
“Figuring Out My Part in All of This”: Understanding Ambiguity and Uncertainty in Shaping Teacher Learning within Reform

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Purpose: Attending to teachers’ instructional contexts is integral for understanding their learning and implementation of education reform. However, there is still much to be understood about the processes that surround teacher decision making and their navigations through change in their work contexts.

Research Methods/Approach: This article utilized sensemaking theory to explore decision-making dynamics for eight middle school science teachers adopting instructional practices associated with the *Framework for K–12 Science Education* and Next Generation Science Standards. Using a multiple case study approach, I examine patterns of teachers’ sensemaking and their connection to instructional decision making over a 2-year period, with particular attention to the sources of ambiguity and uncertainty that initiated sensemaking and how teachers navigated them. Data include interviews, classroom videos, instructional artifacts, and professional development workshop field notes. **Findings:** Teachers’ institutional knowledge served as a key resource for sensemaking that supported noticing what was new about reform and managing conflicting priorities. Experiencing and resolving ambiguity supported by institutional knowledge tended to lead to greater shifts in classroom practice. However, an absence of institutional knowledge tended to result in feelings of “stuckness” that impeded change. I describe teachers’ navigational strategies to resolve ambiguity, moments of stuckness, and how such experiences shaped the ways reform ideas became integrated into practice.

Implications: Designing opportunities for teachers to notice discrepancies and engage in sensemaking, and leveraging teachers’ local expertise and ingenuity, can support teacher learning and change to classroom practice.

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Over the past few decades, a growing body of work has demonstrated the integral role schooling environments have in shaping teachers’ learning. Teachers’ organizational contexts mediate their perceptions of teaching, learning, and content, and they influence teachers’ decisions about how or if to integrate reform into their practice (Coburn 2005). These prior studies have pointed to the challenging task teachers face when being asked to engage with ideas of reform while simultaneously navigating the numerous institutional practices that manage and monitor their instruction (see Penuel 2019). Further, these studies demonstrate the multitude of (often conflicting) messages from colleagues, school and district leaders, and prior reform efforts about what constitutes best practice. When a teacher makes decisions about their instruction, they must contend with these myriad messages and navigate through the accompanying ambiguity and uncertainty to translate salient messages into their own practice (Allen and Penuel 2015). In this way, processes of teacher learning can be viewed as phenomena embedded within and mediated by the complexity of organizational routines and practices that are also informed by local and translocal policies, politics, and priorities (Rigby et al. 2016).

Research on teachers’ learning and decision-making processes within reform have identified aspects of teaching contexts that can be supportive of change. For example, contexts with consistent leadership (McLaughlin and Mitra 2001), collaborative colleagues (Horn and Kane 2015), adequate professional learning and material resources (Davis and Krajcik 2005), and that allow for teacher autonomy (Rajala and Kumpulainen 2017) can lead to deeper understandings of reform goals, informed decision making, and sustained changes to instructional practice. However, literature also demonstrates that teachers’ perceptions of reform must be considered as well in understanding the dynamics of reform uptake (Coburn 2005). Teachers’ perceptions of “fit”—such as how (or if) reform fits into their existing schooling contexts—ultimately shape which aspects of reform get implemented. Therefore, understanding the processes through which teachers come to certain views of reform is paramount in our efforts to support teachers in accomplishing lasting instructional changes.

In this article, I explore this meaning-making process for several middle school science teachers within one large school district in the United States as they engaged with reform ideas in science education and multiple district-wide

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initiatives. Data reported in this article come from a 5-year mixed-methods randomized controlled trial (RCT) study designed to understand the effect of curriculum materials and professional development (PD) on teacher instruction and student learning. I focus here on qualitative data of teacher implementation over a 2-year period to understand teachers' perceptions of and decision making about reform as embedded in their work contexts.

To explore these processes, I drew conceptually on the process of sensemaking (Weick 1995). Whereas other theories support an understanding of teacher enactment of reform, sensemaking situates these enactments in the context of teachers' work environments (Woulfin and Allen 2022). Specifically, sensemaking frames teacher learning, decision making, and actions as processes (1) responsive to change within one's work environment (Weick 1995), (2) focused on reducing ambiguity and uncertainty caused by change, and (3) leading to actors "structur[ing] the unknown" (Waterman 1990, 4) in which they make retrospective as well as prospective sense of change. Further, whereas others have examined collective teacher sensemaking in reform (e.g., Heredia 2020), I focus here on the processes of individual teachers to better surface sensemaking patterns connected to ambiguity and uncertainty and instructional practice. I consider what it looked like for each teacher to navigate their local reform contexts while negotiating multiple meanings of valued teaching and learning in their daily instructional practice.

I find that teachers' familiarity with their local context—its values, priorities, and current evaluation practices—was especially critical in navigating instructional decision making. Teachers without this institutional knowledge benefited from colleagues with this type of awareness. Teachers' navigations through ambiguity toward instructional decisions demonstrated their ingenuity and agency in utilizing knowledge of their institutional values, practices, and expectations to determine actionable pathways forward. Furthermore, ambiguity seemed to support teachers in noticing and attending to discrepancies between local practices and reform; however, experiencing ambiguity "too late" or experiencing uncertainty tended to result in feelings of "stuckness" that impeded learning and changes to classroom practice.

Conceptual Framework

Teacher Learning in Changing Contexts

Studies of teacher learning have increasingly considered how reform ideas take on meaning in the context of teachers' work environments. This body of work richly supports the notion that teachers' instructional contexts mediate their learning processes (Spillane et al. 2002). Understanding teacher learning, then,

requires an exploration of not simply the shifts in ideas or practice within the context of PD but of the movement and translation of these practices into teachers' work contexts (Beach 1999).

Scholars in organizational science have put forth sensemaking theory as a means for understanding learning in work contexts, particularly in response to change. Sensemaking is occasioned when change is introduced to the work environment. Such changes are often experienced as "shocks" to those within the organization, as they disrupt daily practices and routines (Weick 1995). When what is new or what "does not fit" (Weick 1995, 4) is noticed, this can cause uncertainty and ambiguity for those in the organization, and this noticing "triggers" (initiates) sensemaking for organizational actors. Through sensemaking, actors work to reduce ambiguity and uncertainty and to resolve the disruption caused by the introduced change, drawing on available resources and cues from their environment to do so. At its core, sensemaking is rooted in constructing narratives (Currie and Brown 2003) to understand action, motivated by anticipating trajectories that enable actions that bring about desired outcomes (Klein et al. 2006).

Although ambiguity and uncertainty are used rather interchangeably in the literature on teacher learning and educator work experiences (Helsing 2007), they have distinct meanings and theoretical leverage for sensemaking. As Weick (1995) describes, "In the case of ambiguity, people engage in sensemaking because they are confused by too many interpretations, whereas in the case of uncertainty, they do so because they are ignorant of any interpretations" (91). That is, ambiguity occurs when there is too much information, causing confusion about the next steps. Sources of ambiguity can include the presence of conflicting goals, contradictions or paradoxes, or mixed or unclear messages with respect to roles and responsibilities as a result of change (Weick 1995). Ambiguity in this way "calls for social construction and invention" (Weick 1995, 95) to craft a sense of clarity with regard to one's actions.

Uncertainty, however, concerns itself more with a lack of necessary information for making a choice. This is especially true when considering future outcomes (Burns and Stalker 1961). With uncertainty, an individual experiences a "perceived inability to predict something accurately" (Milliken 1987, 136). For example, people may not have information about how different aspects of the system are changing, the potential impact of change on the system, or the response options available to them (Weick 1995). To reduce uncertainty, actors may turn to "the earliest available information that will show what direction the actor ought to be going" (Stinchcombe 1990, 2).

The introduction of new initiatives is likely to be experienced as "shocks" by teachers, which interrupt the day-to-day routines, practices, and shared ideas regarding science education within the school, district, or state. As teachers engage with reform, they may encounter ambiguity from conflicting goals for

instruction, such as competing district initiatives, limited resources to support instruction that aligns with the standards, a lack of clarity with respect to roles and responsibilities with the new standards, and the absence of measures for judging how successfully they have accomplished goals of reform (Allen and Penuel 2015). In addition, teachers are likely to experience uncertainty around what reform means with regard to how and in what ways the different aspects of the system are changing because of the reform.

The *Framework for K–12 Science Education* (*Framework*; NRC 2012) and Next Generation Science Standards (NGSS; NGSS Lead States 2013)—the reform ideas of interest in this study—are especially well poised to bring about ambiguity and uncertainty for teachers, as the approach called for suggests ambitious shifts for science teaching and learning (Krajcik et al. 2014). The *Framework* and NGSS espouse a vision that science learning should integrate science and engineering practices with disciplinary core ideas and crosscutting concepts that span scientific domains. Students develop their understanding of content and crosscutting concepts through their engagement with science practices and demonstrate their understanding through their application of these ideas. However, in most science classrooms, teachers use hands-on and laboratory activities to reinforce content already taught through lectures or reading (Banilower et al. 2018). Therefore, the espoused vision diverges significantly from current classroom practice and the organizational arrangements surrounding science teaching and learning (Allen and Penuel 2015).

Resources for Teacher Sensemaking

As people engage in sensemaking, they draw on a variety of resources to do so. These resources are both formal and informal in that they can be structured by organizational tools, routines, and practices or through designed PD activities or they can be informal, such as unplanned interactions with colleagues or conversations in the hallways. Resources for sensemaking can generally be categorized into personal (e.g., background, history in current position), social (e.g., interactions with colleagues), and material (curriculum, time to plan; Allen and Penuel 2015).

Teachers' personal, social, and material resources influence how they make sense of new messages about teaching and address disruptions to their work practice. Personal resources may include teachers' conceptions of science, and how students' understanding develops within science (Cohen and Ball 2001), and can include teachers' repertoires of strategies for supporting student learning in science (Harris et al. 2012). Teachers' social resources can include their informal collegial interactions and shared artifacts of practice. Such informal alliances can provide teachers with access to greater resources and expertise (Coburn 2001).

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Finally, material resources may include curricular materials, instructional time, and formal PD.

Across organizational contexts, personal, material, and social resources may be accessed and leveraged within sensemaking; however, these processes are shaped by organizational structures and practices. For instance, the multitude of practices and structures within schools that organize teachers’ instruction—pacing guides, curriculum, standards, instructional coaches, teacher evaluation, student assessment—are incredibly influential in shaping teachers’ sensemaking and instruction (Hopkins and Spillane 2015). Teachers often use this local and state guidance as a way to make sense of reforms, comparing that guidance with messages they receive from external PD providers (Furtak and Heredia 2014). Teachers’ use of guidance about reform as a resource for sensemaking can expand their sense of possibilities for their practice; however, this guidance about reform can just as easily be assimilated into teachers’ existing ideas about practice (Heredia 2020). Standards additionally influence teachers’ sensemaking. In Coburn’s (2001) analysis of teachers’ sensemaking of reading reform, teachers considered the reform through the lens of the standards. In addition, Allen and Penuel (2015) and Heredia (2020) found that teachers ultimately privileged standards over other things that influenced their planning and teaching, as they felt most accountable to these measures.

Schools’ formal structures for facilitating teacher collaboration about their practice—such as intentionally designed, school-based teacher workgroups or teams—constitute another type of organizational influence on teachers’ sensemaking. A cohesive network within a school provides a strong basis for collective sensemaking efforts to result in a shared vision for reform (Coburn 2001), whereas a more fractured network with multiple poles of leadership can result in more splintered visions (Penuel et al. 2010). Further, embedded institutional opportunities for teachers to design lessons, plan together, and make collective sense of reform provide time to more deeply engage with ideas of reform.

Teachers’ Sensemaking Processes and Instructional Decision Making

Teachers’ sensemaking processes—what forms of ambiguity or uncertainty they experience, what resources are available and drawn on during sensemaking, and to what degree teachers have time and opportunity to engage in sensemaking—inform their decision making about instructional design. Sensemaking will look different depending on the teacher and the organizational context (Penuel et al. 2009). For example, within the same district, teachers may experience different levels of ambiguity due to their schools’ institutional context, and within the same school, teachers might experience more acute ambiguity due to a lack of personal or social resources (such as colleagues to plan with; Allen and Penuel 2015).

Penuel et al. (2009) found that teachers' sensemaking about standards alignment—regardless of the state-level policy makers' alignment—affected their decisions about the implementation of an earth science program.

Further, not all sensemaking processes support teachers in learning or growing. The nature of sensemaking processes can get short-circuited—such as quickly coming to conclusions about reform ideas rather than deeply engaging with them—and lead to surface-level engagement with reform ideas (Coburn 2001). For example, when teachers in Coburn's (2001) study of reading reform had conversations with little connection to the classroom or in time frames that shortened in-depth discussion, teachers were unable to engage with reform messages in more than superficial ways. These conversations additionally seemed to encourage teachers to interpret reform in ways that aligned with their pre-existing views of teaching and learning.

Although the shared views regarding teaching and learning on a campus or within a grade-level team serve as resources for sensemaking, individual teachers ultimately translate their sensemaking into classroom practice. Just because change is introduced, it does not necessarily mean that sensemaking is initiated for every organizational actor (Allen and Heredia 2021). Given that sensemaking is occasioned by ambiguity or uncertainty, teachers must first notice change and feel that these changes are significant for their work. In fact, organizational actors, such as teachers, can be quite adept at explaining away or normalizing changes in the work environment (Maitlis and Christianson 2014). This is especially the case in environments in which organizational practices reduce mindfulness (Lilius et al. 2011). Teachers, for example, might disregard a new initiative or new standards as similar to what they have already been doing (Spillane et al. 2002). Thus, what is different must “catch our attention” to initiate the process of sensemaking (Maitlis and Christianson 2014, 71).

Teachers' sensemaking processes have significant implications for how or if reform ideas and practices become integrated into instruction. Understanding the dynamics around these processes, including the interplay between sources of ambiguity and uncertainty, organizational practices, teachers' resources for sensemaking, and how they navigate and negotiate change with regard to their practice, can support our efforts toward designing for teacher learning in reform contexts.

In this analysis, I explore the sensemaking processes for eight individual middle school teachers in the context of the current science education reform affecting the United States and Canada—namely, the *Framework*, NGSS, and associated curriculum. I explore the conditions surrounding their sensemaking, including how the suggested changes were experienced by teachers, the sources of ambiguity or uncertainty that emerged for individuals, and the ways teachers navigated through uncertainty and ambiguity, drawing on available personal, social, and material resources. Furthermore, I examine the relationship between teachers'

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sensemaking and their instructional practices. Specifically, I asked, (1) What are the sensemaking processes regarding ideas and practices of the NGSS and the *Framework* for teachers within the same district? (2) What are the relationships among teachers’ sensemaking processes, their perceptions of NGSS and the *Framework*, and their instructional decision making?

Methods

To examine the relationships among teachers’ sensemaking, their perceptions of the *Framework* and NGSS, and their instructional decision making around reform ideas, I employed an embedded multiple case study methodology (Yin 2013) for eight sixth-grade science teachers from the same large school district. The analysis draws on multiple forms of teacher implementation data from a 2-year period, including teacher classroom videos, interviews, and classroom artifact data (e.g., lesson examples).

Research Context

This study takes place within a large, urban school district—Georgetown School District—in the Southeast.¹ All sixth-grade science teachers in the district participated in an RCT study that aimed to study the impact of curriculum materials in supporting *Framework*-oriented instruction when combined with PD (Harris et al. 2015). The analysis presented in this article comes from qualitative data collected as part of the larger study focused on teachers’ experiences during PD and efforts to implement ideas from PD.

At the time of the study, Georgetown served more than 140,000 students, and the district’s demographics resembled many urban districts in the United States, with a student composition of 42% African American, 32% White, 18%, Hispanic, and 5% Asian; 54% of the students in the district were eligible for free or reduced-price lunch, and the district had a growing emergent bilingual population.

Georgetown was in a state that was one of the “lead states” that provided guidance for the writing of the NGSS; however, at the time of the study, they had not yet adopted the standards. This is important to note, as current standards play a critical role in guiding teachers’ sensemaking (Heredia 2020). Further, the district had recently adopted a variety of other initiatives that were likely to affect science teaching and learning. For example, just prior to the start of the study, teachers in the district had participated in PD on Common Core (National Governors Association Center for Best Practices and Council of Chief State School Officers 2010) and had adopted a new science curriculum.

Framework and NGSS PD.—As part of the study, teachers participated in PD four times throughout each of the two school years. The *Framework* (Year 1) and NGSS (Year 2) workshops took place during August prior to the start of the school year in 2012 and 2013. Members of the research team and the committee that developed the *Framework* and NGSS led the workshops. PD activities in workshops emphasized learning about disciplinary core ideas through driving questions; science practices; and how core ideas, practices, and crosscutting concepts are integrated into performance expectations (PEs). Teachers developed and revised models, wrote scientific explanations related to the material they were required to teach, and examined PEs and had the opportunity to adapt state standards into PEs.

Project-Based Inquiry Science curriculum and PD.—The curricular text analyzed in the larger study is called Project-Based Inquiry Science (PBIS). PBIS comprises science units in life, physical, and earth science, spanning grades 6 through 8. A typical unit takes 8–10 weeks to complete. The text is organized by “Learning Sets,” which are guided by a driving question or a challenge that targets a crosscutting concept in science. The activities within each unit provide students with multiple occasions for investigating as scientists would—through observations, asking questions, designing and carrying out experiments, building and using models, reading about the science they are investigating, constructing explanations, and so forth. In this way, the curriculum design emphasizes a knowledge-in-use perspective (NRC 2012) and reflects in a broad sense the principles of the *Framework*. At the same time, the goals of PBIS units do not align perfectly to PEs as articulated in the NGSS; however, at the time of the study, very few curricular materials reflective of *Framework* principles existed, which made PBIS a promising option to support teachers.

Teachers in the current study received PD focused on this curriculum, in addition to the PD they received related to the *Framework* and NGSS at three time points throughout each school year. These sessions ranged between 1 and 3 days and were intended to coincide with teachers’ curricular pacing. During these workshops, teachers shared what were framed as “innovations” in their teaching. These included scaffolding tools, such as those that teachers had created to support students’ development of explanations, other textbook or lesson adaptations, and student work as a product. The teachers additionally shared strategies they had used to address differences in pacing between the textbook and the district pacing guide and other planning tools they used.

Participants

Teachers selected for this analysis participated in both years of the study, were part of the treatment group (28 total), participated in a smaller video study in

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which teachers recorded focal lessons and completed weekly online logs, and agreed to be interviewed. Teachers in this sample also attended roughly the same number of PD days. PD participation was included in the selection process, given its likely role in supporting teacher sensemaking and reform implementation (Krajcik et al. 2014). Further, although PD participation was comparable, concerns with implementation (interpreted as uncertainty and ambiguity) and questions raised during PD and throughout implementation in teacher interviews varied. This resulted in eight focal teachers within four different school contexts, with varying forms of ambiguity or uncertainty and diverse sets of personal, social, and material resources (table 1 [table 1 is available online]).

Data Collection and Sources

Given that sensemaking concerns itself most with constructing narratives to understand new information and plan pathways forward, data collection favored opportunities to elicit teacher stories and interpretations of both the reform and their teaching practice. In addition, this analysis concerned itself with understanding the connections between sensemaking processes and classroom practice. Therefore, data included ethnographic field notes from all teacher PD sessions, teacher interviews, and multiple sources of classroom-level data over the 2-year period of the project.

Field notes and teacher interviews.—The research team took ethnographic field notes (Emerson et al. 2011) during each of the PD sessions (described above, eight sessions total) teachers participated in over the 2-year project. Field notes were organized by primary PD activities and aimed to capture detailed descriptions of how ideas were presented by the PD facilitators, how activities were structured, and how teachers responded to and participated in PD. Researcher comments were offset by italics throughout detailed notes and included an open reflection to capture key observations that surfaced during sessions.

In addition, the author interviewed focal teachers during fall 2013 and spring of 2014 (2 interviews per focal teacher; 16 interviews total). The interview protocol was developed using a construct-centered approach to assessment design (Wilson 2023). Fall interview topics included instructional management and accountability practices at teachers' school sites—such as teaching and classroom-organizational practices (e.g., objectives posted on board), building administration look-fors, lesson planning expectations, and teacher responsibilities—and teachers' perceptions of coherence between the *Framework*, their current instructional approaches, and state and district goals. The spring interview focused on lessons in which teachers engaged students in science practices, the objectives of these lessons, any modifications teachers made, what type of student the reform seemed most effective for, and what materials teachers used in the planning and

implementing of these lessons. The interviews were conducted over Skype, phone, or in person and were audio recorded and transcribed. Interview length ranged from 25 to 75 minutes.

Classroom data.—Teachers were asked to record video of the same six lessons across two curricular units within PBIS and during both years of the study (12 videos per teacher; 336 videos total). The lessons selected were chosen because of their alignment with NGSS practices. Included in this analysis are two of these six lessons—one from each curricular unit. These PBIS lessons include prompts for students to engage in the practices of modeling and explanation and include prompts for teachers to engage students in reasoning about science phenomena. The videos typically ranged between 45 and 90 minutes in length and were submitted electronically through a secure online portal. Members of the research team (author included) reviewed each video; lesson segments that were whole-class interactions were transcribed for analysis. In addition to recording lessons, teachers were asked to submit in-depth descriptions of lessons they taught during both years.

Data Analysis

Because I was interested in both teachers' sensemaking and the relationships between these processes and their implementation of *Framework*-oriented instructional practices, I conducted my analysis in a multiple-stage process. First, I coded classroom videos and teacher assignment data for teacher questioning patterns, student engagement in science practices, and learning activities provided in the lesson. I considered the ways teachers used and adapted lesson activities; data were also scored using a rubric for opportunities for students to engage in scientific modeling or explanations.

Teacher interviews were coded for (1) sources of ambiguity and uncertainty, (2) sensemaking resources, and (3) views of *Framework* instruction. Sources of ambiguity included conflicting goals, absence of measures, and limited resources, and sources of uncertainty included role ambivalence, such as a lack of clarity regarding how to move forward or take action. Sensemaking resources included personal, social, and material resources: curriculum materials, school leadership, formal learning communities, informal collegial support, and teaching histories. Views of *Framework* instruction included descriptions of the *Framework* and NGSS, discussions of lesson activities, and descriptions of how and why teachers made instructional choices.

Compiling all coded data, I developed case summaries for each teacher of enactment decisions, experiences of ambiguity and uncertainty, resources for sensemaking, and perceptions of reform. I then created a series of data displays focused on the sources of ambiguity and uncertainty teachers experienced

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(table 2), the resources teachers drew on during their sensemaking, and sense-making patterns in relation to instructional patterns. This allowed me to discern relationships between sensemaking and implementation patterns across teachers. These patterns were discussed and deliberated with other members of the research team and scholars with expertise in teacher sensemaking in science.

Finally, I returned to patterns of ambiguity or uncertainty and resources for sensemaking to note themes of navigation—understood as teachers’ processes of resolving sources of ambiguity or uncertainty and making plans or taking action. This also enabled me to understand individual differences for teachers in similar contexts and/or with similar resources for sensemaking.

Findings

Teachers’ sensemaking around *Framework*-oriented practices and associated curriculum was initiated at multiple points and occurred throughout their implementation of the reform, beginning with the initial PD on the *Framework* and then again throughout the school year as they encountered pushback, feedback, or institutional conflicts in response to their instructional shifts. At each point, teachers noticed a difference or discontinuity between reform ideas and practices and the existing practices within their schools, district, or state regarding science education. This noticing led to either ambiguity or uncertainty for teachers around future actions to take, including what of the reform to integrate into their instructional practice and how to prioritize their time and attention. Both in the noticing of difference and in managing ambiguity or uncertainty, teachers’ personal, social, and material resources played an integral role.

In what follows, I describe the dynamic between noticing, resources, and sources of ambiguity and uncertainty as they emerged and unfolded for teachers across the two school years of this study. I begin by describing sources of ambiguity and uncertainty that initiated sensemaking for teachers. I then describe teachers’ navigations through ambiguity, demonstrating their ingenuity and careful decision making supported by available personal, social, and material resources. I follow this with descriptions of two teachers who experienced uncertainty and felt stuck and the implications of these sensemaking processes for teachers’ classroom practice.

Instances When Sensemaking Was Initiated through Noticing Difference

There were multiple points throughout the 2-year project in which teachers’ sensemaking about the reform was initiated through noticing “what does not fit” (Weick 1995). These moments occurred in the context of PD and while

implementing ideas from PD into their instructional contexts. In this section, I describe these instances of noticing, organized around teachers' narratives of the change and the ambiguity or uncertainty it brought about for them.

Noticing Difference during PD

Newness in "a lot of changes."—For many, sensemaking was first initiated during the PD on the Framework when teachers were presented with the ideas of the reform for the first time. This information served as a source of ambiguity for teachers, in which they had to wrestle with what the ideas being presented meant for their instruction. Alice, for example, described:

It was kind of very intimidating to think of, "Wow, we just got these essential standards two years ago and now they're going to be introducing these new standards." It was all kind of new and a little frustrating. There's been a lot of changes. . . . They've implemented the Common Core here in [our state] over the last few years. As far as the science standards, they just implemented what they consider the essential standards, which was supposed to be more compact, and "this is what the kids really need to know." But, actually, they've added more than we had before.

Alice expressed frustration with what felt like more change within a context of "a lot of changes," while noting inconsistencies between what was purported to be true in prior standards ("what the kids really need to know") and what she perceived them to be ("they've added more than before").

Similarly, Abby described initial resistance to the *Framework* and curriculum materials when the *Framework* was first presented during PD:

Abby: When [the PD providers] were first giving us all of that [information about the *Framework*], I was like, Whatever.

Author: What made you "like whatever"?

Abby: Well, just because, our district wasn't doing that, [our state] wasn't doing that, so it's kind of like, uh—alright, I see where we're going with this, OK. . . . Like alright, they are throwing this *Framework* on us, but our school is adopting Common Core, so we got to make sure that's in there [too].

This sentiment of "more changes" was common across teachers when they described their initial reactions to the ideas presented in the PD, in addition to questions about alignment between what was being presented and the relatively new standards they had just adopted at the state level. In both Abby and Alice's

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constructions of the change, there is a characterization of “they”—some outside source—imposing new changes on them. They describe noticing the myriad messages about standards and priorities—our state just adopted Common Core and now we have new standards to consider—and the accompanying ambiguity, such as how to “make sure that’s in there” while also including new information being presented.

“Everything was new anyway.”—For other teachers, however, this initial shock of noticing inconsistencies around *Framework*-oriented instruction did not occur during PD. Joe, a teacher new to his role in the first year of the study, described feeling that everything was new: “Everything was going to be new anyway . . . [the information in the PD] was definitely new for me. . . . I mean, I’m still just trying to kind of learn it and learn about what all [the PD] included. I’m trying to wonder and actually . . . remember if it was already covered; if like when the science standards are actually going to be a part of everyone’s curriculum, or supposed to be, expected to be.” For Joe, the information was “new,” but it was an additional piece of new information in a whole suite of new tasks and roles. Thus, Joe was unaware of preexisting expectations and therefore not noticing what was “different” from these expectations and ideas presented in PD. Instead, Joe was overwhelmed with all the newness and his attention was on “trying to learn it . . . all” rather than resolve inconsistencies. As I will describe in the next section, Joe’s sensemaking was initiated much later during implementation after receiving low student test scores, which played an integral role in his instructional decision making moving forward.

Noticing Difference during Implementation

In addition to PD initiating sensemaking and surfacing ambiguity with regard to fitting the *Framework* into existing and new standards and initiatives, teachers’ sensemaking was also initiated as they brought these ideas into their instructional contexts. This included ambiguity associated with conflicting goals surrounding (1) building-level expectations for “good teaching,” (2) “hitting standards” and aligning with district pacing, and (3) contending with prevailing views of and approaches to science teaching.

Conflicting goals regarding building-level expectations.—Part of the ambiguity teachers experienced around all of the “newness” and change came from evaluation practices and espoused priorities of building-level leaders (e.g., instructional coaches and principals). As Alice and Abby mentioned, Common Core had just been adopted by the state, and in the first year of the study, many teachers received PD on the Common Core standards just prior to the project’s PD on

the *Framework*. Including connections to the Common Core or having essential science standards listed on teachers' boards were just a few of the common expectations that teachers had across schools in the district.

In addition, each building had its own priorities for instruction that often incorporated these district and state-level priorities, while also layering additional school-level ones. These building-level priorities framed perspectives of "good teaching" and shaped building leaders' evaluations of teachers. For Rich and Kate at Robinson, one of these building-level foci was "differentiation":

Rich: Our administration, they were a little resistant at first [to the reform practices], but after . . . they started coming in our rooms and really seeing how effective this method is and the means that we're doing, I feel like they jumped right onboard. Now it's just been, "OK, so now [a year later] that you've got the curriculum down, how are you differentiating?" They want to see that. They want to know how we're implementing the Common Core. A lot of the stuff that we talked about [during PD] of how are [we] doing all these other things that [we] need to be doing for the district?

Kate: Yeah, and "differentiation" to them a lot of times is different than what we look at it as. To them, it's like they have to see something—

Rich: Written down.

Kate: —Like this, this, this (*mimicking a check list*) written down and implemented and everything, when this [approach] doesn't really one hundred percent lend [itself] to that. It's probably built in—

Rich: There's a differentiation [in this approach]—yeah, it's built in.

Kate and Rich name a tension that many teachers felt—not all aspects of an effective lesson were necessarily present in writing or in ways noticeable to administrators. They also describe being aware of how aspects of the curriculum did align with building-level expectations, but how limitations in evaluation practices did not capture these alignments. This awareness of the conflicting approaches was a source of ambiguity for the two.

However limited, the systems for evaluating teachers did have significant weight in how "good teaching" was recognized and defined:

Rich: They've always had evaluation systems. They think they're improving [the systems] as they go along, but they're still a checklist. When they are coming in and they're looking for something, they're checking it off. If they see it, you're a good teacher. They don't say, "You're not a good teacher." [They say,] "You need improvement,"

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even though you’re never going to see every single thing you have on the checklist—

Kate: In one lesson.

Rich: Yeah, in one single lesson. . . . What constitutes good teaching? We got good teachers in this school that are being marked down. We got some teachers I would never want my kid in their class, they’re “great teachers.”

Evident in Rich and Kate’s reflections are both an awareness of the “system” of evaluation practices and its limitations in noticing effective teaching practices, such as those within the reform. Although they saw how the reform lesson aligned with expectations in the building—such as differentiating—this was not a connection immediately evident to building administrators. Their sensemaking was, at least in part, centered around distilling these alignments—such as coming to understand differentiation as “built in” to the lessons—and how to communicate these alignments to their building leaders to satisfy leaders’ expectations for instruction.

“This is how we’re doing it in science!”—Alexis, a teacher at Norman and in her first year of teaching, was similar to Joe in that her background was in elementary teaching, not middle school or science. Like Joe, she was navigating an “all-new” teaching environment. She described being under extra scrutiny by her building administrators, who—similarly to Rich and Kate’s administrators—were looking for specific aspects “written down” in her lessons:

Alexis: I’d have to be like, “You have to go look!”—because they look harder at a new teacher’s stuff than they do—you know . . . [the administration is] going to flip through [Joan], but they’re going to look at mine and be like—(*Raises hands, gives confused expression.*)

Author: Yeah.

Alexis: I’m like, “Well, this is how we’re doing it in science, so go look at [Joan]’s [lessons]. This is how she’s doing it, too. This is how I was told to do it.” We’ve worked out a balance over the two years, where they see what we do, and they’ve adjusted to it. Now it’s good.

Author: When they first were coming in . . . were they looking for things that weren’t happening in that particular lesson?

Alexis: Just maybe in lesson planning. Not necessarily in the classroom. On paper, more . . . it was just more like the six-point lesson plan wasn’t

being fulfilled because it's [PBIS] not that type of lesson, for the most part. . . . [The lesson format is] linked to prior knowledge and warm-up, teacher input, guided practice, independent practice, homework and assessment, closure.

As opposed to the ambiguity experienced by Rich and Kate, Alexis dealt with initial pushback from her administration for PBIS lessons not aligning with current lesson expectations, which led to uncertainty. In this case, Alexis saw the pushback as being centralized around not having lessons that followed the six-step lesson plan format (traditional direct instruction lessons).

Although she recognized that PBIS did not follow this more traditional plan, she also seemed limited in her ability to articulate connections or purposes for the approach beyond it being “how we’re doing it in science.” This differed from Rich and Kate’s delineation of difference and connection. Alexis seemed unaware of the conflicting messages between the materials and her building-level expectations (until receiving institutional pushback), and unclear about how to organize her instruction outside of the grade-level team’s plan.

Conflicting goals regarding standards and misalignments with pacing.—Another instance in which sensemaking was initiated for teachers as they integrated materials was around pacing and addressing required sixth-grade standards. Although the curriculum did cover most of the standards teachers were expected to teach in sixth grade, there was one topic—ecology—that was not. In addition, there was a “launcher” unit that was intended to open the school year and establish science dispositions and practices for the class community. This included activities that situated science within phenomena and encouraged students to ask questions and explore answers through collaboration and iteration. The lack of coverage of ecology and this “extra” unit were two prominent pacing challenges for teachers.

Most teachers experienced pacing conflicts as ambiguity, noticing these discrepancies early on and throughout their implementation of the reform materials. The teachers at Norman, for example, noticed pacing inconsistencies immediately during the initial summer PD. Joan led the sixth-grade team—including Abby, Alexis, and Marcus—in identifying pacing differences and adjusting lessons to match pacing expectations for the district. Throughout the year, Rich supported noticing pacing inconsistencies and making these shifts with Kate by trying out lessons at home prior to teaching them. Even so, the team described “running out of time” at the end of the year and “cramming” in a condensed unit that covered topics not yet discussed in the school year.

Experiencing ambiguity late: “Lost time.”—Although all other teachers talked about being aware of the pacing inconsistencies and “rushing” to cover certain topics, Joe noticed these differences much later in the year, after receiving students’ test scores from their end-of-year exams:

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One of the things that I was kind of frustrated with was last year I just focused on PBIS's pacing guide because we were told we needed to follow this with fidelity to see how the numbers come out, how the testing comes out. I did that, so that's what I kind of dedicated my year to learning. Then this year, after those scores came out, I said, "Shoot. I'm going to look at our pacing guide for our district, what the students should know after nine weeks and so on." I noticed that with the [first] unit, there's actually no . . . time in our [pacing guide] for that. . . . To get to know what it means to be a good scientist. That's like four weeks of lost time, essentially, in terms of the standards.

Joe's reflection on his decision making is a relatable one: he was following the messaging he heard from one source in his environment, which itself was "all-new" given his transition to teaching middle school for the first time. Joe was unaware of the conflicts between district pacing and the pacing suggested by the curriculum materials; that is, until student test scores came back indicating incongruities. Joe had "dedicated [his] year to learning" the curriculum, and, in doing so, unintentionally missed other messages that had real consequences for his students, his school, and his job. His feelings of "lost time" were palpable. Similar to Alexis focusing primarily on "what we are doing in science," Joe had targeted attention on the curriculum to inform his instructional decision making in Year 1 of the study. In both instances, their sensemaking was initiated much later, after integrating ideas and practices in ways that did not fully account for institutional expectations.

Conflicting goals regarding approaches to teaching science.—In addition to building-level practices for assessing "good teaching," issues of coherence surrounding views of and approaches to teaching science initiated sensemaking for teachers. Teachers became concerned with how to support their students in having coherent learning experiences and whether or not students would be adequately prepared for the types of activities they would be expected to do when they moved into other grade levels and classes. Teachers described tensions they felt between the more "traditional" approaches, such as "lecture" or "telling you what to think" that other teachers in their schools used. Abby, for example, described: "[The students are] doing all this stuff in sixth grade and then they get to seventh grade, totally reversed. Back to opposite: I'm going to teach, teach, teach; you're going to write notes, write notes, and then we're going to do a lab about it that you really don't get, and then we're going to move on. You know, so they reverse it back to the original teaching. Seventh and eighth grade, they are still harping on the scientific method, so they are going to have to teach [the kids that]." Further, Rich described tensions between their teaching and the approaches of other science teachers in their building: "They're still doing it old school. They're really following the scientific method word for word and everything. We've had not really arguments about it, but in our verbal planning when we get together with the

other grade groups there's discussion about that. They didn't think that we were preparing the kids for that [scientific method]. . . . One of the seventh-grade teachers was always putting us down somewhat." Here, teachers expressed conflicting views about the best science teaching practices and differing approaches to teaching present in their buildings—a key source of ambiguity.

For many of the teachers, their use of the PBIS materials and, to a lesser extent, their experiences in PD supported them in noticing key differences between a more science-practice, phenomena-based approach to teaching and more traditional approaches (such as the teaching approaches referenced in relation to their building-level colleagues). These teachers described how ideas in PBIS initially caused ambiguity with respect to their previous approaches to science teaching. However, through their sensemaking, their own thinking about effective science teaching had shifted. Marcus described, "[Before] it was like, 'Oh yeah. You have to introduce the vocabulary. You have to give these kids some background information before the lab, because otherwise the lab won't mean anything to them.' Now my psyche has reversed on that. I really do see that you have to give them the lab. That's the experience that they're getting. Then you can help them make the connections with the vocabulary and the facts and the information after." Further, Alice shared,

I do think [my instruction] has changed . . . working with the curriculum that we've had the last couple years. . . . Before I was always—I've always been a very hands-on science teacher. I really want to get the kids involved in actually doing science and not just me talking about it. That's always been my method. It's one thing doing hands-on labs. It's another thing applying what you've learned and into a project or having to learn it and to be able to do the project. You need to have a purpose for it. I think the instruction is more purpose driven as far as, OK, we have this project, what do we need to know to complete it? . . . I've been able to take that idea . . . and put [it] into the other grades as well.

The curriculum served as a key material resource for teachers' sensemaking in resolving ambiguity with respect to science teaching approaches. Yet integrating the curriculum spurred additional sources of ambiguity with respect to fit—how the reform ideas and practices fit within their existing work environments, especially when compared to other approaches to teaching science in their buildings.

In addition, as teachers implemented lessons, they described seeing differences in students' engagement, including hearing feedback from parents regarding their child's interest in science and witnessing students' applications of classroom content to their experiences at home. Kate, for example, shared how her students would "challenge their parents" with questions that emerged during class. Abby also described an email she received from a parent: "I even

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received a parent email saying, ‘Ms. W, you’ve done amazing. I’ve had four kids go through the school district, and you’ve been the only science teacher that’s gotten to my child and that she brings that science home every day.’” Through the combination of noticing differences in students’ learning and differences between reform lessons and the more prevalent approaches to teaching science in their buildings, many teachers experienced new forms of ambiguity regarding coherence. Many teachers wondered about their responsibility in preparing students for more traditional science learning expectations. As Marcus described, having more “integration” across grade levels would be helpful for students.

Key here for the teachers was the productive role that ambiguity played in driving the noticing of differences between existing approaches to science teaching and the reform. Furthermore, ambiguity supported continued sensemaking during enactment that initiated new forms of ambiguity related to the longevity of reform practices within their schools and the coherence of learning experiences for students.

Not experiencing ambiguity around science teaching practice.—Although experiences implementing the reform materials did initiate sensemaking around one’s own instructional approaches, this was not always the case. In contrast to Marcus, who had described how his “psyche has reversed,” or Alice, who described a deepening of her views of “hands-on” teaching to being more “purpose driven,” Joan instead described the reform as primarily what she was “already doing”:

Well, I guess a lot of [the science and engineering practices] are things that I’ve tried to do anyway. Like, when I wrote my National Boards paper, several years ago at this point, the science practice I pulled out for Entry 1 was on using models. That was already in my brain, so that’s not something that came out of this [study] . . . there have been times that I have done labs for years that are much more open-ended and just designed for [students] to choose. I [already] knew that [science teaching] shouldn’t be all about me in front of the room teaching—it should be the kids doing and experiencing.

So, although Joan recognized differences between the reform and more traditional approaches—as noted previously—her sensemaking around how reform differed from her current practices was not initiated in the same ways as described by others, like Marcus and Alice.

Navigating Ambiguity toward Possible Pathways and Desired Outcomes

Teachers drew on personal, social, and material resources as they engaged in sensemaking about the aforementioned sources of ambiguity. One resource

that surfaced as especially integral for teachers' navigations through ambiguity was their institutional knowledge. Institutional knowledge involves an awareness of local-level priorities and expectations, including (and especially) grade-level standards and building administrator preferences and priorities. This knowledge came either from one's own prior experiences teaching (personal resource) in their particular role or from a colleague (social resource).

When teachers had access to institutional knowledge, they more readily noticed inconsistencies between local priorities and reform and seemed to navigate through them more nimbly. In what follows, I describe this dynamic in what emerged as three common navigational strategies that teachers employed as they resolved ambiguity and made decisions about their practice. These strategies included (1) "not looking at" messages that did not have an immediate impact on their daily practice; (2) "teaching two lessons" when administrators observed them; and (3) relying on familiar approaches.

"Not looking at" auxiliary messages.—The newness that teachers like Alice and Abby had described when they were first introduced to the *Framework* through PD did not lead to sustained sensemaking around the *Framework* or NGSS. As Alice explained, "Well, actually, to be honest, I really don't remember the eight science practices right off the bat because of the fact that I'm not—I'm more looking at the [state] essential standards than the practices because in reality I'm still teaching the essential standards. You know what I mean?" Similarly, Joan shared, "Because our state has not adopted the [*Framework* or NGSS]—aside from the training that we had—it's not a conversation that takes place. It's very much out of sight, out of mind, and so the PD has not impacted me to the point that I'm thinking, 'How can I be doing NGSS?' Like, I don't process that question." When given opportunities to look back at the science and engineering practices, teachers could make some connections to the lessons they taught through the curriculum; however, there remained some lack of clarity for most around specifics, given they had not spent time on them.

Knowing what messages mattered most seemed to come from having familiarity with one's role. It required an awareness of the current standards, building-level expectations, and current priorities within the school and district. Having this knowledge served as an integral tool for cutting through the noise and determining which messages to amplify for informing actionable pathways. Joan seemed particularly clear on this, being able to offer direction to her grade-level team. Marcus described this support from Joan: "I need somebody else to digest [new information] and narrow it down a little bit for me. That's why I love working on this team, especially Joan—I don't know how she finds the time to do all that stuff. She is one of those types of people that she'll narrow it down and say, 'OK, this is what it is.'" Alexis—also in Joan's sixth-grade team—shared, "The timing was hard and I got really behind. I spent all of January trying to catch up. I was cutting stuff left and right. [Joan] would just be like, 'OK, this you can cut,

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this you can cut, this you can cut.’ This year I’ve stayed on track with them. I feel a lot better about it.”

Although Marcus saw Joan as “one of those types of people” who could “narrow it down,” there is evidence that Joan’s ability to narrow things down came from her clear understanding of local priorities. She shared, “In the sense that it has just been beaten into our heads, it doesn’t matter what else, the [state] standards are what you have to do. Until [our state] heads in that direction [I’m not going to consider it]. . . . If I can connect [a lesson activity] to our current standards, I know I’m good to go. If I can’t connect it there, then I don’t feel like I can teach it at this point.” Joan articulates why engaging in more sensemaking around the NGSS felt like a fruitless use of time, given what material she needed to ensure her students knew how to successfully take the state test. Joan’s decision making was grounded by her clear understanding of the required sixth-grade content, per the state standards. Furthermore, this personal resource of institutional knowledge that Joan had supported her colleagues’ decision making, serving as a social resource for them.

“Teaching two lessons.”—A key material resource for teachers was the PBIS curriculum. As evidenced previously, teachers came to see the curriculum itself as the reform, with their deeper, sustained sensemaking focusing on the aspects of the lesson materials that differed or not from their current practice and not on the standards themselves. However, as described in the previous section, the materials also caused ambiguity for teachers with respect to pacing and building-level expectations for science teaching. Navigating these sources of ambiguity involved drawing on institutional knowledge about what building-level administrators wanted to see in lessons and adapting instruction appropriately.

Rich and Kate, for example, knew that differentiation—in addition to other initiatives—was expected to be observed during any walk-through. However, as Rich and Kate had relayed, seeing all teaching expectations in every observed lesson was “ridiculous.” This was the case especially when reform lesson activities included connections to valued classroom practices in less overt ways, such as “built-in” differentiation. Teachers navigated this ambiguity through what they described as “teaching two lessons”—one that was planned for the day and one that they would teach if and when an administrator came into their room. Alice described this process for her own practice: “I know what [my principals] want. . . . I can up the level as I need it and tweak the lessons to fit what . . . they want.” Similarly, Rich shared, “[Administrators] do the walk-throughs and everything, which are good, but still, they want to see [specific things] in your observation. Teachers (*pauses, looks around*) basically, OK, this is what happens. OK, they have two lessons: the one they’re going to teach and the one if an administrator walks in, OK?” This “two-lesson” approach that Rich and Alice describe was reflective of teachers’ innovation in managing the conflicting priorities in their environment. Having this ability to improvise to

highlight various aspects of a lesson or make connections to what administrators wanted to see indicated their knowledge of local priorities.

Similar to Joan's clarity with regard to instructional decisions that align with standards, Alice described adapting her instruction in ways that supported her students: "I have to look at what my students need. As far as the pacing guide, I look at [it], but . . . I need to teach my kids. I don't worry so much about getting through a pacing guide as I worry about what my kids need . . . my administration expects me to teach the kids, not feel like I have to be limited by a pacing guide." What Alice describes is a clear sense of what her students need and what her administration expects of her. She is less concerned about "getting through" a pacing guide and is more focused on supporting her students' learning, drawing on what she knows as an experienced teacher. In this sense, Alice's prior experiences teaching science and in her role at her school, Columbus, supported her in distilling competing messages about her practices.

Using familiar approaches.—As teachers navigated competing messages about their practice, an additional strategy they used was relying on familiar approaches to instruction. Relying on familiar practices could be a product of sustained sensemaking with reform ideas, such as considering ideas and materials in depth, trying them out in the classroom, and reflecting on what approaches felt "best" for students. However, relying on more familiar practices was, at times, a product of abbreviated sensemaking, such as filtering messages based on their saliency (e.g., choosing not to pay attention to the NGSS) or defaulting to the earliest available source of information for making instructional decisions in the midst of uncertainty.

In what follows, I describe instances in which teachers drew on their institutional knowledge and prior experiences teaching to work through ambiguity through sustained sensemaking. Alice's sentiment of needing to "teach my kids" is one example of sustained sensemaking with the materials that eventually led to drawing on more familiar practices. For example, she taught the curriculum as written for much of the first year, but then she shifted her instruction to incorporate only parts of the curriculum that best met students' needs. Similarly, for Rich and Kate, these shifts came after trying out the lessons prior to teaching them, then again in the classroom, and finally reflecting through regular meetings about what to tweak.

Along these same lines, teachers at Norman developed unit assessments to monitor students' progress toward state exam standards. These assessments were not aligned with the reform but fit within existing practices at the school. Abby shared that "administration likes common assessments" but that she prefers the types of assessments given by the study (as part of efforts to develop NGSS-aligned assessments): "I like the questions that [the study] gives us with those tests that they give [the students] the picture . . . and then they're [told to] explain. . . . I like that the best because then you do see if the students understand it. Us, we're just in such

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a time constraint I feel that it’s always multiple choice. This is the easiest, fastest way to give [an assessment].” So, although Abby recognizes the value of different types of assessments and the limitations of what they were developing and using, she still felt tied to this approach, given limited time. Being both aware of what was “better” but defaulting to prior practices was common for all teachers.

Even in classrooms in which teachers’ classroom data suggested close and regular alignment to reform practices, they struggled with the duality of noticing and valuing differences while feeling a need to use prior approaches. Joan represented a case of lower integration of reform practices. She shared her feeling like when she did “real old school” lessons of using PowerPoint and asking students to take notes that, although she knew it was not “best,” she also felt she was preparing them for future learning experiences: “What’s a little sad though is at the same time, I knew that I was preparing them for what they were going to experience in seventh grade. Because I know that the people up there are really into that whole, teacher stands up at the front and goes through a PowerPoint. Well, that’s not the best thing. That is what I know my students are going to be dealing with next year. It was a little bit of a way in their interest in preparing them for that again.”

The modifications that teachers described reflect a process of drawing on available resources—particularly their institutional knowledge—to resolve ambiguity and make informed decisions for their classroom practice, even if not the most ideal, given current institutional practices, limited time, and perceptions of student needs. In these cases, teachers often had a mix of prior approaches with more reform-aligned approaches.

Feeling Stuck: Timing of Ambiguity and Uncertainty

Relying on familiar practices also came as a result of feeling stuck about how to move forward—associated with an unawareness of inconsistencies (e.g., experiencing ambiguity late) and uncertainty (not having necessary information), in which teachers were unaware of possible interpretations. In these cases, teachers felt and remained confused about the next steps for their practice and gravitated toward what was most readily available to them. They described feelings similar to being “stuck” or confused about what to do. Teachers who experienced this stuckness tended to enact more traditional approaches overall, with less alignment with the reform. In this section, I describe two examples of when this phenomenon of feeling stuck occurred for teachers.

“Between a rock and a hard place.”—As mentioned previously, Joe was new to his role teaching middle school and described feeling that “all” was new to him that first year of the study. However, unlike others who had noticed inconsistencies

between the reform and current school practices, Joe had focused on the newness of the curriculum materials and teaching these “to fidelity” (using his words here). Once Joe had received student test scores, he only then came to realize pacing discrepancies between the curriculum and the district and state: “It’s a little frustrating. I feel like it’s—we’re kind of between a rock and a hard place where we need to make growth, and that’s our sixth standard that we’re rated upon. Yet we’re trying to follow this [curriculum and associated reform] with integrity. It’s kind of a tough place where I don’t know if there’s a good answer for what we should do.” Joe felt stuck. He “did not know” if there was a “good answer” for how to address the mismatch between the curriculum and the district pacing and tested standards. Ultimately, Joe deprioritized the reform curriculum and returned to more familiar and traditional approaches to instruction in Year 2. Whereas others had managed this similar experience as a source of ambiguity through developing materials or modifying lessons, Joe was left “between a rock and a hard place” with confusion about how to move forward. Both the timing of when Joe experienced ambiguity around pacing and the lack of resources for supporting his sensemaking—for example, colleagues with institutional knowledge, additional material resources—contributed to these feelings.

“Trying to figure out my part in all of this.”—Unlike Joe, Joan did experience some early ambiguity between existing messages about local practice expectations and ones touted by the reform. Her institutional knowledge supported her in seeing the multiple and mixed messages surrounding these bodies of expectations, and she used this knowledge to navigate through ambiguity. However, Joan additionally experienced uncertainty when it came to understanding her role with respect to her broader instructional context: that of the state and nation.

As Joan made decisions about what to integrate into her classroom from the curriculum and PD, she ultimately foregrounded her state’s standards and skills she anticipated her students needing as they navigated school science. This commitment to her students and to her practice led her to struggle with understanding her role as someone adopting the reform. Although Joan did have multiple messages about her practice, she lacked a source of key information for her decision making: the direction her state was planning on going. That is, Joan was unsure about whether or not her state was planning to adopt the NGSS or *Framework*-oriented standards. Just prior to the start of the study, the state had been deeply involved in the development of the *Framework*; however, recent political shifts had resulted in a movement away from NGSS. She described uncertainty around trying to “figure out [her] part in all of this” and being “worried about getting [students] from Point A to Point B and getting that done well and then trying to shift gears and going another direction when I know that the people next year aren’t going to be continuing [using a *Framework*-oriented approach].” Joan worried that adopting a *Framework*-oriented approach would

do a disservice to herself and her students, depending on the direction of the state.

Discussion/Conclusion

This analysis examined the processes surrounding teacher sensemaking and instructional decision making in the context of a grade-level, district-wide adoption of *Framework*-oriented practices and reform-oriented curricular materials. Taking the lens of sensemaking theory, I considered what it looked like for teachers to navigate their local reform contexts while negotiating multiple meanings of valued teaching and learning in their daily instructional practice. Teachers’ experiences of ambiguity or uncertainty were initiated both during PD and during implementation.

Teachers’ sensemaking centered around attending to “more newness” and fitting this newness into existing evaluation practices of “good teaching,” standards and pacing, and prevailing views of science teaching within their local contexts. Teachers’ navigations through ambiguity toward instructional decisions demonstrated their ingenuity and agency in utilizing knowledge of their institutional values, practices, and expectations to determine actionable pathways forward. They used strategies of ignoring auxiliary messages, teaching two lessons, or relying on familiar practices to both satisfy local expectations and integrate approaches called for in the reform.

On occasion, teachers described feeling “stuck” and lacking clarity with regard to how to move forward. In these instances, teachers lacked institutional knowledge or adequate guidance about “what’s next” for their district or state. In instances of “stuckness,” teachers tended to rely more prominently on one material resource for guidance—such was the case with Joe and Alexis with PBIS materials—or on the personal resource of practices most familiar to them (as was the case with Joan, and eventually Joe after Year 1). This pattern tended to result in relying on more traditional approaches to teaching science and less engagement with the reform.

The findings from this analysis contribute to the body of teacher sensemaking and reform implementation in a number of ways. One implication is that ambiguity may serve as an important mechanism for supporting teacher learning when combined with appropriate resources for reducing ambiguity. Having some ambiguity present enabled noticing of a difference that prompted processes of working with and through the ideas of reform. However, the timing of noticing discrepancies and experiencing ambiguity seemed to also matter. When ambiguity was experienced late and in highly consequential ways (e.g., low test scores), the productivity of ambiguity seemed lost. In addition, where teachers did not experience ambiguity, this tended to lead to surface-level interpretations of reform ideas, such as the idea that the “terminology has changed” but the standards are

the same. This reflects what Coburn (2001) and others (e.g., Furtak and Penuel 2019) have described as assimilating reform ideas into existing practices and considering reform through current standards (Heredia 2020). Similarly, uncertainty seemed unproductive in supporting teacher learning, as the feeling of stuckness impeded deep engagement with reform ideas. This suggests that shifting through too many or conflicting messages for practice can work in favor of learning, whereas an absence of guidance may impede it.

Understanding what tended to initiate teachers' sensemaking also serves as an indicator of the likely tensions and challenges teachers perceive as they integrate new practices in their local contexts. Sources of ambiguity or uncertainty were largely around "more newness," pacing, and coherent learning experiences for their students, which serve as indicators for those working with teachers to consider designs that attend to these spaces of incongruence. Teachers in this study had to rely significantly on their or others' knowledge of local expectations to make decisions that felt manageable. However, this information was not always readily available or apparent to teachers new to their roles or overwhelmed with too much newness. Furthermore, what is readily available is often an overabundance of material resources (Allen and Penuel 2015; Heredia 2020), with little guidance regarding which to prioritize.

Teachers' attention to their most pressing expectations is a reminder that what feels auxiliary to them may be subject to the phenomenon of translating new ideas into old practices and beliefs in ways not reflective of the reform. Engaging in the nuances of the NGSS or the *Framework* were "extras" for teachers in this study, given that they were unsure of their state's intention to adopt these in the future. Thus, the curriculum materials themselves became—for all intents and purposes—the reform. However, the curriculum did not fully align with the NGSS and *Framework*, only partially so. How teachers prioritize messages in their sensemaking processes is an indicator of what seems doable, given the current practices and guiding infrastructures of teachers' instructional contexts (Hopkins and Spillane 2015). This builds on prior research that demonstrates that teachers' perceptions of what is most pressing and consequential are likely to shape their sensemaking of reform (Spillane et al. 2002), what material resources they draw on in their sensemaking (Allen and Penuel 2015), and the instructional decisions they make (Heredia 2020). Therefore, it is imperative that, as a field, we elicit what matters most to teachers as they engage with instructional reform ideas.

The experiences of the teachers in this analysis are a reminder of the heavy onus often placed on teachers to make meaning of and craft coherence around reform ideas and practices (see also Heredia 2020). Although some teachers had resources supportive of their sensemaking, others—such as Joe—did not. In particular, having other colleagues (a social resource) to make sense of ideas and decide how and where ideas fit into local practice was especially integral for supporting teacher sensemaking. Furthermore, whereas we tend to think of

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teachers’ local contexts as their classroom, school, and district, Joan’s experience suggests it is important to consider the nestedness of teachers’ local contexts and look beyond the school building and classroom as we design for change (Allen and Heredia 2021; Penuel 2019). Joan’s experiences of stuckness were situated in broader concerns for state and national directions.

The roles of ambiguity and uncertainty and available resources for supporting or impeding teacher learning suggest important considerations for PD design. If initiating sensemaking earlier can serve as an important mechanism for teacher learning, PD designers may consider how to surface ambiguity intentionally during the context of PD (Allen and Heredia 2021). In addition, sensemaking can be triggered during PD and continue throughout the process of implementation as teachers receive messages back from institutional actors (e.g., other colleagues, building administration, students). This has important implications for the design and structure of PD, as it indicates that the needs initially surfaced for teachers may shift or become more nuanced as they try out practices in their schools. These patterns indicate that teachers need opportunities during PD for noticing discrepancies and engaging in sensemaking around them, rather than leaving it to chance whether teachers have the necessary institutional knowledge and available resources to navigate their work contexts (Allen and Heredia 2021).

Distinguishing between ambiguity and uncertainty as an affectual experience for organizational actors during change may provide conceptual leverage for future studies of reform. Stinchcombe (1990) argued that amid uncertainty, organizational actors are likely to turn to information most readily available to them. For teachers in reform, this may include relying on what is familiar and in less tension with institutional practices as they currently stand. This is particularly the case when predicting future directions does not feel possible (Milliken 1990), a phenomenon acutely familiar for most educators working in shifting educational landscapes. That some teachers experienced uncertainty whereas others ambiguity around the same experience is an area to explore in more depth. More research should explore the dynamic between teachers’ resources, noticing, and experiences of either ambiguity or uncertainty and its relationship to instructional decision making and practice.

As we learn from teachers’ instruction and the processes that lead to their decision making in reform, it is important that we understand these practice decisions as evidence of what is needed and what works. This study aimed to understand these processes for teachers in one district in the United States charged with enacting ideas and practices reflective of science education reform. Further research is needed to explore the intersections of teacher perceptions, their sensemaking processes, and their instruction within the contexts of their workplace.

Notes

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1. All names are pseudonyms.

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