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Author Biography

Hosun Kang is an assistant professor in the School of Education at the University of California, Irvine. Her work is centrally concerned with promoting powerful science learning at public schools that serve the students from multi-racial and multi-linguistic backgrounds and low-income families. Her research interests include non-white students' science identity development, effective instructional practices that facilitate meaningful engagement in secondary science classrooms, and the design of learning environments to support teacher learning.

Preservice Teachers’ Learning to Plan Intellectually Challenging Tasks

Abstract

This study explores how and under which conditions preservice secondary science teachers (PSTs) engage in effective planning practices that incorporate intellectually challenging tasks into lessons. Drawing upon a situative perspective on learning, eight PSTs’ trajectories of participation in communities of practice are examined with a focus on planning throughout student teaching. Data include 32 sets of teaching artifacts, interviews with PSTs, interviews with methods course instructors, and interviews with mentor teachers. The analyses show that instructional tasks observed at the beginning of lessons link to the ways in which PSTs engage in the three interrelated processes of: (a) framing instructional goals, (b) constructing a lesson scenario, and (c) addressing problems of practice. The consistencies and changes observed in the PSTs’ trajectories of planning reveal the dynamic, responsive, and contentious nature of planning situated in local contexts. Three implications for designing productive learning opportunities for PSTs are discussed.

Key words: planning, preservice teacher learning, instructional task, student teaching, curriculum use

Introduction

Designing or identifying high quality instructional tasks and implementing them with students are core aspects of teaching that can influence students' opportunities to learn in classrooms (Author and others; Doyle & Carter, 1984; Stein, Grover, & Henningsen, 1996; Stein & Lane, 1996). Studies show that solely providing curriculum materials to teachers is not sufficient to facilitate robust student learning (Alozie, Moje, & Krajcik, 2010; Barab & Luehmann, 2003; Brown, 2002; Davis, Beyer, Forbes, & Stevens, 2011; Forbes & Davis, 2010; Lloyd, Remillard, & Herbel-Eisenmann, 2009; Penuel, Gallagher, & Moorthy, 2011; Remillard, 2005). Teachers activate inert curriculum materials into lived instructional tasks by specifying resources, procedures, and outcomes for a particular set of students in a particular time frame during planning (Kennedy, 2005). Supporting teachers to engage in effective planning practices that leads them to begin a lesson with intellectually challenging tasks is essential to promote deep student learning (Brown, 2002; Cohen, Raudenbush, & Ball, 2003; Penuel, Fishman, Yamaguchi, & Gallagher, 2007; Penuel & Gallagher, 2009).

Research on teacher planning was primarily conducted in the 1970s through the 1990s and has relatively scarce attention over the last two decades. Early on, researchers across disciplines largely focused on describing teacher behaviors during the 'pre-active' phase of teaching. For example, Zahorik (1975) asked 194 teachers to list the decisions that they made before the lesson and reported that the most frequently listed decision (listed by 81 percent) related to activities with students. With the advancement of teacher cognition research in 1980s, teachers' mental process became the main focus of research on teacher planning (Clark & Peterson, 1986; Clark & Yinger, 1987). Planning was conceived of as a cognitive enterprise where teachers create mental images of a plan to guide their action (McCutcheon & Milner, 2002). Teachers’ thought processes that involve effective planning were characterized by comparing novice vs. expert decision-making (e.g., Griffey & Housner, 1991; Livingston & Borko, 1989). Overall, three lessons emerge from the previous planning literature. First, selecting or designing activities with students is a teachers’ central concern (Clark & Lampert, 1986; Peterson, Marx, & Clark, 1978; Yinger, 1979; Zahorik, 1975). Yinger (1979) argues that instructional activities function as the basic structural units of planning and action in classrooms. Second, even though many teacher preparation programs use a linear, rationale curriculum-planning model that typically consists of four steps—(a) specifying objectives, (b) selecting learning activities, (c) organizing them, and (d) specifying evaluation procedures—as was first proposed by Tyler in 1950, teachers’ thoughts during the planning is neither linear nor do they necessarily follow the objective-first model (Clark & Peterson, 1986; John, 2006; McCutcheon, 1980; Yinger, 1980). John (2006) criticizes that this dominant planning model “demands linearity thinking that doesn’t necessarily exist,” and it “leads to a limited view of teaching and learning as well as a restricted approach to learning to teach” (p. 483). Finally, the process of planning is creative and essentially bounded by contextualized knowledge, including detailed understanding of teachers’ students (Calderhead, 1996; Mutton, Hagger, & Burn, 2011).

Despite the insights from these prior studies, the current knowledge base on teacher planning is limited in supporting preservice teachers’ engagement in effective planning. In general, teacher planning was studied separately from instruction; therefore it is unclear *how* the complex thinking during the planning is related to different characteristics of instruction, and in turn affect students’ learning experiences (Hall & Smith, 2006). In addition, research on teachers’ planning was often conducted in a controlled setting to uncover cognitive decisions made by teachers. Researchers tend to rely on either teacher-self reported data or data generated from think aloud methods (e.g., Byra & Sherman, 1993; Housner & Griffey, 1985). There is little empirical evidence that focuses on teachers' effective planning in the natural teaching environments.

Building upon the argument supported by other scholars, in this study, I posit planning as one core aspect of teaching that significantly affects student learning experiences as well as preservice teachers' learning to teach. This study explores how eight preservice secondary science teachers (PSTs) engage in planning practices in the context of student teaching and its relationship to instruction. Specifically, I focus on one key aspect of teaching that is directly related to students' learning experiences in classroom—planning and enacting instructional tasks. I trace eight PSTs' planning and enactment of instructional tasks throughout a year-long student teaching period. The purpose is to understand the conditions under which PSTs engage in effective planning practices that lead them to incorporate intellectually challenging tasks into science lessons. The following questions guide the analysis:

1. How did PSTs select or design instructional tasks in the process of preparing their lessons while participating in multiple communities of practice (i.e., school and teacher preparation programs) during student teaching?
    a. What curricular resources were leveraged by PSTs to design their instructional tasks? How did PSTs use the curriculum resources?
    b. How did the PSTs interact with other educators (methods course instructors, mentor teachers, and other candidates) during planning?
2. What is the quality of the instructional tasks (i.e., intellectual demand built into the tasks) taught by PSTs in classrooms? How are PSTs' planning practices related to the quality of instructional tasks observed in their lessons?

Theoretical Framework

Situative perspective and PSTs' learning of planning

I draw upon a situative perspective on learning (Greeno, 2006; Greeno & Gresalfi, 2008) to study PSTs' learning about how to design intellectually challenging tasks for science instruction. A situative perspective posits that learning by an individual in a community can be viewed as "a trajectory of that person's participation in the community—a path with a past, present, shaping possibilities for future participation" (Greeno & Gresalfi, 2008, p. 170). From this perspective, understanding of how and why some PSTs come to take up the practices advocated by the teacher preparation program, such as designing and using intellectually challenging tasks for teaching, necessitates the analyses of learners (PSTs), the features of settings, and the nature of interactions mediated by tasks, resources, practices, and facilitation over time.

A situative perspective serves as a useful analytical lens to study PST learning for several reasons. First, considering learning as a trajectory of participation encourages a focus on learning as a process occurring over time, which reveals both consistencies and changes in the direction of the trajectory (Greeno & Gresalfi, 2008). For example, a PST, who repeatedly designs and uses some hands-on activities to deliver canonical science ideas at the beginning of the program, comes to design intellectually challenging tasks that prompt students to engage in scientific sense-making at the later stage of the program. The tasks designed by this PST still include a hands-on component (i.e., consistency), but this hands-on activity is used as a mean for students to collect evidence to support their argument (i.e., change). The consistencies and changes observed from this PST reveal how this PST's agency, which is likely rooted in his or her prior experiences of teaching and learning, play out in particular settings over time. In addition, attention to the *desired* changes in PSTs' trajectories toward the practices advocated by the teacher preparation community help to identify and configure the conditions that are conducive for PST's learning.

Furthermore, a situative perspective can shed light on the role of the unique contexts of PSTs' learning that typically involves multiple communities. During the student teaching period, PSTs encounter multiple (sometimes conflicting) discourses, expectations, curriculum resources, tools, and practices of science teaching from both the teacher education program and local schools. From this perspective, instructional tasks observed at certain moments can be viewed as the outcomes produced from individual PSTs' complex interactions in the *layered* systems of activities created between the program and local schools. When PSTs select certain curriculum resources over others among multiple available resources, PSTs come to prioritize certain social and cultural practices of teaching and learning embedded in the artifact in those particular moments. Attending to the sources of the leveraged curriculum resources or tools (e.g., school, program), PSTs' actions on the resources (e.g., use as-is, modify), and the outcomes (i.e., instructional tasks) help to recognize PSTs' responses to different social and cultural practices foregrounded by each community. It also reveals the formative influence of PSTs' socialization with and participation in the multiple communities of practices on PSTs' learning how to plan intellectually challenging tasks that advance students' scientific thinking.

Intellectually challenging tasks for science instruction

Instructional tasks have received a great deal of attention from researchers who try to link instructional practices to student learning in classrooms (see Author and others; Doyle, 1983; Jackson, Garrison, Wilson, Gibbons, & Shahan, 2013; Stein et al., 1996). Instructional tasks refer to some form of work assignment to students that is defined by teachers for the purpose of developing understandings of concepts, skills, disciplinary practices, and that results in some inscribed documentation of the outcomes of intellectual work (Author and others). It is an activated form of curriculum materials for a set of students in a particular time and setting.

One important characteristic of instructional tasks is the type and nature of intellectual work built into its design—intellectual demand. There is a significant body of literature that explores how student learning is affected by the intellectual demand of tasks presented to students (Jackson et al., 2013; Stein et al., 1996). In the field of mathematics education, Stein and her colleagues identifies six discernible kinds of what they call ‘cognitive demands’ and/or thinking processes that occur in reform mathematics classrooms (Stein et al., 1996; Stein & Lane, 1996). In the field of science, author and others (in press) characterized the built-in intellectual demands of science tasks based on the analysis of 57 science lessons and literatures (Author and others). *High intellectual demand science tasks* are defined as the ones that have potential for advancing students’ thinking by inviting students to link observable phenomena and either unobservable or theoretical science ideas. Those tasks prompt students to either: (a) reason with science ideas to explain observable phenomena, (b) reason through data and observation to construct or evaluate explanatory models, or (c) develop arguments with use of evidence. In contrast, *low intellectual demand science tasks* prompt students to either (a) remember, recall, confirm, describe, or reproduce known scientific ideas, (b) practice skills procedurally, or (c) solve generic problems without connecting to existing knowledge. Using this framework, author et al. show that students’ learning opportunities in science lessons are the product of both careful planning *and* goal-directed pedagogical support provided for students during the enactment.

Despite the significance of using high quality instructional tasks, it is unclear when, where and how PSTs learn to incorporate intellectually challenging tasks into science lessons.

Previous studies on teachers’ curriculum use are informative because PSTs’ planning of instructional tasks involves using existing curriculum resources. The curriculum studies suggest that the quality of original curriculum materials, contextual factors, as well as novice teachers’ personal resources, such as knowledge or beliefs, plays out together in the process of PSTs planning (Beyer & Davis, 2011; Remillard, 2005). In a study on preservice elementary science teachers’ adaptation and enactment of inquiry-oriented curriculum, for example, Beyer and Davis (2011) found that the quality of the original curriculum resources significantly affected elementary preservice teachers’ enactment of inquiry lessons. Researchers theorize that curriculum resources—as artifacts that mediate professional activities—enables, extends, or constrains the design work undertaken by teachers (Brown, 2002). Using curriculum resources involves what Remillard calls “participation on the part of both the teacher and the text” (Remillard, 2005, p. 221). Both the teacher and curriculum resources likely influence and are influenced by each other during the interaction.

In addition, research on teachers’ curriculum use point to the critical influence of context on novice teachers’ planning. In a study that examines the use of reform-based criteria in supporting 24 elementary preservice teachers, Beyer and Davis (2012) found that many PSTs, who successfully analyzed lesson plans as expected by the program, struggled with analyzing lesson plan in a reform-oriented way during student teaching. The researchers accounted for PSTs’ struggles in relation to the nature of PSTs’ learning environment where PSTs have to navigate multiple ideas for lesson modification while engaging in both school and program communities. Other studies show that teachers’ social and professional interactions with people, such as colleagues, teacher educators, curriculum designers, and students, also affect the ways in which they engage in, interpret, and modify curriculum materials (Lloyd et al., 2009; Roth

McDuffie & Mather, 2009). Taken together, the prior curriculum studies suggest that multiple elements that constitute PSTs' learning environments are closely related to their planning. This study intends to reveal *how* those elements shape (or shaped by) PSTs' planning practices throughout student teaching.

Methods

This study employs a qualitative multiple case study approach (Merriam, 2008; Stake, 2004) to provide in-depth description and analysis of eight PSTs' trajectories of planning practices in contexts.

Research context

Teaching cycle: Scaffolded learning opportunities for PSTs. The context of this study was a five-year, undergraduate teacher preparation program in a large Midwestern university in the United States. The PSTs took four sequenced disciplinary specific methods courses from senior (4th year) to internship (5th year). At their field sites, PSTs began as part-time student teachers (6-7 hours per week) during their senior year. During the internship year, they worked as full-time student teachers from Monday to Thursday, taking courses at the university on Friday. Due to the historical relationship between the program and local schools, the program had great flexibility to structure PSTs' experiences at the schools. The program guided PSTs to repeatedly engage in the 'teaching cycle' throughout the two years. Each teaching cycle consisted of structured activities of planning, enacting, analyzing records of teaching (e.g., student work or teaching video), and reflecting. PSTs generated a set of teaching and learning artifacts from each teaching cycle (hereafter a set of artifacts generated from one teaching cycle is referred as a teaching episode). During their senior year, PSTs taught four single lessons and one 3-day lesson sequence while engaging in a total of five teaching cycles. During the internship year, PSTs taught four units over four teaching cycles. This project focuses only on PSTs' engagement during the internship year.

During the fall semester of the internship year, PSTs were expected to co-plan and co-teach two 2-3 week units with their mentor teachers. In the spring semester, they assumed full teaching responsibilities during a 10-week "Lead Teaching" period.

The system of activities. When PSTs engaged in teaching cycles, PSTs typically consulted with mentor teachers and methods course instructors to design their lesson or unit. PSTs submitted their plans to course instructors in a written form using a template provided by the program. The template included detailed prompts, checklists, and rubrics to support PSTs' planning of intellectually challenging tasks. Before the enactment of their plan, PSTs typically received formal written feedback from the course instructors as well as informal feedback from classmates and mentor teachers. During the enactment at local schools, PSTs collected records of teaching, such as samples of student work and teaching videos. After the enactment, PSTs brought the records of teaching to the methods course and analyzed them in small groups with their classmates and field supervisors. The teaching cycle ended with the submission of PSTs' written reflective report. PSTs then received written comments, feedback, and grades from their instructors.

Two course instructors typically worked with a cohort of about 30 PSTs as a team for two consecutive years. At the beginning of the senior year, the course instructors presented research-based models of science instruction. One key characteristic of the model was its emphasis on engaging students in scientific practices for sense-making, which reflected the new vision of learning supported by science education community in the United States (see NGSS Lead States, 2013; NRC, 2012). The instructional models were expected to serve as "conceptual tools"

(Grossman, Smagorinsky, & Valencia, 1999) that assist PSTs' effective planning, including the incorporation of intellectually challenging tasks into lessons. The instructors provided planning templates, rubrics, and sometimes curriculum materials for certain topics. Simultaneously, PSTs interacted with mentor teachers and other teachers at the field sites while planning their lessons. Most PSTs had access to curriculum materials housed at their schools, such as worksheets, textbooks, etc. At some schools, PSTs were forced to use mandatory curriculum selected by the school.

Participants

Among a total of 60 PSTs who enrolled in the 2007-09 academic year, about 80% of PSTs volunteered to participate in this project. In general, the non-volunteering PSTs were those who had difficulties in making extra time for research due to either long-commuting time or other personal commitment. I selected eight focal PSTs among the volunteers to maximize the variation among cases (Merriam, 2009; Yin, 2013) using three criteria: (a) personal characteristics, (b) the types of curriculum resources available to PSTs, and (c) school contexts (see Table 1). The selected participants represented all four subjects of sciences while balancing gender and school contexts (e.g., under-resourced urban schools vs. well-resourced suburban schools). All PSTs had access to their mentor teacher's curriculum materials. Two of them also had access to the curriculum materials shared by the department. One had to use the mandatory curriculum materials selected by the school. Eight mentor teachers and two methods course instructors who worked with the selected PSTs also participated.

--Insert Table 1 about here—

Data Sources

Multiple forms of data were collected to document PSTs' planning and enactment of instructional tasks in contexts. The primary source of data was the 32 sets of teaching episodes generated by eight PSTs during the internship year (i.e., four teaching episodes per PST). Typically, a teaching episode included: (a) a written plan that described the planned instructional task and report about how the plan was actually enacted with students at a local school, (b) records of teaching, either samples of student work or teaching video, or both, and (c) curriculum materials (e.g., student worksheets, presentation slides, etc.). These data were used to trace the types and nature of instructional tasks that PSTs designed and used throughout the internship year.

The other source of data was individual interviews conducted with the PSTs, methods course instructors, and mentor teachers upon the completion of the internship year. The interviews provided information about the nature of PSTs' interactions with other educators over planning. In addition, this interview provided information about PSTs' selection, creation, and or adaptation of curriculum resources in the process of designing instructional tasks in a specific context, and how PSTs accounted for both the process and the outcomes of their experiences. During the interview, participants engaged in a video exercise where the researcher showed two segments of pre-selected sections of the PSTs' teaching videos that highlighted key features of instructional tasks. The questions were focused on the curriculum resources and tools used by PSTs in the lesson of the video, how and why they came to design the tasks, and how PSTs interacted with mentor teachers, course instructors, classmates, or students. Some examples of questions were, "Where did you get the idea or how did you choose or come up with this task?" and "How did you work with your mentor teacher (or student teacher) in planning for this lesson?" The questions to the mentor teacher and course instructors included, "How did you work with this candidate in terms of planning and teaching throughout this year?" and "How did the candidate respond to your comments and suggestions?"

Data analysis

The analysis focused on examining the quality of instructional tasks observed in the lessons throughout student teaching in conjunction with the trajectories of PSTs' planning practices (select or design instructional tasks). I first identified the instructional tasks in the lessons of the 32 teaching episodes using reports, PSTs' teaching videos or the produced student work. Specifically, each lesson was examined holistically by determining: (a) what students are asked to produce, and (b) how and with what resources. After identifying the main instructional tasks, the intellectual demand of tasks was coded as either high or low using the *Science Task Framework* (Author and others, 2016; see the details in the section of theoretical framework).

Next, the analyses moved into the process of planning—how PSTs selected or designed instructional tasks in contexts. Eight transcripts of the interviews with the PSTs were coded with respect to: (a) the types and sources of the curriculum resources or tools leveraged by PSTs, (b) the types of PSTs' actions on curriculum resources to design instructional tasks (e.g., creating, adapting, or using as-is), (c) PSTs' accounts for their choices of actions, and (d) the nature of the relationship with and interactions between PSTs and other educators in the process of designing instructional tasks (e.g., how often they interacted, who initiated the interactions, and why) (see the coding scheme and results of coding in Table 2).

In addition, ten transcripts of the interviews with eight mentor teachers and two course instructors were analyzed focusing on the types and nature of PSTs' relationship and interactions with other educators over planning. This analysis triangulated how PSTs interacted with other educators during lesson planning in student teaching contexts. It also revealed the accessible curriculum resources, expectations, and practices of teaching privileged by each community.

Cross-case analyses. The results of the coding revealed four patterns of PSTs' trajectories: (a) consistently designing intellectually challenging tasks throughout student teaching period over four teaching episodes (H-H-H-H; one PST), (b) shifting from low to high (L-L-H-H; two PSTs), (c) consistently designing low demand tasks (L-L-L-L; four PSTs), and (d) inconsistent across four teaching cycles (L-H-H-L; 1 PST) (see Table 2). I categorized the eight cases into two groups: *disciplinary practice* group and *content* group. Three candidates (one with H-H-H-H and two with L-L-H-H) showed a trajectory toward incorporating intellectually challenging tasks that engaged students in disciplinary practices for sense-making as expected by the program, resulting in placement in the *disciplinary practice* group. The remaining five candidates in the *content group* largely used low demand tasks that focused on either content or process. Employing the constant comparison method (Glaser & Strauss, 1967), the cases within and across the two groups were compared and contrasted. Specifically, the analysis was focused on the interactions between PSTs and curriculum resources—how the PSTs of each group selected, created, or adapted curriculum resources to activate them into instructional tasks, and how the two groups of PSTs accounted for their design choices. Next, the cases of each group were compared and contrasted in relation to affordances of the settings, including available and leveraged resources, use of tools, and their relationships and interactions with other educators. Particular attention was paid to the cases that showed a shift of the trajectories toward incorporating intellectually challenging tasks into lessons. A pictorial model was developed to theorize how the process of designing instructional tasks is related to PSTs' interactions in the settings (see Figure 1).

Trustworthiness

The trustworthiness of this study was ensured in four ways (Merriam, 2009). First, multiple sources of data and data collection methods were used to increase credibility and reliability through triangulation. Second, the cases were purposefully selected to maximize variation, and therefore allow for a greater range of application of the findings. Third, I provided rich and thick descriptions of the research context as well as the processes of data collection and analyses. Finally, the study design, data collection, analyses, and interpretation were discussed and revised with a senior science education faculty member throughout the project.

Findings

The analyses show that the instructional tasks observed in the lessons link to the ways in which PSTs engage in the three inter-related planning processes: (a) framing instructional goals, (b) constructing a lesson scenario, and (c) addressing problems of practice (see Figure 1). The two groups of PSTs engaged in each of the planning processes in substantially different ways (see Table 2). The three PSTs—Susie, Monica, and Leslie—in the *disciplinary practice* group framed their goals broadly, including engaging students in disciplinary practices and thinking in addition to teaching specific content. By contrast, the five PSTs, in the *content group,* framed their goals by mainly focusing on teaching specific content. When constructing lesson scenarios to design tasks, the three PSTs in the *disciplinary practice* group followed students' thought process with attention to the big ideas in the unit. By contrast, the other PSTs primarily followed either a canonical science storyline or the order of the curriculum topics. Finally, both groups of PSTs noted some challenges in "enlisting student participation" (Kennedy, 2005, 2016) in the tasks as intended. They interpreted and addressed these problems of practice in a different way. The three PSTs in the *disciplinary practice* group noted students' specific difficulties in completing tasks, and built scaffolds into the task design to assist with those difficulties. In contrast, the five PSTs in *content* group attributed the students' difficulties to a lack of students' willingness or inability to do the work.

--Insert Figure 1 and Table 2 about here—

The analyses also revealed notable differences between the two groups of PSTs in terms of leveraged curriculum resources and interactions with other educators (see Table 2). The three PSTs in the *disciplinary practice* group drew upon multiple curriculum resources from both the program and their schools. They frequently and actively consulted other educators, and substantially modified (or created) curriculum materials to setup intellectually challenging learning opportunities for students. By contrast, four out of the five PSTs who consistently used low demand tasks—Teresa, Adam, David, and Shannon—mostly relied on as-is curriculum resources from either their schools or from past teaching experiences. In the *content* group, PSTs' relationships and interactions with other educators over lesson planning appeared to be just at the level of fulfilling their formal responsibilities. One PST, Alice, who showed an inconsistent planning trajectory (L-H-H-L), used expert-developed curriculum materials mandated by the school. Alice and her mentor teacher, who were getting along very well, strictly followed the curriculum materials, which resulted in inconsistent quality of instructional tasks.

In the following, I present two cases—Susie and Teresa—from each group. Both Susie and Teresa worked in similar school contexts (i.e., urban high schools that served ethnically and linguistically diverse, low-income students), but designed and enacted instructional tasks differently, providing very different learning experiences for students in their classrooms throughout the student teaching period. Susie is one of the two PSTs in *disciplinary practice* group who shifted her trajectory toward incorporating intellectually challenging tasks (L-L-H-

H). With the case of Susie, I intend to show two things: (a) the shared features of planning practices observed from the three PSTs in *disciplinary practice* group, and (b) the condition that helped a PST, who used to design low-demand tasks, to engage in effective planning that incorporated intellectually challenging tasks. The case of Teresa in the *content* group shows how a dedicated PST, who wanted to be an urban teacher, began her lesson with low demanding tasks repeatedly (L-L-L-L).

The case of Susie: Shifting the trajectories toward intellectually challenging tasks

Introduction of Susie. Susie was a "quiet," "very reflective," "thoughtful" candidate who was always asking "why questions" of both her course instructor and mentor teacher. Susie was placed in Mrs. B's chemistry classroom in her senior and internship years. Mrs. B had approximately 20 years of teaching experience and had served as a mentor teacher for over 10 years. Mrs. B was known for her skill-oriented, management-centered approaches, and teaching "facts and skills." Susie described Mrs. B as "very orderly and organized," and she "holds everyone responsible for their task." The methods course instructor, Dr. R commented, "It's like having somebody from the military be your teacher. Not in a bad way, but in the sense of structure." Dr. R described Mrs. B's mentoring approach: "Mrs. B does choreograph her moves to manage. She sets up lots of norms for teaching and learning in her classroom and Susan learned those, which isn't bad. But I just feel like there's something more in Susie."

The trajectory of planning over time: L-L-H-H. Susie's instructional tasks observed in two units in the fall semester were coded as low-demand because the tasks prompted students to simply either receive information or solve problems procedurally. For example, instructional tasks of the first unit, "Atomic theory" were: (a) copying down lecture notes on isotopes, and answering practice problems, (b) watching flame test videos and answering the questions, (c) counting and weighing the beans that simulate the various isotopes, etc. In her report, Susie noted, “Many students complained loudly about the value of learning how to calculate isotopes,” “Some students choose to simply follow their lab partner’s calculations and directions in the lab–not thinking on their own. This was very frustrating.”

During the Lead Teaching Period of the spring semester, however, Susie planned and used intellectually challenging tasks that facilitated students’ scientific reasoning. For example, in one videotaped lesson in the chemical reactions unit, Susie designed a task that prompted students as a group to develop a scientific model that illustrated how different factors influenced the rate of reaction at the molecular level. Building on the prior day’s lab activity, Susie launched the task saying, “Develop some sort of visual that shows how the factor influences or impacts the rate of reaction.” In the videotaped lesson, students actively engaged in the discussion and collaboratively created visuals as a small group despite the few moments of Susie’s less skillful facilitation. Each group presented and explained their visuals to the whole class. The ideas discussed at the beginning of the class were referred to and discussed during the later student presentations, indicating students’ intellectual engagement.

The process of designing intellectually demanding tasks. This section focuses on the planning of high-demand tasks observed at the latter teaching episode in order to illustrate the shared features of Susie and the other two PSTs’ planning practices in the *disciplinary practice* group. In the chemical reaction unit, Susie wanted her students to understand the ideas of collision theory and how certain factors influence the rate of reaction. Besides this content goal, Susie also wanted her students to understand “the process that [students] went through and the thought process that you went through to determine whether [their conclusion] was inconclusive or not is the more important part.” Cultivating broad competence as learners was another important goal for Susie. She commented, “I wanted to encourage students to become problem solvers… I felt like it was time for another team building or a team activity for that particular group of students.”

In addition, the three PSTs in the *disciplinary practice* group constructed their lesson scenarios by unpacking curriculum and figuring out the big ideas. Susie stated, “When I first start off a unit, I look at what is the state requiring. A lot of times it’s in pieces and so they’re not, like they’re not connected. So what pieces do I feel the students need to know to make sense of these concepts *as a whole*, and so that’s how I build a unit.” When designing a specific task, Susie attended to the “pieces” that “students already know.” And she “set it up for [students] so that they had the pieces to come to that conclusion.”

Notably, the PSTs’ design choices were strongly related to the problems PSTs identified while working with students in their classrooms and their approaches to addressing the recognized problems. These problems fell into two categories: students’ abilities and their willingness to complete the tasks. The three PSTs in the *disciplinary practice* group framed the problems as students’ difficulties in completing the task, and they embedded scaffolds to address recognized problems. For example, the key features of Susie’s task design–engaging students in scientific modeling and talking to others—were deliberate design choices to address student difficulties around asserting independence in completing tasks. Susie noticed that many students had a tendency of seeking reassurance from the teacher. She said that, “[students] are constantly asking me questions and wanting me to take them step by step through everything even though they have the knowledge to build off of.” Engaging the class in whole group discussion before each group came up to share with their visuals was a design choice to scaffold students’ task enactment. Susie stated:

> I want to show the students that they know at least some parts and pieces in order to solve the problem. And that they already know, they have prior experience and they have the knowledge to be able to build off of, and I want to help them realize that and help them recognize that.

The other scaffold embedded in Susie's task design was "intermediate questioning." Susie said, "In this lesson I try to scaffold their ideas by asking those types of intermediate questions, by asking 'Well, what does concentration mean and how is that going to affect the number of molecules in such amount of space or volume?' and trying to piece together those ideas to create a bigger picture."

Planning situated in contexts: actively leveraging multiple resources, tools, and advice. At the beginning of the internship, Susie largely relied on Mrs. B's curriculum materials and tried to "imitate" Mrs. B's instruction. Susie stated that Mrs. B wanted things to be very "concrete" and didn't "like things that were very open-ended." Nonetheless, Susie liked students to "take their time," "draw pictures," "work in groups," and "share their answers." Susie said, "At the beginning of the year I was like, pretty similar to my mentor teacher"; "At first I felt very like, uncomfortable doing [things different from Mrs. B's], and as I was planning and things, I would try to avoid things like that, because I thought maybe [Mrs. B] would feel like, that's really unnecessary or that's really foolish or that's… you know, whatever." Susie stated, "As the year went on, I wanted to try different things and try new ideas and, yeah, do things like that."

The shift in Susie's trajectories occurred along with the three changes of her circumstances. The first change was in the roles and responsibilities that Susie could assume in the process of planning when Mrs. B released the planning to Susie during the 10 weeks of Lead Teaching. After spending four weeks of co-planning, Mrs. B "felt very comfortable and confident in Susie's ability to plan for her classes." Therefore, in the last two units, Susie didn't really work with her mentor teacher. The second change was the use of tools provided from her preparation program. Throughout the internship year, Susie's major curriculum resource was Mrs. B's binder consisting of previously-designed unit plans, tests, activities, etc. During the Lead Teaching period, however, Susie drew upon the Activity Sequence Framework provided by the program to design her instructional tasks instead of using Mrs. B's typical activities. Susie still addressed Mrs. B's expectation as reflected in her comment, "As long as things are very structured, it's okay [for my mentor teacher]." It appeared that with the use of intellectually challenging tasks, Susie was able to better access students' ways of thinking during the Lead Teaching Period, which in turn informed her design of tasks. Susie commented:

> I think the strategy, for the actual strategy for this videotaped lesson, I got it because as I was going through my lead teaching, I started to recognize that a lot of chemistry is very abstract, and it's very difficult to look at molecules and to be able to show students that or to just say, 'this relationship affects the equation this way.' And I have found that students really understand a little bit better when I ask them to describe something or ask them to explore something at a molecular level.

The case of Teresa: Consistently using hands-on, experiential, but low demanding tasks

Introduction of Teresa. Teresa was a biology intern who had teaching experiences at an out-of-school science program in California. Teresa was placed at an under-resourced urban high school because she expressed her desire to be an "urban teacher." Teresa's mentor teacher, Mrs. R graduated from the same preparation program eight years prior, and Teresa was her third intern. Therefore, Mrs. R. was familiar with program activities and expectations for the interns. Although Mrs. R. was fairly traditional in her instructional approaches (i.e., lectures combined with some hands on activities), she was supportive of her student teacher's attempts at different approaches.

The trajectory of planning instructional tasks over time: L-L-L-L. Even though Teresa's instructional tasks commonly included various hands-on components, the tasks observed across the lessons prompted students to either procedurally solve problems or regurgitate factual information delivered by the teacher (i.e., coded as low demand). In the first unit about cell structure and function, for example, Teresa designed a sequence of instructional tasks using a 'cell company laying off its members' scenario. The tasks were: (a) students individually coloring a diagram of a cell and its components, (b) students as a group making a t-shirt that had various organelles-like objects glued on the back and their team name and logo on its front, and (c) each team, that was assigned as a particular cell organelle and played the role of a member of cell company, coming up with a presentation about why 'their team' (i.e., certain cell organelle) is important and who they think should be "laid off" when the cell company does not have enough energy.

Teresa continued to design and use similar kinds of low-demand, hands-on tasks in her Lead Teaching period. In the videotaped lesson about pedigree in genetics unit (Teresa's 3rd teaching episode), Teresa designed a *family pedigree puzzle activity* modifying some activities from the Internet. The task was to first find a 'family member' who had the same colored worksheet (distributed to each student by the teacher). Students then as a family had to make a pedigree, in which they constructed Punnett squares that they practiced over the prior three weeks. Another 'puzzle' that Teresa set up in this task was identifying the types of pedigrees using the provided 'hints' (i.e., checklist). While launching the task, Teresa gave instructions to the students by shouting:

> So based on your phenotype, your color, you are going to find your family members, okay? Ladies! And then you are going to figure out in order, and then you can put yourself in, each individual in that you have, and then try to figure out how that can work if you make Punnett squares for each generation.

During the remaining of the video, students worked as a small group showing various degrees of engagement. By design, completing the task involved little scientific reasoning or sense-making other than practicing the Punnett squares.

The process of designing low-demanding tasks. Teresa and other PSTs in the *content* group tended to frame instructional goals primarily focusing on covering specific content or curriculum. Teresa wanted to teach how to use Punnett squares to figure out the genotypes of the individuals in the pedigree. She also wanted her students to develop “critical thinking skills,” meaning a content-independent “life skill.”

Teresa and other PSTs in the *content* group constructed their lesson scenario focusing on a topic and following canonical scientific explanations. The family pedigree puzzle activity was following the order of topics in the genetics unit. Teresa stated:

> I usually start thinking about the topic…then I start thinking about a conceptual storyline and how I want that to be laid out…and then look at the state objectives and what I have to cover. And then go through…if it was one of those chapters, lay it out for [my methods course] somehow that way. Mrs. R has like old binders full of past lessons and stuff. So I would go through that and look at her past lessons and see if I could pull out anything from that. And then I did a lot of research online, looking up lessons from there, and then from past teaching.

Finally**,** the five PSTs in the *content* group talked about the problems of practice, attributing student difficulties largely to either a lack of students' abilities or willingness. For example, Teresa repeatedly expressed the difficulty of getting "students to do any of the work, so that's usually the hardest." She also expressed her struggles with students who "just don't want to do it." Three features of Teresa's task design reflected her efforts to address these problems: (a) getting students to do the work in a small group setting, (b) relating the task to students' lives, and (c) making students a part of the content story. First, Teresa set up the family pedigree task as group work. Teresa identified that the students in the class "need[ed] individual attention, individual explanation" and she could not re-explain things to all students individually; she hoped students would get help from their peers by working together. Second, the task feature of finding family members with the same colored worksheet (i.e., representation of the same phenotype among families) was her intentional design choice to make the task relevant and realistic to students. Teresa stated, "A lot of my kids just didn't get into genetics…I was hoping to relate it to their lives by having them work with their 'family members.'" In addition, the task design of "being a part of the pedigree" was another design choice to address this problem. This idea of putting students into a part of the content story was inspired by her past experiences at the out-of-school program in California. Teresa commented:

> A lot of stuff I just come up with because I worked in the [Red] woods [an out-of-school science program in California] before…I really want to do something that has the kids, like, put themselves into the idea of being part of the pedigree, so that they can think of themselves as like, 'I'm this part of the pedigree,' and this is how I would organize it.

In fact, this strategy of making students be a part of content stories, such as “being the [cell] membrane or something that they transport across the membrane,” was one salient and recurring pattern of Teresa’s task design across the four teaching episodes.

Planning situated in contexts: relying on personal resources. With support of Mrs. R, Teresa had a relatively high degree of freedom in designing her lessons throughout the internship year. Teresa started planning her own lessons in the beginning of the fall semester, and did most of her planning independently. Mrs. R said, “I don’t ever remember [Teresa] saying, ‘Do you have anything for this?’”, “She didn’t ask for help a lot”, “not very outspoken”, “did a lot of work on her own.” Mrs. R stated, “I felt like I would offer, but she just always said, ‘No, I’m okay.’” Although Mrs. R thought that Teresa was a very responsive intern, she was concerned about the lack of personal interactions with Teresa, and “not knowing anything about her emotion.” Dr. R also expressed her concern because Teresa did not take steps to seek out help from her mentor teacher despite her struggles in classroom management. Dr. R stated, “Until the spring, Teresa was really struggling”, “She had no control in the classroom”, “She let the kids walk all over her. They did not respect her.” It appeared that Teresa’s rejection on her mentor’s curriculum resources or advice had something to do with Teresa’s images of good science teaching. Teresa’s images of good science teaching were different from the one observed in her mentor teacher’s classroom. During the interview, Teresa commented, “My mentor teacher does a lot of worksheets, and I don’t think [students] were seeing it and visualizing it…I was trying to figure out how I could use the kids as like components of the lesson.”

In planning her lessons, Teresa primarily leveraged curricular materials from her teaching experience in the out-of-school program. She only used her mentor teacher’s curriculum materials briefly at the beginning stage of the intern year. The lesson design framework provided by the program was used at the minimal level only for assignments. Despite Teresa's persistent efforts to design and use hands-on, embodied experiences, Teresa continued to struggle to engage students in her instruction. Referring to Teresa's field journals throughout the year, Dr. R commented:

> Teresa gave lip service to the fact that they were urban kids and that they needed to have more support, they needed to be guided, they needed to develop these skills. But then, in another breath, Teresa would get so frustrated because she wasn't getting respect that she would just blame them.

Dr. R narrated Teresa's situations as the follows:

> Teresa really did want to be an urban teacher. She thought of herself as pretty good in that context, she'd had experiences out in California with kids who were not privileged. And she thought she was pretty successful there. Then, when she got into this context, I think she finally realized she wasn't being very successful here and didn't know what to do.

Discussion

This study began with one premise about the importance of effective planning—beginning a lesson with intellectually challenging tasks is essential to promote deeper learning in classrooms (Author and others; Jackson et al, 2013; Stein et al, 1996; Stein & Lane, 1996). I make three claims based on the analyses of the PSTs' engagement in planning in the context of student teaching. Each claim offers guidelines for designing learning opportunities that facilitate PSTs' engagement in effective planning in contexts.

Provide opportunities for PSTs to *expand* the goals of instruction into engaging students in disciplinary practices

The analyses show the strong relationship between the ways in which PSTs frame instructional goals during planning and the quality of designed tasks observed in the lessons (see Table 2). By definition, intellectually challenging tasks in science prompt students to engage in disciplinary practices that deepen their understanding of the world through scientific reasoning. It is not surprising that the PSTs who framed task goals by separately focusing on either teaching a science idea or covering standards began a lesson with low demand tasks.

As suggested by other researchers, the instructional goals framed by each PST seemed to reflect, in part, PSTs' developing understanding about science as a discipline (see Davis et al., 2011; Forbes, 2013; Zangori, Forbes, & Biggers, 2013). For example, the PSTs who see science as the combination of two separate entities, content and process, instead of science-as-practice—the new image of science advocated by science education community (Lehrer & Schauble, 2006; NGSS Lead States, 2013; NRC, 2012), likely frame their goal as teaching either a piece of content or process in a lesson. Researchers note that specifying learning goals for the instructional episode (i.e., "what are students supposed to learn?") is one central competence for promoting student learning in classrooms (Shulman, 1987;Wiggins & McTighe, 2005) and for learning from teaching (Jansen, Bartell, & Berk, 2009; Hiebert, Morris, Berk, & Jensen, 2007). Notably, most PSTs in this study had *multiple* goals when designing their tasks (see Table 2). Susie wanted her students to develop team skills and learn how to work together, in addition to teaching collision theory and scientific thought processes. Teresa wanted her students, who seemingly were not interested in science, to get to see how science is fun and interesting. It seemed that the varied goals expressed by PSTs reflected their personal goals and identities as science teachers—who they wanted to be and what kinds of experiences they wanted to provide for their students in classrooms.

The consistencies and changes observed in the PSTs' trajectories suggest that framing instructional goals is a dynamic, responsive, and contentious process shaped by their social and professional interactions in contexts. Some PSTs like Susie had to negotiate and respond to the goals and expectations communicated by her mentor teacher in addition to the goals advocated by the program. It might be difficult for Teresa to consistently put forward her personal goal if Teresa was set up to actively consider and negotiate with other goals. The analyses showed that the three PSTs in *disciplinary practice* group took up the goal advocated by the program (i.e., engaging students in disciplinary practices) at certain points of the student teaching period by *expanding* their goals for science teaching. By design, it was largely up to PSTs whether PSTs took up the goals advocated by the program or not. On the one hand, this structure enabled both PSTs and the program to work flexibly with various mentor teachers at local schools. On the other hand, this set-up seemed to constrain opportunities for some PSTs like Teresa to begin a lesson with intellectually challenging tasks, which further constrained their opportunities to learn about students' interesting ideas.

Support PSTs in attending and responding to students' thinking by planning big ideas

The PSTs who began their lessons with intellectually challenging tasks constructed their lesson scenarios while envisioning students' thinking process. The in-depth analyses indicate that the two groups' different approaches to construct lesson scenarios (e.g., following students' thought processes vs. following canonical science storylines, curriculum, or standards) are related to PSTs' attention to the big science ideas of the unit. As evident with Susie's case, the

PSTs in the *disciplinary practice* group planned their daily tasks considering the big ideas of the unit. By contrast, the *content* group PSTs including Teresa selected or designed tasks that covered the daily topics and relevant standards.

There is a growing consensus among researchers in the field of mathematics and science education that organizing instruction centering on big ideas is essential for promoting deep learning in classrooms (Charles & Carmel, 2005; Kloser, 2014; NCTM, 2000; NGSS Lead States, 2013; NRC, 2012; Windschitl, Thompson, Braaten, & Stroup, 2012). Big ideas for science instruction refer to “substantive relationships between concepts in the form of scientific models that help learners understand, explain, and predict a variety of important phenomena in the nature world” (Windschitl et al, 2012, p. 888). Despite its significance, prior studies show that identifying big ideas for instruction is difficult, especially for novice teachers. In a longitudinal study with 26 beginning science teachers, for example, Thompson and her colleagues (2013) found that many of novice science teachers, even with curriculum in hand, were unable to identify big ideas to teach. Similarly, in this study many PSTs focused on one specific topic or idea in the processes of designing their daily tasks, instead of designing the daily tasks with the goal of moving students’ understanding toward the big ideas. When PSTs aim to teach big ideas that transcend a specific content within an activity, then attending and noticing students’ thought processes and progress toward the big idea becomes the central part of teaching. The in-depth analyses indicates that attending to big ideas likely put PSTs in a better position to design tasks in response to developing students’ thinking toward the big ideas. In contrast, if PSTs engaged in designing instructional tasks at a daily topic level, the focus of planning becomes addressing either one or the other ideas of the topic.

One important question raised from this study is what pedagogical activities or tools may better support PSTs' learning of effective planning by assisting them to identify big ideas. The preparation program-designed tool (i.e., Activity Sequence framework) helped some PSTs like Susie, but the tool was not sufficient for other PSTs like Teresa to effectively plan lessons. Effective pedagogies and scaffolds that support PSTs' identification of big ideas in the process of designing instructional tasks need to be further explored.

Facilitate social and professional interactions that lead PSTs to use high quality curriculum resources

The ways in which PSTs framed problems of practice, in particular their students' abilities and willingness to complete tasks, was strongly related to the quality of instructional tasks set up in the lessons. Researchers who study teachers' curriculum use or planning practices reported similar patterns (e.g., Choppin, 2011; Davis et al., 2011), explaining that the teachers' knowledge or perception of students as learners influenced the teachers' interpretations about the problems and their curriculum use.

The analyses suggest that PSTs' differential framing of the problems of practice not only reflect PSTs' understanding about students, but also relate to *the uneven opportunities provided for each PST* to learn about students and their ways of thinking throughout the student teaching period. Under the strong mentorship of Mrs. B, for example, Susie could learn how to run a lesson while managing a group of diverse students, and then later she designed intellectually challenging tasks using the framework from the program. As evident from Susie's comments, using intellectually challenging tasks in a well-managed classroom enabled Susie to recognize when and under which instructional condition her students better understand abstract ideas, which directly informed her task design. In contrast, Teresa's opportunities to learn about students and their thinking through her student teaching appeared to be very sparse. Teresa mainly relied on the curriculum resources from either her past teaching experiences or Internet search with minimal use of any other resources either from her mentor teacher or program.

As Brown (2002) notes, curriculum artifacts or tools from a particular community bear the practices and cultures of teaching and learning supported by the community. On one hand, the curriculum resources leveraged by Teresa enabled her to create the tasks that set up students to feel, touch, visualize, and be part of the science stories—the cultural practices of the out-of-school program that Teresa enjoyed. On the other hand, these curriculum resources constrained Teresa from providing intellectually challenging learning opportunities to students of the urban school. Teresa's less sophisticated professional skills (i.e., does not know how to ask for help), continuing difficulties in managing classroom throughout the student teaching period, the repeated use of low quality tasks that produce little information about students, and their thinking all together seemed to create very different learning opportunities for Teresa. Under these conditions, it might be difficult for Teresa to see what students are capable of with appropriate and sufficient instructional support. This finding suggests that simply making quality professional and material resources *available* to PSTs is not sufficient to support their learning of effective planning. The kinds and forms of social and professional interactions that facilitate PSTs' *use* of high quality resources need to be further examined.

Conclusion and Implications

This study explored how and under which conditions PSTs engage in effective planning practices that incorporate intellectually challenging tasks into lessons. The analyses show that instructional tasks observed at the beginning of lessons link to the ways in which PSTs engage in the three interrelated processes of: (a) framing instructional goals, (b) constructing a lesson scenario, and (c) addressing problems of practice. The consistencies and changes observed in the PSTs' trajectories of planning suggest the dynamic, responsive and contentious nature of planning shaped with social and professional interactions in contexts.

The findings of this study contribute to the pedagogy and practice of teacher education by unpacking the complex processes of PSTs' learning of planning. With the movement toward 21st century competencies, teacher educators face the challenge of developing learning experiences that are powerful enough to help teachers facilitate deeper learning in classroom (Hollins, 2015). Articulating effective planning practices that are related to rigorous curriculum observed in lessons help teacher educators to develop those learning experiences in a principled way.

This study also sheds light on the nature and role of clinical experiences in the process of PSTs' learning to teach. Clinical experiences have been recognized as the crux for preservice teacher learning, but there are few empirical studies that describe how clinical experiences are set up and how learning to teach takes place (Cochran-Smith & Zeichner, 2005). The findings of this study reveal the idiosyncratic nature of clinical experiences provided for most PSTs during the initial preparation period, and its consequential impact on the learning of PSTs and their future students in classrooms. Two PSTs, who worked at similar under-resourced urban schools, developed different language to describe their students from their clinical experiences. Future studies that inform how to create powerful learning experiences for preservice teachers to see what is possible for all underserved students in classrooms will be fruitful.

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