development group?

Grade levels (graduate or undergraduate) were not initially intended to be an aspect of the analysis for this study. However, in looking once more at Table 5.1, I highlight the distribution of graduates and undergraduates between those programs. Specifically, of the 12 PSTs whose teacher educators were module developers, only one was a graduate student (Carey Kochen). Of the five PSTs whose teacher educators were not module developers, only one was an undergraduate student (Rose Johnson). It may be the case that, as graduate level PSTs, they were afforded more opportunities to actively teach in K-12 settings (such as in classroom takeovers and fieldwork placements). This would more reasonably account for the difference in counts of occurrences of various *actions for teaching for deeper learning* between the two groups.

However, I think this raises an additional question: Why were the counts of *teaching actions* so varied between the two groups (36 to 89) while counts of *TEP experiences* were similar (126 to 134)? Ultimately, all the participants in this study were enrolled in a teacher education program, but it may be that those programs were structured differently. Some of the undergraduates in this study who had fewer instances of describing specific teaching actions still described various *TEP experiences related to deeper learning*, such as engaging in K-12 classroom observations where their cooperating teacher was using a teaching strategy they associated with deeper learning (Hope Lee, Miley Jones, and Riley Sherwood). Classroom observations are one example of a *TEP experience* which does not typically afford PSTs the opportunity to actively practice teaching.

In summary, I found no clear differences in how the PSTs in this study conceived of deeper learning when considering whether or not their teacher educators engaged in the module development process. Further, when trying to identify clear differences in teaching actions used by those PSTs, I find that this study was unable to clearly answer that question and suggest that other factors may be relevant (such as program structure and the teaching opportunities afforded to PSTs), which I treat more in the following discussion.

Chapter 6: Discussion

In this chapter, I first discuss and interpret findings for each of the two question sets. Next, I discuss implications for the findings from each question set before discussing implications for the findings as a whole. Finally, I discuss the limitations of this study and propose some directions for future research.

Question Set 1: Teacher Educators

Conceptions of Deeper Learning

When considering *conceptions of deeper learning*, I found that the teacher educators in this study most commonly described their conceptions of deeper learning by associating deeper learning with other education-related constructs and by considering various outcomes of engaging in deeper learning. These education-related constructs include, but are not limited to, Webb's Depth of Knowledge, Bloom's Taxonomy, 21st Century Learning and 21st Century Skills, constructivism, Understanding by Design, productive struggle, and socioemotional learning. These teacher educators also frequently described deeper learning in terms of outcomes such as transferring learning or skills from one context to another, integrating content knowledge, the ability to engage in relevant and theory-backed teaching practices, and the ability to scaffold instruction. These last two highlight a key finding of this study in terms of how teacher educators *conceived* of deeper learning, namely, that teacher educators who were focused on preparing preservice teachers (PSTs) for teaching for deeper learning also held *conceptions of teaching for deeper learning*. In other words, while conceptions of deeper learning and conceptions of teaching for deeper learning are distinct constructs, for many of these teacher educators they overlapped significantly.

These conceptions of deeper learning highlight a partial alignment between how teacher educators described deeper learning and how deeper learning is described in literature. On the

one hand, conceptions of deeper learning in terms of outcome directly align with definitions of deeper learning which highlight transfer as the main outcome of engaging in the process of deeper learning (Mayer, 2011; NRC, 2012). On the other hand, conceptions of deeper learning in terms of processes only partially align. These teacher educators and researchers and committees all describe deeper learning as a process, but in looking more closely, we see that these teacher educators more commonly described deeper learning as an *external* process. In contrast, researchers and committees describe deeper learning as an *internal*, cognitive process and as a corresponding external process (transfer) (Mayer, 2011, 2014; NRC, 2012, 2018). We can reasonably say that those internal cognitive processes (e.g., selecting, organizing, and integrating) are taking place as an internal aspect of these external processes (e.g., teaching (Fiorella & Mayer, 2016)), but the teacher educators in this study rarely described deeper learning specifically in terms of an *internal*, cognitive process.

And yet, the most common way in which these teacher educators described their conceptions of deeper learning did not focus on deeper learning as either an internal or external process. Rather, these teacher educators tended to describe deeper learning in relation to other education-related constructs. For instance, Webb's Depth of Knowledge is a common construct which teacher educators use to expose PSTs to the idea of different tasks placing different cognitive demands on students. The teacher educators in this study frequently cited constructs such as Bloom's Taxonomy and Webb's Depth of Knowledge as being related to deeper learning, and yet the literature which I reviewed for this study made no explicit connection between either of these constructs and deeper learning. In short, the most common way in which the teacher educators in this study conceived of deeper learning did not align with how the literature defines and describes deeper learning. That said, the fact that these teacher educators used other educational constructs to make sense of deeper learning might indicate

they are actively developing their own well-organized and highly interconnected schemas (Biliac & Campitelli, 2018; Carbonell et al., 2014).

Looking into the specific descriptions of how these teacher educators made connections to other educational constructs indicates that these mental models not only have to do with deeper learning but also connect to their conceptions of *teaching for* deeper learning, which I turn to next.

Conceptions of Teaching for Deeper Learning

One unexpected finding from this study is that teacher educators also held *conceptions of teaching for deeper learning* and that these conceptions were frequently integrated with their *conceptions of deeper learning*. Consider, for example, how Mary Oliver described deeper learning in terms of teaching outcomes: “Deeper learning is getting to know and understand your students on a deep level so that you’re able to scaffold your instruction to best support their learning goals and needs, so that they can really reach that in-depth knowledge” (para. 58). Similarly, Caroline Grey described deeper learning in terms of “how can we help our students generalize information to multiple contexts that make them or help them to be as productive and as integrated into life as possible” (para. 61). These two examples, among others, highlight the notion that for these teacher educators “deeper learning” was not just about learning, but it was also about teaching.

Interestingly, we can further extend this to include the idea that, for some of these teacher educators, deeper learning was about teaching PSTs through deeper learning *and* equipping them to teach future K-12 students for deeper learning. Melissa Stone described picturing “a teacher candidate actually practicing deeper learning in their own classroom” (para. 117). Usha Aziz, when asked to give a definition of deeper learning, explicitly started her definition with an important caveat, that “deeper learning is, *for teacher candidates*, the ability to

make decisions on their own feet based on specific situations they are facing (para. 128, emphasis added). For these two teacher educators, teaching for deeper learning was not just about engaging PSTs and K-12 students in certain types of thinking or obtaining certain types of outcomes. Rather, teaching for deeper learning specifically had implications for PSTs and K-12 students, and that by engaging PSTs in deeper learning about teaching they would develop the skills and abilities necessary for engaging K-12 students in deeper learning (about various K-12 subject matter).

Some of the teacher educators in this study took this notion a step further, and described deeper learning as a potential framework for guiding and organizing teaching and learning. Viewed in this way, not only is deeper learning directly connected to other education-related constructs, but it can also serve to organize those constructs into the sort of well-integrated mental schema which teachers can actually use in practice. For example, Sophia Cardinal noted that “we have equity, we have social emotional learning, we have collaboration, right? Deeper learning gives a framework for these different mindsets and a way to connect them” (para. 41). The education-related constructs she cited in this example (equity, social emotional learning, collaboration) are relevant for both teaching and learning. These constructs align with some of the five dimensions of teaching for deeper learning, such as focusing on equity (Darling-Hammond & Oakes, 2019), and with specific instructional strategies which can help facilitate deeper learning in classrooms, such as attending to students’ socioemotional needs (Davidson et al., 2020; Pierson et al., 2022) and providing opportunities for collaboration (Ottmar, 2019). If deeper learning as a framework is to be useful for teacher educators and K-12 teachers, it needs to speak to both the general approaches to teaching (e.g., learning that is contextualized) and the specific strategies which facilitate that type of learning (e.g., using storyline instruction in science education (Penuel et al., 2022)). Further, if viewed as a framework, deeper learning must also be

used to meet the needs of *both* K-12 students and preservice teachers. That said, one teacher educator in this study provided an interesting warning for viewing deeper learning as a framework, namely, that it risks “being one of a number of available frameworks” (Ryan Snow, interview, para. 13). I believe part of the risk Ryan implicated was that if we view and describe deeper learning as a framework, how will it be separate from any of the other “research-backed frameworks” out there? In practical terms, in order for educators to incorporate teaching for deeper learning into their practice, proponents of deeper learning as a framework will need to convincingly position it as more useful than other available frameworks.

Whether deeper learning is viewed as a framework, as an internal or external process, or in terms of teaching and learning, the teacher educators in this study tended to view deeper learning as something which *both* PSTs need to engage in when learning about teaching and K-12 students engage in when learning about content. As such, there is value in teacher educators teaching PSTs to engage in deeper learning in their own learning (about teaching), as it might one day provide opportunities for K-12 students to engage in deeper learning.

To consider this in greater detail, I recall the conceptual model of a learning chain for teaching for deeper learning. At each level, participants are engaging in deeper learning with different content, which yields different outcomes. K-12 students develop highly integrated schema and transferrable knowledge and skills pertaining to physics, literature, stagecraft, and more. They develop this transferrable knowledge through various learning activities, which are facilitated by K-12 teachers. And yet, those K-12 teachers have themselves engaged in deeper learning, and developed their own highly integrated schema and transferrable knowledge and skills. In their case, this transferrable knowledge is not just about their subject matter, but also about *teaching* their subject matter. Following the same pattern, K-12 teachers developed this transferrable knowledge through engaging in various learning activities. At least for the purposes

of this dissertation, those learning activities for beginning teachers are facilitated by teacher educators. Even the teacher educators in this study are engaged in the process of deeper learning as it pertained to their own teaching practice. Recall how Sue Eastern and Bryn Knight described that deeper learning provided language for them to use in their teaching and in integrating various teaching concepts together.

This illustration has demonstrated how deeper learning goes “up” the learning chain. Viewed from the perspective of teacher educators in this study, the goal of preparing PSTs to teach for deeper learning is to eventually provide rich opportunities for K-12 students to engage in the same kind of learning.

With this said, I highlight one potential risk of viewing deeper learning in this way, namely, if we focus on teaching for deeper learning only from the perspective of teacher education, we risk approaching the endeavor exclusively from a top-down approach. In a sense, the current orientation of the learning chain (top-down) illustrates what seems to be the current approach to teaching for deeper learning: Committees, researchers, and teacher educators promote various approaches, frameworks, or curricula into K-12 schools. Perhaps, viewed more optimistically, K-12 students would be at the top of the learning chain, reminding us that K-12 students are the ones who, ultimately, teaching for deeper learning should benefit.

Actions for Preparing Preservice Teachers for Teaching for Deeper Learning

Research question 1.2 focuses on teaching actions for preparing preservice teachers for teaching for deeper learning and also focuses specifically on how teacher educators use the various deeper learning modules (DLMs) to do so. These DLMs are a new resource geared towards teacher educators (SCALE Group, 2024, see also Appendix A), and this aspect of this dissertation represents some of the initial findings on how teacher educators used these modules

to prepare PSTs to teach for deeper learning. Here, I highlight two key findings which illustrate how these teacher educators used the DLMs.

First, I found that the most common way in which the teacher educators in this study described using the DLMs in their courses involved deliberate planning and reflection. In terms of planning, this looked like becoming familiar with the modules (Emily Riemann), collaborating with colleagues on module implementation across multiple courses (Alderwood College), and editing the modules to better fit within the course (Miriam O'Connor). Reflecting and planning often went hand in hand, as some teacher educators used module implementation as an opportunity to reflect on their teaching practice past, present, and future (Ryan Snow). Other instances of reflection highlighted what motivated teacher educators to use the modules in their courses, such as modeling teaching for deeper learning to PSTs (Layla Brussels).

These instances of planning and reflection were also tied to how teacher educators in this study adjusted module delivery to their PSTs. For example, Miriam O'Connor described that she did not "just plug and play" when using the modules in her courses. She described how in the fall semester she explored the module and considered how she wanted to use it in her courses in the upcoming spring semester. When she said that she does not "just plug and play", for Miriam, this meant actively editing and manipulating module content into her existing course structure. Out of the 14 teacher educators in this study, 12 of them described adjusting module delivery in some way. Many of these teacher educators also described *why* they made those adjustments: to meet the needs of their students and to make adjustments to instruction based on contextual factors (e.g., hybrid or remote learning days).

Taking these findings together, it becomes clear that the teacher educators in this study were not simply using the modules as they were designed. By adjusting module delivery, these teacher educators actively demonstrated various dimensions of teaching for deeper learning.

They actively considered the needs of their students and adjusted which aspects of the modules they used accordingly (consider dimension one: learning that is developmentally grounded and personalized). They provided opportunities for students to integrate content from the modules into their own planning and teaching practices (dimension three: learning that is applied and transferred). And they worked to adjust the modules to better align with the contexts and content their PSTs were teaching in (dimension two: learning that is contextualized).

Differences Between Groups

The third research question in this question set focused on the fact that some of the teacher educators in this study engaged in the module-development process while others did not. In the findings, I noted two potentially insightful differences. First, that teacher educators who did not develop the modules more commonly viewed deeper learning as a framework. It may be that these teacher educators were less familiar with deeper learning, and so using deeper learning as a framework helped them to organize their own learning on the matter. Second, teacher educators who participated in module development tended to describe limitations that considered a larger perspective on teacher education and teaching for deeper learning. For example, Tiffany Ryan described deeper learning as being “essentially nonexistent” in the curriculum for preparing future teachers. As another example, Ryan Snow described how other teacher educators may see the value of deeper learning, but simply lack the capacity to implement it in their coursework due to obligations to other, competing frameworks. While this study can describe these “larger” perspectives on deeper learning and teaching for deeper learning, it cannot speak to how they are connected to the experience of developing the various modules. Perhaps this “larger” view of deeper learning in teacher education helped motivate their desire to collaborate with the SCALE Group in the first place. Perhaps developing the modules was a necessary experience in developing this “larger” perspective.

Question Set 2: Preservice Teachers

Conceptions of Deeper Learning and Conceptions of Teaching for Deeper Learning

When considering *conceptions of deeper learning*, I found that the preservice teachers (PSTs) in this study most commonly described deeper learning by contrasting it with “surface learning”. They also frequently described various limitations to their understanding of deeper learning, which would indicate they are still developing their understandings of deeper learning. Interestingly, despite not being asked directly about their conceptions of *teaching for* deeper learning, many of these PSTs described deeper learning in terms of teaching (much like the teacher educators in this study). When looking at how these PSTs contrasted deeper learning with surface learning, they considered both how the actual learning is different and how teaching for deeper learning is different from teaching for surface learning. While just considering learning, this contrast looked like “figuring out the why...rather than just what’s happening” (Carey Kochen, para. 43). When considering teaching, some PSTs sometimes highlighted specific aspects of classroom teaching (e.g., tests) while others highlighted more general aspects of teaching (e.g., going beyond the standards or objectives).

Considering that having a limited or developing understanding of deeper learning was the second most common way in which these PSTs described deeper learning, it may be that contrasting deeper learning with surface learning is a common way in which they are *starting to* make sense of deeper learning. In other words, perhaps contrasting deeper learning with surface learning is part of a “beginning” understanding of deeper learning. Recall the example from Rose Johnson, who noted, “I feel like I’m just saying buzzwords” (para. 48). Interestingly, in the rest of her quote she described deeper learning in two ways, in terms of transfer and in contrast to surface learning: “not just learning content or curriculum, but also being able to apply it and develop other skills that can be used outside of an academic environment”. Despite giving what

we might consider the “right” answer for what deeper learning is, Rose qualified her answer in a way that indicated she did not feel like she properly understood deeper learning.

Math- and Science-Specific Conceptions of Deeper Learning

I also found that the PSTs in this study used math and science concepts in their descriptions of deeper learning and teaching for deeper learning. In some cases, this related to how they conceptualized deeper learning as in contrast to surface learning (Dylan Stewart, Miley Jones). In other cases, they used math or science content to describe specific teaching strategies and approaches (Elsa Henley, Gemma Bailey). One possible interpretation of this finding draws on the notion that by engaging in the process of deeper learning, learners are actively integrating new knowledge with prior knowledge into well-developed schema (Biliac & Campitelli, 2018; Carbonell et al., 2014; Mayer, 2011). Using this idea, concepts of *deeper learning* and *teaching for deeper learning* are new knowledge, while math and science concepts are prior knowledge. We can also put this in a more linear format: If these PSTs are still developing their understandings of deeper learning and teaching for deeper learning, and if they are actively working to connect new and prior knowledge together, it is reasonable to think that they would use their math and science content knowledge to help make sense of deeper learning and teaching for deeper learning.

To further illustrate this point, we can also incorporate one of the critiques from teacher educators about the modules. Melissa Stone, a secondary math methods instructor, noted that one video from the DLM on facilitating discussions was taken from a fifth-grade social studies lesson. *Ideally*, PSTs would be able to watch that video and extract the main ideas for facilitating discussions for deeper learning. However, consider that these PSTs are still learning about using discussions for deeper learning. Not only that, but they are still learning about teaching in general, teaching math, using discussions for teaching math, and more. In a sense, using a fifth-

grade social studies lesson to illustrate facilitating discussions for deeper learning might be, at least cognitively, a step too “far”. This may be making it harder for PSTs to use content from the video as a part of their schema for teaching for deeper learning. On the other hand, subject-specific examples might be “more applicable” not just because they are subject-specific, but also because they are more easily incorporated into the mental models for teaching for deeper learning which PSTs are actively developing.

Actions for Teaching for Deeper Learning in K-12 Contexts

In line with the findings that these PSTs were still developing their understandings of deeper learning, they were also still developing their teaching practices for deeper learning. Many of the PSTs in this study were undergraduate students, and, as such, had not yet had the same opportunities for putting teaching for deeper learning into practice (i.e., they had fewer fieldwork experiences where they were teaching instead of observing). That said, there were a number of specific instructional strategies which the PSTs in this study described using. Rather than reiterate them all, I highlight one example where the DLMs impacted how that PST taught for deeper learning. Cheng Han described using essential questions as a part of facilitating math discussions, but they explicitly noted doing this after engaging with the DLM. While many of the other examples connect teaching practices with TEP experiences, relatively few made such an explicit connection between the content of the module and teaching practice. This leads into discussion about other teacher education program experiences for deeper learning and teaching for deeper learning.

Teacher Education Program Experiences for Deeper Learning and Teaching for Deeper Learning

In addition to engaging in the various DLMs, these PSTs described various teacher education program (TEP) experiences for deeper learning and teaching for deeper learning.

When looking at these examples, I noted two trends. First, PSTs seemed to be actively working to integrate their various TEP experiences together. In other words, they were reflecting on various TEP experiences and trying to fit them together in helping them to develop understandings of teaching and to develop their teaching practice. Second, PSTs highlighted having opportunities for deliberate practice (Fries et al., 2021). These opportunities primarily came in TEP courses and fieldwork placements, and took a variety of forms: practicing math discussions with cohort members, planning and co-planning with cohort members, writing and critiquing lesson plans, and classroom takeovers.

Considerations From Both Question Sets

Taking all of these findings together, this study provides novel insight into how teacher educators and PSTs conceived of deeper learning. Interestingly, the most common conceptions of deeper learning held by these two groups were not aligned. While teacher educators frequently viewed deeper learning in terms of other education-related constructs and outcomes related to deeper learning, PSTs frequently viewed deeper learning in contrast to surface learning.

These conceptions of deeper learning highlight a critical disconnection between how practitioners view deeper learning and how deeper learning is described in the literature. As discussed in the literature review, literature related to deeper learning uses this term in multiple ways. To briefly reiterate, sometimes “deeper learning” refers to cognitive processes that take place *inside the brain* during learning which lead to transfer (Mayer, 2011; NRC, 2000, 2012, 2018); sometimes it refers to these cognitive processes while also including classroom behaviors (Darling-Hammond & Oakes, 2019); sometimes it refers to specific cognitive outcomes (Fries et al., 2021); and sometimes it refers to a set of competencies which learners develop (Hewlett

Foundation, 2013). With these definitions in mind, the teacher educators in this study tended to focus on demonstrable outcomes of deeper learning (e.g., transfer).

Next, and perhaps more importantly, these findings highlight a disconnect between how teacher educators and the PSTs in their classes viewed deeper learning. Ultimately, teacher educators not only wanted PSTs to have well-developed schema about education concepts, but they hoped PSTs would be able to actively use those concepts in practice. Since PSTs viewed deeper learning, and therefore teaching for deeper learning, strictly by defining what it is not, it is not clear how they were able to use this in their practice. Consider the old idiom: “Give a man a fish and you feed him for a day; teach a man to fish and you feed him for a lifetime.” Teaching a man to fish is drastically different from teaching a man how *not to fish*. If you only teach a man how not to fish, will he actually know how to fish? Likewise, if teacher educators only prepare PSTs to teach for “not surface learning”, will they actually know how to teach for deeper learning? Ultimately, if teacher educators intend PSTs to move beyond viewing deeper learning as defined as what it is *not*, they will need to provide PSTs with learning opportunities that help them develop clear but actionable understandings of deeper learning and teaching for deeper learning. This study can provide insight into how teacher educators can integrate various DLMS into their existing teaching practice to facilitate rich opportunities for PSTs to learn how to teach for deeper learning in K-12 contexts.

Limitations

Here, I describe three significant limitations of this study. In the following subsection, I outline some directions for future research which might address these limitations.

The first limitation of this study is that it fails to identify clear connections between conceptions of deeper learning and teaching practices for deeper learning; this study can only partially outline these connections between conceptions and practice (Butcher et al., 2022; Kang

& Wallace, 2004). This study outlines how teacher educators and PSTs described their conceptions of deeper learning. It also outlines how they described their teaching practices for deeper learning in their respective contexts. However, this study lacks the ability to make clear connections between the two.

The second significant limitation of this study had to do with coding for the five dimensions of teaching for deeper learning (Darling-Hammond & Oakes, 2019). As noted, these five dimensions are meant to describe learning opportunities afforded to both preservice teachers and K-12 students. However, these five dimensions also describe holistic approaches to teaching practices. As such, it was difficult to identify and consistently code for instances of these five dimensions. Interviews and artifacts collected describe specific instances of teaching for deeper learning, but they do not provide a clear enough picture to determine how, or to what degree, certain teaching practices in this study illustrate these five dimensions. As a result, in discussion with the second coder, we decided to exclude this from the coding process.

The third significant limitation of this study comes from considering the third research question of each question set. In asking questions pertaining to differences between two groups of participants, it presumes (whether implicitly or explicitly) that there might be some reason for those differences. To put this more concretely, if participation or non-participation in module development generated some sort of difference in conceptions of deeper learning or teaching practices for deeper learning, this study can only describe those differences. It cannot explain them.

Future Directions

Following from these limitations, I offer a few potential directions for future research.

Consider the first limitation, that this study lacks the ability to clearly connect *conceptions of deeper learning* with *teaching practices for deeper learning*. A methodological change could address this

shortcoming. This could be done through in-person or video observations and by collecting a more comprehensive array of teaching artifacts. Additionally, a potentially insightful methodological approach would be to incorporate teaching artifacts into the interviews, asking the educators in the study to describe the goals of the teaching artifact and how they see it leading to deeper learning.

Consider the second limitation, that this study found it difficult to consistently identify the five dimensions of teaching for deeper learning. Again, a different methodological approach could more powerfully outline how these five dimensions of teaching for deeper learning show up in teaching practice. In considering that these five dimensions are meant to characterize learning opportunities afforded to both PSTs and K-12 students, one potentially fruitful avenue for research could be through practitioner research (Cochran-Smith & Lytle, 2015). Some teacher education programs provide opportunities for students to earn a master's degree by completing an action research or practitioner research project. In this sort of context, research could then focus on *both* how teacher educators facilitate learning opportunities for deeper learning for PSTs and how those PSTs facilitate learning opportunities for deeper learning for K-12 students.

Finally, consider the third limitation, that it was difficult to clearly identify how engaging in the process of module development may have impacted conceptions of deeper learning and teaching practice for deeper learning (for both teacher educators and PSTs). I find that using the learning chain of teaching for deeper learning highlights this limitation more clearly while also providing insight into how future research can work to address it (see again Figure 1.1)

If engaging in the process of module development leads to some discernible difference in either conceptions of deeper learning or teaching practices for deeper learning, we might see evidence of it elsewhere in the learning chain. For example, engaging in the process of

developing the models is an example of how teacher educators engage in deeper learning. If they have engaged in deeper learning, there should be evidence of it in their teaching practice.

Presumably, their teaching practice would be somehow different from the teaching practices of those who did not develop the modules. Evidence of this could show up in teaching artifacts, descriptions of teaching, or even how PSTs describe their TEP experiences. Stretching this line of thinking even further, if there were some critical difference in the TEP experiences afforded to PSTs, evidence of this might show up in their teaching practices in K-12 contexts.

This study, however, did not show a substantial difference in teaching practices for deeper learning at either level. Reasons for this could be methodological, and a different approach could better highlight these differences in practice. As noted previously, such an approach might incorporate a greater focus on observations and discussions with educators using teaching artifacts as a point of discussion. A longitudinal approach which follows teacher educators through the process of module development to implementing the modules in their courses could also provide insight into how their conceptions of deeper learning and teaching for deeper learning change over time. This method could also illustrate how their teaching practices change over time. That said, a longitudinal study of this nature also opens the door for other, confounding factors, which might also impact how educators conceive of deeper learning and teaching for deeper learning. It is possible that developing the modules would be but one step along the path.

Briefly considering my own position as a researcher and teacher educator, at the beginning of this study, I would have argued that identifying *differences* between the two groups would have been insightful into how these sorts of opportunities impact teacher educators. That said, at the end of this study, I would now argue that a *lack of difference*, practically speaking, is preferable. Allow me to put it another way: I would want all teacher educators to have the

opportunity to experience conceptual and professional growth as a result of using the various DLMs as one part of their teaching practice. If actively developing the modules led to a significant difference in teaching practices for deeper learning such that developing the modules was demonstrably better, it would be a shortcoming if the modules' chief impact benefitted those who made them, rather than those who incorporated them into their own teaching practice.

We can also use the learning chain as visual tool to highlight other areas for potential research. Consider one of the quotes from Bryn Knight discussed above, where she described a disconnect between herself and site supervisors or cooperating teachers specifically as it pertained to preparing PSTs to teach for deeper learning: "I feel like if the supervisors had a better understanding of what we're teaching in class with the deeper learning, then maybe they could follow through on that with what they're seeing them do in their practicum" (para. 160). This relationship (teacher educators and site supervisors/cooperating teachers) would be situated within the "Teacher Educators" box of the learning chain (top left) and is just one of a number of potential areas for future research.

We can also use the learning chain to identify opportunities for research which are situated "along" parts of the learning chain. For two brief examples, future research could use this conceptual model of a learning chain to explore other questions related to deeper learning in other education contexts. This could include questions like how teaching actions taken by teacher educators lead to different learning and teaching outcomes for K-12 teachers (a research approach focused on moving "down" the chain) or how K-12 students' experiences in classrooms that teach for deeper learning influence how their K-12 teacher teach for and conceive of deeper learning (a research approach focused on moving "up" the chain).

Finally, I consider one implication of this study for researchers and practitioners who use the term “deeper learning.” It may be that “deeper learning” is not the best term for describing the kinds of teaching and learning discussed and described throughout this dissertation. As it stands, depending on the context, deeper learning can refer to internal, cognitive processes; external, classroom-based processes; internal, cognitive outcomes of learning; external, transferrable outcomes of learning; or a set of skills and competencies. This creates undue confusion, not only for researchers but also for educators. If we want the term “deeper learning” to be useful, there needs to be agreement on both what deeper learning is and what it is not. For this dissertation, I adopted terms which I believe helped clarify what we mean when we say “deeper learning.” First, in considering deeper learning as an internal process, I adopted the term *deeper cognitive processing*. I reserved the term *deeper learning* to refer to the various external, classroom-based processes in which learners engage. These external processes facilitate opportunities for *deeper cognitive processing*. Then, in considering outcomes, I adopted the term *deep understanding* to refer to the internal, cognitive states which result from engaging in deeper learning, and I used *transfer* to refer to external, demonstrable outcomes of engaging in deeper learning. One challenge in clearly defining and distinguishing between these terms is that they are all interconnected, which further highlights the need for clearer language surrounding the processes and outcomes related to deeper learning. By more clearly defining “deeper learning” in education, we can also more clearly define *teaching for deeper learning* and describe how *teaching for deeper learning* connects to the various definitions described above.

Regardless of how we define deeper learning, in my view, the end goal of *teaching for deeper learning* is to adequately serve the teachers and learners in both teacher education programs and K-12 schools. Ultimately, I hope that we can look at the kind of teaching which illustrates *teaching for deeper learning* and think, “That’s just good teaching.”

References

- Aina, S. A. O., & Aina, M. A. O. (2023). Rethinking the use of classroom cases: Leveraging generative and multimedia principles for meaningful preservice teacher learning. *Creative Education, 14*(05), 972–992. <https://doi.org/10.4236/ce.2023.145062>
- Adler, J., & Davis, Z. (2011). Modelling teaching in mathematics teacher education and the constitution of mathematics for teaching. In T. Rowland & K. Ruthven (Eds.), *Mathematical knowledge in teaching* (pp. 139–160). Springer.
- Allen, C. D., & Heredia, S. C. (2021). Reframing organizational contexts from barriers to levers for teacher learning in science education reform. *Journal of Science Teacher Education, 32*(2), 148–166. <https://doi.org/10.1080/1046560X.2020.1794292>
- Bennett, M. D., Mujtaba, O., Su, J., Santana, D. R., Doss, Y., Gao, Y., Harlow, D. B., & Wang, M. (2026, April). *Teaching teachers for deeper learning: How teacher educators support preservice teachers in learning to teach for deeper learning* [Paper presentation]. AERA Annual Meeting, Los Angeles, CA.
- Boveda, M., & Weinberg, A. E. (2020). Facilitating intersectionally conscious collaborations in physics education. *The Physics Teacher, 58*(7), 480–483. <https://doi.org/10.1119/10.0002066>
- Boyle, J. R. (2013). Strategic note-taking for inclusive middle school science classrooms. *Remedial and Special Education, 34*(2), 78–90. <https://doi.org/10.1177/0741932511410862>
- Brennan, R. L., & Prediger, D. J. (1981). Coefficient kappa: Some uses, misuses, and alternatives. *Educational and Psychological Measurement, 41*(3), 687–699. <https://doi.org/10.1177/001316448104100307>
- Carpenter, S. L., Iveland, A., Moon, S., Hansen, A. K., Harlow, D. B., & Bianchini, J. A. (2019). Models are a “metaphor in your brain”: How potential and preservice teachers

- understand the science and engineering practice of modeling. *School Science and Mathematics*, 119(5), 275–286. <https://doi.org/10.1111/ssm.12340>
- Carroll, G., & Park, S. (2024). Towards expansive model-based teaching: A systematic synthesis of modelling pedagogies in science education literature. *Studies in Science Education*, 1–39. <https://doi.org/10.1080/03057267.2024.2417157>
- Chen, Y., & Techawithayachinda, R. (2021). Developing deep learning in science classrooms: Tactics to manage epistemic uncertainty during whole-class discussion. *Journal of Research in Science Teaching*, 58(8), 1083–1116. <https://doi.org/10.1002/tea.21693>
- Cherbow, K., & McNeill, K. L. (2022). Planning for student-driven discussions: A revelatory case of curricular sensemaking for epistemic agency. *Journal of the Learning Sciences*, 31(3), 408–457. <https://doi.org/10.1080/10508406.2021.2024433>
- Cochran-Smith, M., & Lytle, S. L. (2015). *Inquiry as stance: Practitioner research for the next generation*. Teachers College Press.
- Committee on How People Learn II, Board on Behavioral, Cognitive, and Sensory Sciences, Board on Science Education, Division of Behavioral and Social Sciences and Education, & National Academies of Sciences, Engineering, and Medicine. (2018). *How people learn II: Learners, contexts, and cultures*. National Academies Press. <https://doi.org/10.17226/24783>
- Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). SAGE Publications.
- Darling-Hammond, L., & Oakes, J. (2019). *Preparing teachers for deeper learning*. Harvard Education Press.

- Davidson, S. G., Jaber, L. Z., & Southerland, S. A. (2020). Emotions in the doing of science: Exploring epistemic affect in elementary teachers' science research experiences. *Science Education*, 104(6), 1008–1040. <https://doi.org/10.1002/sce.21596>
- Education for life and work: Developing transferable knowledge and skills in the 21st century. (2012). National Academies Press. <https://doi.org/10.17226/13398>
- Fiorella, L., & Mayer, R. E. (2016). Eight ways to promote generative learning. *Educational Psychology Review*, 28(4), 717–741. <https://doi.org/10.1007/s10648-015-9348-9>
- Fries, L., Son, J. Y., Givvin, K. B., & Stigler, J. W. (2021). Practicing connections: A framework to guide instructional design for developing understanding in complex domains. *Educational Psychology Review*, 33(2), 739–762. <https://doi.org/10.1007/s10648-020-09561-x>
- Greca, I. M., & Moreira, M. A. (2000). Mental models, conceptual models, and modelling. *International Journal of Science Education*, 22(1), 1–11. <https://doi.org/10.1080/095006900289976>
- Gubrium, J., Holstein, J., Marvasti, A., & McKinney, K. (2012). *The SAGE handbook of interview research: The complexity of the craft*. SAGE Publications. <https://doi.org/10.4135/9781452218403>
- Hernández-Barco, M., Cañada-Cañada, F., Corbacho-Cuello, I., & Sánchez-Martín, J. (2021). An exploratory study interrelating emotion, self-efficacy and multiple intelligence of prospective science teachers. *Frontiers in Education*, 6, 604791. <https://doi.org/10.3389/feduc.2021.604791>
- How People Learn: Brain, mind, experience, and school (expanded ed.). (2000). National Academies Press. <https://doi.org/10.17226/9853>

- Jones, N. A., Ross, H., Lynam, T., Perez, P., & Leitch, A. (2011). Mental Models: An Interdisciplinary Synthesis of Theory and Methods. *Ecology and Society*, 16(1), art46. <https://doi.org/10.5751/ES-03802-160146>
- King, D., Bellocchi, A., & Ritchie, S. M. (2008). Making connections: Learning and teaching chemistry in context. *Research in Science Education*, 38(3), 365–384. <https://doi.org/10.1007/s11165-007-9070-9>
- Kleinknecht, M., & Gröschner, A. (2016). Fostering preservice teachers' noticing with structured video feedback: Results of an online- and video-based intervention study. *Teaching and Teacher Education*, 59, 45–56. <https://doi.org/10.1016/j.tate.2016.05.020>
- Kvale, S., & Brinkmann, S. (2016). *InterViews: learning the craft of qualitative research interviewing* (Third edition.). Sage Publications.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.
- Lawson, A. P., & Mayer, R. E. (2021). Benefits of writing an explanation during pauses in multimedia lessons. *Educational Psychology Review*, 33(4), 1859–1885. <https://doi.org/10.1007/s10648-021-09594-w>
- Leinhardt, G., & Greeno, J. G. (1986). The Cognitive Skill of Teaching. *Journal of Educational Psychology*, 78(2), 75-95.
- Levin, O. (2024). Simulation as a pedagogical model for deep learning in teacher education. *Teaching and Teacher Education*, 143, 104571. <https://doi.org/10.1016/j.tate.2024.104571>
- Malone, K. L. (2023). The effects of modeling-based pedagogy on conceptual understanding, scientific reasoning skills, and attitudes towards science of English learners. *Science Education*. <https://doi.org/10.1002/sce.21805>

- Mayer, R. (2020). Principles of multimedia design. In *Multimedia learning* (pp. 397–416, 3rd ed.). Cambridge University Press. <https://doi.org/10.1017/9781316941355.026>
- McDonald, S., Bateman, K. M., & McCausland, J. (2020). Practice-embedded methods courses for preservice teachers. In *Preparing science teachers through practice-based education* (pp. 171–186). Harvard Education Press.
- Miller-Cotto, D., Booth, J. L., & Newcombe, N. S. (2022). Sketching and verbal self-explanation: Do they help middle school children solve science problems? *Applied Cognitive Psychology*, 36(4), 919–935. <https://doi.org/10.1002/acp.3980>
- Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory Into Practice*, 31(2), 132–141. <https://doi.org/10.1080/00405849209543534>
- Morales-Doyle, D. (2017). Justice-centered science pedagogy: A catalyst for academic achievement and social transformation. *Science Education*, 101(6), 1034–1060. <https://doi.org/10.1002/sce.21305>
- Murray, K. A. (2020). Queering agricultural education research: Challenges and strategies for advancing inclusion. *Journal of Agricultural Education*(4). <https://doi.org/10.5032/jae.2020.04296>
- Orrill, C. H., & Kittleson, J. M. (2015). Tracing professional development to practice: Connection making and content knowledge in one teacher's experience. *Journal of Mathematics Teacher Education*, 18(3), 273–297. <https://doi.org/10.1007/s10857-014-9284-5>
- Ottmar, E. (2019). The effects of deeper learning opportunities on student achievement: Examining differential pathways. *Psychology in the Schools*, 56(5), 840–855. <https://doi.org/10.1002/pits.22237>

- Patterson, A., & Gray, S. (2019). Teaching to transform: (W)holistic science pedagogy. *Theory Into Practice*, 58(4), 328–337. <https://doi.org/10.1080/00405841.2019.1626616>
- Penuel, W. R., Reiser, B. J., McGill, T. A. W., Novak, M., Van Horne, K., & Orwig, A. (2022). Connecting student interests and questions with science learning goals through project-based storylines. *Disciplinary and Interdisciplinary Science Education Research*, 4(1), 1. <https://doi.org/10.1186/s43031-021-00040-z>
- Pierson, A. E., Brady, C. E., & Lee, S. J. (2023). Emotional configurations in STEM classrooms: Braiding feelings, sensemaking, and practices in extended investigations. *Science Education*, 107(5), 1126–1162. <https://doi.org/10.1002/sce.21799>
- Putnam, R. T. (n.d.). What do new views of knowledge and thinking have to say about research on teacher learning? [Unpublished manuscript].
- Rayner, G., & Corkill, P. (2015). Building greater capacity in science education: A partnership between a secondary science school and a research-intensive university. In B. Cozza & P. Blessinger (Eds.), *Innovations in Higher Education Teaching and Learning* (Vol. 5, pp. 99–117). Emerald Group Publishing Limited. <https://doi.org/10.1108/S2055-364120150000005006>
- Reed, D. K., Rimel, H., & Hallett, A. (2016). Note-taking interventions for college students: A synthesis and meta-analysis of the literature. *Journal of Research on Educational Effectiveness*, 9(3), 307–333. <https://doi.org/10.1080/19345747.2015.1105894>
- Reiser, B. J., Novak, M., McGill, T. A. W., & Penuel, W. R. (2021). Storyline units: An instructional model to support coherence from the students' perspective. *Journal of Science Teacher Education*, 32(7), 805–829. <https://doi.org/10.1080/1046560X.2021.1884784>

- Ríordáin, M. N., Johnston, J., & Walshe, G. (2016). Making mathematics and science integration happen: Key aspects of practice. *International Journal of Mathematical Education in Science and Technology*, 47(2), 233–255. <https://doi.org/10.1080/0020739X.2015.1078001>
- SCALE Group LLC & William and Flora Hewlett Foundation. (2024). SCALE/Hewlett Deeper Learning Modules: 2024-25 Summary Overview.
- Schoenfeld, A. H. (1999). Models of the Teaching Process. *The Journal of Mathematical Behavior*, 18(3), 243–261. [https://doi.org/10.1016/S0732-3123\(99\)00031-0](https://doi.org/10.1016/S0732-3123(99)00031-0)
- Saldaña, J. (2013). *The coding manual for qualitative researchers* (2nd ed.). SAGE.
- Shemwell, J. T., Capps, D. K., Fackler, A. K., & Coogler, C. H. (2023). Integrative analysis using big ideas: Energy transfer and cellular respiration. *Journal of Science Education and Technology*, 32(4), 510–529. <https://doi.org/10.1007/s10956-023-10040-5>
- Sølvik, R. M., & Glenna, A. E. H. (2022). Teachers’ potential to promote students’ deeper learning in whole-class teaching: An observation study in Norwegian classrooms. *Journal of Educational Change*, 23(3), 343–369. <https://doi.org/10.1007/s10833-021-09420-8>
- Son, J. Y., Blake, A. B., Fries, L., & Stigler, J. W. (2021). Modeling first: Applying learning science to the teaching of introductory statistics. *Journal of Statistics and Data Science Education*, 29(1), 4–21. <https://doi.org/10.1080/10691898.2020.1844106>
- Stake, R. E. (1995). *The art of case study research*. SAGE Publications.
- Su, J., Mujtaba, O., Bennett, M. D., Santana, D. R., Doss, Y., Gao, Y., Harlow, D. B., & Wang, M. (2026, April). *Preparing future educators for deeper learning: Insights from a qualitative study on teacher candidate engagement with the deeper learning modules* [Paper presentation]. AERA Annual Meeting, Los Angeles, CA.

- Thompson, J., & Larkin, D. B. (2020). Partnering with schools and districts to improve ambitious science teaching. In *Preparing science teachers through practice-based education* (pp. 221–236). Harvard Education Press.
- Tolbert, S., Gray, S., Rivera, M., & Schindel, A. (2022). Teaching science to transgress: Portraits of feminist praxis. *Journal of Research in Science Teaching*, 59(1), 127–165.
<https://doi.org/10.1002/tea.21723>
- Tolbert, S., & Knox, C. (2016). ‘They might know a lot of things that I don’t know’: Investigating differences in preservice teachers’ ideas about contextualizing science instruction in multilingual classrooms. *International Journal of Science Education*, 38(7), 1133–1149. <https://doi.org/10.1080/09500693.2016.1183266>
- Varelas, M., Morales-Doyle, D., Raza, S., Segura, D., Canales, K., & Mitchener, C. (2018). Community organizations’ programming and the development of community science teachers. *Science Education*, 102(1), 60–84. <https://doi.org/10.1002/sce.21321>
- Wahyuni, S., & Noor, A. Q. (2025). *English teachers’ perceptions of deep learning implementation in classes: A survey-based study* [Unpublished manuscript].
- Wang, Y., Wang, F., Mayer, R. E., Hu, X., & Gong, S. (2023). Benefits of prompting students to generate summaries during pauses in segmented multimedia lessons. *Journal of Computer Assisted Learning*, 39(4), 1259–1273. <https://doi.org/10.1111/jcal.12797>
- William and Flora Hewlett Foundation. (2013). Deeper learning defined.
<https://hewlett.org/library/deeper-learning-defined/>
- Yin, R. K. (2016). *Qualitative research from start to finish*. The Guilford Press.
- Zangori, L., Ke, L., Sadler, T. D., & Peel, A. (2020). Exploring primary students’ causal reasoning about ecosystems. *International Journal of Science Education*, 42(11), 1799–1817.
<https://doi.org/10.1080/09500693.2020.1783718>

Appendices

Appendix A – SCALE/Hewlett Deeper Learning Modules, 2024-25 Summary Overview

Appendix B – Sample Interview and Focus Group Protocols

Appendix C – Final Codebook for Question Set 1: Teacher Educators

Appendix D – Final Codebook for Question Set 2: Preservice Teachers

Appendix E – Counts of Code Occurrences and Example Quotes

Appendix F – Select Examples of Teaching Artifacts

Appendix A

SCALE/Hewlett Deeper Learning Modules, 2024-25 Summary Overview

See project website for more detail: <https://deeperlearning.education.ucsb.edu>.

SCALE/HEWLETT DEEPER LEARNING MODULES 2024-25 SUMMARY OVERVIEW



WHAT ARE THE MODULES ABOUT?

This collection of online modules and applied activities focuses on building teacher candidates' capacity to foster deeper learning for all students. It highlights deeper learning principles and practices while making authentic connections to P-12 practice.

Overarching goals of modules:

- Develop candidates' disposition towards integrating deeper learning competencies such as collaboration, communication, & problem-solving with academic content instruction
- Engage candidates as "adaptive experts" to make equitable and intentional adjustments to teaching practices
- Require analysis and reflection on candidate's own teaching decisions through the lens of deeper learning

Six modules are currently linked below as open education resources (OER):

- ["Facilitating Effective Discussions to Promote Deeper Learning and Equitable Engagement"](#)
- ["Supporting Students' Mindset Development as They Navigate Challenges"](#)
- ["Developing a Critical Lens to Promote Socially-Just Narratives and Represent Diverse Identities"](#)
- ["Supporting Student Collaboration Within Performance Assessments"](#)
- ["Creating Responsive Learning Spaces: Leveraging Students' Voices & Assets"](#)
- ["Equitable and Effective Feedback"](#)

WHO DEVELOPED THESE MODULES?

The Stanford Center for Assessment, Learning and Equity (SCALE), now known as the SCALE Group, led the development of the modules with the support of the Hewlett Foundation, working in close collaboration with a national design team of teacher educators and experts in deeper learning. Feedback from pilot use in 2020-24 informed their current release as customizable, adaptable open education resources (OER). The California Teacher Education Research and Improvement Network (CTERIN) is continuing to research their impact.

We are grateful to our design & research partners at Alverno College; California State University, Sacramento; California State University, Northridge; Carnegie Foundation for the Advancement of Teaching; Elon University; Innokas Network; James Madison University; Learning Policy Institute; Lehman College, City University of New York; KnowledgeWorks; NC State University; San Diego State; Spelman College; Stanford d.School; Stanford Graduate School of Education; University of California, Santa Barbara; University of North Carolina at Chapel Hill; Urban Teachers/Johns Hopkins University; & Vanderbilt University, along with our funders at the William & Flora Hewlett Foundation.

What role do faculty & instructors play?

- Integrate module(s) as desired within an existing course(s) in order to **actively facilitate** and extend candidate learning about the module topic (*estimated total completion time 8-10 hours*)
- **Adapt** and customize the materials to your program context, subject-area focus and virtual vs. in-person learning settings
- Help candidates **navigate** between segments of online content, videos/case examples, real-time engagement in interactive/applied activities with their peers, and opportunities for reflection throughout each module sequence



How do the modules engage candidates?

The strategic design of the modules combines online instruction with applied activities that:

- Can be **flexibly infused** into existing educator preparation programs and coursework
- Immerse candidates in **inquiry-driven** learning experiences, facilitated and customized by their course instructor for their particular context
- Require candidates to **make connections** between deeper learning, learner-centered practice backed by learning science, and real-world P-12 classroom teaching



Module Materials

Faculty/instructors will have access to:

- All module materials and accompanying resources in the Canvas Free for Teacher platform and project website
- A facilitator's guide with additional guidance and supplementary resources for flexible implementation
- A tech guide to using and customizing the modules in Canvas, as needed

All activities can be completed virtually if you are facilitating an online course, but will require some synchronous instruction and collaboration. Being able to have access to a classroom and/or meet in-person with candidates when completing the modules may be beneficial in some cases, but it is not always required.



Each of the modules focuses on at least one of the **Deeper Learning Competencies** listed here (Hewlett, 2013).

"Supporting Students' Mindset Development as They Navigate Challenges" Pilot Module Overview

Driving question: "How can you support P-12 students in building their academic mindset towards persisting and persevering with challenging activities?"

Overall learning goal: For candidates to design deeper learning opportunities that integrate support for academic mindset development as students persist & persevere with challenges

Section 1 - What is your mindset towards tackling challenging activities?

- Candidates directly engage in a challenging collaborative learning activity & reflect on their own mindset (e.g., attitude/beliefs) towards navigating it together, while making connections to implications for P-12 learning.

Section 2 - What is an academic mindset?

- Candidates explore foundational concepts such as academic mindset, persistence, and perseverance through assigned readings, supplemental resources & discussion.

Section 3 - How can persisting & persevering through productive struggle help build academic mindset?

- Candidates examine the role of "productive struggle" in building academic mindset, using videos of classroom practice to identify the skills, strategies and supports that help students persist/persevere through challenging deeper learning activities.

Section 4 - Analyzing how teachers can foster academic mindset development

- Candidates analyze & discuss case examples that demonstrate how teachers can 1) intentionally design opportunities for students to develop their academic mindset within the context of content instruction and 2) offer meaningful feedback/support for persisting/persevering through productive struggle throughout the cycle of teaching and learning.

Section 5 - Designing a challenging activity that integrates academic mindset development (CORE ACTIVITY)

- Candidates design a P-12 learning activity that includes support for academic mindset development as students persist/persevere in their work together & then use peer feedback from other candidates to refine their design further.

"Facilitating Effective Discussions to Promote Deeper Learning and Equitable Engagement" Pilot Module Overview

Driving question: "How can teachers facilitate effective discussions that promote equitable engagement, effective communication and critical thinking?"

Overall learning goal: For candidates to create, implement, and reflect on an effective discussion plan that promotes equitable engagement, critical thinking, and effective communication

Section 1 - How can discussions promote deeper learning and equitable engagement?

- Candidates analyze a classroom discussion to understand the use and implications of "equity moves" to promote equitable engagement and deeper learning.

Section 2 - How can I use essential questions & talk moves to facilitate an effective discussion?

- Candidates explore essential questions and talk moves in order to analyze a classroom discussion; candidates will identify the use and implications of each, to promote deeper learning and equitable engagement.

Section 3 - Planning our practice: Essential Questions

- Candidates use resources to develop Part 1 of an effective discussion plan, focused on designing essential questions.

Section 4 - Planning our practice: Equity Moves and Talk Moves

- Candidates use resources to develop Parts 2-4 of an effective discussion plan, focused on designing discussion protocols, talk moves and monitoring protocols

Section 5 - Being adaptive experts: Analyzing & improving our discussion practices (CORE ACTIVITY)

- Candidates implement their effective discussion plans, while peers observe and collect monitoring data.
- Candidates examine feedback, make and justify changes to more effectively disrupt inequities through equitable engagement and deeper learning.



"Developing a Critical Lens to Promote Socially-Just Narratives and Represent Diverse Identities" Pilot Module Overview

Driving question: "How can we develop a critical lens to be culturally responsive to the diverse identities in our classrooms?"

Overall learning goal: For candidates to use a critical lens to analyze and adapt instructional materials to construct socially-just narratives and represent diverse identities

Section 1 - Reflecting on Identity & Representation in Schools

- Candidates think critically about how the representation of identities and stories in instructional materials impacts learners, complete a 6-word memoir to reflect on their own identity, and engage in a small-group reflection on how their own identity impacts students.

Section 2 - Developing a Critical Lens

- Candidates analyze instructional materials for representation of identities and dominant and non-dominant narratives.

Section 3 - Adapting Instructional Materials to be More Culturally Responsive (CORE ACTIVITY)

- Candidates adapt instructional materials to improve representation and offer non-dominant narratives, making them more culturally responsive.

"Supporting Student Collaboration Within Performance Assessments" Pilot Module Overview

Driving question: "How can teachers support deeper learning by making opportunities to collaborate on performance-based assessments more meaningful for students?"

Overall learning goal: For candidates to identify ways to support students in becoming effective collaborators as they work together on performance-based assessments to solve problems and deepen their content understanding

Section 1 - Opportunities for Collaboration During Performance-Based Assessments

- Candidates explore how performance-based assessments (PBAs) can integrate meaningful opportunities for collaboration through sample PBA plans & classroom videos.
- Candidates engage in a team activity to determine what effective collaboration looks like.

Section 2 - Strategies for Supporting Students in Becoming More Effective Collaborators

- Candidates identify ways teachers can support students in working together to demonstrate and deepen their content understanding, and draw from strategies/resources from the field to build a Collaboration Support Toolkit.

Section 3 - Planning to Deepen Learning by Supporting Collaboration on Performance-Based Assessments (CORE ACTIVITY)

- Candidates use their Toolkit to create and share an implementation plan for strategically supporting collaboration on a PBA within their content area.

"Creating Responsive Learning Spaces: Leveraging Students' Voices and Assets" Pilot Module Overview

Driving question: "How can teachers leverage students' assets to promote culturally and linguistically responsive learning spaces?"

Overall learning goal: For candidates to collaboratively design a learning space to address a student-driven equity challenge

Section 1 - Building Awareness and Defining Culturally Responsive Education

- Candidates engage in reflective learning activities as they define culturally and linguistically responsive education (CLRE) and cultural lens - and examine their own cultural lens.

Section 2 - Getting to Know Your Students and Equity Challenges Within Learning Spaces

- Candidates define learning spaces, examine research on learning spaces and equity, and engage in a learning spaces activity that integrates student voice.

Section 3 - Exploring an Equitable Design Process

- Candidates explore the Equitable Design Process and prepare to apply it in a P-12 classroom.

Section 4 - Improving Our Learning Space Through an Equitable Design Process (CORE ACTIVITY)

- Candidates implement an Equitable Design Process in a P-12 classroom alongside a small group of students from their learning context and create a prototype.

"Equitable and Effective Feedback" Module Overview

Driving question: "How can teachers provide equitable and effective feedback to build and sustain a culture of feedback?"

Overall learning goal: For candidates to plan and practice providing equitable and effective feedback.

Section 1 - Exploring Equitable & Effective Feedback

- Candidates define and research feedback and what makes it effective and effective.

Section 2 - Understanding and Applying the Characteristics of Equitable & Effective Feedback

- Candidates explore a "culture of feedback" and EEF resource & engage and reflect on a feedback activity; they have an option to prepare and complete an analysis of feedback with a peer

Section 3 - Implementing and Reflecting on Equitable & Effective Feedback (CORE ACTIVITY)

- Candidates plan, implement and reflect on practicing equitable and effective feedback with one of their P-12 students

For more info about the modules, please contact: nicole@thescalegroup.org

Appendix B

Sample Interview and Focus Group Protocols

Faculty Interview Protocol - v2.2

ao 10 June 2024

NOTE: this interview protocol is primarily intended to learn about a combination of faculty experiences ranging from conceptions of DL, experiences planning for implementing the modules, and implementing the modules.

MEMO:

Before the interview starts:

Before we start the interview, do you have any questions?

Do I have your permission to begin recording the interview?

[if yes, start recording]

Today is [date] at [time], and this is the Fall 2023 interview with [name]. The interviewer is [name].

Warm-Up/Background Questions

1. Can you describe your role in the teacher education program?
 - a. *(prompt if needed - see implementation plan)* What courses do you teach and in what quarters/semesters?
2. What are your responsibilities, if any, as it pertains to your program's engagement with the deeper learning modules?
3. How were you first introduced to the Deeper Learning project and modules?

Prior Experiences with DL, Perceptions of DL

These next few questions ask about your understanding of deeper learning and teaching for deeper learning, as well as any experiences related to deeper learning prior to engaging with the modules.

4. What comes to mind when you hear the term “deeper learning”?
 - a. *(listen for specific parts of the response)* What resources did you learn [that] from?
5. Can you tell me more about your understanding of deeper learning from before engaging with the modules?
 - a. What about your understanding of teaching for deeper learning?
 - b. *(reiterate stated understanding if helpful)* How did that understanding influence your approach to implementing the module(s) in your course(s)?
6. How, if at all, did that understanding (or related experiences) shape or motivate how you engaged with the modules?
 - a. *(if minimal or no prior experience with deeper learning)* What motivated you to engage with the deeper learning modules in the first place?
7. What have you learned about deeper learning since engaging in the modules?
 - a. *(prompt if needed)* How has engaging in the modules added to or changed your understanding of deeper learning?
8. How have your views on the importance or value of deeper learning and teaching for deeper learning changed since engaging with the modules?
 - a. *(prompt if needed)* How did that impact how you incorporated the modules, or other content related to deeper learning, into your course(s)?
9. If you had to give a formal definition of deeper learning, how would you define it?

DLM Preparation and Implementation

These first few questions ask about your experiences relating to preparing for and implementing the deeper learning modules.

10. What sorts of activities have you used to engage your students in the modules?
 - a. How have you adjusted delivery of the content from the modules to better meet the needs of your students? OR How has your implementation of the modules in your coursework adapted over time? → *look for specific examples to follow up on*
 - b. Have you found any strategies in particular are more or less effective for engaging your students in the module(s)?
11. Can you describe your experiences in preparing to use the module(s) in your course(s)?
 - a. How did you decide which module(s) to use in your course?

- b. Was your preparation mostly done individually or in a group/community of practice? Can you tell me about what that was like?
 - c. What sorts of resources did you use to help prepare you to teach the modules?
- 12. What aspects/elements of the DLM did you anticipate would be the most challenging for you and your students? What aspects did you anticipate would be easier?
 - a. How did that affect your planning, if at all?
 - b. *(prompt if needed)* Can you give a specific example?
- 13. How has a community of practice been a part of your experiences as it relates to planning to implement or implementing the deeper learning modules?
- 14. How, if at all, did you collaborate with any non-faculty (e.g., student teachers, graduate students, cooperating teachers, IT department, etc.) when preparing to implement the modules?
- 15. How have you seen your teacher education program work to foster collaboration amongst faculty, students, and other [critical friends] as it relates to deeper learning and teaching for deeper learning?
 - a. *(prompt if needed)* Can you tell me about a specific example?
 - b. What sort(s) of resources do you think might help further foster communities of practice in your context, specifically as they relate to deeper learning?
- 16. How, if at all, do you see yourself adopting the deeper learning modules into your courses long term?
 - a. If so, which modules and why those ones?

Regarding Teacher Candidates

These next few questions ask about what you've noticed in terms of your students' practices and conceptions about deeper learning since implementing the modules in your courses.

- 17. What have you noticed about your students' understandings of deeper learning and teaching for deeper learning?
 - a. *(prompt if needed)* Can you tell me about a specific example?
- 18. What have you noticed about your students' teaching practices in their practicum classrooms as it relates to teaching for deeper learning?
 - a. How has it changed, if at all?
 - b. Can you cite any specific practices or activities that your students have been implementing that they might not have been implementing before?

Closing

19. What have we forgotten to ask about that you think is important for us to understand?
20. Are there any specific documents or artifacts that we should collect in order to better understand how the deeper learning modules have impacted either your practices or your program on the whole?
21. Do you have any questions for us?

Teacher Candidate Interview Protocol - v2.1

ao 13 January 2025

MEMO:

Before the interview starts:

Before we start the interview, do you have any questions?

Do I have your permission to begin recording the interview?

[if yes, start recording]

Today is [date] at [time], and this is the Fall 2023 interview with [name]. The interviewer is [name].

Warm-Up/Background Questions

1. I have a handful of questions just to get to know where you're at in your teacher education program so far. *(can ask pseudo-rapid fire to increase informal nature of these questions)*
 - a. What's your area of study or credential area?
 - b. *(if applicable)* What have your placements been like so far? What grades/classes have you been teaching?
 - c. Was this the grade level you always wanted to teach?

Deeper Learning Experiences and Perceptions

These next few questions ask about your experiences with and your understanding of deeper learning and teaching for deeper learning.

2. What comes to mind when you hear the term "deeper learning"?
3. Can you tell me about your understanding of deeper learning before starting your teacher education program?

4. What have you learned about deeper learning from your teacher education program so far?
 - a. What have you learned about *teaching for deeper learning* from your teacher education program so far?
 - b. *(prompt if needed)* Can you tell me in which course(s) you've explicitly engaged with topics about deeper learning and/or teaching for deeper learning?

5. Can you tell me about your overall experience with using the deeper learning module(s)?
 - a. *(prompt if needed)* Can you tell me which module(s) you used in your coursework?
 → *use for grounding to ask for example if needed*

6. How have your professors engaged you in topics of deeper learning or teaching for deeper learning? Give specific examples if possible.
 - a. *[make reference to specific example given]* Can you tell me your thoughts on that experience? What were some positives or negatives of that experience/activity?

7. How, if at all, have your perceptions of deeper learning or teaching for deeper learning changed since participating in your teacher education program?
 - a. *(prompt if needed)* How did your experiences in engaging with the module(s) impact your perceptions of deeper learning?

8. How have your views on the importance or value of deeper learning and teaching for deeper learning changed since engaging with the modules?
 - a. *(prompt if needed)* How, if at all, did this impact your teaching practice?

Teacher Candidate Practice

These next few questions ask about what you've noticed in terms of your teaching practices related deeper learning since engaging in topics of deeper learning and teaching for deeper learning.

[ask clarifying question about placement role/responsibilities]

9. Can you tell me about any specific teaching practices that you're being taught as it pertains to deeper learning?
 - a. *(prompt if needed)* Maybe it's something specifically related to your subject area or [grade] learning in general?
 - b. What do you like or dislike about those practices and why?

10. What have you noticed about your teaching practices as they relate to teaching for deeper learning since first being exposed to these topics in your coursework?
 - a. *(prompt if needed)* Can you tell me about a specific example?

- b. *(prompt if needed)* Is there anything specific that you've drawn directly from the module(s)?
- 11. *(if applicable)* What have you noticed about your students' learning since you've started to incorporate more aspects of teaching for deeper learning into your placements?
 - a. *(unsure what sorts of follow-ups might go here, but it seems like there could be some useful ones)*
- 12. *(if applicable - e.g., if teaching for deeper learning isn't something they've been able to implement)* Are there any practices relating to teaching for deeper learning that you haven't been able to attempt or implement in your placements so far? If so, can you tell me about those?
 - a. Why would you like to implement those practices? OR What about those practices do you think might be beneficial for your students?

Communities of Practice

This is the last section of the interview, and these questions ask about your experiences working as a part of a community of practice within your teacher education program, specifically with respect to deeper learning.

- 13. How have you collaborated with other teacher candidates in implementing various teaching practices for deeper learning?
 - a. *(prompt if needed)* Can you tell me about a specific example?
- 14. How have you collaborated with faculty in implementing various teaching practices for deeper learning in your placements?
 - a. *(if applicable)* How have you seen that collaboration impact your teaching practice, if at all?
- 15. Can you share any specific ways that collaboration related to deeper learning has impacted your teaching practice?
- 16. How have you seen your teacher education program work to foster collaboration amongst faculty, students, and other critical friends as it relates to deeper learning and teaching for deeper learning?
 - a. *(prompt if needed)* Can you tell me about a specific example?

Closing

- 17. What more would you like to learn about deeper learning and/or teaching for deeper learning in your classroom(s)?
- 18. What have we forgotten to ask about that you think is important for us to understand?

19. Are there any specific documents or artifacts that we should collect in order to better understand how the deeper learning modules have impacted either your practices or your program on the whole?
20. Do you have any questions for us?

MEMO:.

Introduce ourselves: [need to clarify roles of researchers within the group

Also need to clarify:

Names, schools, what module(s) the TCs engaged with (especially if they are from different units)

Deeper Learning Modules; Teaching Practice; Supports

1. What comes to mind when you hear the phrase deeper learning? (NOTE: I may have to choose a person to begin with their thoughts... then ask if anyone has similar or different thoughts.)
2. So, you all engaged in at least one of these modules in your teacher education coursework. What did you learn from using the module you were exposed to? Was there anything in particular that stood out to you?
 - a. Alternatively, was there anything ABOUT THE CONCEPT OF DEEPER LEARNING OR TEACHING FOR DEEPER LEARNING you found confusing or could be better explained? If so, what was it and why was it confusing? (NOTE: Don't let them get bogged down on technical aspects of modules)
3. How were you supported in the learning process of understanding the competencies of teaching for deeper learning? This could include the various modules, activities your professors had you do, colleague collaboration, or something else which you found supportive.
 - a. Was there anything you found particularly valuable?
 - b. Were there any supports or resources you wish you had while learning about them?(After first response, "Anyone want to add to that?" NOTE: Do not prompt on competencies until after you've given the TCs chance to respond.)

4. How has learning about deeper learning led to YOU changing your teaching practices in your field placements, if at all (OR, IF NOT TEACHING, HAVE YOU MADE A NOTE OF PRACTICES YOU MIGHT WANT TO INTEGRATE INTO YOUR FUTURE TEACHING? HOW DO YOU ANTICIPATE WHAT YOU'VE LEARNED ABOUT DL PLAYING A ROLE IN YOUR FUTURE CLASSROOM?
 - a. *(prompt if needed)* Can you give some specific examples of activities and/or instructional strategies that you've changed?
 - b. If you have, did you encounter any roadblocks or challenges?
 - c. IF FUTURE: What do you think that might look like?
 - d. What sorts of instructional strategies would you use and why?

Communities of Practice (lesser emphasis on these Qs)

5. In your teacher education program, what kinds of collaborative activities did you engage in that reinforced the concept of teaching for deeper learning?
 - a. Who did you collaborate with and how was this facilitated?
 - b. What did you find helpful about those experiences?
 - c. What sorts of opportunities for collaboration do you wish you had?
6. How, if at all, did you collaborate with anyone outside of your teacher education program as it relates to deeper learning and teaching for deeper learning? (SUPERVISING TEACHER??)
 - a. How did those experiences differ from your experiences collaborating with people within your teacher education program?
 - b. What did you find most helpful or insightful about those experiences?
 - c. What sorts of opportunities for collaboration with people outside of your teacher education program do you wish you had?
7. On a scale of 1 to 5, with 5 being the most useful, how useful do you anticipate the content from this module will be in your future teaching? (Give think time)
 - a. Why did you select (number)?
8. Did you feel this module was useful at this time in your journey as a teacher candidate, or would it have been more helpful as a Professional Development training at a future school site?

Closing

9. Is there anything else I should know about deeper learning and teaching for deeper learning in your program?
10. Are there any questions that you have for me/research team?

Appendix C

Final Codebook for Question Set 1: Teacher Educators

Note: Parent codes are numbered and given in a column spanner. For example, *1. Conceptions of Deeper Learning* is the parent code for the subcodes given below it in the table.

Specific Form of Code	Example or Description from Relevant Literature (if applicable)	Examples from Data
<i>1. Conceptions of Deeper Learning</i>		
1a. Deeper learning as a process → for my paper, this refers to a classroom-based process, but it is possible that participants describe it as a cognitive process	Deeper learning as a process, specifically one which is evidenced by the transfer of learning from one situation to another (Mayer, 2011; NRC, 2012; NRC, 2018) [NRC] goes on further to identify three critical aspects of this process: “accumulating information (in part by noticing what matters in a situation and is therefore worth attending to); tagging this information as relevant or not; and integrating it across separate episodes” (NRC, 2018, p. 93). More recently, Fries et al. (2021) characterize deeper learning through “the ability to perceive and make explicit the underlying structure of a domain, its connections and relations in the form of coherent mental schemas, which [allow] for transferable and flexible application of domain principles” (p. 743).	“I would define deeper learning as becoming able to engage in practices that are supported by relevant theory and recent research on a moment-to-moment basis in practice, which for my population is the practice of secondary teaching.” (ER, para. 85) <i>NOTE:</i> In this case, deeper learning is described as the process of “become able to” do a particular activity or demonstrate certain evidence of that process.

Specific Form of Code	Example or Description from Relevant Literature (if applicable)	Examples from Data
1b. Deeper learning as possessing understanding/knowledge	It remains challenging to separate understanding deeper learning as a process in which learners engage from the notion that deeper learning is the result itself. Use this code if the participant describes deeper learning more as a result of engaging in something, as a state of knowledge, or as something “static” rather than dynamic.	“What comes to mind [when I hear the term deeper learning] is knowing the why and the how behind what you’re doing to solve a problem.” (MS, para. 27) “[Deeper learning means] understanding the complexities of the topic in a variety of ways. And, you know, because we’re at [school], to be able to show that understanding in a variety of ways.” (TM, para. 81) <i>NOTE:</i> “Understanding” in this case is what is meant by a state or status of deeper learning. This could be rephrased as something like “deeper learning is the status of having an understanding of the complexities of a topic”. Further, in this case, this also serves as an example of an outcome of deeper learning, because of the reference to “show that understanding in a variety of ways”.

Specific Form of Code	Example or Description from Relevant Literature (if applicable)	Examples from Data
1c. Outcomes of engaging in DL	As noted above, deeper learning is evidenced by transfer of learning from one situation to another (Mayer, 2011; NRC, 2012; NRC 2018). However, participants may note other evidence of deeper learning, and that should be captured in this code.	“[Deeper learning] is not just learning content or curriculum, but also being able to apply it and develop other skills that can be used outside of an academic environment.” (RJ, para. 48) e.g., “I would define [deeper learning] as a method where students can explain what they know and how they know it.” (MS, UCSB interview, l. 381). Here, DL is defined as a method and has a clear outcome associated with it, and so this code should be used in addition to (1a). <i>NOTE:</i> Again, “being able to apply it” indicates an outcome of deeper learning.
1d. Associations with other education-related frameworks	Participants may describe deeper learning specifically with respect to an association with another education- or learning-related concept. For example, Bloom’s taxonomy, Webb’s Depth of Knowledge, etc.	A participant talks about how deeper learning makes them think of Webb’s Depth of Knowledge levels, and specifically relates to levels 3 and 4. (MS, para. 165-69)

Specific Form of Code	Example or Description from Relevant Literature (if applicable)	Examples from Data
1e. Limitation or confusion about DL; developing understanding of DL	Use this code <i>only</i> if the interviewee states this explicitly. Not to be used if assumption or inference must be made about their understanding of DL.	“I knew things like collaboration. I knew things like critical thinking and problem solving. I knew things like communication, but I didn’t have the specific language from the deeper learning framework that you all sent us.” (SE, para. 29) <i>NOTE:</i> This is an example where the participant explicitly mentions a lack of understanding or developing understanding related to deeper learning.
1f. Deeper learning as framework or resource	Some participants note that DL as a concept has given them words or “given [them] the language” for describing certain concepts, practices, etc. Participants may also note that deeper learning is a part of meaning making, etc.	“I think the modules help me to be more intentional about [deeper learning]. So, like, philosophically, I don’t think I’ve changed a lot. But it’s given me the tools, definitely given me tools to use that and be more intentional in how I teach.” (BK, para. 41)
1g. Deeper learning in contrast to surface learning	Some participants describe deeper learning in contrast to surface learning. Use this code whether or not they expand on the differences between deeper and surface learning.	“With the content acquisition and application, it’s going deeper with it.” (LB, para. 81) “Going beyond the surface, and really figuring out the why, why is this happening, rather than just what’s happening” (CG, para. 43)
1z. Other (note in annotation)	If participants describe deeper learning by some other means, use this code and note in an annotation.	

Specific Form of Code	Example or Description from Relevant Literature (if applicable)	Examples from Data
<i>2. Conceptions of Teaching for Deeper Learning</i>		
2a. DL as framework for teaching	Separate from the above code (1f), this should be used if it's specifically talked about with respect to teaching actions and DL/teaching for DL providing an overall framework for teaching in general.	"I would say [the deeper learning modules have] helped me because—I know that I included it in my teaching without really knowing it, but it's given me the language. And I think in that way, it's helped me because I call it out more than I did before." (BK, para. 37)
2b. Learning chain of teaching for DL	Participant describes deeper learning and teaching for deeper learning within a greater context. This context might be related to local school districts, K-12 classrooms, their university, the research efforts affiliated with this project, or other participants within their specific teacher education system. Participants are unlikely to use the term "learning chain," but this code is meant to help clarify some of the interactions and responsibilities outlined by the learning chain included in the conceptual framework.	"I feel like if the supervisors had a better understanding of what we're teaching in class with the deeper learning, then maybe they could follow through on that with what they're seeing them do in their practicum. And that's not often the case." (BK, para. 160)

Specific Form of Code	Example or Description from Relevant Literature (if applicable)	Examples from Data
2c. Teaching for DL as process	Participant describe teaching for DL as a process which happens over time, whether within a class session, over multiple class sessions, or over the course of a semester/year/career.	“As the instructor and teaching with the deeper model, it’s my role to facilitate and create an environment that allows the students to interact with the material, interact with each other, and, like apply their abilities and skills to reach, based on the outcome of that kind of interaction. What’s the purpose of it? So my role would be more facilitate, guide, support and engage students in that model.” (UA, para. 23)

Specific Form of Code	Example or Description from Relevant Literature (if applicable)	Examples from Data
2d. Limitation/developing understanding of teaching for DL	Use this code <i>only</i> if the participant states this explicitly. Not to be used if assumption or inference must be made about their understanding of teaching for deeper learning.	“So, I would say again, using different language, I felt as though I was I was good at implementing some of those things in my own teaching before coming to higher learning. And then so that that made a natural transition for me to bring some of those things in to my mind instruction at the higher education level. But, there again, it wasn’t necessarily part of this deeper learning framework as a holistic view; but it was definitely intended so like doing things like having students intentionally engage in discussion. Like I knew before this that that was an important part of teaching and learning, not only in my K-12 experience, but then bringing that into higher ed. But the overall structure of what was provided to me by all of you, it was just different and it was definitely missing pieces.” (SE, para. 37) <i>NOTE:</i> The participant is describing how their approach to teaching for deeper learning has changed as a result of engaging with the deeper learning modules.
2z. Other	Note in annotation	

Specific Form of Code	Example or Description from Relevant Literature (if applicable)	Examples from Data
<i>3. Actions for Preparing Preservice Teachers for Deeper Learning</i>		
3a. General Use of SCALE/Hewlett Deeper Learning Modules (DLMs)	Participant notes using the DLMs generally. They may reference a specific module, which can be noted in an annotation, but this code can be used generally and liberally to capture instances where teacher educators describe using any DLMs in their courses. This code should not be used if the teacher educator is referring to planning but not actually implementing the modules.	“I am currently implementing the deeper learning modules in one of the Para to Teacher licensure courses. It’s the last class that they take before they move into a full semester of student teaching.” (MO, para. 13)
3b. Adjusted use of SCALE/Hewlett DLMs	Specific forms can emerge here → this can look like adjusting based on student needs, adjusting based on course structure, adjusting based on time of year (note specific form in annotation, but if a theme arises which seems pertinent, I can deep dive later).	
3c. Specific instructional strategy for teaching for DL	Use this code to capture specific references of instructional strategies for teaching for DL. This could include discussions (whole or small group), guided lesson planning, reflections, etc.	

Specific Form of Code	Example or Description from Relevant Literature (if applicable)	Examples from Data
3d. Reasoning/motivation	Teacher educator describes their reasoning or motivation for a specific instructional strategy or action as it pertains to deeper learning. It may be the case that they describe their reasoning or motivation for something else, like why they participated in the overall research project. Code that <i>if</i> it seems clearly relevant to teaching for deeper learning. If unsure, code it and note in annotation.	
3e. Planning and/or Reflection	<i>Planning:</i> Teacher educator describes planning practices related to engaging students in deeper learning. Can also code collaboration within this category. <i>Reflection:</i> Participant reflects on their experiences or practices related to deeper learning or teaching for deeper learning. For now, this is separate from planning. They might go together, but not necessarily. Some good potential future RQs here: “are teachers who teach for DL more reflective teachers (when compared with teachers who do not explicitly teach for DL)?”	

Specific Form of Code	Example or Description from Relevant Literature (if applicable)	Examples from Data
3f. Modules as resource for TCs; providing skills to TCs for teaching for DL	Use this code if the teacher educator describes positioning or utilizing the DLMs as a resource or tool for PSTs. This code should be used if the TE intends for the module itself to be something PSTs return to, rather than just something from which they draw activities and the like. For example, if a TE talks about their PSTs returning a module from a prior unit or course in order to self-evaluate their own teaching. In this way they're going beyond using the module for course materials/exercises/etc.	
3g. Limitation or confusion re: teaching for DL	Use this code <i>only</i> if the interviewee states this explicitly. Not to be used if assumption or inference must be made about their practice of teaching for DL.	
3z. Other	Note in annotation	
<i>4. Context</i>		
4a. Undergraduate TEP		
4b. Graduate TEP		
4c. Teacher educator designed modules		

Appendix D

Final Codebook for Question Set 2: Preservice Teachers

Note: Parent codes are numbered and given in a column spanner. For example, *1. Conceptions of Deeper Learning* is the parent code for the subcodes given below it in the table.

Specific Form of Node	Example or Description from Relevant Literature (if applicable)	Examples from Data
<i>1. Conceptions of Deeper Learning</i>		
<i>NOTE:</i> These codes are identical to those from Question Set 1 (see: Appendix C)		
1a. Deeper learning as process	Deeper learning as a process, specifically one which is evidenced by the transfer of learning from one situation to another (Mayer, 2011; NRC, 2012; NRC, 2018) [NRC] goes on further to identify three critical aspects of this process: “accumulating information (in part by noticing what matters in a situation and is therefore worth attending to); tagging this information as relevant or not; and integrating it across separate episodes” (NRC, 2018, p. 93). More recently, Fries et al. (2021) characterize deeper learning through “the ability to perceive and make explicit the underlying structure of a domain, its connections and relations in the form of coherent mental schemas, which [allow] for transferable and flexible application of domain principles” (p. 743).	“I would define deeper learning as becoming able to engage in practices that are supported by relevant theory and recent research on a moment-to-moment basis in practice, which for my population is the practice of secondary teaching.” (ER, para. 85) <i>NOTE:</i> In this case, deeper learning is described as the process of “become able to” do a particular activity or demonstrate certain evidence of that process.

Specific Form of Node	Example or Description from Relevant Literature (if applicable)	Examples from Data
1b. Deeper learning as state	It remains challenging to separate understanding deeper learning as a process in which learners engage from the notion that deeper learning is the result itself. Use this code if the participant describes deeper learning more as a result of engaging in something, as a state of knowledge, or as something “static” rather than dynamic.	“What comes to mind [when I hear the term deeper learning] is knowing the why and the how behind what you’re doing to solve a problem.” (MS, para. 27) “[Deeper learning means] understanding the complexities of the topic in a variety of ways. And, you know, because we’re at [school], to be able to show that understanding in a variety of ways.” (TM, para. 81) <i>NOTE:</i> “Understanding” in this case is what is meant by a state or status of deeper learning. This could be rephrased as something like “deeper learning is the status of having an understanding of the complexities of a topic”. Further, in this case, this also serves as an example of an outcome of deeper learning, because of the refence to “show that understanding in a variety of ways”.

Specific Form of Node	Example or Description from Relevant Literature (if applicable)	Examples from Data
1c. Outcomes of engaging in DL	As noted above, deeper learning is evidenced by transfer of learning from one situation to another (Mayer, 2011; NRC, 2012; NRC 2018). However, participants may note other evidence of deeper learning, and that should be captured in this code.	“[Deeper learning] is not just learning content or curriculum, but also being able to apply it and develop other skills that can be used outside of an academic environment.” (RJ, para. 48) e.g., “I would define [deeper learning] as a method where students can explain what they know and how they know it.” (MS, UCSB interview, l. 381). DL is defined as a method and has a clear outcome associated with it, and so this code should be used in addition to 1a <i>NOTE:</i> Again, “being able to apply it” indicates an outcome of deeper learning.
1d. Associations with other education-related frameworks	Participants may describe deeper learning specifically with respect to an association with another education- or learning-related concept. For example, Bloom’s taxonomy, Webb’s Depth of Knowledge, etc.	A participant talks about how deeper learning makes them think of Webb’s Depth of Knowledge levels, and specifically relates to levels 3 and 4. (MS, para. 165-69)

Specific Form of Node	Example or Description from Relevant Literature (if applicable)	Examples from Data
1e. Limitation or confusion about DL; developing understanding of DL	Use this code <i>only</i> if the interviewee states this explicitly. Not to be used if assumption or inference must be made about their understanding of DL.	“I knew things like collaboration. I knew things like critical thinking and problem solving. I knew things like communication, but I didn’t have the specific language from the deeper learning framework that you all sent us.” (SE, para. 29) <i>NOTE:</i> This is an example where the participant explicitly mentions a lack of understanding or developing understanding related to deeper learning.
1f. Deeper learning as framework or resource	Some participants note that DL as a concept has given them words or “given [them] the language” for describing certain concepts, practices, etc. Participants may also note that deeper learning is a part of meaning making, etc.	“I think the modules help me to be more intentional about [deeper learning]. So, like, philosophically, I don’t think I’ve changed a lot. But it’s given me the tools, definitely given me tools to use that and be more intentional in how I teach.” (BY, para. 41)
1z. Other	Note in annotation	
<i>2. Conceptions of Teaching for Deeper Learning</i>		
2a. Deeper learning as framework for teaching	Separate from the above code (1f), this should be used if it’s specifically talked about with respect to teaching actions and DL/teaching for DL providing an overall framework for teaching in general	

Specific Form of Node	Example or Description from Relevant Literature (if applicable)	Examples from Data
2b. Learning chain of teaching for deeper learning	Participant describes deeper learning and teaching for deeper learning within a greater context. understandably, they might not use the term "learning chain" or "ecosystem", but it's clear they view DL and teaching for DL within a context that extends beyond the TE program and into the K-12 classroom and vice versa.	"I would say [the deeper learning modules have] helped me because—I know that I included it in my teaching without really knowing it, but it's given me the language. And I think in that way, it's helped me because I call it out more than I did before." (BY, para. 37)
2c. Teaching for deeper learning as process	Participant describe teaching for DL as a process which happens over time, whether within a class session, over multiple class sessions, or over the course of a semester/year/career.	"As the instructor and teaching with the deeper model, it's my role to facilitate and create an environment that allows the students to interact with the material, interact with each other, and, like apply their abilities and skills to reach, based on the outcome of that kind of interaction. What's the purpose of it? So my role would be more facilitate, guide, support and engage students in that model." (UA, para. 23)

Specific Form of Node	Example or Description from Relevant Literature (if applicable)	Examples from Data
2d. Limitation/developing understanding of teaching for deeper learning	Use this code <i>only</i> if the interviewee states this explicitly. Not to be used if assumption or inference must be made about their understanding of teaching for deeper learning.	“So, I would say again, using different language, I felt as though I was I was good at implementing some of those things in my own teaching before coming to higher learning. And then so that that made a natural transition for me to bring some of those things in to my mind instruction at the higher education level. But, there again, it wasn’t necessarily part of this deeper learning framework as a holistic view; but it was definitely intended so like doing things like having students intentionally engage in discussion. Like I knew before this that that was an important part of teaching and learning, not only in my K-12 experience, but then bringing that into higher ed. But the overall structure of what was provided to me by all of you, it was just different and it was definitely missing pieces.” (SE, para. 37) <i>NOTE:</i> The participant is describing how their approach to teaching for deeper learning has changed as a result of engaging with the deeper learning modules.
2z. Other	Note in annotation	

Specific Form of Node	Example or Description from Relevant Literature (if applicable)	Examples from Data
<i>3. Actions for Teaching for Deeper Learning (in K-12 contexts)</i>		
3a. Specific actions or instructional strategies for teaching for deeper learning	PST references specific actions which engage K-12 students in deeper learning. This could be things like summarizing, drawing, notetaking, guided discussions, etc.	
3b. Reasoning/ motivation	PST describes their reasoning or motivation for a specific instructional strategy or action as it pertains to deeper learning. It may be the case that the PST describes their reasoning or motivation for something like why they became a teacher. Code that <i>if</i> it seems clearly relevant to teaching for deeper learning. If unsure, code it and note in annotation.	
3c. Planning and/or Reflection	PST describes planning actions related to teaching for deeper learning. Participant reflects on their experiences or practices related to deeper learning or teaching for deeper learning. For now, this is separate from planning. They might go together, but not necessarily.	
3e. Limitation and/or developing practice re: teaching for deeper learning	Use this code <i>only</i> if the interviewee states this explicitly. Not to be used if assumption or inference must be made about their practice re: teaching for DL.	
3z. Other	Note in annotation	

Specific Form of Node	Example or Description from Relevant Literature (if applicable)	Examples from Data
<i>4. Teacher Education Experiences Related to Deeper Learning</i>		
4a. General engagement in Hewlett Deeper Learning Modules (DLMs)	Participant references engaging in any of the various deeper learning modules.	
4b. Specific instructional strategy (general for now, add in annotation then create sub-nodes later)	This code should be used for specific instructional strategies that are used in addition to the modules. This might take the form of worksheets, guided discussions, developing or analyzing lesson plans, and so on.	
4c. Limitation and/or confusion re: TEP experiences re: deeper learning	Some faculty members do not make it clear to PSTs that they are engaging in the DLMs, which occasionally leads to confusion when PSTs are asked questions about them. Further, it's possible that the PST is not immediately able to make connections between their coursework/fieldwork experiences and deeper learning. In these cases, use this code.	

Specific Form of Node	Example or Description from Relevant Literature (if applicable)	Examples from Data
4d. Fieldwork experiences re: deeper learning	In some programs “fieldwork” is also referred to as “teaching placements” or simply “placements”. In general, use this code if the PST refers to TEP experiences which happen outside of the university context and within a K-12 context. These fieldwork experiences often take place in cooperation with a “cooperating teacher” or “mentor teacher”. In other instances, PSTs will participate in a “classroom takeover” or simply a “takeover”, in which they become the primary teacher in the classroom. In these cases, the PST may make reference to their students, referring to the K-12 students in their placement classroom(s). In any of the above instances, use this code.	
4e. General TEP experiences re: deeper learning	PSTs may refer to experiences in their TEP which do not directly relate to the modules or to their fieldwork. This could be things such as coursework, discussions with their colleagues or classmates, or other TEP-experiences which they explicitly related to deeper learning.	“There was another class where we—it was like teaching. It was like deeper learning adjacent; I think it was called secondary math methods. And so in that course, we talked about how when we have students practice, we have students cooperate and present their work. And, you know, we try to, like, facilitate these discussions. I think that would also be something that I would like to learn more about. Like, what are the kind of questions we ask students to ensure that they’re hitting, like, the deeper learning of mathematics.” (CH, para. 53)

Specific Form of Node	Example or Description from Relevant Literature (if applicable)	Examples from Data
4z. Other	Note in annotation	
<i>5. Math- or Science-Specific Conception of Deeper Learning</i>		
5. Math- or Science-Specific Conception of Deeper Learning	Use this code if a participant explicitly uses math and/or science language in their description of deeper learning or teaching for deeper learning. It may be that they are using it to communicate their understanding of deeper learning, as in a math or science example.	“I keep going back to this idea of procedural versus conceptual math. In procedural math, there’s no real connection to it. It’s just like, you do these three steps and then you get your answer. And I think part of that conceptual understanding is building in the background knowledge and building in cultural responses. And making sure that your students are represented in whatever word problem you’re doing, and it’s not just ‘Do 1 through 10 for homework.’ It’s like, here’s a real-life example of this bicyclist and he’s like riding down a hill in a certain area—just giving more context to a math problem, than having kids do randomness. I think that has become a lot more important to me, too. Also, procedural it’s just like, so bad because the kids don’t learn anything” (MJ, para. 77)

Appendix E

Counts of Code Occurrences and Example Quotes

Note: The table numbers are associated with the corresponding findings chapters. Tables E4.1 and following correspond to findings discussed in Chapter 4: Findings, Part 1: Teacher Educators. Tables E5.1 and following correspond to findings discussed in Chapter 5: Findings, Part 2: Preservice Teachers.

Tables Corresponding to Chapter 4: Findings, Part 1: Teacher Educators

Table E4.1

Teacher Educator Conceptions of Deeper Learning (Counts Ordered by Frequency)

	Teacher Educator Initials (Pseudonyms)														<i>Total</i>
	BK	CG	ER	LB	LF	MO	MOc	MS	RS	SC	SE	TM	TR	UA	
Associations with other education-related constructs	7	3	1	3	5	3	4	1	4	4	1	2	4	2	44 (14)
Outcomes of engaging in DL	4	7	2	9	1	3	1	2	0	2	1	3	1	1	37 (13)
DL as a process	3	6	2	2	0	2	1	1	0	0	1	0	1	0	19 (9)
DL as a framework	5	0	0	1	1	1	0	0	1	2	4	2	0	1	18 (9)
DL in contrast to surface learning	0	0	0	2	3	0	0	0	0	0	0	1	1	0	7 (4)
DL as a state	0	0	1	0	0	0	0	1	0	0	0	2	1	1	6 (5)
Limitation/Developing understanding of DL	2	0	0	0	0	0	2	0	1	0	0	0	1	0	6 (5)
Other	3	4	2	0	0	0	0	0	2	2	0	1	1	0	15 (7)
<i>Total</i>															152

Table E4.2*Examples of Deeper Learning as Related to Other Educational Constructs*

Interview Quotes	Other Education-Related Construct(s)	Participant Pseudonym
“One thing I’ve loved about these modules is talking about deeper learning in an elementary context. It’s kind of transformative for some of them, because I think we can associate deeper learning with middle and high school curriculum. So, I think of a lot of hands-on learning. I also dig pretty deeply into constructivism in this child development class, so I tie it in with the constructivist methods of teaching and being very hands on, very participatory.” (para. 28)	Constructivism	Bryn Knight
“I’m coming from a special education lens, and we always looked at what was a life skill—how can we help our students generalize information to multiple contexts that make them or help them to be as productive and as integrated into life as possible. So, I think I always had that lens, and so stepped away from teaching to a textbook. I also was trained and have a strong philosophical bent towards Understanding by Design. So, the backwards planning, the Understanding by Design, which again lends itself to looking at Enduring Understandings and bigger pieces.” (para. 61)	Understanding by Design; Enduring Understandings	Caroline Grey
“The quickest translation I have is 21st Century Skills. And then, you know, beyond that, there’s an emphasis on transferable skills, like real world applications, project-based learning—those are kind of whatever cluster of things in my brain that I associate with deeper learning.” (para. 25)	21 st Century Skills	Miriam O’Connor
“Have you ever heard of depth of knowledge? So, when I was teaching high school, we practiced that a lot, like a Depth of Knowledge (DOK) 1, 2, 3, or 4. And so, deeper learning for me is like a DOK 3 or 4.” (para. 169)	Webb’s Depth of Knowledge	Melissa Stone

Interview Quotes	Other Education-Related Construct(s)	Participant Pseudonym
“And like, honestly, it kind of reminds me of, like, 21st Century Learning. Which was when I did a teacher prep program, which, I finished mine in 2004, right? Like, we were talking about 21st Century Learning then, and a lot of the concepts are just the same. I think that there are so many foundational concepts that you want your teacher candidates to develop, right? And it’s really hard to choose. I do like that this overall framework connects some things that seem disconnected, right? So, we have equity, we have social emotional learning, we have collaboration, right? Deeper learning gives a framework for these different mindsets and a way to connect them.” (para. 33, 41)	21 st Century Learning; social emotional learning; collaboration	Sophia Cardinal
“I mean, I guess I would think of things that I teach like Bloom’s Taxonomy and Webb’s Depth of Knowledge. So, making sure that our students aren’t just doing activities where they’re listing things or labeling or filling out a worksheet, but that they’re actually co-creating, and they’re utilizing resources that are in the room that they’ve co-created—things like that.” (para. 29)	Bloom’s Taxonomy; Webb’s Depth of Knowledge	Tamera Marion
“When we think about mathematical proficiency, I would definitely say that deeper learning—the productive struggle or problem solving and stuff like that—I definitely feel like that’s very easy to fit in math. Then with exceptional learners, I just feel like the module fit well as far as engagement, like just ways in to engage student teachers in deeper conversations beyond their scaffolding and content knowledge.” (para. 113)	Productive struggle	Tiffany Ryan

Table E4.3*Examples of Deeper Learning in Terms of Outcomes*

Interview Quotes	Outcome(s)	Participant Pseudonym
“What comes to mind for me when I think of deeper learning is the skills, the concepts, the experiences that we would be giving students in our schools that really transcend education, transcend the classroom into lifelong learning, lifelong application of being able to use those experiences and skills in other contexts.” (para. 43)	Skills, concepts, and experiences; able to use those experiences and skills in other contexts	Caroline Grey
“I would define deeper learning as becoming able to engage in practices that are supported by relevant theory and recent research on a moment-to-moment basis in practice, which for my population is the practice of secondary teaching.” (para. 85)	Able to engage in practices supported by relevant theory	Emily Riemann
“Deeper learning is getting to know and understand your students on a deep level so that you’re able to scaffold your instruction to best support their learning goals and needs, so that they can really reach that in-depth knowledge.” (para. 58)	Able to scaffold instruction to support learning goals; in-depth knowledge	Mary Oliver
“Deeper learning is, I think, moving students away from lower levels of Bloom’s Taxonomy to higher levels of Bloom’s Taxonomy, while, at the same time, developing skills that they can use across academic disciplines or potential careers that they may have.” (para. 189)	Skills that students can use across academic disciplines or potential careers	Sophia Cardinal
“I had a general sense about what was meant by deeper learning before engaging with these modules. So, I knew that there were several areas in which students could engage in specific skills that would actually allow them to incorporate content knowledge at a deeper level to be able to apply that content knowledge across multiple situations. I knew things like collaboration, critical thinking, problem solving, and communication, but I didn’t have the specific language from the deeper learning framework.” (para. 29)	Able to incorporate content knowledge and apply that across multiple situations	Sue Eastern

Interview Quotes	Outcome(s)	Participant Pseudonym
“Deeper learning is, for teacher candidates, the ability to make decisions on their own feet based on specific situations that they are facing. Deeper learning is about their ability to, in the moment, as they are facing a specific situation, to make that decision of what works best in this case and be able to implement it quickly.” (para. 128)	Able to make situationally aware teaching decisions	Usha Aziz

Table E4.4

Examples of Deeper Learning as Related to Teaching for Deeper Learning

Interview Quotes	Aspect Related to Teaching for Deeper Learning	Participant Pseudonym
“One thing I’ve loved about these modules is talking about deeper learning in an elementary context. It’s kind of transformative for some of them, because I think we can associate deeper learning with middle and high school curriculum. So, I think of a lot of hands-on learning. I also dig pretty deeply into constructivism in this child development class, so I tie it in with the constructivism methods of teaching and being very hands on, very participatory.” (para. 28)	Constructivist methods of teaching	Bryn Knight
“I’m coming from a special education lens, and we always looked at what was a life skill—how can we help our students generalize information to multiple contexts that make them or help them to be as productive and as integrated into life as possible. So, I think I always had that lens, and so stepped away from teaching to a textbook. I also was trained and have a strong philosophical bent towards Understanding by Design. So, the backwards planning, the Understanding by Design, which again lends itself to looking at Enduring Understandings and bigger pieces.” (para. 61)	Understanding by Design	Caroline Grey
“Deeper learning is getting to know and understand your students on a deep level so that you’re able to scaffold your instruction to best support their learning goals and needs, so that they can really reach that in-depth knowledge.” (para. 58)	Understanding students and scaffolding instruction	Mary Oliver

Interview Quotes	Aspect Related to Teaching for Deeper Learning	Participant Pseudonym
“If I could picture in my head, a teacher candidate actually practicing it in their own classroom. And then maybe looking at student performance and seeing if there is any improvement after participating in the discussions. Like if it proved that they did have a deeper understanding of the mathematics. (para. 117)	Teacher candidate classroom practice	Melissa Stone
“I always think about how we, as a field, we’re trying to help them understand theoretically how learning happens. And I also think about how that exists in practice, and I feel like deeper learning means bringing those together as much as possible. So not being like, first we’re going to tell you all the theory, and now you’re going to go do it; or, and now we’re going to show it to you in a video, but how can we, as much as possible, weave those two things together, which, to me, supports the deeper learning of teaching itself.” (para. 49)	Supporting the deeper learning of teaching itself	Emily Riemann
It reminds me of something that we talk about in teacher education, which is developing thinkers rather than assignment doers. And so, when I think about deeper learning, I think about how I could do a sort of surface level task, maybe for some content development or some sort of basic skills. But I think of taking it to a literal deeper level. So, a more realistic or life application, and being able to take content and apply it in different ways, more than just basic level repeating back content or a basic level of a skill. So, application in different places. (para. 21)	Developing thinkers	Layla Brussels

Table E4.5*Counts of Occurrences for Teacher Educator Conceptions of Teaching for Deeper Learning*

	Teacher Educator Initials (Pseudonyms)														<i>Total</i>
	BK	CG	ER	LB	LF	MO	MOc	MS	RS	SC	SE	TM	TR	UA	
Learning chain of teaching for DL	4	3	2	3	3	2	3	0	5	2	2	3	6	4	42
DL in terms of teaching (general)	1	3	2	5	5	3	3	1	1	3	4	2	0	2	35
Limitation and/or developing/changing conception of teaching for DL	5	3	0	0	3	0	2	1	4	0	1	0	2	0	21
Teaching for DL as a process	1	1	0	4	0	1	0	0	1	0	0	0	3	1	12
Other	1	0	0	2	0	0	0	0	3	0	0	0	0	0	6
															116

Table E4.6*Examples of Descriptions of Teaching for Deeper Learning Which Align with a Learning Chain of Teaching for Deeper Learning*

Interview Quotes	Relevant Aspect of Learning Chain	Participant Pseudonym
“I feel like if the supervisors had a better understanding of what we’re teaching in class with the deeper learning, then maybe they could follow through on that with what they’re seeing them do in their practicum.” (para. 160)	Supervisors or cooperating teachers	Bryn Knight
“Honestly, we do lots of collaboration within our division within the education division, but then we collaborate college-wide maybe not so much. Other departments might not have the same depth of knowledge of deeper learning practices, but that gives space for future—that’s just making me think of future professional development opportunities for other faculty members to really hone in on these deeper learning practices that really apply to other fields of study.” (para. 62)	Departmental versus college-wide collaboration re: deeper learning	Mary Oliver

Interview Quotes	Relevant Aspect of Learning Chain	Participant Pseudonym
“But I wonder, if the structure of residencies gets developed in a good way that both the district and the university are working far more collaboratively and innovatively, that you wouldn’t do some of these modules with the guide teachers. So, because one of the pieces of that renewed or expanded partnership is that the university would have, a couple of times per semester, the opportunity to do guide teacher training to be able to meet with the mentor teachers to share what we’re doing at the university or to look at what their issues are. So then you’ve got the teacher candidate, and the classroom mentor teacher, thinking about the same deeper learning concept. And that could be really cool. (para. 572)	University-district partnership; teacher candidate and mentor teacher alignment	Caroline Grey
“As I said, I had already been involved with the with the edTPA and PACT teaching event before that. And those, those efforts from the same unit, from SCALE, those efforts were the ones that that really deepened the work that we were doing in teacher ed, particularly in my discipline and history social science, they had already taken us in the direction of new and better ways of teaching history that involved serious critical thinking skills and departing from students just reading a textbook and answering the questions at the end of the chapter, or at the bottom of the page, they had taken us in directions of contesting history and asking harder questions.” (para. 61)	In relation to a history of research and reform regarding teaching for deeper learning	Ryan Snow

Table E4.7

Cooccurrences of Conceptions of Deeper Learning with Other Conceptions of Deeper Learning

	Type of Conception of Teaching for Deeper Learning (DL)								<i>Total</i>
	DL as a process	DL as a state	Outcomes of engaging in DL	Associations w/ other education-related	Limitation/developing understanding of DL	DL as a framework	DL in contrast with surface learning	Other	
DL as a process	-	2	15	4	0	1	2	7	31
DL as a state	2	-	6	1	0	1	1	2	13
Outcomes of engaging in DL	15	6	-	13	1	3	4	6	48
Associations w/ other education-related constructs	4	1	13	-	2	8	5	7	40
Limitation/developing understanding of DL	0	0	1	2	-	1	0	0	4
DL as a framework	1	1	3	8	1	-	0	2	16
DL in contrast with surface learning	2	1	4	5	0	0	-	1	13
Other	7	2	6	7	0	2	1	-	25
<i>Total</i>	31	13	48	40	4	16	13	25	190

Table E4.8*Cooccurrences of Conceptions of Deeper Learning with Conceptions of Teaching for Deeper Learning*

	DL in terms of teaching (general)	Learning chain of teaching for DL	Teaching for DL as a process	Limitation/ Developing understanding of teaching for DL	Other	<i>Total</i>
Associations with other education- related constructs	13	6	2	3	3	27
Outcomes of engaging in DL	7	3	4	1	1	16
DL as a framework	8	3	0	2	1	14
DL as a process	3	2	4	1	1	11
DL in contrast with surface learning	3	1	1	0	1	6
Limitation/ Developing understanding of DL	1	0	0	4	0	5
Other	1	1	1	1	1	5
DL as a state	1	2	0	0	0	3
<i>Total</i>	37	18	12	12	8	87

Table E4.9*Counts of Codes for Actions for Preparing Preservice Teachers for Deeper Learning*

	Teacher Educator Initials (Pseudonyms)														<i>Total</i>
	BK	CG	ER	LB	LF	MO	MOc	MS	RS	SC	SE	RM	TR	UA	
Planning/Reflection	7	11	6	7	3	5	2	2	9	5	8	4	3	5	77
Specific Instructional Strategy	14	5	1	12	6	2	3	5	5	3	5	0	4	1	66
Reasoning/Motivation	6	7	3	7	2	6	3	3	5	7	2	4	7	1	63
General Use of DLMs	8	7	1	4	6	3	4	5	10	2	1	4	2	3	60
Limitation and/or Developing Practice	3	7	4	8	2	0	6	4	7	6	1	0	4	1	53
Adjusted Use of DLMs	6	4	2	10	0	1	3	2	6	2	3	1	0	1	41
Uses DLMs as a Resource for PSTs	0	0	1	2	1	2	1	2	0	1	0	0	0	1	11
Other	2	0	1	0	0	2	0	0	0	3	1	0	0	0	9
<i>Total</i>															380

Table E4.10*Examples of Teacher Educator Planning and/or Reflections Regarding DLM Use*

Interview Quotes	General Focus of Planning/Reflection	Participant Pseudonym
“I had my PSTs look back at their lesson plans, and said, ‘Okay, now that you know about this, where can you add some more and again?’ I did that towards the end of the semester when they were so done. So, I’m going to try to move that up next semester. But I really would love to do that again, because I think having them work on something and then say, ‘Now, let’s go back to your lesson plans now and let’s add to it practically.’ And they didn’t take it super seriously in their written assignment, but in the class discussions it was clear that it was good that they were able to say, ‘Oh, yeah, I could add something here or add something there to make it more critical.’” (para. 124)	Reflection for future changes to implementation	Bryn Knight

Interview Quotes	General Focus of Planning/Reflection	Participant Pseudonym
“I’m thinking about how can I use more outside resources—in teacher ed., I think a lot of times we think we have to create everything on our own, that’s sort of the attitude—but there are many times that we can use well-made materials that are not of our own creation, and we should model that for our students, right? So, I teach a lot of elementary students. They’re generalists. I would never want them to think they have to create everything, that they can’t use book lists to pick titles, that they have to create every lesson plan and every handout. Like, that’s bananas. So even just me being deliberate about modeling that for students, right? Picking high quality materials is an important piece. Or thinking about, ‘is this the best use of time? Is this the best use of their energy?’ And just being deliberate, we only have so much time, but we can pick quality materials in that time frame. And I hope that’s what they’re going to do with their kids, you know?” (para. 25)	Reflection which highlights motivation (in this instance, oriented towards modeling behavior for PSTs)	Layla Brussels
“I think it has made me really look through the materials as looking for things that have videos of students learning or has like a really concrete tool that was used because those are the things that I guess were most meaningful to be that I’ve seen lead to the most shifts in some of my teacher candidates. And so that’s kind of what I’ve been looking for. And also the questions associated with them, but that’s—as I scan through and compare different videos, I look and think, ‘wow, we can actually see students collaborating together in a group.’ And that’s a thing that my students are not seeing in their student teaching, but are so desperate to be able to do, and that made me value the videos as a resource within the modules.” (para. 65)	Planning in terms of reviewing materials	Emily Riemann

Interview Quotes	General Focus of Planning/Reflection	Participant Pseudonym
“If the topic is classroom discussions and formulating good questions, the deeper learning Effective Discussions module gave me and my students another set of ideas. That isn’t how I’ve been teaching discussions all these years, but now I use the module and it supplements the things that I had been doing for years. So, it’s a different way to look at it. In fact, one very specific thing that is different about the deeper learning modules is that they do assume and they do take a stronger political stance than I was used to doing in my teacher education classes. Especially when teaching about skills like conducting discussions, implementing and administering assessments that—I’ll keep it to those two. The SCALE modules introduce, in fact, they almost assume a certain political or ideological bias.” (para. 41)	Reflection on modules as supplementing and challenging current teaching methods	Ryan Snow
“We kind of individually looked at different modules and the description to select a module that we felt was the best fit for our classes. We decided to meet as a team and discuss which modules we were selecting, and which class we would like to implement the module in. We talked about the idea of selecting one module and all of us implement the same one, or selecting different modules and each one of us select a different one. But we immediately came to the idea like, ‘Oh, no, it has to be different. Because we share a lot of students.’” (para. 51)	Planning in collaboration with teacher education colleagues	Usha Aziz

Table E4.11*Examples of Teacher Educator Adjustments to DLM Delivery*

Interview Quotes	Adjustment to Module Delivery	Participant Pseudonym
“If I weren’t teaching sophomores, I probably would have still used those activities and just said, “keep in mind, this is not really going to be relevant,” but I didn’t want to overwhelm them with that. So, it’s not necessarily that it was too challenging, just that I was concerned it didn’t fit in with where they were in the program.” (para. 79)	Meeting the needs of students	Bryn Knight
“I’m just thinking about how to make it small and bite-sized enough for them to still get something out of it, but actually be able to engage with everything that I share with them. “I looked at the videos introducing things, and I included those videos but I’m going to say these are optional things for you to do on your own time if you want more information, because I do think I have some students who will want to do that. But I’m not going to require that of all of my students, because I think that if they’re not using something that’s deeply connected to a classroom practice, I see them on their computers lesson planning for the next day, which I understand.” (paras. 106, 110)	Meeting the needs of student	Emily Riemann
“Well, the last one was where they actually plan an effective discussion, but they didn’t do it. In the module it was phrased as optional, but I think at that point it was just bad timing on my part. I think they were burned out, you know, from the EdTPA, and then coming back from spring break, and their student teaching. They were just busy, and so that’s another reason I would like to do it earlier in the year and actually have them plan the effective discussion as an assignment and not make it optional.” (para. 121)	Meeting the needs of students; contextual adjustments	Melissa Stone

Interview Quotes	Adjustment to Module Delivery	Participant Pseudonym
“I thought some of the actual resources were a little overwhelming, and there was a lot in some of them. So, the one resource that was—I can’t remember the exact name—the effective discussion strategies resource had different sections with a bunch of different links in them. I took that and broke that up. So that it wasn’t where you really unpack all of this in one sitting. We kind of broke that down. And this is me being brutally honest. I chose not to use some of the videos in my in-person sessions. And the reason I chose not to use them was, I thought some of them were not as easily engaging as I think it would have been if I had presented the same material in a different way. I think it can be challenging sometimes to have students sit—so we have four-hour classes. We meet once a week for four hours—And, the thought of watching some of those videos on top of doing some of the other stuff that we needed to get done to meet our state licensing standards, was just a little bit much.” (para. 91)	Meeting the needs of students; contextual adjustments	Sue Eastern
“I’ve looked through the module, and I’ve culled it a little bit, taking out some activities, making sure these other activities are the important ones that I want them to do, while having some activities be asynchronous, some with peer collaboration, some with classroom discussion—but I think that’s been more based on time management for me and looking at what [the PSTs] have to do than it has been, ‘oh, this is the best way to use the module.’” (para. 340)	Contextual adjustments	Caroline Grey

Table E4.12*Counts of Various Code Occurrences for Teacher Educators, Grouped by Module Development*

	Module Developers (6 participants)	Not Module Developers (8 participants)	<i>Total</i>
<i>Codes for Conceptions of Deeper Learning</i>			
Associations with other education-related constructs	21	23	44
Outcomes of engaging in DL	12	25	37
Deeper learning as process	8	11	19
DL as a framework	4	14	18
Other	9	6	15
DL in contrast with surface learning	1	6	7
Deeper learning as state	2	4	6
Limitation/Developing understanding of DL	4	2	6
<i>Subtotal</i>	61	91	152
<i>Codes for Conceptions of Teaching for Deeper Learning</i>			
Learning chain of teaching for DL	23	19	42
Deeper Learning in terms of teaching (general)	12	23	35
Limitation/Developing understanding of teaching for DL	11	10	21
Teaching for DL as a process	6	6	12
Other	3	3	6
<i>Subtotal</i>	55	61	116
<i>Codes for Actions for Preparing Teachers for Deeper Learning</i>			
Planning/Reflection	35	42	77
Specific instructional strategy	21	45	66
Reasoning/Motivation	30	33	63
General use of DLMS	28	32	60
Limitation and/or developing practice	31	22	53
Adjusted use of DLMS	16	25	41
Uses DLMS as a resource for PST's	3	8	11
Other	3	6	9
<i>Subtotal</i>	167	213	380

Tables Corresponding to Chapter 5: Findings, Part 2: Preservice Teachers

Table E5.1

Preservice Teacher Conceptions of Deeper Learning (Counts)

			Interview Participant Initials (Pseudonyms)										
	New Cypress FG1	New Cypress FG2	CH	CK	DS	EH	GB	HL	RJ	MJ	RS	<i>Total</i>	
DL in contrast with surface learning	3	3	3	1	2	1	2	1	0	1	1	18	
Limitation/developing understanding of DL	0	0	1	1	0	4	1	1	3	3	3	17	
Outcomes of engaging in DL	1	3	0	0	2	1	1	0	2	1	0	11	
Associations with other education-related constructs	0	0	2	1	0	0	1	0	1	3	1	9	
Deeper learning as a process	0	0	1	0	0	1	1	0	1	0	2	6	
DL as a state	0	0	3	0	0	0	0	0	1	0	1	5	
Other	1	0	2	0	0	2	0	0	0	0	0	5	
DL as a framework	0	0	0	1	1	0	1	0	0	0	0	3	
<i>Total</i>												74	

Note. FG = Focus Group; DL = Deeper Learning

Table E5.2

Examples of Deeper Learning in Contrast to Surface Learning

Interview Quotes	Contrast Between DL and Surface Learning	Participant Pseudonym (credential)
“When I think about deeper learning, it’s sort of hinting at that idea of there’s a surface level memorization that students can do in order to, you know, pass the class or do well on a test. And then there’s the higher level like meta thinking of these concepts, and being able to apply critical thinking to a problem that they haven’t quite seen yet.” (para. 35)	Higher level or meta thinking and application <i>vs.</i> Memorization	Dylan Stewart (Math)

Interview Quotes	Contrast Between DL and Surface Learning	Participant Pseudonym (credential)
“It’s like what I said about going beyond the surface, and really figuring out the why—why is this happening? Rather than just what’s happening?” (para. 43)	Why <i>vs.</i> What	Carey Kochen (Science)
“Deeper learning to me is like learning more than just like the surface information, like really going in-depth about everything, and kind of pulling real-life experiences in there.” (para. 35)	Going more in- depth; pulling in real-life experiences <i>vs.</i> Surface information	Hope Lee (Science)
“What comes to mind for me is going more into the content and almost past content, I guess and trying to think more about the way that we are teaching kids and how they learn and just diving further than the surface level standards and objectives they need to learn and continuing past that to give them a well-rounded picture of what we’re going over.” (para. 26)	Going past standards and objectives; providing a well- rounded picture; application to daily life <i>vs.</i> Surface level standards and objectives; expected curricular content	Multiple participants, New Cypress FG1
“I was kind of thinking about how it’s learning without limits. Thinking back to all my experiences in a classroom, I definitely see where it’s important to go beyond what’s in the curriculum and to think deeper about the things that we can apply to daily life or the things that we need in order to function as a society. Especially for kids who are still developing educationally and mentally, I just think it’s really important to sometimes go beyond what’s expected as far as how a teacher goes about things.” (para. 30)		

Table E5.3

Examples of Limitations in or Developing Understandings of Deeper Learning

Interview Quotes	Specific Limitation or Developing Understanding	Participant Pseudonym (credential)
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“I would say I wasn’t really sure before doing this program, like, how to start with doing deeper learning. Like, I don’t know what kind of activity would help with that, or what I should even do as a teacher elicit that. And I feel like through to my different classes and placements, I’ve kind of realized it doesn’t always have to be a big activity. Sometimes even just doing class discussions using certain type of questioning and getting students to respond to each other, or even just explain, can do it in small ways.” (para. 87)	Developing understanding in terms of teaching for deeper learning	Gemma Bailey (Math)
“What was my understanding of deeper learning before? I never heard that word before. Nobody cared. You either have it or you don’t, move on. So, before all of this, I wouldn’t say it was someone else’s responsibility. I didn’t think that another person could care about your own learning. I didn’t think that it was another person’s responsibility to care about how to help you learn. So no, I knew nothing about deeper learning.” (para. 53)	Developing understanding of deeper learning	Elsa Henley (Math)
“I don’t think I could say a lot about deeper learning, but I guess learning more or realizing that there’s so many things that are in education, and like there’s so many things going on, and so many things to learn about. That’s about it.” (para. 85)	Limited understanding of deeper learning within education	Hope Lee (Science)
“I think if someone asked me to describe in my own words what deeper learning means, I wouldn’t quite be sure. I think what I put on the survey when I filled it out was not just learning content or curriculum but also being able to apply it and develop other skills that can be used outside of, like an academic environment. Sort of like a mix of interdisciplinary—I feel like I’m just saying buzzwords.” (paras. 44, 48)	Limited understanding of the meaning of deeper learning	Rose Johnson (Math)

“I think I’ve been really lucky in the way that it’s been, not necessarily spoon fed to me, but I’ve been given a lot of guidance on how to make things deeper, how to make critical thinking happen. I think that I just need a little bit more opportunities to do that individually, because I know that I’m going to have to do that eventually. And that scares me because it’s like, I can stick to what I know and teach what I’ve been taught surface level. But to actually make it click, and to make you think, it takes a special kind of teacher to do that. And it takes a lot of effort and a lot of content knowledge. A lot of pedagogical content knowledge as well. And I really just would like more practice, more and more like real life practice, especially with kids.” (para. 105)	Developing understanding in terms of teaching for deeper learning	Ruby Shaw (Science)
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Table E5.4

Examples of Outcomes of Engaging in Deeper Learning

Interview Quotes	Specific Outcome of Engaging in Deeper Learning	Participant Pseudonym (credential)
“And I think that is a big point in deeper learning is that you’re teaching them not the exact concept, but you’re teaching them how to use these concepts and apply them into different areas within your subject. I think that’s a big thing in math and science, especially.” (para. 35)	Use/application of concepts into different areas	Dylan Stewart (Math)
“I think of, like, less procedural and more getting kids to understand the meaning behind why things work, rather than just like memorizing the steps.” (para. 17)	Understanding the meaning behind why things work	Gemma Bailey (Math)
“I think I’ve learned a lot on the application side, if we’re defining deeper learning as taking a curriculum and being able to make it applicable outside of that lesson or that unit or whatever.” (para. 72)	Making curricular content applicable beyond one lesson	Rose Johnson (Math)
“The first thing that comes to mind for me is just learning beyond rote memorization and being able to apply what you learn into different situations. And so it’s more than just having a surface level knowledge. You gain a deeper understanding of whatever the	Application of information and skills in different contexts; deeper understanding of subject; ability to	Multiple participants, New Cypress FG2

subject is and you're able to go out and use that." (para. 40)	conceptualize, transform, and apply an idea
"I think deeper learning is when you learn something beyond surface level. And not only the skills you learn, you're able to apply that information in different contexts." (para. 46)	
"I agree. Like, I think some people are just like on the surface and stuff. But critical thought, you know, being able to conceptualize an idea and then transform it and apply it to something else rather than just memorizing facts." (para. 48)	

Table E5.5

Examples of Preservice Teachers Use of Math and Science in Describing Deeper Learning

Interview Quotes	Specific Math or Science Construct	Participant Pseudonym (Credential Area)
"When it comes to math, my understanding of deeper learning is always making sure that the students are understanding it conceptually, and not just procedurally. I guess an example of this would be something with exponents. Procedurally, if you have negative exponents, most students would know, 'oh, you just flip it or you do the inverse of it, and then change the negative exponent to be a positive,' but I guess conceptually, I'd like students—deeper learning, to me, would be students knowing that actually with negative exponents you're just dividing by that number." (para. 21)	Negative exponents	Cheng Han (Math)

Interview Quotes	Specific Math or Science Construct	Participant Pseudonym (Credential Area)
“When I think about deeper learning, it’s sort of hinting at that idea of there’s a surface level memorization that students can do in order to, you know, pass the class or do well on a test. And then there’s the higher level like meta thinking of these concepts, and being able to apply critical thinking to a problem that they haven’t quite seen yet. And I think that is a big point in deeper learning, is that you’re teaching them not the exact concept, but you’re teaching them how to use these concepts, and apply them into different areas within your subject. I think that’s a big thing in math and science, especially.”	Importance of transfer within math and science	Dylan Stewart (Math)
“For example, we talked about indigenous mathematics. In class, one of my professors introduced me to the Lénárt sphere, which I purchased, and it’s under my desk, which will be in my classroom where we will learn about spheres. And those are all hands-on things. To me, that’s deeper learning.” (para. 149)	Indigenous mathematics; hands-on math tools (e.g., Lénárt sphere)	Elsa Henley (Math)
“When I was in high school, I just memorized the formulas and stuff. Probably the closest I got to deeper learning was maybe in calculus. I had a really good AP Calc teacher, and she would explain a lot of the reasons why things work and make connections even just between procedures. So it was clear what was happening, especially with area and volume problems. Those you have to really understand what’s happening to be able to even write them up.” (para. 25)	Calculus; area and volume problems within calculus	Gemma Bailey (Math)

Interview Quotes	Specific Math or Science Construct	Participant Pseudonym (Credential Area)
“I keep going back to this idea of procedural versus conceptual math. In procedural math, there’s no real connection to it. It’s just like, you do these three steps and then you get your answer. And I think part of that conceptual understanding is building in the background knowledge and building in cultural responses. And making sure that your students are represented in whatever word problem you’re doing, and it’s not just ‘Do 1 through 10 for homework.’ It’s like, here’s a real-life example of this bicyclist and he’s like riding down a hill in a certain area—just giving more context to a math problem, than having kids do randomness. I think that has become a lot more important to me, too. Also, procedural it’s just like, so bad because the kids don’t learn anything” (para. 77)	Procedural versus conceptual math; providing context for math problems	Miley Jones (Science)
“Being in science, I guess it’s kind of an advantage with deeper learning. What I think of—I’ll take a personal example. Like, we know what things are. But there’s so many times when I’ve been humbled where I’m like, ‘Oh, I actually don’t really know fundamentally what that is.’ I don’t know, I was thinking about soil and dirt. And I was like, ‘What actually is dirt made of? Like, what is dirt?’ You have an image in your mind and you can kind of guess, but it’s like, is it sand? Is it organic matter?—And, I have a friend who is in emergency medical services school right now. And, as part of his studying, he will tell me what’s actually happening when a heart beats, that deoxygenated blood is being pulled in and then it’s pushing in oxygen, and it’s pushed out. And so I was like, ‘I have no idea how things work.’ As I’ve gotten older, I’ve realized that I’ve got a lot of learning to do. So, when I think of deeper learning, it’s like, you might think you know what things are, and you do. Sometimes you’re surprised by how much you know. But to really, truly understand something is to pick it apart so intricately. And that’s part of what brings the awe of science, to think about things microscopically. I know that’s more related to my content area than this general abstract, like education. But that’s what I think of.” (para. 25)	Soil and dirt; how human hearts work	Riley Sherwood (Science)

Table E5.6*PST Conceptions of Teaching for Deeper Learning (Counts)*

			<u>Interview Participant Initials (Pseudonyms)</u>										
	New Cypress FG1	New Cypress FG2	CH	CK	DS	EH	GB	HL	MJ	RJ	RS	<i>Total</i>	
Limitation/Developing conception of teaching for DL	0	0	2	3	4	9	0	0	3	1	8	30	
DL in terms of teaching (general)	4	1	5	1	5	0	2	0	0	0	0	18	
Other	0	1	2	0	0	0	1	0	2	0	2	8	
Learning chain of teaching for DL	0	0	3	0	0	0	0	0	0	0	3	6	
Teaching for DL as a process	0	0	1	0	0	0	0	0	0	0	1	2	
<i>Total</i>												64	

Table E5.7*Examples of Limitations or Developing Understandings of Teaching for Deeper Learning*

Interview Quotes	Specific Limitation or Developing Understanding	Participant Pseudonym (Credential Area)
“I would like to learn more about critical education. I understand that critical thinking is one part of critical education. I would like to learn more about UDL (Universal Design for Learning), but not online. I would like to learn it in person so that way I can actually absorb it, rather than just have it go in one ear and out the other.” (para. 139)	Desire to learn more about critical education and UDL	Carey Kochen (Science)

Interview Quotes	Specific Limitation or Developing Understanding	Participant Pseudonym (Credential Area)
“When I first came here, I hated those open-ended questions. I thought, ‘Ugh, can you just give me multiple choice so we can move on?’ But now, I ask open-ended questions all the time. It’s even helped my relationship with my husband. I’m always like, ‘Let’s ponder and let’s kind of talk through this. And let’s think about it.’ I’ve even changed my vocabulary. It sounds kind of cheesy, but saying things like, ‘I wonder if we could do this,’ and ‘I wonder if we could do that,’ and ‘I invite you to try this out.’ Just kind of changing the way that I communicate with people, not thinking that I have to be blunt all the time and direct all the time. But being able to connect, wanting to connect, with the person that you are learning with and teaching with, and just being patient. I feel like the classes we’ve taken have really allowed for that. There was a lot of self-reflection, and looking at your own education, and looking at how you were brought up and considering what you’re trying to bring to your future learners or future students.” (para. 57)	Developing understanding of the value of open-ended questions; considering one’s own educational experiences in contrast to future students’ educational experiences	Elsa Henley (Math)
“I definitely think deeper learning is more important than I thought it was. Especially the idea of incorporating everyone’s background knowledge and different cultural backgrounds. I have a little bit of personal experience with that, because I went to a very small school. I was the only Jewish girl in my whole grade for as long as I can remember. And we would do activities that were related to Christian things, and I was just like, ‘Okay, I don’t care, good to know.’ And I think having that personal experience and then watching the modules and being like, ‘Oh, other people are going through this, too,’ and ‘Here are ways that I can make it better for those students in my classroom.’” (para. 73)	Developing understanding of the value of deeper learning	Miley Jones (Science)

Table E5.8*Examples of Preservice Teachers Use of Math and Science in Describing Teaching for Deeper Learning*

Interview Quotes	Specific Math or Science Construct	Language Indicating Teaching	Participant Pseudonym (Credential Area)
“I think deeper learning is like helping students engage in materials other than what you’re giving them. So, if you’re teaching cell organelles, giving students the resources to help research for themselves and get more information. I think that’s what deeper learning is.” (para. 54)	Cell organelles	“helping students engage”; “teaching cell organelles”	New Cypress FG1
“When it comes to math, my understanding of deeper learning is always making sure that the students are understanding it conceptually, and not just procedurally. I guess an example of this would be something with exponents. Procedurally, if you have negative exponents, most students would know, ‘oh, you just flip it or you do the inverse of it, and then change the negative exponent to be a positive,’ but I guess conceptually, I’d like students—deeper learning, to me, would be students knowing that actually with negative exponents you’re just dividing by that number.” (para. 21)	Negative exponents	“making sure that the students are understanding”	Cheng Han (Math)

Interview Quotes	Specific Math or Science Construct	Language Indicating Teaching	Participant Pseudonym (Credential Area)
“We’ve been talking a lot about the five practices. It’s like creating open-ended tasks, where you have the five core mathematical principles. So, anticipating, monitoring—it’s anticipating student challenges when you create a task and then monitoring students as they work on them in groups. Then selecting students to share in such a way that whatever you select for them to share and show some sort of deeper learning that you then can make connections between. So, there’s selecting and then sequencing it so it’s in an order that the kids can make sense of the connections happening. And then you have the actual class discussion where you make connections between students work and whatever your learning objective is.” (para. 95)	Five core mathematical principles (see Smith & Stein, 2011)	“five practices”; “creating open-ended tasks”	Gemma Bailey (Math)
“I think on the application side, if we’re defining deeper learning as taking a curriculum and being able to make it applicable outside of that lesson or that unit. This class was kind of my first introduction to how you can create a math lesson that’s not just like, ‘Here’s how you do it, and then here are these practice problems. (para. 72)	Creating math lessons	“taking a curriculum and being able to make it applicable outside of that lesson or unit”	Rose Johnson

Table E5.9*PST Actions for Teaching for Deeper Learning in K-12 Contexts (Counts)*

	New Cypress FG1	New Cypress FG2	Interview Participant Initials (Pseudonyms)									<i>Total</i>
			CH	CK	DS	EH	GB	HL	MJ	RJ	RS	
Planning/Reflection	3	1	6	0	2	4	11	1	1	4	6	39
Specific instructional strategies for teaching for DL	4	4	7	2	2	2	9	0	2	0	4	36
Limitation/Developing practice in teaching for DL	0	0	8	1	3	5	6	1	0	3	0	27
Reasoning/Motivation	1	0	3	0	1	5	3	0	1	3	4	21
Other	0	0	0	0	0	0	2	0	0	0	0	2
<i>Total</i>												125

Table E5.10*Examples of PSTs' Planning and Reflections for Teaching for Deeper Learning in K-12 Contexts*

Interview Quotes	Specific Focus of Planning/Reflection	Participant Pseudonym (Credential Area)
“What I’ve done with the modules is I looked over the lessons like a week in advance, and I tried to think about what the essential questions of each day were, or the notes for that day. And based off what I could see with the worksheet, try to come up with those essential questions and try to facilitate those discussions with the students more often. Prior to the modules, I kind of just asked questions that I thought would help students understand the question, like, ‘Does that make sense?’ They’ll ask me questions about how to do the work, and I would reply with more questions about what they could do. Whereas after the modules my questions are more specific and geared towards the objective of the day.” (para. 113)	Reflection on change in question-asking practices before and after engaging in modules	Cheng Han (Math)

Interview Quotes	Specific Focus of Planning/Reflection	Participant Pseudonym (Credential Area)
<i>Context: discussing collaborating with fellow PSTs</i>		
“We’re always bouncing our ideas off of each other. And the big thing that’s helped me is having people to test run my curriculum on. That way I get to build something and I can say, ‘Okay, let’s run through this together.’ Then they say, ‘Oh, I like this problem,’ or ‘I don’t like this problem. This is a really big logical leap—maybe we need to build in some scaffolding here.’ So, I think being able to run that with others makes the experience in the classroom much smoother. It’s never my first time doing curriculum with students. Students are always the second, third, fourth run.” (para. 91)	Engaging in collaborative planning practices	Dylan Stewart (Math)
“I was talking with this 12th-grader, and his entire career in school has been just learning how to be a calculator and not really seeing the connection between math and the real world. So, I think that being in a math classroom and working really hard to incorporate real-life experience with math, and showing the students how we can use math as a tool to solve our real-life issues, but also use math to understand our real-life issues—I feel like that’s where you can make a strong case for deeper learning in a math classroom.” (para. 149)	Reflection on teaching for deeper learning as providing contrasting educational experiences for K-12 students	Elsa Henley (Math)
“We had an assignment where we could make kind of like an icebreaker activity to allow students to be able to share their community, personality, and culture. We didn’t have to present to any students, but we presented it like to everyone else in the class. I thought that was really fun. I think a lot of those activities I could really implement in my classroom in the future. We have been doing them in class and I hope that our future students would also really enjoy that. (paras. 97-101)	Future-oriented reflection	Hope Lee (Science)

Interview Quotes	Specific Focus of Planning/Reflection	Participant Pseudonym (Credential Area)
“We also have PLC groups, professional learning community groups. And that’s who we planned with and doo some of our work with. And that’s who we do our lesson with at the end of observation—that’s who we plan and execute that with. When we write that lesson plan, and we actually put the plan into action, there’s a lot of incorporating standards and thinking about the types of students that we’re teaching and what kind of activities would fit best for them. For example, we’re teaching about plate tectonics, and asking, like, what does this activity represent? And are they going to understand that? Just really digging deep into the student population that we have and what would fit best for them.” (para. 99)	Planning within PLC groups; incorporating understandings of students into planning	New Cypress Focus Group 1

Table E5.11

Examples of PSTs’ Specific Teaching Practices for Deeper Learning in K-12 Contexts

Interview Quotes	Specific Teaching Practice	Participant Pseudonym (Credential Area)
“I’m a culinary arts teacher right now. And making sure kids think outside the box more than just what’s happening. Maybe they’re thinking, ‘the dough is rising.’ But why is it rising? Is it yeast? Because yeast is eating the simple sugars, burping and farting, causing carbon dioxide to fill the dough and make it rise. So, making them think beyond the ‘what’s happening?’ and into ‘why is it happening?’ Also with the critical ethnic portion, I like to begin each week with land acknowledgement. Making sure that the students realize that we’re on unceded land, and making sure that they they’re thinking critically about cultures. Not just with the land acknowledgments, but also with their food that they’re making and the cultural aspects of the food that they’re producing.” (para. 83)	Moving students from “what” to “why”; incorporating cultural aspects of food	Carey Kochen (Science)

Interview Quotes	Specific Teaching Practice	Participant Pseudonym (Credential Area)
“For our second placement, we had to do a two-week takeover with us leading the class. And what I’ve done with the modules, I’ve looked over the lessons a week in advance, and I tried to think about what were the essential questions of each like day, or the notes for that day, and based off what I could see with the worksheet, try to come up with those essential questions and try to facilitate those discussions with the students more often. Whereas prior to the modules, I think what I did was I kind of just asked questions that I thought would help students understand the question, like, ‘Does that make sense?’” (para. 113)	Using essential questions; facilitating discussions	Cheng Han (Math)
“Some of the strategies from the modules I’ve done in my own classroom, like, “think, pair, share,” things like that. Or even, like, four corners—I’ve done that with my kids. They love that. But some of the other strategies, I just couldn’t really picture how it would work in a math classroom.” (para. 54)	Think, pair, share; four corners	Gemma Bailey (Math)
“In my math field placement, I was doing like a fraction worksheet. I was like, ‘Okay, let’s do something that everyone knows what it is.’ So, I made a fraction sheet about baking cookies. Because I feel like that’s something that a lot of kids know. And then on that worksheet I had another problem about baking some kind of pizza. And I was like, ‘I think a lot of kids know about pizza as well.’ Especially given the conversations that go on in the classroom. And then with the lesson plans that I’m writing now, if a kid’s not interested, I try to relate it back to something that I know they’re interested in.” (para. 81)	Fraction worksheet incorporating student interests	Miley Jones (Science)

Interview Quotes	Specific Teaching Practice	Participant Pseudonym (Credential Area)
“One day, the students went to the art room. And they figured out how many kilometers would equal how many inches so they could make the planets to scale. So, they measure the diameter, and then they’ve cut out the planet so you could really see how little how tiny Mercury is compared to Jupiter. Yeah, you can tell them that stuff. And it might just go over their head. But if they’re really thinking about it, and they’re actually in the process of making it, and then they put them on the wall, and they see how little their planet is compared to their classmates.” (para. 101)	Hands-on activity creating the Solar System to scale	Riley Sherwood (Science)

Table E5.12

PST Teacher Education Program Experiences for Teaching for Deeper Learning (Counts)

	Interview Participant Initials (Pseudonyms)											<i>Total</i>
	New Cypress FG1	New Cypress FG2	CH	CK	DS	EH	GB	HL	MJ	RJ	RS	
General TEP experiences regarding DL	2	3	11	6	11	11	9	4	2	6	8	73
Specific instructional strategy	10	7	3	2	5	5	8	4	3	3	6	56
General engagement in DLMs	11	9	7	0	0	1	7	4	5	5	5	54
Limitation/Confusion regarding TEP experience for DL	5	1	9	1	2	2	5	3	2	2	5	37
Fieldwork experiences regarding DL	4	3	7	1	0	2	4	1	2	0	3	27
Other	1	0	0	0	2	6	1	1	1	0	1	13
<i>Total</i>												260

Table E5.13*Examples of PSTs' TEP Experiences for Teaching for Deeper Learning*

Interview Quotes	Specific Aspect of TEP Experience	Participant Pseudonym (Credential Area)
“Deeper learning is something that I’ve always had in mind. Just because in my undergrad, I had to take a critical analysis class, but it was like an English prerequisite class. And that really opened up my mind when I was doing my undergraduate work at Sycamore State. But the graduate work in the teaching credential program really solidified that. And really made it to where I was like, ‘Okay, yeah, I’ve had the foundation, and now I’m building the scaffolding.’” (para. 39)	TEP program solidifying understanding of deeper learning	Carey Kochen (Science)
“There was another class where it was deeper learning-adjacent, secondary math methods. In that course, we talked about how when we have students practice, we have students cooperate and present their work. And we try to facilitate those discussions.” (para. 53) “In math methods, our professor for that has us teach a topic of whatever we choose, and then he wants us to keep in mind these deeper learning things. He wants us to essentially keep in mind deeper learning as we are teaching the subject, the topic of the day. And at the end of that, he kind of reviews how we did our lesson.” (para. 57)	Math methods class	Cheng Han (Math)
“The class I’m in now with Dr. Riemann is called Math Visualization. Basically, the entire class is focused around creating this exploratory math pedagogy, where we’re bringing in math concepts but in a way that the students discover the important pieces. So, the students will discover these pieces of math and then be able to apply them onto the problems that you give them in the future. It creates this foundation for them because they’re the ones actively finding the information and not just being told. It creates these deeper roots within their brain that they can hold on to this information.” (para. 51)	Exposure to math pedagogy and corresponding strategies	Dylan Stewart (Math)

Interview Quotes	Specific Aspect of TEP Experience	Participant Pseudonym (Credential Area)
“I think one of the things I gained from being in a space with undergrads and younger people, it’s helping me get ready for the younger people I’m going to be working with in a classroom. But like I said, we’ve worked on group projects together, and we’ve collaborated. Usually, it’s in class. I think it was my first my first year that I had projects where we met outside of the classroom. But for the most part, the collaboration is done in the classroom, where we can create lesson plans together. We did some interdisciplinary lesson plans where we merged music and math and came up with a lesson plan and gave a mini lesson in class.” (para. 109)	Collaboration on lesson plans	Elsa Henley (Math)
“We’ve been talking a lot about the five practices. It’s like creating open-ended tasks, where you have the five core mathematical principles. So, anticipating, monitoring—it’s anticipating student challenges when you create a task and then monitoring students as they work on them in groups. Then selecting students to share in such a way that whatever you select for them to share and show some sort of deeper learning that you then can make connections between. So, there’s selecting and then sequencing it so it’s in an order that the kids can make sense of the connections happening. And then you have the actual class discussion where you make connections between students work and whatever your learning objective is.” (para. 95)	Five principles for engaging students in math discussion	Gemma Bailey (Math)
“I think it was my math education class last semester. We were taught a lot of strategies for mathematics-related discussions. The professor gave us a kind of easy multiplication problem, and we would all work it out with whatever method works best for us. It was really interesting to see that for that one math problem, there’s so many different ways to solve that problem. It was really fascinating to learn that that could kind of gauge how students are seeing it. Everyone is different. Everyone has their own thought process and there’s more than one way to do things. And that can lead on to discussion, as well. (para. 124)	Specific activity within math education class	Hope Lee (Science)

Table E5.14

Code Cooccurrences: Teaching Actions for Deeper Learning in K-12 Contexts with TEP Experiences for Deeper Learning and Teaching for Deeper Learning

	Teacher Education Program Experiences re: Deeper Learning					Other	<i>Total</i>
	Fieldwork Exp. re: DL	General TEP Exp. re: DL	General DLM Engage.	Specific Instr. Strategy	Limitation/ Confusion re: TEP Experience for DL		
Planning/ Reflection	14	12	7	10	6	2	51
Specific instructional strategies for teaching for DL	13	10	9	9	2	3	46
Limitation/ Developing practice in teaching for DL (K–12)	8	9	1	3	3	2	26
Reasoning/ Motivation	4	4	3	3	1	1	16
Other	0	0	0	0	0	1	1
<i>Total</i>	39	35	20	25	12	9	140

Note. This table shows cooccurrences of these two codes: various *teaching actions for deeper learning in K-12 contexts* are listed in the leftmost column, and *TEP experiences for deeper learning and teaching for deeper learning* are listed across the top row, with numbers representing the total number of cooccurrences of those two codes.

Table E5.15*Counts of Various Code Occurrences for PSTs, Grouped by Module Development*

<i>Codes for Conceptions of Deeper Learning</i>	Module Developers	Not Module Developers	<i>Total</i>
DL in contrast with surface learning	10	8	18
Limitation/Developing understanding of DL	8	9	17
Outcomes of engaging in DL	5	6	11
Associations with other education- related constructs	5	4	9
Deeper learning as process	2	4	6
Other	1	4	5
Deeper learning as state	1	4	5
DL as a framework	1	2	3
<i>Subtotal</i>	33	41	74
<i>Codes for Conceptions of Teaching for Deeper Learning</i>			
Limitation/Developing understanding of teaching for DL	14	16	30
Deeper Learning in terms of teaching (general)	6	12	18
Other	5	3	8
Learning chain of teaching for DL	3	3	6
Teaching for DL as a process	1	1	2
<i>Subtotal</i>	29	35	64
<i>Codes for Actions for Teaching for Deeper Learning in K-12 Contexts</i>			
Planning/Reflection	12	27	39
Specific instructional strategy	16	20	36
Reasoning/Motivation	6	15	21
Limitation/Developing practice for teaching for DL (K-12)	2	25	27
Other	0	2	2
<i>Subtotal</i>	36	89	125
<i>Codes for TEP Experiences Related to Deeper Learning</i>			
General TEP experiences re: DL	25	48	73
Specific instructional strategy	32	24	56
General engagement in DLMs	34	20	54
Limitation/Confusion re: TEP experiences for DL	17	20	37
Fieldwork experiences re: DL	14	13	27
Other	4	9	13
<i>Subtotal</i>	126	134	260

Appendix F

Select Examples of Teaching Artifacts

Example 1: Activity on Features of Effective Discussion

Context: This artifact was submitted by Ryan Snow from State University Nettlebrook. It shows student responses to one of the activities from the Facilitating Effective Discussions Module.

ACTIVITY 1 - Features of Effective Discussion

THINK ABOUT IT: Reflect on your varied (positive and negative) experiences with discussions in academic settings.

WRITE ABOUT IT: Use T-chart below to make a list of features that you think made those discussions effective or not so effective from your perspective.

ACTIVITY 1	
PART 1: Independently reflect on your varied (positive and negative) experiences with discussions in academic settings.	
Directions: - Make a list of “Effective” and “Not so Effective” features of discussions in your designated column.	
Partner 1:	Partner 2:
Effective Features: Taking turns, looking for patterns, keeping language neutral and non judgmental, cooperation	Effective Features: staying on topic. Exploring differences of opinion one at a time, checking back in on the prompt/topic question to make sure everything is covered.
Not so Effective Features: Yelling, insulting, taking opinion personally, mistaking opinion for fact	Not so Effective Features: Free-for-all discussion, talking over one another, letting the conversation veer off topic, bogging down in details

PART 2: With your partner, develop one mutually created list of features of effective discussions.

Directions:

- Discuss and compare your lists above
- Collapse similar items; consider both effective and not effective features and how they relate; reframe the "not effective" features
- Create a single list of essential effective features below that capture both of your thinking and experiences.

Essential Features of Effective Discussions:

Taking turns

Being respectful

Staying on topic

Making sure details are discussed, but do not outweigh the topic as a whole

No yelling

Focusing on facts

Example 2: Discussion Prompt on Learning Experience from Module

Context: This artifact was submitted from Caroline Grey, State University South Dogwood, and it shows a student response to an assignment where students were asked to reflect on how they would apply what they had learned from engaging with the Performance Assessments Module into their teaching practice.

“Building Capacity for Deeper Learning” - Applying what you have learned

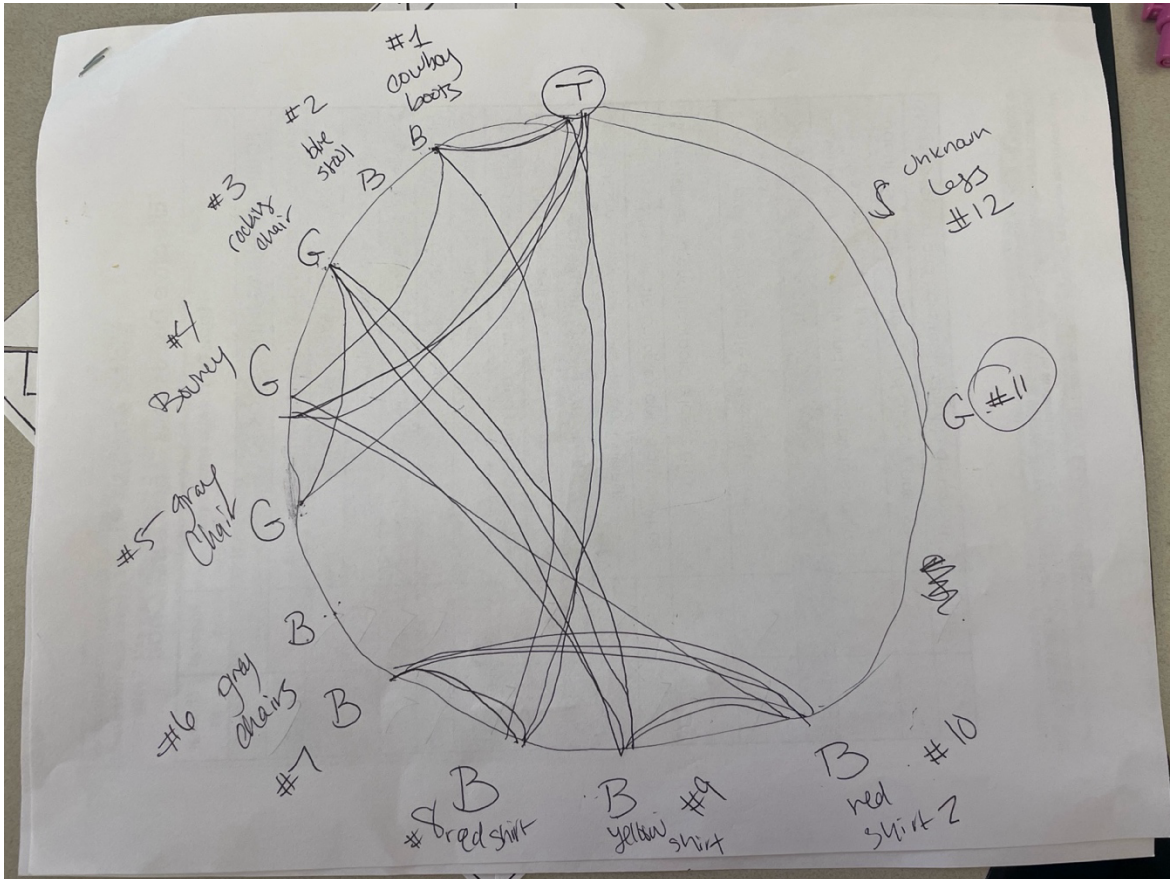
Throughout this module, I built upon my understanding of the role of productive struggle and how it ultimately supports a student’s development of their academic mindset. This tool is valuable for various reasons. The first being cognitive development. Students are engaged in critical thinking, problem-solving, and decision-making processes, where they are challenged and led to deepening their understanding. It also instills a sense of autonomy over their learning. They actively engage with challenging material to become more independent learners. This is done through developing the skills to seek out information, ask questions, and find solutions. Productive struggle can also be collaborative through fostering communication amongst students. They can work together to overcome these obstacles, share ideas, and learn from one other in the process.

Some actionable steps I can take to embed these practices and approaches in my student teaching placement is simply through creating the lessons, activities, and opportunities to challenge students. This is done through meaningful and appropriately difficult tasks that require critical thinking. I will make sure to communicate high expectations for effort and engagement, emphasizing that struggle is a normal part of the learning process. I will also offer feedback that focuses on the process rather than just the end result. In doing so, highlighting effort, strategies used, and areas for improvement. This will guide students toward self-reflection by asking questions that prompt them to think about their learning process.

In thinking ahead to my future classroom, some approaches and practices I would like to implement first include creating a supportive environment. By establishing a classroom culture that values persistence, effort, and learning from mistakes, students will feel more comfortable in asking questions and seeking help. I will also offer scaffolding, but gradually releasing responsibility. This will become temporary support to help the students take on more complex tasks as their skills increase. This can be done by breaking down challenging problems into smaller, manageable steps, and providing guidance as they work through each stage of the process. Finally, but not limited to, I will ensure that exploration and curiosity are at the forefront of their learning and my teaching. I want to foster a sense of curiosity by posing thought-provoking questions and encouraging my students to explore different forms of inquiry. I will allow time for students to explore topics independently and pursue their interests within the curriculum. By implementing these strategies, I can create a learning environment that promotes productive struggle, helping students develop resilience, critical thinking skills, and a positive attitude towards challenges.

Example 3: Discussion Map

Context: This discussion map was submitted from Melissa Stone, University of South Boxelder. It shows a discussion map which students developed through watching a video which was a part of the Facilitating Effective Discussions Module.



Example 4: Lesson Plans

Context: This discussion map was submitted from Bryn Knight, Juniper University. Bryn described having preservice teachers create lesson plans, then she engaged them with the Developing Students' Mindsets Module, and then she had students reevaluate their lesson plans. Just based on this lesson plan, it is unclear how those PSTs adjusted their lesson plans after engaging with the module.

TITLE OF LESSON – All About Weather!

CONTEXT OF LESSON - We are learning about the variations of weather. Students are able to name different types of weather such as sunny, cloudy, and rainy. Students are asking about what the temperature is and what clothes are appropriate for specific weather.

OBJECTIVES-

1. The students will identify and describe the different types of weather.
2. The students will demonstrate how to measure the temperature.
3. I can identify different types of weather.
4. I can experiment using tools to measure temperature.

PLAN FOR ASSESSMENT-

1. Students can identify the characteristics of several forms of weather by naming, describing, collaborating, and drawing them on paper. They can communicate with one another and assist each other to understand the qualities that distinguish them from the others. Students may get creative with their drawings, and each group will be able to view what the others created at the end of the lesson.
2. Students will be able to use a thermometer to measure different water temperatures with practice reading the measurements on a thermometer. Then, students may explore outdoors and measure different areas. Experimenting outside can help them become engaged and interact with their classmates.

VA SOL: 2.6 The student will investigate and understand that there are different types of weather on Earth. Key ideas include

- a) different types of weather have specific characteristics.
- b) measuring, recording, and interpreting weather data allows for identification of weather patterns

MATERIALS NEEDED:

- For the topic of weather on Earth, a book called "What will the weather be" by Lynda Dewitt is relevant because the book addresses the different types of weather on Earth and what their characteristics are.
- Three different temperatures of water in cups (hot, cold, lukewarm).
- Worksheet printed with thermometers showing different temperatures
- A thermometer for each student to have and use (quantity of 20)
- Large poster paper (Easel pad) (5 posters)

- Markers, crayons, and color pencils for each table
- Notebook for their observations

PROCEDURE:

Preparation:

Place bins on each table that include all of the art supplies such as markers, crayons, and colored pencils. There should also be a few weather-related stickers as well as cotton balls that they can use for their poster. Form 5 groups of four randomly by picking out of the cup with names. Provide one large poster paper for each table to work on together.
Describing types of weather- poster activity

Measuring temperature

Have papers printed and ready

Three cups of different temperatures of water for each table

Buy or ask around for thermometers that are safe for students

Implementation:

1. Start with a discussion with how they decide what to wear to school based on the weather. Students may share what they think is appropriate to wear based on the weather during this time.
2. Continuing that discussion, introduce the characteristics of different types of weather by showing a PowerPoint.
3. Watch the weather video on YouTube to teach the basics of weather.

After the discussion on the characteristics of weather, students will be working as a group with their table to complete a poster of a specific type of weather that is assigned to their table.

- I will be assigning each table with a type of weather including cloudy, rainy, windy, and thunderstorm.
- When they are assigned a weather, they will work in groups to draw what they think goes with that type. Their posters can include the type of clouds, activities that they can do, what the environment looks like, and words that help them differentiate from the other types of weather.
- After they complete this, they can present it to the class and elaborate more on their poster. They can share what they observed about the types of weather prior to the project and what they learned from the activity.
- During the discussion, ask questions such as “What would you wear in this type of weather? Or “how do you know that it is windy outside?”

CLOSURE:

Students will reflect on their experience by using their journal where they can write what they learned about or want to learn more about. During the reflection, I can help them form answers by providing questions such as, “How does weather affect your life?”. Transitioning to the next activity, I will say, “Now that we learned about the different weather types, let’s talk about how we can measure different temperatures”. I will explain how different weather types have also different temperatures and teach them how to read a thermometer.

DIFFERENTIATION:

To provide an opportunity for every student, I will implement visuals using many pictures on the slides. I will also be showing a video to introduce the topic for students who prefer to listen when learning. For students who like to work in groups, there will be plenty of opportunities for them to collaborate with their tablemates as well as other classmates during discussion time. For students who learn better independently, there will also be independent work using printed worksheets. Students who finish early, I will provide them with a choice of writing a poem about weather or they can draw anything related to what we learned about weather types. If a student is struggling with the topic, I will make time for a one-on-one conversation, or I will pair them up with a classmate that is confident with the subject.