

How Principals Make Sense of and Influence
the Implementation of Instructional Reform in Secondary Science

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Abstract

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After decades of calls to change science instruction, including the recent Next Generation Science Standards (NGSS), classroom practices remain largely stable. Research has much to say about who principals are and what practices they engage in, yet there is little research explicating *how* principals and their school leadership practices influence instructional change. I studied a large urban school district invested in science reform implementation that leveraged embedded learning at eleven secondary schools, supported by a cross-school, networked improvement community to investigate how school contexts influenced the development of such varied enactments of reform practices at each school. Through iterative qualitative analysis, I found that the degree to which principals integrated the science reform with their views of other school priorities impacted the extent of opportunities available to teachers to work with reform practices. Furthermore, the more often that principals co-participated with teachers in making sense of the reform practices in the context of classroom enactments, the more likely principals were to employ a broader array of school leadership practices to support the reform enactment, and the greater the extent to which teachers engaged and became proficient with the reform practices. This study provides additional details outlining multiple contextual factors at play in determining how principals' sense-making and school leadership practices influenced reform enactments and presents a conceptual model to better integrate the elements of leadership practices, instruction, and their intersection.

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While the *Next Generation Science Standards* (NGSS, 2013) embody the push towards more experiential and authentic science instruction, they are not the first and will likely not be the last, attempt to advance this change in science classrooms. Over the more than quarter century of sustained efforts in this direction, classroom instruction has remained largely unchanged (Cohen, 2011; Cuban, 2013; Elmore, 2004; Spillane, 1999; Spillane, Reiser & Reimer, 2002; Tyack & Cuban, 1995). In response, over time, research has shifted its focus and its scope to shed light on the systemic changes necessary to support such a transformation at scale. This study offers another piece of that research and seeks to bring together instructional and administrative elements to reveal a richer picture of how they interact. Initially, researchers and practitioners alike focused their attention on the *classroom*, and the changes that *teachers* and *students* needed to make (e.g., Spillane, 1998; Lortie, 2002). Over time, the literature expanded focus to include the role of school leadership in driving educational reforms and in impacting instructional outcomes in general (e.g., Spillane, 2012; Lortie, 2009). Researchers first examined the types of leaders – transformational, transactional, instructional – that principals embodied (Neumerski, 2013; Robinson, Lloyd & Rowe, 2008), and eventually began to define the principal’s role by constructing categorical lists of practices in which principals engaged (individually and via shared leadership) (e.g., Hallinger, 2003; Leithwood, 2012). Mounting evidence confirms that principals and school leadership practices can and do exert positive influences on learning and instruction (Leithwood & Louis, 2012; Robinson, Lloyd & Rowe, 2008). Many continue to explore these practices more deeply (e.g., Fullan & Quinn, 2016). Yet, research has not established *how* principals’ sense-making about reform practices and their related leadership practices influence instruction.

In this study I aimed to more deeply explore the links between principals’ sense-making and their leadership practices, and the ways in which school leadership practices influence reform implementation. In-so-doing, I also sought to provide a conceptual framework to ground additional research about how

school leadership practices impact instruction. I based my investigation on a research-practice partnership between a large urban school district and a university research team, that together invested over four years in a major initiative to reform science instruction in the district's secondary schools. Begun at an individual school in the district, the initiative was quickly credited with improvements in student performance. As a new Superintendent entered the district and the Next Generation Science Standards (NGSS, 2013) were accepted as the long-term state standards for science, the district partnered with the university team to secure a grant that would allow the work to spread more equitably across secondary schools in the district. This initiative grew to include a network of teachers, coaches, researchers, and others from eleven secondary schools across the district. This broader activity-based research project leveraged improvement science to enact instructional change, through embedded collaboration and learning, in a functioning system of science classrooms. Despite a consistent, sustained, and networked approach across multiple schools, teachers' engagement with and enactment of reform practices varied substantially among the different schools. While the effort was deployed across eleven secondary schools in the district, there were no formal goals established for participating schools and principals were left to interact with and support the work at their own discretion. I focused this study to better understand *how* school-based contexts, and *principals in particular*, through their sense-making and school leadership practices, may have impacted the enactment of reform-based instructional practices by their science teachers.

Research Questions

This study began with the understanding that there was substantial variation among the different schools participating in this somewhat opportunistic instructional reform effort. I sought to leverage this variation in reform implementation and the different school contexts to look more deeply at how the differences in school leadership contexts were influencing the differences in instructional practice enactments (also recognizing that the instructional enactments were likely exerting influence on the leadership contexts). My study was guided by two overarching and evolving questions:

- *How* do principals and assistant principals make sense of and interact with discipline-specific instructional reform initiatives?
- Ultimately, *how* do principals' school leadership practices impact enactment of instructional reform practices at each school?

These questions evolved from an early collection of more specific questions (see Appendix A) that I iteratively reframed over the course of the analysis to better reflect the study contexts and emerging findings. Although eventually reworked, by considering the principals' sense-making, their interactions with teachers and the reform, and their influence on teachers' different types of engagement with the reform, these questions provided a firm foundation and yielded productive insights about the connections and influence among principals' sense-making, school leadership practices, and instructional reform enactment.

Literature Review

For decades, researchers, educators and scientists have pressed for significant changes to the way science is taught and learned in schools. In particular, the American Association for the Advancement of Science (AAAS) and the National Research Council (NRC) have consistently advocated for science learning that extends beyond content and skill acquisition (AAAS, 1989; AAAS, 1993; NRC, 1996; NRC, 2012; NGSS, 2013). Twenty years ago, the 1996 National Science Education Standards presented “a vision of a scientifically literate populace [outlining] what students needed to know, understand, and be able to do to be scientifically literate.” More recently, a consortium of states collaborated with federal organizations to author a new set of standards that extends beyond outlining appropriate content for K-12 science instruction. These *Next Generation Science Standards* (NGSS, 2013) define a set of science and engineering skills and practices that students should experience and develop fluency with; and they emphasize sense-making as core to learning. NGSS summarizes a collection of fundamental scientific concepts, relevant across multiple scientific disciplines that students should be able to recognize, understand and connect across contexts. Yet these new standards provide little guidance about

instructional practices themselves, and fundamental changes to them, that are required to enact this new vision with students.

Reforming Science Instruction

Instructional reform requires the transformation of instructional practices (Cohen, 2011; Cuban, 2013; Spillane, 1999; Spillane, Reiser & Reimer, 2002; Stein & Coburn, 2008). Such change is complex because it requires teachers to both become familiar with new ideas about instruction and learning, *and* to shift their professional identities (Wenger, 1998), particularly their core beliefs about pedagogy, so they can internalize and apply these new understandings. Teachers enacting reform practices in their classrooms must “unlearn” much of their current ways of thinking about instruction (Elmore, 2000; Spillane, Reiser & Reimer, 2002; Spillane & Thompson, 1997). Teachers must have reasons to learn new practices and they must be provided with sustained opportunities over time for learning about and engaging with new practices (Spillane, 1999; Spillane, Reiser & Reimer, 2002). Stein, Grover & Henningsen (1996) caution less knowledge is available to guide best practices around the more student-centered, higher-cognitive-demand type of instruction called for by reform practices. Frequently, teachers receive training that provides them new resources but does not connect them with other teachers to make sense of those resources (Cohen, 1990, 2011; Spillane, 1999). Teachers committed to enacting reforms may also focus on surface levels of reforms only, and, when they apply reform-based resources to develop new tasks for students, they ignore less familiar reform components (like increasing cognitive demands on students) (Cohen, 1990; Stein, Grover & Henningsen, 1996). “In short,” Elmore (2000) claimed, “we must fundamentally re-design schools as places where adults and young people learn.”

Instructional strategies. An assortment of instructional strategies have emerged to address these convergent changes to move science education to center more on students’ cognitive engagement and practice of scientific skills. Such approaches include project-based learning as well as increased use of “modeling” in science classrooms; yet, in each case, results are highly variable and core instructional shifts are often not employed by teachers. When Alozie and her colleagues (2010) examined the extent to which project-based learning promoted “the development of scientific discourse in classrooms,” they

found that teachers generally shifted such discussion opportunities into more traditional “recitation” style dialogues that did not fundamentally shift instruction or student discourse. Similarly, in their consideration of the different ways in which teachers apply modeling in science classrooms, Gouvea and Passmore (2017) recognized a divergence in approaches. They noticed that textbook presentations of, and even descriptions in the latest science standards (NGSS, 2014), describe models solely as representations and do not acknowledge the epistemic role of the construction of models in developing students’ scientific explanations and applications. Gouvea and Passmore (2017) reflect that the evolving standards and research about science education call “for students to participate in the science rather than just learning about it” (p.1).

Despite challenges to changing the nature of science instruction, Thompson, Windschitl and Barton (2013) documented success with 26 novice science teachers, who, “By the end of their first year of teaching all...had developed a suite of practices that resulted in discursively oriented classrooms, yet the depth of their students’ talk about scientific models and explanations varied.” The teachers in their study had participated in a university teacher preparation program designed around a core set of four discipline-specific, high-leverage, instructional practices outlined in prior research (Windschitl, et al., 2012): selecting big ideas, treating them as models; eliciting students’ ideas, using them to adapt instruction; choosing activity and framing intellectual work; and pressing for explanation. In their 2012 work, Windschitl et al. explained that these particular practices were not a panacea, but that the combination of high-leverage practices, supporting tools, and inquiry driven instruction, coordinated in the context of a teacher preparation program, can help teachers to enact responsive, equitable, ambitious science teaching (AST) practices beginning early in their careers. However, additional or different supports are likely to be important to enacting instructional changes in *practicing* teachers’ classrooms. To that end, Alozie et al. suggested the need to embed instructional strategies more explicitly into the organization and presentation of curricular materials. Other researchers considered different ways to support instructional change.

Improvement science offers another strategy that can be applied to help drive changes in educational practice. In 2011, Bryk, Gomez and Gronow introduced the idea of a networked improvement community (NIC) to enact changes in community college students' success with math coursework. They anchored this effort in the stance of "learning by doing" and investigated a collective approach in which instructor participants shared goals and strategies that they then enacted in their individual practices to help create change. They appropriated a tool from Langley et al. (1996), the plan-do-study-act (PDSA) model, to provide a structure for their work; and they achieved success via iterating through cycles of this model. The Carnegie Foundation (2016), which sponsored Bryk, Gomez and Gronow's work, has continued to sponsor development of this approach to educational change and has identified six core principles for improvement, including two principles related to measurement: "We cannot improve at scale what we cannot measure;" and, "Anchor practice improvement in disciplined inquiry." This approach is consistent with a widespread theme in education that promotes data-driven instruction, although, as Coburn and Turner (2011) acknowledge, the practice of applying data to inform instructional decision-making is ahead of the research. Consistent with the localized improvement cycles advocated by the NIC approach, Supovitz (2012) identified three qualities of data (specifically, attributes of tests) that provided actionable insights to teachers about student thinking. These included tests that revealed one or more of the following items: state of progress toward a learning goal, student thought processes, and students' misconceptions in a content area. Other research about school improvement looks beyond teachers' instructional practices themselves, and considers additional aspects of the system that also exert influence on instruction.

Changing Systems. Beyond changing individual teachers, instructional reforms also necessitate transformation of the systems in which those teachers function (Fullan & Quinn, 2016; Greeno, Collins & Resnick, 1996; Spillane, Reiser & Reimer, 2002). Implementing instructional reform is both multi-dimensional and dynamic as it is enacted over time (Coburn, 2003; Spillane, Reiser & Reimer, 2002). While reform research historically focused on the number of instances of implementation (by district or school or even classroom), Cynthia Coburn (2003) advises that researchers consider not only

the spread of the reform, but also the depth and degree of fidelity with which it is implemented, the sustainability of the enactment, and the movement of ownership from those who initiated it to those who must sustain it. She contends that “reforms can be adopted without being implemented, and can be implemented superficially only to fall into disuse.” (Coburn, 2003, p.6). Not only must we consider multiple factors, we must account for the inherent complexity of the systems - formal and informal - in which reforms are implemented.

Multiple layers of complexity plague both researchers and practitioners in pursuit of reform implementation. Cobb and Jackson (2011) cite a significant lack of research around how to support reform implementations at scale. Yet scale is only one complication of reform; the enactment of education reform itself is plagued by complex considerations, many of which extend beyond the classroom and into the organizational culture and structures. As early as 2001, Fullan describes the necessary complexity of an organizational leader’s role in supporting change in striking a balance between reining the system in and letting go so change can take root. By 2016, Fullan & Quinn, in their exploration of leadership organized around driving effective change, note that the “complex part” of leading the change comes in creating coherence after identifying a few key factors to address a difficult problem. They acknowledge that there is no prescription for how leaders bring those factors together and help them “gel under the reality of action with its pressures, politics, and personalities in the situation” (Fullan & Quinn, 2016, p.127). Cuban (2013) describes the importance of considering enactment at multiple levels of a district as well as at local, state and national policy levels, *and* influence by community, political and social factors. Elmore (2000) draws attention to issues in variability in quality and outcomes across multiple classrooms and over time. Valli, Croninger & Walters (2007) caution about the related application of teacher accountability systems to drive reform, and explore the possibilities of better coordinating the efforts of multiple teachers and support professionals who serve the same population of students.

Perhaps the most salient issue raised, considering the beyond-classroom nature of the factors identified, is the loose coupling initially introduced by Weick (1976) and further developed by Elmore

(2000; 2004; 2007). Loose coupling describes an association between the many different organizational entities in education—from state, federal and local policies, to districts to school leaders, to the technical core of the classroom—such that while they are related to one another they operate largely independently of one another. Such independence insures that fluctuations or instabilities in one entity will not unnecessarily impact another entity – even when there is an intention or desire for a change in one (e.g., policy or district goals or school leadership) to impact another (e.g., classroom instruction). Cohen (2011) calls out the difficulties that such disconnectedness causes in creating consistent expectations across an educational system. Vallie, Croninger & Walters (2007) allude to the problem that applying policies and directives to make isolated classroom teachers more “accountable” may be less the solution than changing the structures that keep them so isolated from the related policies and from the school organization in which teachers do their work. Elmore’s (2000) theory of loose coupling further describes how school leaders, via the operational structures they reinforce in their schools, often unintentionally “protect” teachers from the disruptive forces of change that they simultaneously seek to exert on and with them.

Conflicting and inconsistent messaging about the principles, requirements, and aims of reform impedes smooth enactments across system levels and even among professionals at any given level or location of the system. Cuban (2013) brings to light how the individualization called for by the movement for more student-centered learning can appear at direct odds with the push towards standardization that is implied by the movement towards standardized curricula and testing. Even when the policies themselves do not drive direct conflicts, interpretations by professionals across systems can yield very different messages about reform (Cuban, 2013; Spillane). Particularly when these reforms are driven top-down, initial policies are interpreted and reinterpreted at each level of the system, being distilled into various artifacts that provide partial representations of the initial policy and the principles behind it (Cuban, 2013). Without a shared understanding of the core principles at work, individual reform enactments by classroom teachers can vary radically, raising their own set of challenges. For example, if a teacher focuses on the content-based nature of NGSS, that teacher may approach instruction

differently than a district may intend from if teachers were to consider the experiential nature of the multi-dimensional NGSS. In such a case, a teacher may interpret even the science and engineering practices as discreet elements to include in particular lessons rather than skills to be acquired via immersive instruction in the experience of regularly performing overarching scientific practices, such as constructing explanations. As far back as 1990, Cohen presented the case of Mrs. Oublier, a math teacher who thought she had transformed her teaching of mathematics through her adoption of her state's reform-oriented math curriculum; yet her focus was on the new activities of the curriculum and not on the instructional shifts in engaging student in discussions of mathematical understanding. Regardless of the particulars, inconsistent interpretations of critical aspects of reform dilute its effectiveness and its scalability.

Entrenched norms (e.g., loose coupling between teachers and school organizations) at all levels of educational systems increase the challenges in enacting consistent changes. At the ground level, teachers have a set of knowledge, beliefs and experiences that influence their instructional decisions and frequently results in unprincipled "implementations" of reform that focus on surface level aspects that do not yield the targeted changes in instruction (Coburn, 2003; Spillane, Reiser & Reimer, 2002; Cuban, 2013; Spillane, 1998, 1999). Such predispositions exist at all levels of the system, and not only reside with particular actors in the system, but also the interactions among those actors (Coburn, 2003; Spillane, Reiser & Reimer, 2002). Even researchers themselves can get caught in thinking about reform as a sort of additional thing to do rather than a fundamental change to make in the system. Coburn (2003) herself calls out issues like reform efforts running out of funding -- which implies that reform is an additional thing to be done. If reform is to become truly sustainable, one would expect its practices to be integrated into existing budgets and operating practices over time, not to be called out as a separate line item from the core instructional budget and practices of which it should be an inherent component. This negotiation of considering reform as an add-on rather than a shift across the system presents yet one more challenge for those working – in classrooms or in school leadership – to enact new practices.

As the call for reform in schools has progressed and intensified, researchers have shifted focus within and across multiple contexts contributing to reform implementation. Although researchers (e.g.,

Cuban, 1988) have always studied school leaders, it has taken time for the broader research on school leadership to intersect with the more instruction-centric reform literature. Initial focus in instructional reform research was on the *classroom*, and the changes that *teachers* and *students* needed to make, but that shifted. For example, in 1998, Spillane published research about improving teacher practices, while in 2012, he wrote more about distributed leadership in schools. Similarly, in 2002, Lortie published his book studying the *Schoolteacher*, and by 2009 he had published *School Principal*. Although research has continued around classroom aspects of reform, over recent years researchers have added school leaders, the role of *principals* and their *school leadership practices* in enacting instructional reforms, as objects of inquiry. Even in the literature that did take an early look at principals as agents of change (e.g., Fullan, 2001), the work focused largely on principal actions and outcomes and did not delve deeply into its intersection with particular instructional practices. This study builds on past work to push our understanding of not only what practices, but *how* school leadership practices, influence the enactment of instructional reform.

Describing Principals

Research about school principals' connections to instruction initially centered on descriptions of "who" principals were and what traits they embodied. Educational reform and leadership literature alike often position the principal as a sort of heroic figure whose action can unproblematically drive positive results (Firestone & Riehl, 2005; Elmore, 2000). Principals have been described as goal-oriented (Hallinger, 2003), "Type A" (Engels et al., 2008), "inquiry oriented" (Elmore, 2000), and needing to exhibit self-control (Lortie, 2009). To support change at the classroom level, principals are expected to possess both subject area and pedagogical knowledge (Hallinger, 2003, 2011; Robinson, 2006). Researchers have even explored links between principals' personal attributes (e.g., age, gender, years of experience, etc.) and school performance (Hallinger & Murphy, 1985). This lengthy list of personal attributes, while it may reflect particular propensities for principal effectiveness, does little to reveal *how* and *why* these particular principals' school leadership practices may yield higher impacts on instruction or learning.

Defining leadership. Eventually, research about principals drifted more heavily into describing “types” of leadership and explicating their relative merits. In 2006, in their quest to identify the essential items needed to support school improvement, Sebring et al. found that “Deft leadership, in turn, stimulates and nourishes the development of the four other core organizational supports” (p.1). Researchers conceptualized the principal as a sole instructional leader, then later as more of a transformational leader, and finally embraced the idea of “leadership for learning,” which Hallinger (2011) described as somewhat of a blend between instructional and transformational leadership (Hallinger, 2011; Leithwood & Louis, 2012). Over time, the practices of “transformational leadership” have become increasingly associated with instructional reform (Hallinger, 2003; Leithwood, 2012; Koh, Steers & Terborg, 1995; Howell & Avolio, 1993). Although the labeling of such practices has been neither consistent nor pervasive, the evolving leadership practices advocated in educational reform generally aligned with the construct of transformational leadership (Neumerski, 2013).

In 1993, Howell & Avolio confirmed that organizational leaders who enacted more transformational leadership experienced greater organizational success than those who employed a more transactional style of leadership. The key difference relevant to educational leaders is that transformational leaders worked through a more indirect system in which they influenced organizational performance through building of a higher purpose to which employees subscribed. In contrast, transactional leaders operated via a more direct system of rewards and punishments that intermittently reinforced particular desired behaviors. While Howell & Avolio began to identify causal relationships, these were not grounded in the school context. Building on this research, in 2000, Bass made the case for the greater need for a transformational approach to leadership in schools, but even at that time, he cautioned that applying the notion of transformational leadership to schools required additional context-specific considerations. Still, the sentiment of transformational leadership remained pervasive in the educational sphere, and continues to be recognized as a significant characteristic of strong school leaders (Louis et al., 2010; Neumerski, 2013). However, research has not converged on a requisite set of contextual qualifications regarding the practices of transformational leaders in education. In 2008,

Robinson, Lloyd & Rowe's 2008 meta-analysis of principals' impacts on instruction further complicated this general perception of the value of transformational leadership when it revealed that instructional leadership practices (which the authors inductively identified from the practices represented their data set, but did not define in the article), demonstrated a three-to-four times greater impact on learning outcomes more transformational leadership practices. The literature's lack of shared understanding of the critical practices of transformational leaders in school settings has rendered the descriptive term of "transformational" an ineffective means of representing any critical set of leadership practices.

Similarly, the effective schools movement begun in the 1970's, introduced the idea of an "instructional leader," but did not introduce an accompanying explanation for how such a role might be enacted (Hallinger, 2003; Neumerski, 2013). In 2003, Hallinger postulated that instructional leaders "lead from a combination of expertise and charisma"; in 2005, he summarized that instructional leaders are "strong directive leaders", "culture builders" and "goal oriented". Despite becoming more specific about the qualities of principals, Hallinger's descriptions remained limited to categorical statements about who leaders were and what categories of work they did without providing a practice-based explanation of *how* leaders develop the conditions that promote learning and transformation of practice. Spillane, Halverson & Diamond suggested in 2004 that such a description was absent from the literature perhaps because it was so challenging to build. By 2010, Knapp and colleagues proposed an ambitious conception of instructional leadership that they defined as "intentional efforts at all levels of an educational system to guide, direct, or support teachers as they seek to increase their repertoire of skills, gain professional knowledge, and ultimately improve their students' success" (p.5). However, this did not reflect a convergence among researchers. In 2013, Neumerski summarized that although researchers definitions of instructional leadership had evolved beyond a "trait approach, they offer lists of behaviors and actions, not an understanding of the process behind enacting these behaviors" (p.319). Vague notions of the roles of instructional leaders continue to populate the literature punctuated by calls for and steps toward richer explanations (Cobb & Jackson, 2011; Engels et al., 2008).

Research confirms that how principals enact their roles makes a difference in their effectiveness. Researchers have articulated the role of principals as culture builders (Engels et al., 2008; Hallinger, 2003; Spillane, Halverson & Diamond, 2004) who work largely through indirect/mediated means (Leithwood & Louis, 2012; Szczechsiul & Huizenga, 2014). Consider school cultures, for example. We know that creating a strong culture/environment is associated with higher performing principals, yet if principals create a collegial environment with teachers, it only impacts the school's performance if it is connected to instructionally relevant activity (Elmore, 2000). Fullan (2001) recognized earlier than many that educational leadership needed to be about enacting change, or as he put it, "Leadership, then, is not mobilizing others to solve problems we already know how to solve, but to help them confront problems that have never yet been successfully addressed" (p.3). Fullan outlined five components of leadership including having a moral purpose, understanding change, building relationships, creating and sharing knowledge, and making coherence. While he was able to outline some pieces to help advance the work of school leaders, including in particular, the importance of leaders learning in context, this early work did not connect deeply with the instructional contexts that it sought to change; and when it looked at principal learning opportunities, examples by and large were in the leadership context and were somewhat removed from the instructional context of the schools. It can be more challenging to measure *how* principals interact with instructional contexts to fulfill their roles, but research is converging on the importance of building that understanding (Neumerski, 2013).

Principals and school leadership practices. Recognizing a need to look more at specific practices, researchers have enumerated various sets of categories of school leadership practices, but each with a different lens (Elmore, 2000; Firestone & Riehl, 2005; Hallinger & Murphy, 1985; 2012; Hallinger, 2003, 2005; Heck & Hallinger, 2009; Lawrenz, Huffman & Lavoie, 2005; Leithwood, 2012; Louis et al., 2010). In a 1985 conception of the instructional leader, Hallinger and Murphy identified a set of core leadership practices that focused primarily on the direct actions of the principal him/herself. Categories of practice included "defining the school mission", which included the direct practices of framing and communicating goals. In their 2008 list of practices, Robinson, Lloyd and Rowe also

focused on more autonomous and direct practices, including “establishing goals and expectations”. In 2004, Leithwood and colleagues conducted a comprehensive literature review of principals’ practices and their impacts on instruction, identifying a core set of principal practices that they categorized into three groups (setting directions, developing people and redesigning the organization), all of which centered on actions of the principal. Over time, Leithwood and his colleagues refined both the categories and the individual practices, adding a category to reflect “management” of the instructional program (Leithwood et al., 2007). By 2012, Leithwood identified a more nuanced set of core leadership practices that reflected the combined direct and indirect natures of a principal’s role enactments. He replaced terms like “managing” with “improving,” and “redesigning” with “refining and aligning”. Leithwood identified categories such as “setting direction”, but framed practices more in terms of indirect and collaborative activities such as building a shared vision and fostering acceptance of goals. Over time, these categorical lists of practices became more descriptive. Leithwood’s (2012) four categories of leadership practices embodied a collection of sixteen specific practices that his research had determined to have an impact on instruction and learning. Figure 1 lists these practices by category.

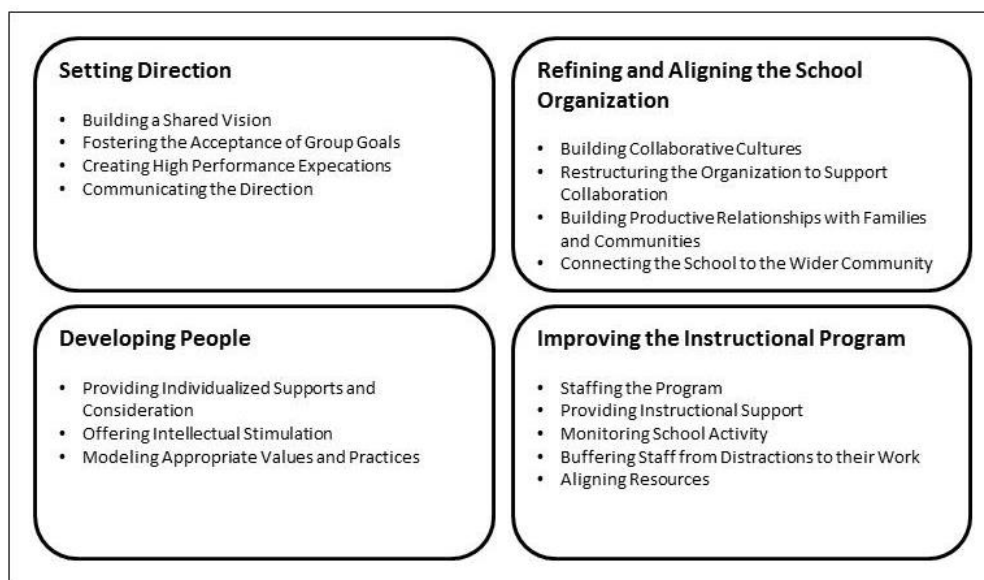


Figure 1. School Leadership Practices, from Leithwood, 2012.. These four categories of leadership practices, and the sixteen specific practices they capture, were applied throughout this study in analyses, of sense-making, execution of school leadership (including shared or delegated leadership), and impacts on reform scalability and stability.

Shared leadership. In addition to adding detail, practice descriptions like Leithwood's became more contextual and offered researchers additional paths for making connections between principals' practices and learning and instruction. Researchers' descriptions of leadership practices also evolved to acknowledge the shared and distributed nature of the in situ enactments of these practices (Spillane, 2005; Gronn, 2000, 2002; Leithwood et al., 2007). Interestingly, however, rather than converging in definitions of practice, researchers continued to offer competing characterizations of the nature of leadership practices. Spillane, Halverson & Diamond (2004) situated distributed leadership practices in the context of interactions among "school leaders, followers, and the situation" (p.3). In contrast, Leithwood et al. (2007) explicitly recognize that they are *not* considering practices from the situated activities of Spillane, but instead, envisaged practices as "behaviors of functions of leaders during such interactions." Unfortunately, such a conception leaves the field with a less contextual understanding of the practices, but also the distribution of them, and allows for deeper confusion about the nature of distributed leadership, such that some researchers (e.g., Louis et al., 2010) describe it as almost an alternative to "instructional leadership", while other researchers (e.g., Spillane) describe it as more of a way of enacting leadership practices. That said, as with other descriptors of "types" of leadership, investigations did reveal positive impacts of distributed leadership on learning.

In 2010, Louis et al. (including Leithwood) reported positive indirect effects of distributed leadership on student learning. In 2012, Leithwood reported that collective leadership had a greater positive impact on learning than more individual leadership, and further, that distribution of leadership in schools did not diminish the influence of the principal. In its 2015 list of ten detailed principal standards, the National Policy Board for Educational Administration (NPBEA) also recognized the distributed nature of the principal's work, for example, citing in its first standard that, "Effective educational leaders develop, advocate, and enact a *shared* mission, vision..." (emphasis added). While NPBEA's standards reflected researcher's (e.g., Robinson, 2006) warning that such lists must be "infused with educational content," by explicitly tying instructional factors to leadership practices, enactments can be both implemented and analyzed with a more concrete connection to instruction. And, whether distributed or

individual leadership, researchers can better uncover *how* particular approaches to leadership may be impacting instruction.

The attention to distributed leadership makes space for this study and others to attend to the role of the instructional science coach, as well as teacher leaders, in helping to guide and/or lead instructional reform efforts. As we investigate the role of principals in enacting discipline specific instructional reforms, we must also consider how that role is envisioned and enacted with respect to other supporting resources, specifically, coaches and teacher leaders. Stein & Spillane (2005) intimate a potential role of principals to build teacher leadership to add to the pool of school expertise. Whether or not such work is considered a practice in itself, it seems clear that the work of the coach is related to enactments of leadership at a school, and that such work is connected to choices and actions of the principal. In her overarching review of instructional leadership literature, Neumerski (2013) chose to include what she labeled as "traditional" instructional leadership (focused on principals) as well as teacher and coach instructional leadership. This aligns well with Spillane's notion of distributed leadership that involves multiple leaders operating in a shared context.

With little direct attention paid to understanding how coaches influence instructional change (Neumerski, 2013), and the possibility of treating distributed leadership as a set of isolated activities, Spillane's approach to consider distributed leadership as a situated activity system becomes more compelling. Even in light of Leithwood's argument (Leithwood et al., 2007) that distributed leadership practices should be treated as individual role enactments, his collection of leadership practices makes space to consider coaches. For example, Coggins, Stoddard & Cutler (2003), identify coaching contributions to leadership practices of "directly coaching teachers," "building capacity for instructional support," and "working with principals in determining how the school vision will get enacted." Each of these acts engages one or more of Leithwood's (2012) leadership practices, such as providing individualized supports, staffing the program, building a shared vision, and fostering acceptance of group goals. By considering these more distributed engagements of leadership practice in conjunction with principal's own leadership practices, researchers can gain a more complete understanding of how

leadership practices impact each other and instruction. At the very least, qualitative analyses should take the more open-ended opportunities to continue to refine how distributed leadership might be better defined with respect to principals and in terms of school leadership practices.

Pushing past practices to a theory of leadership. Fullan's (2001, 2014; Fullan & Quinn, 2016) work on educational leaders has taken a unique direction of grounding itself in the development of practice-based theories of leadership that reduce emphasis on a list of practices and instead harness those practices in service of promoting meaningful change. For over a decade, Fullan has promoted the need for leaders to focus on collective professional development that makes room to support individuals but that organizes development around building collective capacity of the school organization. Like Knapp et al. (2010), Fullan acknowledges the importance of the principal as an instructional leader; and like Knapp et al., he recognizes that such leadership does not need to translate into the principal becoming an individual instructional coach for each teacher, which he refers to as micromanagement of instruction. Instead, Fullan describes the importance of the principal invoking multiple practices in service of creating change. While Knapp et al. note how ambitious such a vision for instructional leadership can be, Fullan also sees the extensive expectations as not being positioned to scale. To address that issue, through examination of the work conducted across the province of Ontario and in a large district in California, Fullan distilled a set of principles for the work of the principal. Over a decade of time, both these systems saw marked improvements in instructional outcomes like graduation rates, and in the case of Ontario, in literacy. From these contexts, he identified the core "role" of the principal to include being a "learning leader," a "system player," and an "agent of change" (Fullan, 2014). Further, Fullan identified a set of four system drivers that were critical to address from the right perspective and that were more often applied ineffectively. For example, he suggested that direct accountability of individuals in the system is the wrong driver to apply, and instead, leaders should focus on driving capacity building of the instructional professionals in the schools. In the Ontario case, by focusing on capacity building, teachers had opportunities to build their skills, share practices with one another, and share a focus on progress, which ultimately motivated an internal accountability in the system. In beginning to define more of a

theory of strong school leadership, Fullan began to push past the list of practices, but in this initial instantiation, he offered little specific description of the detailed practices and how to fit them together.

By 2016, Fullan joined with Quinn to propose a more comprehensive framework (as shown in Figure 2) to drive school leadership not only in individual practices, but also in terms of how those practices fit together. Fullan and Quinn define coherence as consisting of “the shared depth of understanding about the purpose and nature of the work. Coherence, then, is what is in the minds and actions of people individually and especially collectively” (p. 2). Rather than simple categorization of practices, Fullan and Quinn organized their leadership action framework around four key drivers of change: focusing direction, cultivating collaborative cultures, deepening learning and securing accountability. These are not a superset of the Leithwood (2012) practices described above, but are instead a carefully chosen and focused set of leadership practices that promote effective change. According to Fullan and Quinn, “Leaders build coherence when they combine the four components of our Coherence Framework to meet the varied needs of the complex organizations they lead. Coherence making is a forever job because people come and go and the situational dynamics are always in flux” (p. 128). They also recognize that “achieving coherence in a system takes a long time and requires continuous attention” (p. 128). In their descriptions of the various drivers, Fullan and Quinn show how they are relevant to instruction and how instructional staff, like teachers, fit into this work. However, they do not fully explore how these practices overlap and interact with instructional practices.

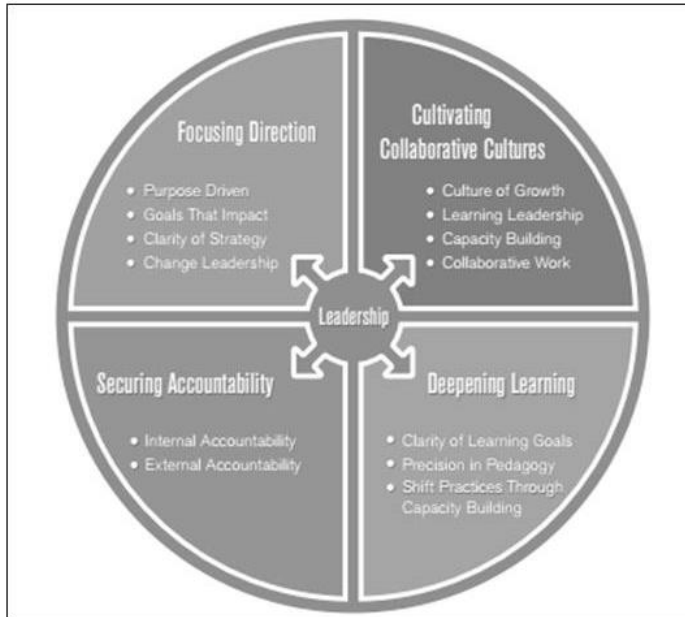


Figure 2. Coherence Framework, from Fullan & Quinn, 2014 (p.12). These categories of leadership practices are rooted in Fullan & Quinn’s theory of leadership that is organized around enacting change and is accompanied by a set of drivers and principles of leadership.

Connecting Leaders, Leadership Practices, and Instruction.

Research, particularly in the past fifteen years, has revealed many links between school-based leadership practices and students’ outcomes, both academic and affective (Firestone & Riehl, 2005; Fullan, 2014; Fullan & Quinn, 2016; Hallinger, 2003; Hallinger & Heck, 1998; Leithwood & Louis, 2012; Robinson, Lloyd & Rowe, 2008). In 2004, Leithwood et al. reviewed an extensive compilation of data from school leadership studies and determined that school leadership is “second only to teaching among school-related factors in its impact on student learning” (p.3). They found that the combined indirect and direct effects of leadership accounted for one quarter the impact of all school-based effects on student learning. Research confirms that *how* principals enact their roles makes a difference in their effectiveness, and their approach plays a significant role in defining the operational context for instructional reform enactments. Many researchers (Hallinger, 2003; Hallinger & Heck, 1998; Firestone & Riehl, 2005; Leithwood & Louis, 2012) have identified a link between school leadership and

instruction as well as student learning; and Hallinger (2003) found that leaders also influence teachers' perceptions about instructional change and student learning. To this end, it is important to not only understand what leadership practices are particularly impactful, but to understand under what circumstances and in what ways such practices exert positive influence.

To more deeply examine the means by which principals' practices have influenced instruction, researchers have had to create very specific frameworks to analyze the data and these frameworks are situated independently of the larger context in which administration and instruction takes place. Fullan and Quinn's 2016 coherence framework for change leadership, while it connects leadership drivers to relevant aspects of instruction, is not itself situated in the instructional context and so cannot serve as a research tool for unpacking the connections between instruction and leadership. In 2013, Penuel, Coburn & Gallagher proposed two different frameworks – one related to cultural exchange and another based on social movement with respect to status and authority – to examine the comparative influence among different groups (e.g., teachers, principals, researchers) involved in research-practice partnerships focused on implementing instructional reforms. While productive for those particular studies, or others like them, such frameworks are so contextually driven that they undermine our ability to draw conclusions from convergence of related research because the actual relationships are hidden by differences in the conceptual underpinnings of the studies. In 2008, when Robinson, Lloyd and Rowe analyzed the literature to identify studies linking principals' practices to outcomes, they were forced to apply a broad definition of outcomes due to the inconsistency among studies, and, in their analysis examining specific types of principals' instruction-related practices, they were only able to consider twelve of twenty-seven studies they had found. By 2015, Spillane (2015b) acknowledged that a lack of a consistent framework for examining the connections between principals' leadership practices and the instructional practices of their teachers was significantly hindering the progress of research and its application in this area. In the absence of a consistent framework to examine connections, individual studies have addressed inconsistent components of the administrative and instructional contexts, making it difficult to identify trends among

the findings and to know which studies took into account the most significant aspects and which may have left out key factors.

Whatever framework is applied must allow researchers to consider both direct and indirect influence of leadership practices on instruction. As Louis et al. (2010) found, many of the influences of leadership on learning and instruction were due to indirect paths. Particularly in a qualitative study, that suggests a need to account for the surrounding contextual factors that may mediate indirect interactions between school leadership and instructional practice. For example, when principals help to build clear direction in their schools, they need to consider not only how the direction itself may have influenced instructional decisions, but also in how teachers may have co-participated in defining that instruction, how they received communication about it, and ways teachers may have interacted with the direction. Elmore (2000) and Lasky (2005) have both observed that clarity about organizational focus, and the meaning and target of desired reforms, has helped align efforts across systems and helped teachers converge around shared principles of reform. On a more granular note, multiple researchers have found that the nature and focus for collaborative work combined with a school's operating culture, both of which may be influenced by principal leadership practices, can make the difference in whether teachers focus their time on substantive aspects of reform versus procedural logistics (e.g., which materials to use or the pacing of lessons) (Elmore, 2000; Spillane, 1999; Stein & Coburn, 2008; Cobb & Jackson, 2011). Cultural aspects of influence in particular necessarily require examination of the context of the leadership practice. For example, if a school publishes a set of operating norms but does not use them, results would be different than at a school where the same norms were adopted but applied – in such a case, the act of establishing the norms was itself insufficient to provide insight into the influence of leadership on instruction. In fact, shared norms and a shared sense of responsibility for students (not just content delivery) across a school have been observed to increase the success of reform learning and implementation (Cobb & Jackson, 2011; Lasky, 2005; Spillane & Kim, 2012; Spillane, Reiser & Reimer, 2002).

Finally, in considering the influence of leadership practices on instruction, one must consider the interaction of multiple leadership practices with one another. Fullan and Quinn (2016) inductively corroborated this need for creating coherence in a system by coordinating multiple leadership practices. First and foremost, they found the focusing of direction to be critical in creating a coherent system; and their other practices, such as cultivating collaborative cultures (rather than focusing on developing individual capacities), further contributed to a coordinated system. In another example, in 2008, Stein and Coburn studied two districts that were implementing new mathematics programs. In both cases, the enactments included leadership decisions around available time, focus of time, buffering of teacher's from demands outside the reform work, etc. In the end, one district was significantly more successful than the other in teacher enactment of reform practices that reflected the deeper instructional changes necessary to the reform. In the less successful district, school leaders expressed resentment over the time teachers spent in training and also tasked coaches with non-math-instruction-related tasks; while in the more successful district, principals actively advocated with district administrators to keep "the math coach role focused on teaching and learning in mathematics" (p.615). Moreover, in both cases, curricula were supplied, but the accompanying tools and focus, as well as the opportunities to make sense of them, varied considerably. Just as teachers cannot just "do" reform, districts and school leaders cannot just "do" professional development that will result in principled teacher learning about reform. Principals enact multiple leadership practices that collectively influence the trajectory of reform. Further, in the sense-making that teachers must do to apply changes to their instruction, they often create assorted instructional tools that influence the operational context for both sense-making and practice (Stein & Coburn, 2008; Spillane, 1999; Spillane & Kim, 2012). Principal's interactions with this context will inevitably influence their own sense-making, and likely, their leadership practices over time.

Simultaneously Situating Practices in Cognitive and Sociocultural Contexts

To best evaluate how and why the administrative practices at a school may be impacting the instructional practices, it is important to apply a unit of analysis that considers more than the practices alone. As described above in detail, principals' practices, and instruction alike, necessarily occur within

greater contexts and they are both motivated and influenced by their interactions in those contexts and the way in which they make sense of those interactions. A situated cognitive perspective offers a way to consider both the learning of individuals as dynamically influenced by and influencing the context. Greeno (1998) calls out the “main distinguishing characteristic of the situative perspective [as] its theoretical focus on interactive systems that are larger than the behavior and cognitive processes of the individual agent” (pp.5-6). In 2014, Spillane and Anderson applied a multiple methods study that considered novice principal sense-making in multiple socioculturally situated contexts that led to conflicting leadership enactments. Such an analysis highlights the value of simultaneously accounting for both situated cognitive and sociocultural considerations in a study of school leadership practices. Other researchers, like Rueda (2011), confirm the importance of this combined perspective. The ensuing paragraphs offer additional background about these distinct, but related, theoretical perspectives. I follow this with a description of my conceptual framework that joins these two lenses into a single model to guide this study.

Sense-making and the situated cognitive perspective. As principals encounter new demands, they must connect those demands to their operational visions to make sense of them and subsequently take action to address them. In effect, principals are reconciling the demands with their existing understanding of both what must be done and how they will approach it (for example, the novice principals investigated by Spillane & Anderson, 2014). Vygotsky’s (1997) claim that individuals make meaning of their social environment and internalize it as a component of future sense-making further substantiates the need to apply not only a sense-making lens to this work, but a situated cognitive sense-making lens. Such a lens helps extend the boundaries of cognition beyond the individual and into the relevant environment (Robbins & Aydede, 2009) – in the case of this study, the overlapping contexts of both school leadership *and* instruction. Other researchers note the importance of considering sense-making in a situated way because of its capacity to inform how a person will subsequently interact, directly and through shared tools, structures and practices, in a given context (Lasky, 2005; Rogoff, 1997). Further, Fullan and Quinn (2016) inherently recognize the role that sense-making plays both in

how individuals form understandings and also of how related actions and understandings help to align efforts of multiple entities: “Coherence, then, is what is in the minds and actions of the people individually and especially collectively” (p.2).

Researchers also acknowledge the importance of sense-making in instructional reform enactments because of the fundamental shifts in how individuals must approach their work. For reform implementations to be successful, alignment is necessary to organize activities across multiple groups of professionals toward common goals (Stein & Coburn, 2008; Wenger, 1998). Teachers are not the only professionals whose practices must align with reform aims and the related work of other professionals - instructional leaders must also learn about reform principles and transform their own practices. Research from a variety of angles has reached similar conclusions that educational leaders are equally in need of opportunities to make sense of reforms in principled ways (Cobb & Jackson, 2011; Elmore, 2000; Louis et al., 2010; Neumerski, 2013; Portin et al., 2009; Spillane, Reiser & Reimer, 2002; Spillane & Thompson, 1997). In one study, Spillane, Reiser & Reimer (2002) found that eighty percent of district leaders formed a superficial understanding of reform ideas that focused on procedural aspects rather than the deeper principles of the reform. Educational leaders must be able to interpret reform and translate it into school-specific policies and resources of which, they can help teachers and others, make sense (Elmore, 2000; Spillane & Thompson, 1997). Educational leaders must understand the core instructional principles of reform practices and be able to recognize the difference between high- and low-fidelity instantiations of them (Cobb & Jackson, 2011). Neumerski (2013), in her review of the reform literature, found that principals who were identified by staff as being most supportive, worked with and understood the work of teacher leaders. When school leaders participate in teacher learning opportunities, they help to establish trust with teachers (Spillane & Kim, 2012), acknowledge the importance of the learning activities and accompanying practices, and build enough familiarity to provide more relevant resources and supports to teachers (Cobb & Jackson, 2011).

Situating the Sociocultural Context. While it may be useful to describe principals’ participation in leadership practices in terms of their individual agency, because the practices themselves

are inherently social to the school, such representations alone are inadequate. Greeno (1998) suggests that a situated perspective is best applied over a more isolated cognitive approach in instances of “Engagement in activities, including contributions to group functions” (p. 8). Principals’ leadership practices contribute to the group function of the school. Rogoff (1997) explains that while we may isolate one plane of participation from another for analytic discussion, we cannot isolate them from one another in operation – individual, interpersonal, and community planes all function together. Principals, even in making a unilateral decision, do so in the context of the school community and communicate about that decision in some form of interactions. By considering principal leadership practices in light of the instructional and leadership contexts of the school, we can ensure that we understand not only what action the principal may have taken, but also how and why that action interacted with the greater sociocultural context of the school in the ways that it did.

The situated nature of both administrative and instructional practices does not negate the role of cognition in contributing to these practices, but instead, helps to better contextualize and understand that role. The Spillane and Anderson study (2014) of novice principals provides a particularly salient illustration of how the schools’ operating contexts, experienced by the principals via different types of demands, both influenced and was influenced by the principals’ actions. Had Spillane and Anderson looked only at the principals’ actions, they would have encountered contradictions in principals’ individual behaviors that the leadership practice alone would not have explained. Similarly, inherent tensions that researchers like Cuban elevated with respect to principals’ operating contexts suggest the need to view leadership practices situated in the greater sociocultural contexts of the school. Such tensions include demands on principals to balance supervision with teacher empowerment (1984) or to prioritize standardized tests versus sense-making about instruction (2013). The practices alone do not reliably surface these tensions to researchers or practitioners.

Conceptual Model

Figure 4 illustrates the conceptual model that I used to help uncover how and why principals’ leadership practices may be exerting particular influences on instructional practices teachers apply in

classrooms, and in this study, science classrooms in particular. As Spillane (2015b) recently highlighted, current literature lacks a strong and consistent framework that examines links between administrative and instructional practices. While Spillane himself proposed a framework (see Figure 3) that factors the multiple components of each set of practices—instructional and administrative—there remains an opportunity to further develop that framework to account not only for movement between the practices, but that offers insight into how and why administrative practices influence instructional practices (and the reverse, although that is not a primary focus of this study). Spillane’s work identified the components of administrative practice as school leaders, followers (including teachers), and the situation of administrative practice; and he represented the “internal dynamics of instructional units” to include students, teachers, material technologies and context. Because I wanted to focus more on identifying key paths of influence, I chose to represent these two systems with respect to their overlapping contexts and to focus on key activities in those contexts rather than individual actors or materials (though both can be located in my model). I also elected to explicitly represent a space to trace movement of influence between the contexts and practices of the system.

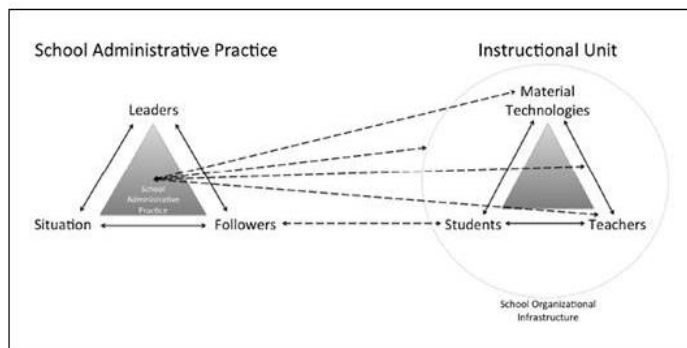


Figure 3. Relationship Between School Administrative Practice and Instructional Practice, from Spillane (2015b, p. 284). Spillane identifies the components of the administrative and instructional contexts and recognizes the different connections that can occur between these contexts.

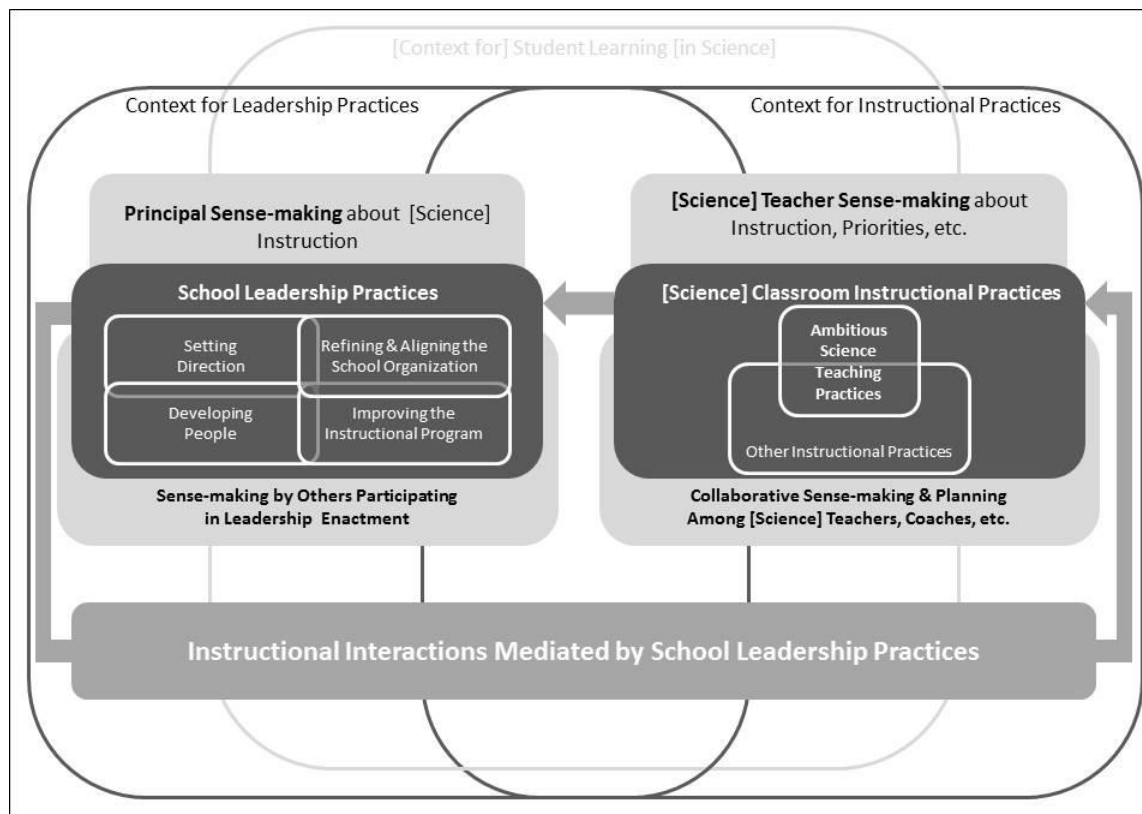


Figure 4: Initial Conceptual Model: School Leadership Influence on Instruction. This figure illustrates key elements contributing to leadership practices that influence instruction. These include contexts, practices, and individual and collective sense-making.

I hypothesized that influence would occur via direct and indirect interactions of school leaders with teachers; and, I recognized that indirect interactions could take a number of different paths. In selecting which activities to include in this model, I drew on multiple sets of literature that recognized both cognitive and social aspects of this situated model. As described above, there is a situated cognitive component to both leadership and instructional practices (Coburn, 2001, 2005 ; Neumerski, 2013; Greeno, Collins & Resnick, 1996). For that reason, my model offers sense-making components of both instructional and leadership practices, and in each case, includes the sense-making of the primary actor (i.e., the teacher and principal, respectively) and of the actors who may directly interact with the primary actors. In considering those interactions, I acknowledged individuals and groups, such as those sharing in a distributed leadership model (e.g., teacher leaders, coaches, other school administrators) and those

collaborating on instructional design and implantation (e.g., peer teachers, coaches). In this study, I focused primarily on unpacking principals' sense-making, though I touched on some related sense-making by coaches and teachers.

At the center of my model, I located the practices themselves. Rather than leave these practices to emerge from the study, I anchored them in research and the study focus. Specifically, I applied Leithwood's (2012) categories of leadership linked to student learning to characterize my model's subcomponents of leadership practices: setting direction, developing people, refining and aligning the school organization, and improving the instructional program. By rooting this model in research-identified relevant practices, I hoped that I would both increase the likelihood of the model to help recognize principal-related influence on instruction, and that I would introduce connections between the more generalized reform implementation literature and the more granular research on principals' role enactments. I took a different approach to the instructional practice side, and chose not to include a detailed breakdown of instructional practices or components. Instead, I highlighted reform practices and acknowledged remaining instructional practices to focus my own investigation on influence of reform enactment. Subsequent research could add value by further defining the various aspects of instructional practices and organizing them in ways that highlight potential for influence. For example, although I do not discuss extensively in this study, the below findings begin to uncover the potential importance of principals collocating some of their instructional interactions with the "technical core" in which teachers bring together not only general instructional approaches, but also discipline-specific strategies and student-responsive choices. Further organization of the instructional practice component of this model could help better recognize and define potentially critical nuances of effective influence.

I joined the two overlapping systems of leadership and instruction in this conceptual model via a bi-directional path of influence that I described as representing direct and indirect interactions. I focused more expansively on the path of influence from leadership to instruction, but acknowledged the path from instruction to leadership. I expected interactions between principals and teachers to often be mediated by school and district goals, interactions with coaches, curricular choices and materials, professional

development plans, collaboration time, and other contextual and tangible factors. And I conjectured that such influence would move from a leadership practice, through some kind of intermediate outcome, into the instructional context, and ultimately, in some way into the classroom instructional practices of the individual science teachers. While I made significant revisions to this model over the course of my analysis, this original conception provided a sound foundation that guided by perspectives and my analysis of study data. In the discussion section of this report, I propose an updated conceptual model, based on the same convergence of research applied to the initial model, but that emerged from my grounded findings.

Methodology

In this study, I applied a multiple case study qualitative analysis to investigate how principals and assistant principals made sense of an initiative to reform science instructional practices and how that sense-making translated to school leadership practices, ultimately influencing the enactment of the science instructional reform in their buildings. Using a situated conceptual framework depicted in Figure 4, I examined the research questions from both the socio-cognitive lens of how principals made sense of the reform work and from the socio-cultural lens of how principals' evolving understanding shaped their participation in school leadership practices and influenced teachers' enactment of the reform instructional practices. To connect the principals and school leadership practices with the reform implementation, I combined three focused analyses: a qualitative comparison of the ambitious science teaching (AST) enactment data across all nine schools; a deep coding and analysis of principal interviews; and the construction of a collection of focused narratives that illustrated contextual connections between the instructional and leadership data.

Data used include a broad collection of information from nine secondary schools (middle and high schools) in one urban school district. The data represents a balanced collection of schools—two middle schools, 2 comprehensive high schools, and 5 “small” high schools grouped onto two multi-school campuses. While I present one particular school in a deeper case study narrative, all schools are represented in the study and all were analyzed through the same processes. Teachers across all nine

schools participated in a common cross-district networked improvement community that anchored this reform initiative. Yet these schools also represent distinctive perspectives in implementation of the reform work – with varying degrees of teacher buy-in and participation in the various learning, reflection, planning, sharing and enactment reform activities. It is this dichotomy that defined the problem of interest for this study.

Context of the Study

A large urban school district, in partnership with a university research team, invested over four school years in a major initiative to reform science instruction in its secondary schools. Begun as a pilot-level program at an individual secondary school in the district, the initiative was eventually supported at the district level and grew to include nine secondary schools that have participated for a minimum of two years, and two additional schools (not included in this study) that joined in the last two years of the program. This activity-based research partnership leveraged improvement science to enact instructional change in schools. Despite a consistent and networked approach across multiple schools, results of the initiative have varied substantially among different schools. The problem of interest in this particular study is to better understand how school-based contexts, and building-based leadership practices in particular, may impact the enactment of reform-based instructional practices by their science teachers.

At the time of the study, a new Superintendent had recently joined the district, the state had agreed that over the next few years it would transition from its own science standards to the emerging Next Generation Science Standards (NGSS, 2013), and the district had recently established its strategic plan. The instructional framework supporting the district's strategic plan included a focus on standards-based instruction, the use of student data to inform instruction, and the push for teachers to develop professional goals and an ongoing professional growth plan. Separate from the science reform, the district itself was involved in a separate university-district partnership focused on the organizational practices of the district. That effort, coupled with the strategic plan, increased district emphasis on standards and the use of data to inform instruction. Principals were directly engaged in this latter data driven instruction update, but were positioned more peripherally to the science instructional reform.

Principals could meet with science coaches or teachers, and were invited to join on science professional learning days, however, there were no specific goals set for them or their schools with respect to the science instructional reform initiative. From Year 2 of the program, principals were given the choice of whether to invest in coach time to support the science reform work.

As in the initial single-school collaboration, the larger initiative, that provided the focus for this study, was a collaborative venture in which small groups of science teachers (grouped by school, or by campus when multiple schools share a site) collaborated with science instructional coaches and university researchers in professional learning activities that centered around student work/talk and links to instructional practice. Specifically, the work is founded on ambitious science teaching (AST) practices and principles (Thompson, Windschitl & Braaten, 2013; Windschitl, et al., 2012; Windschitl & Barton, 2016). Together, these smaller school/campus-based groups formed a networked improvement community (NIC) that focused on adjusting science instruction to help students take on the cognitive load of constructing gapless, evidenced-based explanations of observable scientific phenomena.

This NIC-based reform initiative comprised a comprehensive system of instructional supports including dedicated science instructional coaches, embedded professional development, and active development of a network of science and ELL teachers, coaches and researchers. The move to AST practices generally intimated changes to approaching instruction that required teachers to *alter* their practices, not just *add to* or *re-organize* them. Grounded in improvement science (Bryk, Gomez & Grunow, 2011), this work sought to engage teachers and coaches not only in the learning, but in defining areas for improvement and focused professional learning. Across all sites and events, the initiative applied an inquiry-based, collaborative learning approach that is anchored in AST. Despite multi-level support, substantial investments, and the steady fostering of a district-wide network of practitioners, the project has yielded substantially different levels of change in instructional practice and teacher engagement with reform practices at the nine participating schools in this study.

Detailed Context and Participants

The New Pacifica School District, in which this study was conducted, is a large urban school district in the northwestern United States. Of the roughly twenty thousand students served by the district, less than one quarter were of Caucasian background. Nearly 15% of students were enrolled in special education programs. Roughly one quarter of students were English Language Learners. About two thirds of students received free or reduced price meals. Table 1 outlines the student make up of these nine schools. In all cases, students of color made up the majority of students at the school and nearly 50% or more of the students received free and reduced price lunch. Table 2 acknowledges the principals, science teachers and instructional coaches at each school. In this district, over fifty science teachers, and six science and English Language Learner coaches at nine secondary schools (two middle schools and seven high schools) have been involved in the science instruction reform initiative for two or more of this four-year project. At least one of the science teachers at each of the six campuses in this study completed teacher preparation through our university program that is also grounded in the AST practices at the root of this reform initiative. Of the 27 science teachers (from seven schools as two were added in Year 2) who participated in the network during Year 1, by Year 4 only 14 remained.

Table 1

General Student Demographics (from Study Year 3)

<u>School</u>	<u>Total Enrollment</u>	<u>Percent Students of Color</u>	<u>Percent Students who Qualify for...</u>		
			<u>Free & Reduced Price Lunch</u>	<u>Transitional Bilingual Services</u>	<u>Special Education Services</u>
Middle Schools (grades 7-8)					
Lincoln	570	90%	81%	21%	17%
Douglas	608	87%	78%	24%	15%
High Schools - Comprehensive (grades 9-12)					
Washington	1,253	74%	62%	14%	13%
Adams	1,638	63%	49%	6%	11%
High Schools - Small Schools on Multi-School Campuses (grades 9-12)					
Cleveland (@Kennedy)	296	85%	77%	32%	20%
Roosevelt (@Kennedy)	373	91%	75%	12%	15%
Wilson (@Kennedy)	290	84%	71%	13%	22%
Jefferson (@Madison)	450	90%	76%	28%	11%
Hamilton (@Madison)	515	87%	75%	26%	18%

Table 2

Teacher and School Participation in Science Instructional Reform

<u>School</u>	<u>Years of School Participation in NIC</u>	<u>School Leaders</u>	<u>Science Teachers Participating in Studio Days (in Y3)</u>	<u>Part-time Science Instructional Coach Assigned</u>
Middle Schools (grades 7-8)				
Lincoln	4	1 Principal 1 AP	6	District (Y1) Building (Y2-Y4)
Douglas	4	1 Principal 1 AP	6	District (Y1); Building (Y2); Building Shared (Y3-Y4)
High Schools - Comprehensive (grades 9-12)				
Washington	4	1 Principal 2 APs	7	District
Adams	3	1 Principal 2 APs	6	District
High Schools - Small Schools on Multi-School Campuses (grades 9-12)				
Cleveland (@Kennedy)	4	1 Principal	2	District
Roosevelt (@Kennedy)	4	1 Principal	2	District
Wilson (@Kennedy)	4	1 Principal	2	District
Jefferson (@Madison)	4	1 Shared Principal 1 AP	3	District
Hamilton (@Madison)	2	1 Shared Principal 1 AP	2	District

In each year of this study, school administrators were given choices about whether to provide their teachers with science instructional coaching supports at their schools. The district and university partnering on this initiative together covered the costs of studio day and cross-network trainings; and the university provided researcher support. The cost of science instructional coaches was covered by the research grant, with costs shifting from the grant to the district over time. To address this expense, the district allowed individual schools to choose to purchase “structured support,” or science-specific, in-building coaching for their teachers. Such district-based supports yielded approximately one day per week of coach support at a given school; school-based coaches worked from two to four days per week at any given school. All participating high schools purchased this support throughout their participation in

the initiative. The model for middle school coach funding shifted over time, with the district supporting schools in the first year, but then leaving middle schools to find their own instructional coaching support in Year 2 and beyond. One middle school paid for a school-based coach to work part-time with science teachers in Years 2-4. The other middle school paid for a part-time (2 days/week) school-based science coach in Year 2, but discontinued this approach in Years 3 and 4 when school leaders assigned a school-based coach to support all STEM disciplines (which teachers, coach and principals acknowledged, led to decreased coach work with science teachers at that school). Coaching choices are summarized in Table 2.

School leaders were also given the choice of the extent to which they wanted to participate in program activities. Principals were invited to attend all or part of both campus-based and cross-network professional learning opportunities. Additionally, in the third year of the project, principals were invited to participate in learning walks to jointly visit science classrooms with a researcher and sometimes also with a coach. These learning walks included pre- and post-visit discussions as well as focused visits to two to five science classrooms. They afforded principals an opportunity to explore the AST practices, the particular focal practices and improvement efforts of their own science teachers, and the connections of these to the next generation science standards and Danielson teacher evaluation framework. Principals and assistant principals were also given an opportunity to learn more about the work in general and with their teachers in particular in one-on-one follow up discussion with a researcher. All principals and assistant principals at the nine schools were invited to participate in both the learning walks and the follow up discussions; in some cases both participated, in others, only one or a subset. Table 3 identifies which principals and assistant principals engaged with the principal-targeted science instructional activities at each school. Principals were also given one or two additional, less structured, opportunities to meet with researchers in Years 1-3 of the program.

Table 3

Summary of Principals/Assistant Principals Participating in this Study by School/Campus

<u>Campus</u>	<u>Year of Science Reform: School Leaders (years in position at time of interview)</u>
Lincoln MS	Y3: Olivia, principal (2)
Douglas MS	Y3: Eva, principal (2) Y3: Anthony, AP (1) Y1: Harry, acting principal/AP (1)
Washington HS	Y3: Cathi, principal (2) Y3: Laura, AP (1) Y3: Joel*, AP Y1: James, principal (4)
Adams HS	Y3: Martha, principal (7) Y3: Irene, AP (3) Y3: Peter*, AP Y3: Kara*, AP (1)
Kennedy HS Campus <i>Cleveland, Roosevelt & Wilson Academies</i>	Y3: Ana, principal (Cleveland) (1) Y1: Collette, principal (Cleveland) (3) Y3: Marie, principal (Wilson) (2) Y1: Mary, principal (Wilson) (4)
Madison HS Campus <i>Jefferson & Hamilton Academies</i>	Y3: Jason, AP (Jefferson) (1) Y1: Ellen, principal (Jefferson) (3) Y3: Collette, principal (Hamilton) (1)

*Participated in science learning walk but not in interview/discussions.

Principals received semi-regular communications about the instructional reform work. Principals each initially connected to the work through various routes. In some cases, principals met with the research team early in the process. In other cases, through their election to pay for and receive structured supports in science instruction from the district, principals and assistant principals connected to the work through meeting with district science coaches and/or talking with the district STEM Director. Throughout the project, principals and assistant principals received intermittent email updates from researchers and coaches about the instructional work in which their teachers have been engaged. Many

also met regularly or intermittently with instructional coaches. It is noteworthy that by Year 4 of the project, only one principal from Year 1 was still in place from the nine participating schools.

Reform Activities. As alluded to above, in this research-practice partnership, all participants became part of a large, networked improvement community that included teachers from eleven secondary schools in this district and an additional five to ten science teachers and coaches from two secondary schools in nearby districts. Teachers were grouped by campus location (single schools or multiple schools on a shared campus) to form ten small working groups, each comprising an average of four to six teachers and one or more district coaches and university researchers. This study focused on six of those working groups, representing nine schools in the main district. In their efforts to grow their instructional practice, beginning in Year 2, each school/campus chose a focal instructional practice to work on improving over the course of each year. The groups leveraged improvement science to make ongoing targeted adjustments to that practice with an eye on both short- and long-term data measures to inform their instructional choices. They applied “PDSA” improvement cycles that included planning a change, collecting data about the change, studying the data, and taking follow up actions based on the data (Bryk, Gomez & Grunow, 2011). Ultimately, all groups’ focal practices were designed to improve students’ construction of gapless, evidence-based explanations of scientific phenomenon. Together, the researchers and coaches designed and implemented professional learning opportunities that aimed to facilitate high engagement and collaboration from network participants and that were relevant to teachers’ day-to-day work. Reform activities are summarized in Table 4 and described in greater detail in the paragraphs below.

Table 4

Formal Science Reform Learning & General Reform Engagement Activities

Activity	Frequency	Year(s)
SCHOOL/CAMPUS LOCATION-BASED LEARNING		
<p>Embedded Studio Day workshops</p> <ul style="list-style-type: none"> * full-day, all science teachers at a school * co-planned lessons, observations, reflective analysis, follow-up planning * initially planned & facilitated by researchers with gradual handoff to district coaches and teacher leaders 	2-5 per year per campus (~62 @6 campuses in 4 years)	Y1-Y4
<p>Data & Planning Meetings</p> <ul style="list-style-type: none"> * grounded in "improvement cycles" (plan, do, study, act) * use of student work/input to reflect on practice * follow-up planning * planned & facilitated by researchers, coaches & teacher leaders 	2-6 per year per campus	Y3 & Y4
<p>Individual & Small Group Coaching</p> <ul style="list-style-type: none"> * part-time science instructional coaches on site * usually one day per school per week (up to 2-3 days at MSs) * plan with and coach individual teachers * sometimes meet and plan with groups of teachers 	approximately weekly	Y1-Y4
CROSS-NETWORK COLLABORATION		
<p>Convening Workshops</p> <ul style="list-style-type: none"> * after school & in summer * all teachers from all schools * share student work, tools, practice implementations * follow up planning * co-planned & facilitated by researchers and district coaches 	2-4 per year	Y1-Y3
<p>Teacher Leader Studio Day workshops</p> <ul style="list-style-type: none"> * full-day, 1-2 teachers per school (chosen for year) * co-planned lessons, observations, reflective analysis, follow-up planning * added meta-layer about leading teacher learning * co-planned & facilitated by researchers and district coaches 	3 total	Y4
<p>Teacher Leader Meetings</p> <ul style="list-style-type: none"> * monthly after school, 1-2 teachers per school (for year) * meeting focus: selecting & collaborating on shared AST practices; communicating with administrators; working with data & practical measures * planned by research team; co-facilitated with district coaches 	approximately monthly	Y4
PRINCIPAL-TARGETED ACTIVITIES		
<p>Principal Meetings</p> <ul style="list-style-type: none"> * ad hoc at each school * review plan for the year and/or work in progress & share information * principal + researcher + sometimes coach or district leader 	1-3 per school over course of project	Y3
<p>Learning Walks</p> <ul style="list-style-type: none"> * AST orientation meeting + walk through multiple science classrooms (~10 minutes each)+ semi-structured debrief * organized around learning walk tool * attended by principal and/or AP(s), researcher(s) + sometimes coach * co-designed by researcher and district coach; facilitated by researcher 	1 per school total (at 8 schools)	Y3

School/campus-based, embedded learning days (a.k.a., “studio days”). During these days, all participating science teachers at a given school/campus were released from their classrooms for a full day of collaborative instruction, reflection and planning centered on their focal practice (often selected/articulated during the studio day). Usually, one teacher at a school hosted the embedded learning day, allowing all teachers (and others supporting the work) to visit the host teacher’s classroom for one or two class periods during that day. In preparation for the day, host teachers collaborated on lesson planning with a science coach and/or a science researcher, and sometimes with other teachers who taught the same course and/or with an ELL coach or teacher.

On the studio day, prior to the first classroom visit, teachers discussed the lesson, the problem of practice they wanted to investigate/improve, what they anticipated they would see from students, and what types of data they would collect to evaluate. Teachers visited the class while the host teacher taught. Subsequently, teachers analyzed data, particularly student talk and student work, with respect to their inquiry around their focal practice and with respect to student explanations in general (i.e. depth of explanation and use of evidence). Teachers then used data from the class to suggest improvements to instructional choices about the lesson itself and its implementation to be applied later that day or the following day when implementing that lesson with a different class period. On the studio day, after the lesson modifications, teachers either visited a later period of the same course and repeated the exercise with a modified lesson plan, or they spent the afternoon planning how to integrate the focal practice, in its improved form, into their upcoming lessons. The science coach, with support/collaboration from the researcher, planned and facilitated the teacher learning agenda for the day. Principals and/or assistant principals sometimes attended some parts of the day. Extent of administrator participation varied across schools. In the Years 3 and 4 of the project, two “studio days” were held at each school/campus – one in early fall and one mid-year. In previous years, 3-5 studio days were held per location.

School/campus-based student data and planning meetings. Beginning in the second year of the program, and more consistently in the third year, researchers worked to support the teachers at each school/campus to hold regular [monthly when possible] data meetings. These meetings were designed to

help the teachers to continue improving their focal practice in between and after studio days were complete for the year. The day and time for these one hour meetings was chosen opportunistically by teachers, sometimes in coordination with building administrators, sometimes using shared planning time (when available), and sometimes voluntarily after school. Optimally, these meetings were organized around each school's/campus's focal practice and included examination of a question about practice and its impact on students. Prior to the meeting, one or more teachers enacted a variation of the focal practice and collected student data from one or more classes to share with science teaching peers. Data was assembled, sometimes analyzed (by teachers, coaches, and/or researchers), and brought to the group for direct examination. Teachers reflected on the data and engaged in planning to iterate on the practice in upcoming lessons. Coaches sometimes participated in these meetings and the preparation for them. Principals and assistant principals rarely participated in this work.

Individual and small group coaching. For schools choosing to invest in “structured support” for science, the district provided a district-level coach one day per week to work with individual teachers and/or groups of teachers to support their instruction. District coaches generally consulted with principals/assistant principals and teachers to determine with which teachers they would work (sometimes all teachers, sometimes a team all teaching the same course) and on what types of support they would provide. At some middle schools, in some years, schools invested funds directly into hiring a part-time science instructional coach who played a similar role. Optimally, coaches' work was aligned with the larger NIC efforts, sometimes directly collaborating with teachers on their focal practice, and other times providing supports around the focal practice. Coaches also provided resources and support around curriculum and areas of instruction beyond the focal practice. Principals' and assistant principals' coordination with and expectations of coaches varied widely across schools.

Cross-network learning workshops (a.k.a., “convenings”). During the first three years of the initiative, the research team collaborated with district coaches to plan and facilitate approximately three cross-network learning opportunities spread out over the course of the school year and located at changing school locations. Teachers were usually asked to bring samples of student work and/or

instructional tools they had designed and tried in their classrooms, as well as learning from their data analyses and studio days. Convenings usually lasted approximately three hours and included blocks of time for sharing practices, tools and questions, for learning together about a particular AST principle associated with their focal practices, and collaboratively planning across schools for tools, data collection and instructional choices for upcoming lessons. During these meetings, teachers both worked on their own cycles of improvement and shared learning and planning of new tools with teachers from other school/campus teams. Principals were invited to attend these meetings particularly the practice-sharing section of the June convening, but very few attended.

District-wide, teacher leadership development workshops. In the fourth year of the project, up to two teachers from each school were invited (based on input from coaches, researchers and to an extent, principals) to participate in a leadership development program to help teachers continue to advance the instructional practice reform work at each of their schools. One or two teachers participated from all eleven participating schools in the district, including the nine from this study, as well as science coaches from across the district. Supporting pairs of teachers from a school allowed those teachers to take turns attending workshops and meetings and to bring their expertise back to different content teams at their schools. Teacher leader objectives were to “enhance ownership for sustained professional learning”, “build capacity for collection and analysis of practical measurements”, “support collaboration across schools within the district and across the region”, and “serve as a resource for principals and other disciplinary team leads.” These teachers were invited to participate in three all-day embedded workshops as well as six monthly learning work sessions. While rooted in ambitious and equitable science teaching practices, this work was also anchored by a triumvirate of supporting considerations: working with school teams on shared practice, working with data and practical measures, and working with administrators.

Cross-network, teacher leader “studio days” were held at three different schools, each hosted by a different teacher leader. Only the teacher leadership group attended these studio days, which were run similarly to a standard studio day. The primary difference was in the debriefing and planning activities,

which were both geared more towards thinking about how to apply the work to teacher learning at their schools (and not only to their individual instructional practice). In some instances, English language learning professionals from the district supported some of the lesson planning and classroom observation aspects of this work.

Two-hour monthly work sessions were held after school beginning in October. The initial session focused on helping teacher leaders to facilitate their school's selection of a focal practice. Subsequent sessions built on teachers' focal interests to leverage improvement cycles through inquiry about the instructional practices and supporting strategies at play in the classroom. Sessions highlighted cases from participating schools and helped teacher leaders develop concrete plans for asking questions, collecting and analyzing data, and revising practices. Sessions also helped teachers develop an intentional plan to productively connect principals/assistant principals with their instructional growth work.

As part of their participation in the teacher leader group, these teachers helped coaches to plan and run the location-based studio days at their respective campuses. They were also encouraged to help the science teachers at their schools to select a focal practice for the year and to organize and facilitate data and planning meetings at their schools to advance this work. Principals were not directly invited to participate in these sessions, but did occasionally receive some information about them from a combination of teacher leaders, researchers and coaches.

Principal learning walks and follow-up discussions/communications. Principals and assistant principals were invited to participate in learning walks at their schools. These walks took place in December through February of the third year of the project. Attendees included one or more building administrators, one or two researchers, and sometimes a science coach. Each learning walk began with an opportunity for principals/assistant principals to read and discuss a brief piece about AST practices and their connections to next generation science standards and to learn about their science teachers' focal practice. After using the observation tool (which also connected AST practices to NGSS and the Danielson teacher evaluation framework) to select a focus for observations (usually student discourse), the learning walk group visited two to five classrooms in the school for ten-fifteen minutes each. The

group paused between classes to share what they observed in each classroom. Following the final classroom visit, the group reconvened for a semi-structured debriefing discussion.

During spring (March-June) of Year 3, principals and assistant principals were individually invited to engage in one-on-one follow-up discussions with the researcher about the progress of the specific work by their science teachers and to share their asks for changes in the work. These meetings were combined with researcher interviews of the principals. Researchers and coaches also initiated and responded to other occasional points of contact with principals.

Data

Data for this study were collected to facilitate development of multiple case studies that straddled instructional and school leadership contexts. In addition to collecting data specifically for use in this study, I selected from among a rich set of supporting data collected throughout the course of the study. To develop an understanding of how principals' sense-making was influencing leadership practices and how those leadership practices were influencing instruction, I drew from a broad set of perspectives and across the duration of the reform partnership initiative. Following, I describe my approach to sampling and the various sources of data I elected to apply to this study.

Sampling. Overall, sampling was purposeful (Patton, 2003) – I chose to examine all available secondary schools that had participated in the reform initiative in some way for at least one full year, specifically two middle schools, two comprehensive high schools, and five small high schools collocated on two campuses. I did not include the two more recently added schools in the district because they had not yet had an opportunity to deeply engage with AST practices and they were brought into the project under different operating circumstances that made comparisons across schools more complicated. I also did not include the two schools from outside the district that participated in the networked improvement community because they had different overarching operational contexts than the in-district schools, and their participation was not consistent over the full four school years of the study.

For the nine schools that I did include, I examined data in aggregate and independently, looking to identify both commonalities across the district and differences among schools. While I considered focusing on only a subset of schools, or examining one set more deeply than others, I settled on analyzing all nine schools because collectively they offered a more compelling range of attributes, including types of participation in reform activities, time of participation in the reform initiative, degree of enactment of reform practices by teachers, and differences in participation of principals (and assistant principals) in those schools. This strategy of purposeful maximum deviation (Merriam, 2009, p.78) helped to expose the range of factors at play in terms of principal sense-making, context, and reform enactment. In recognizing this need to consider a broad sampling of schools, I elected to serve as the research program point of contact for three of these schools and I had previously established a working relationship at a fourth. Together, these four schools represented two demographic pairs – the two middle schools and the two comprehensive high schools. I also attended location-based and cross-network events with teachers at the other schools over the four years of the project; and I worked directly with the researchers supporting those schools on a weekly basis to coordinate activities, reporting and research for the project. I directly participated in Year 2 and 3 principal meetings; and I designed and facilitated principal learning walks and follow-up conversations/interviews in Year 3. I also worked with all science coaches on the project and designed and conducted interviews with each of them during Year 4. Collectively, these experiences provided me deep exposure to the narratives and resources at each of these schools, and increased my ability to provide the rich set of contextual information that was critical to this situated study.

Sources of Data. I sought data to understand three distinct aspects of the reform work in the district: principals' sense-making about the reform and school direction, school leadership practices, and extent of school engagement (e.g., learning about, planning for, reflecting on, enacting and sharing) with the reform practices. Additionally, I selected data that would allow me to construct narratives that connected these three sources of data in specific contexts and incidents. The majority of data for this project was drawn from collaborative learning activities conducted over three and a half years and comprised a mix of the

research-practice partnership professional learning activities and additional reflections (via interviews and surveys) of participants. I also supplemented that data with artifacts collected from email communications, from school and district websites, and from public records requests.

Primary data regarding principals' sense-making came from principal discussions/interviews from Years 1 and 3, instructional walk conversations from Year 3, and principal surveys conducted in the late spring of the Year 2 and the fall Year 4. Primary data school leadership practices, including principals' interactions with teachers, was drawn from teacher, principal and coach interviews; teacher and principal surveys; and principal learning walk discussions. Data about engagement with reform yielded primarily from teacher surveys and researcher logs of studio days, classroom observations, and data meetings. Data used to connect findings together into cohesive narrative descriptions included researcher logs, teacher and coach interviews, assorted artifacts and regular communications with researchers from across the project. All data used are summarized in Table 5 and briefly described in the following subsections.

Table 5

Data Sources

<u>Source</u>	<u>Schools Represented</u>	<u>Number</u>	<u>Year Collected</u>
SEMI-STRUCTURED INTERVIEWS			
* Y3 Principals and Assistant Principals who supervised science teachers	8	11	Y3, end
* Y1 Principals	5	5	Y1, end
* Coaches, various times of service (1 at district Y1-Y4; 1 at district Y1, schools Y2-Y4; 1 at district Y3; 1 at district Y4)	9	4	Y4, mid
* Y3 Teachers	9	32	Y3, end
ELECTRONIC SURVEYS			
* Y3 Principals and Assistant Principals	6	6	Y4, early
* Y1 Principals and Assistant Principals	5	6	Y2, end
* Y3 Teachers	9	29	Y3, end
* Y2 Teachers	8	28	Y2, early
CLASSROOM OBSERVATIONS & LEARNING WALKS			
*Researcher Observation of science classrooms (usually same period per teacher, multiple/yr)	9	158	Y3
* Facilitated multi-science-classroom visits with principals and/or assistant principals (with pre- & post-observation semi-structured discussions)	8	8	Y3, mid
RESEARCHER LOGS AND NOTES			
* Studio Day logs, artifacts, and notes	9	62	Y1-Y4
* Data Day logs, artifacts, emails & notes	9	~30	Y3-Y4
* Cross Network Convening & Workshop artifacts and notes	9	~12	Y1-Y3
* Teacher Leader Monthly & Studio Day Workshop exit tickets, artifacts, & notes	9	9	Y4
* Notes from other school & district meetings	--	~5	Y1-Y4
SCHOOL & DISTRICT ARTIFACTS			
* Principal emails to teachers	2	6	Y1-Y4
* District Strategic Plan & Accompanying Instructional Focus Summary (covered Y1-Y4)	all	2	Y4
* District Charlotte-Danielson Adaptated Teacher Evaluation Framework	all	1	Y3
*District Certificated Staff Collective Bargaining Agreement (covered Y2-Y4)	all	1	Y4

Interviews. Separate interview questions were introduced to each group of participants—principals/assistant principals, coaches, and teachers—in a semi-structured interview that was recorded

(with participant permission). All three sets of interviews focused on AST practices, related sense-making, and participant interactions related to leadership practices and instruction. Questions for each group are described in greater detail below; in each case questions included some simple demographic questions about the interviewee's role and experiences and a set of questions that mapped to the research questions for this study. Appendix B includes a copy of questions asked to each group of participants. All interviews were transcribed by professional transcription services and transcripts used for analysis. Any questions about transcript content were addressed using original recordings and researcher notes from the interviews.

Principal/assistant principal interviews/update discussions. At the end of year 3, all principals and assistant principals at the initial nine schools were invited to participate in planning and research discussions of roughly 45 minutes that included both an update on their school's work pursuing AST practices and a set of formal interview questions. Eleven principals and assistant principals representing eight of the nine schools, chose to participate in these discussions/interviews. I asked a minimum of one interview question to address each research question; several research questions mapped to multiple interview questions. Principals were asked about an array of topics including their understanding of AST practices and the work engaged in by their science teachers; their school-wide goals and priorities; their professional development plans for their teachers; support from science instructional coaches; how they would change or add to science support for their building; and how they support and interact with teachers around instruction. Additionally, principals from five schools were interviewed at the end of the first year of the reform initiative. Those interviews, which have been fully transcribed and analyzed for related research, focused on principal sense-making about high-quality instruction and instructional improvement, their interactions with teachers around instruction, and their participation in reform professional learning activities.

Coach interviews. In the middle of Year 4, I interviewed all science instructional coaches (district or school-based) who had supported any of the nine schools during any part of the four years of the study. Four coaches were asked a very open ended set of questions prompting them to describe the

trajectory of teacher engagement with and learning about ambitious science practices at the schools they supported, with attention to how the principal engaged with the reform via interactions with teachers and coaches and via indirect influence via decision-making about collaboration time, professional development plans, school priorities, data, etc. In some cases, I presented coaches my interpretation of a situation at a particular school and I asked them to comment on it, inviting them to correct, clarify and add to my understanding citing particular experiences. Coaches were also asked to describe their understanding of AST reform practices and the role those practices played in their work. Interviews were each roughly an hour in length.

Teacher interviews. At the end of year three, thirty-two teachers from the nine schools were interviewed about their experiences with the AST networked improvement community. Teachers were asked to describe: school goals and priorities; interactions with their principal/assistant principal around instruction; how they reconciled their science-specific instructional goals with school-wide goals for the year; their interactions with science instructional coaches; their opportunities for collaboration and professional development; and their specific experiences with AST work. Interviews lasted roughly half an hour per teacher, with some running longer.

Surveys. In the first three years, at the end of each school year, comprehensive program surveys were administered to all program participants. In the first year, the same survey was distributed to all who took it. After the second and third years, different versions were created for teachers, coaches/researchers, and principals/assistant principals and the questions were expanded. These surveys were designed to support the full research program (beyond the extent of this study) and included topics from beliefs about practice improvements to tools utilized to social networking. They also included multiple questions that addressed both sense-making about the reform as well as direct and mediated interactions with principal practices. Surveys were conducted independently and online, not in the presence of the researchers. An incentive of an online retail gift certificate was provided to encourage participants to complete the surveys. Surveys conducted following years two and three were used in this analysis. Several of the questions related to administrative practices and their connections to instructional

practices were repeated across all three survey groups, allowing for a comparison of responses. These questions included inquiries about priorities for teachers, valued professional development activities for teachers, and collaboration time available to science teachers. Appendix C lists the survey questions applied to this analysis for each group of participants.

Principal/Assistant Principal Surveys were conducted at the end of year two and in the first half of year four were applied to this study. Principal/assistant principal surveys did not include the social networking component and were relatively brief (on the order of ten minutes) to complete; however, response rates were lower than with other participants, roughly on the order of one third responding each year. Additionally, respondents varied from year-to-year, removing the ability to consider individual changes over time in this analysis, but still providing representation for each for all campuses. Survey results were organized by school and evaluated both in aggregate and with respect to school-specific information.

Teacher Surveys conducted at the end of years two and three were applied to this study. Teacher surveys included a comprehensive social networking portion that significantly increased the time required to complete the survey. Response rates were relatively high for teachers and provided representation across all nine schools – 28 teachers responded in Year 2, and 29 in Year 3. Individual teacher identities were removed from the analysis and data were sorted by school for analyses. Questions of particular consideration included teachers' reported individual focal practices, what teachers worked on with coaches, and the frequency in which teachers engaged in an assortment of instructional collaboration activities. Teachers also answered questions about what they expected principals wanted them to spend more time attending.

Professional learning and collaboration activities. Researchers and coaches stored studio day, convening, and other collaboration activity materials in shared folders that included facilitation documents, teacher learning tools, lesson plans, student activities, samples of student work, individual and collective teacher reflections and sense-making, tools created and follow-up plans and commitments. Additionally, researchers, sometimes with the assistance of coaches, maintained formal logs and summary

documents from these activities. Notes were both open-ended and included multiple-choice scaled scoring of particular aspects of the work. One measure used on multiple occasions was based on a set of AST-based proficiency measures referred to alternately as the “teacher learning progression” and “classroom observation tool” (Thompson et al., 2013; AST, 2017). The tool included four science instructional practices and one English language learning practice, each scored on a scale of one (least proficiency) to five (highest proficiency). For this study, I applied only scores from the four science practices: selecting big ideas, treating them as models; attending to students’ ideas and experiences; using activity to support ongoing changes in reasoning; and, pressing for explanation. Teachers also used a four-point scale to evaluate the depth of student explanations and use of evidence during these teacher learning experiences. Their interaction with that scale also provided descriptive detail related to their proficiency in enacting reform practices. Both scales are included in Appendix D. Researchers also made descriptive notes about their observations, identified particular focal practices at play as well as supporting strategies applied to the instruction.

Principal Learning Walks. Principals and assistant principals at the initial nine schools were all invited to attend a learning walk; all but two principals accepted, with learning walks taking place at all but one of the initial nine schools and at all campuses. Learning walks were book-ended with formal orienting and debriefing discussions, which were audio recorded. Additionally, I took notes for the full course of each learning walk. In the orienting session, principals were asked about their school-wide priorities/goals as well as their concerns related to science instruction. Based on this discussion, principals used the instructional walk tool to choose a focus for the classroom visits portion of the learning walk; most principals chose to focus on the level of student discourse in the classroom. In the debriefing discussions, instructional concerns and opportunities in science were discussed along with general observations. Data included principals’ responses to questions during the pre- and post-walk meetings as well as their observations between classroom visits. Data focused on how principals made sense of AST practices, what they looked for and noticed in instructional settings, integration of broader school priorities into their talk about reform, their focus on practices of their individual and collective

science teachers, and other relevant information that principals noted. Due to the mobile nature of the walk, and the larger number of participants, in some cases, recordings were difficult to transcribe, so I primarily used the recordings to fill in gaps and to clarify extensive notes that I took during all segments of the instructional walks. Appendix E includes the instructional walk protocol and tool used during the visit.

Studio day logs and artifacts. As described above, I applied logs and collections of artifacts from studio days to this evaluation. In the studio day logs, I paid particular attention to proficiency scores for the four science practices and descriptive comments about the group's focal practice, comments on any school-wide priorities, integration of school-wide priorities into studio day lesson plans and professional learning, and regarding roles of teachers and coaches during the day. I examined particular artifacts from the studio days when notes in the logs or interview comments referenced particular issues that arose. I sought further clarity from lesson plans, teacher resources, the professional learning plan, teacher reflections, and even some samples of student work. While I did not perform a systematic search through the logs for this data, when it became relevant, I accessed whatever available materials seemed to provide the richest data about items passing between administrative and instructional contexts.

Data and planning meetings. While these began sporadically during the second year of the program, they occurred more regularly during the third year of the initiative at five of the six campuses, with limited instantiation at the sixth campus, which was newer to the practices. The number and focus of meetings varied significantly from campus to campus. Researchers attended many but not all meetings. Their notes were summarized in a formal reporting form for many, but not all, meetings. Additionally, in Year 4, researchers completed a table of reflective notes about what they had observed in data meetings over Years 3 and 4. These logs and reflective notes provided information about teacher participation, time used to meet, focus on use of data, focus on AST practices, degree of connection from one meeting to the next, and changes observed over time. Appendix F includes summaries of the online data collection forms and categories of reflective notes regarding data days, from which logs were created.

Teacher leadership workshops. Like with school-based studio days, materials for teacher leader studio days and monthly workshop meetings were stored in shared folders that coaches and researchers could use to contribute, collaborate and review data from those days. Unlike the building specific studio days and meetings, there were no formal researcher logs collected from these days. Rather, artifacts, including entry and exit tickets and work products were collected; additionally researchers, including myself, kept individual notes on work, comments and issues that came up during workshops. Events of note were also recorded in summary and discussion emails among researchers. I access this combination of resources to provide supplemental materials for this study.

Research-oriented logs and notes. While the majority of data for this study came from activities to support professional learning and reform implementation, some data was collected with a greater orientation to supporting the research about the reform partnership. In these cases, data were assembled in the form of formal logs and informal researcher notes. Classroom observation notes and individual researcher notes both contributed to this analysis.

Classroom observation data. Participating teachers were observed regularly (most at least two times per year and sometimes as many as eight times) by coaches and researchers who scored the practices observed during the observations with respect to teachers' levels of engagement with core AST practices. In Year 3 of the study, researchers set out to observe teachers at all nine schools multiple times during the same class period throughout the course of the school year. We also collected regular sample sets of student work from these "focal" classes, though the student work did not necessarily correspond to the classroom observations. Following each observation, researchers completed logs that recorded teacher's proficiency with AST general practices and that noted any particular focal practices at play in the classroom. These data provided a sense of practice variation with respect to AST practices within schools and a general point of comparison across schools. Appendix F includes a copy of the researcher class observation log form.

General meeting notes. Over the course of this study, I had the opportunity to attend multiple meetings with individuals and groups at the school and district level. I kept notes about the discussions at

those meetings and referred to them to provide contextual information about various aspects of this study. For example, notes from a district-wide data meeting helped increase insight into principals' sense-making about science instructional reform and how science fit with larger school priorities. And notes from a meeting with district officials revealed additional insights into how coaching relationships were established with principals and the degree to which principals were encouraged to interact with discipline specific instructional work. Other notes came from individual interactions with teachers, principals and coaches. Still others came from individual notes outside the formal logs for structured networked improvement community meetings.

Artifacts. To help provide a more complete picture of school leadership practices, and related mediated interactions with principals and their practices, a small collection of artifacts were collected and examined. Note that a large collection of formal annual school improvement plans was collected, but found to be somewhat peripheral to this particular study, so that collection of materials is not discussed here. Items that provided helpful details include the following assorted emails with principals, the Charlotte-Danielson Teacher Evaluation Framework, the district's collective bargaining agreement for certificated staff, and the district's strategic plan and accompanying instructional focus summary.

Emails. Email messages that principals sent to staff, and/or coaches and researchers, about instructional priorities, sometimes including AST, were opportunistically collected by researchers (with permission) and saved for reference. I assembled a collection of those that I had myself and that I obtained from other researchers on the project. These email messages related to principals' sense-making as well as their school leadership practices related to instruction.

District directional documents. From the district website, I was able to download copies of the district's annual plan and the instructional focus document, both that applied precisely to Year 1 through 4 of the reform effort. Similarly, I was able to obtain a copy of the district's adapted teacher evaluation framework (based on the state-legislated requirements and the Charlotte Danielson teacher evaluation framework). These items provided contextual data that helped me to better understand the principals' expressed instructional priorities, and it helped me recognize particular patterns across the district. Data

from these documents was purely supplemental to the analysis. To protect the confidentiality of the district, copies of district documents are *not* shared in the appendices.

Collective bargaining agreement. I also obtained, from the district website, a copy of the collective bargaining agreement that applied to Years 2 through 4 of the study. This agreement was helpful in providing clarity around the required “professional collaboration time” (PCT) that the teachers negotiated. As with other artifacts, this data was supplemental and clarifying and not a primary object of analysis. As with other district documents, to protect the confidentiality of the district, a copy of the contract is *not* shared in the appendices.

Data Analysis

Because the goal of this study was to identify influence from sense-making to practice, and from leadership to instruction, I conducted a multi-faceted qualitative analysis to establish an understanding of each area of concern and the connections between them. I applied a qualitative evaluation that employed a general narrative approach (Merriam, p.32-33) focused on sense-making and practice interactions. Furthermore, because of the current gap in the literature regarding a substantiated conceptual model, I applied an inductive approach (Merriam,2009) by beginning with an initial set of codes applied to the data to generate initial hypotheses and used subsequent rounds of coding to seek confirming and disconfirming evidence for evolving hypotheses. The three distinct parts of this analysis are described below, and include: iterative coding of principals to uncover an initial representation of principals’ sense-making and related leadership practices; a comparative analysis of multiple data representative of teachers’ enactment of reform practices at each school; and the development of a collection of “miniature” narrative descriptions of particular events or conditions at particular schools that illustrated connections between leadership practices and instruction with respect to reform enactment. I organized this work into a “contextual analysis” to comparatively characterize the reform instructional enactments at each school, and a “narrative analysis” which examined principals’ sense-making and school leadership practices, and ultimately emerged into a distinctive collection of narratives organized by trends observed in the data.

Contextual analysis: comparing teachers' collective enactment of reform practices by school. I performed a collection of analyses of different types of data about teachers' engagement with reform practices. Teachers engaged with instructional reform in professional learning, planning, classroom enactments, reflection about enactments, and instruction-related collaboration with colleagues. I compared numerous sources of data to look for easily identifiable commonalities and differences. I did not pursue deep analysis of data that did not reveal any distinctive trends, but did look at that data to ensure that it did not mitigate or change my interpretation of other data. I looked for these trends in instructional engagement by examining teacher survey responses, organized by school, studio day logs, classroom observations logs, and data meeting logs.

Teacher-focus on AST practices. I examined three sources of data to evaluate what specific AST practices teachers were engaging with in various circumstances – in their own priorities, in their work with coaches, and in their classroom practices. In the Year 3 teacher survey, teachers were given open space to identify the focus of their work with science coaches. I tabulated their responses and grouped them by school to consider if teachers were reporting AST practices or other instructional work, and to identify if there was a common focus of teachers' work with coaches at particular schools. Similarly, I examined teachers' responses to the question of what their own focal practice was. I looked for consistency among teachers and for alignment with AST practices. Finally, I examined the classroom observation logs from over 150 classroom observations made during that same year to identify which focal practices were observed, if any, in each observation. I tallied these and grouped by schools to identify trends among teachers. Finally, I compared these three groupings of school data across the different schools.

Teacher-reported collaboration. In surveys at the end of each year, teachers were asked to report the time they spent collaborating with colleagues. They were allowed to report collaboration with up to nine colleagues, however, only a small handful of the responding teachers reported collaboration with more than three colleagues. Specifically, teachers were asked to report whether they had engaged in nine separate practices (e.g., analyzing samples of student work, co-teaching, exchanging feedback on

instructional practices, and collaborating to create, plan or modify instructional materials), and if so, to indicate the frequency of collaboration over the course of that school year (once or twice, monthly, weekly, daily). Based on guidelines from our principal investigator and our social networking analysis team, I assigned each of those frequencies a value of hours per year and added those hours up for all categories and all colleagues to determine a total number of collaboration hours for each teacher for that year. I then averaged these totals across teachers from the same schools and from the same campuses to capture an average yearly number of instructional collaboration hours per year. I repeated this analysis with both the end of Year 2 and end of Year 3 teacher survey data and compared values across schools.

Observed reform practice proficiencies. To better understand differences in teachers' proficiencies of enacting the AST practices at each school, I considered two different sources of practice data—Year 3 observations and Year 3 and 4 studio days. Proficiency scores were generated by researchers following an observation or studio day using the learning progression observation tool noted above. Researchers generated four separate scores, one for each of the high level categories of AST practices, for each event. For purposes of this analysis, I averaged all four scores for all studio days (not including any teacher leader studio days) at each campus from Years 3 and 4; and I identified the lowest score assigned at the school for any studio days included among any of the four practice scores. I chose these years because researchers had been working for a sustained time with the scoring and Years 3 and 4 were scored by a small group of researchers who were meeting regularly and engaging in work to normalize their scoring. Additionally, this matched up well with the other data sources being considered in this reform enactment analysis. Similarly, I averaged all scores for Year 3 observations of all teachers for each school. (Year 3 was the only year that this rich set of data was available.) I also inspected the data for any visible anomalies. I compared data across schools/campuses.

Participation in data days. To provide a sense of how and when teachers were engaging with AST practices and cycles of improvement, I examined data day logs and researcher reflective notes about teachers' work in data days. I identified their frequency of meeting, the time they used to meet, the degree to which researchers reported teachers focusing on data and focusing on AST practices. I also

looked at the degree to which teachers were reported to be building on their learning from one data meeting to the next, and any changes reported in their engagement with data days from Year 3 to Year 4. I summarized the data and looked for trends across schools.

Summarizing instructional engagement data. Because teachers' engagement with AST practices was multi-faceted and variable, I did not try to create any sort of single score to represent a school's collective engagement with AST. This was also in keeping with Coburn's (2003) work citing four different aspects of reform to measure when assessing the degree to which it has scaled. Instead, I qualitatively compared the various individual measures of engagement, and groups of measures of engagement, to better represent the reform instructional contexts of each school. I applied this collection of contextual information to the narrative analysis (described below) to identify trends in connections between leadership practices and reform-related instruction.

Narrative analysis: starting with principal to trace connections between leadership practices and instructional reform enactment. I used interviews with principals and assistant principals to anchor my analysis seeking to find connections between principal sense-making and school leadership practices and between school leadership practices and instruction. Over a series of evolving rounds of analysis, I moved from coding interviews to assembling and organizing representative narratives to illustrate the connections. My analytic approach for this work included a careful read through all notes and transcripts, multiple rounds of coding (Coffey & Atkinson, 1996), grouping and recoding of data, and an iterative re-examination of research questions and assertions. Following is a description of the discernible rounds of coding, although in implementation, they flowed iteratively with one another throughout the analysis.

Appendix G lists the evolving set of codes and categorizations that were applied in successive rounds of analysis. **Rounds 0-3: Coding principal interviews.** My first round of pre-analysis consisted of reviewing the principal interview transcripts and notes from other data collection. Following this, I developed codes to facilitate examination of the research questions in the context of the conceptual framework described above. Round 1 codes focused on Leithwood's (2012) four categories of leadership practices, as well as codes for reform instruction, related NGSS standards, other instruction and a set of initial codes about interfaces (e.g., working with a science coach, professional development, teacher evaluations, vision for high quality science instruction) that I had observed and that were represented in the literature connecting leadership and instruction. Following this round of analysis, I recognized a need to examine school leadership practices with greater granularity, so I added codes for each of Leithwood's (2012) individual 16 leadership practices represented by the four categories from the first round of coding. Through these two rounds of coding, I noticed several instructional categories (e.g. standards-based planning and focus, student engagement, classroom behavior/relationship management) and several leadership/instruction points of interface (e.g., teacher leadership, principal learning, pro-active connections between AST-related practices and larger context) emerging from the data. In round three, I added codes to reflect the emerging categories, and continued to iteratively code all eleven interviews from Year 3.

Rounds 4-5: Identifying connections. Following coding rounds of the Year 3 principal interviews, I created a set of automated codes to identify parts of the interviews coincidentally related to both leadership practices (by category) and particular instructional or leadership-instruction interface codes. I compared frequencies of encounter and types of activities and sense-making associated with these points of intersection. In Round 5 of my analysis, I reviewed the data on a code-by-code basis across all interviews and I began to identify those codes that revealed particularly rich data across interviews regarding similarities and differences in principal sense-making, leadership practices, and

potential impacts to the instructional context of the school. I summarized the data for each of these categories by principal and sometimes by school.

Rounds 6-7: Beginning construction of focused narratives. From the code-specific summaries of data, I was able to begin identifying events, circumstances and reflections of key sense-making that I could compare across schools. In Round 6, I began to articulate these findings and group narrative stories accordingly. In Round 7, I began the arduous task of adding details to these key anchoring narratives based on the breadth of additional data sources. These included a review of coach and teacher interviews, notes from instructional walks, Year 1 principal interviews, other researcher notes, and some initial comparisons to the contextual data about teacher engagement with reform practices. During this task, I triangulated data sources to find converging accounts of the narratives and I also identified discrepancies in accounts that added sense-making data to my analysis and eventually helped flesh out the narratives as well.

Rounds 8-9: Categorizing, organizing, and confirming. By Round 8, I was able to analyze an evolving set of findings to identify categories that helped describe the level of connections between leadership practices and the reform, both in general and with respect to individual categories of leadership practices. I looked at more specific connections between individual leadership practices and particular aspects of teacher engagement with reform practices at each school. I developed evidence-based descriptions of these categories and assigned each school a general category of connectedness as well as categories for five more granular categories of connections that emerged during the analysis. In Round 9, I sought additional confirming and disconfirming data about these emerging narratives. In addition to reviewing the formal study-specific data sources that I had assembled, I sought clarification through direct conversations with study participants, including teachers, coaches, principals and other researchers. I evaluated district documents to provide deeper contexts for principals' sense-making and actions. And I iterated on the narratives so they reflected this multi-data source construction. During this phase, I also revisited literature to help find connections that were not as apparent during the early analysis. Finally, I applied my findings to create an updated conceptual model that better reflected these findings. I iterated

with this same analytic process to evaluate the appropriateness of various aspects of the existing model and of additions and changes that the emerging data suggested.

Findings

Principals' sense-making about science reforms influenced both their leadership practices and subsequently, the way those practices influenced instructional choices by science teachers at their schools. Consistent with this, four themes emerged from the data, all both confirming and further developing the conceptual model to describe how school leadership practices influence instruction, and particularly the enactment of instructional reform practices. First, perhaps the most salient aspect of principals' sense-making about instructional reform was a tendency to partition science-specific reform work as "separate from, but consistent with," their broader visions for instructional improvements in their schools. While principals generally valued the science reform work taking place at their schools, they did not talk about science reform as a priority for their schools, though they did view the reform as consistent with their broader priorities. Most principals did not take an active leadership role in this work and instead, looked to coaches, research partners and teachers to prioritize which reform practices to enact and to what extent. Principals did employ their leadership practices to support, to varying degrees, some aspects of the science reform. The second and third findings of this study describe how principals applied leadership practices around aligning resources, structuring the organization and developing people, specifically in relation to science teacher collaboration and science instructional coaches, and the ways these decisions affected the degree to which teachers enacted science reform practices. Fourth, the extent to which principals intentionally made connections, between their leadership practices (in all categories) and instruction, visible to teachers, appeared consistent with the degree to which teachers engaged with the ambitious science teaching (AST) practices. To enable me to explore connections between principals' sense-making and school leadership practices, and science reform enactment, I begin by presenting a brief set of comparative findings about how teachers at the different schools engaged AST practices in their instruction and related professional learning and collaboration.

Contextual Findings: Teacher Engagement with Ambitious Science Teaching Practices

These contextual findings support examination of links between principals' sense-making and their school leadership practices as they relate to the enactment of science instructional reform.

Teachers at the six different secondary campuses (including nine distinct schools) engaged with the science reform practices to varying extents, with two schools, Douglas MS and Washington HS, standing out as being particularly more and less engaged, respectively, in their applications of the reform practices. Those results are in the process of being examined in greater detail in a number of other reports (Thompson et al., 2016; Shim & Thompson, 2017; Von Esch et al., 2017). In this study, I define "engaging" the instructional practices as interacting with them in different ways, which included planning to use them, reflecting on their application, applying them during instruction, learning about them, and sharing them with others; teachers may engage the practices individually or collectively, with higher proficiency or with lower proficiency. For purposes of this study, I characterized school/campus engagements with the science reform practices based on the following four factors: (1) demonstrated application of and reflection about AST practices during reform professional development days; (2) self-reported focus on AST practices with science coaches and among individual science teachers at each school; (3) frequency of observed application of the practices coupled with the extent to which subsequent enactments built on previous enactments of the practices; and (4) observed and self-reported instructional collaboration among science teachers. Overall, each school experienced its own successes with aspects of the science reform work. I explore these site-based differences in AST practice enactments in the main findings section to help uncover how principals' school leadership practices influenced adoption of the science reforms. First, however, I present Table 6 and the following four paragraphs to outline key findings about site-based differences in teacher enactment of the science reform practices to provide context for the main findings.

Table 6

Summary of Contextual Findings: Engagement with AST Reform Practices Grouped by School/Campus

<u>Data</u>	<u>Studio Day</u> <u>Average (and</u> <u>Minimum) AST</u> <u>Practice Scores*</u>	<u>Teacher-Reported</u> <u>Focus of Work with</u> <u>Science Coach</u>	<u>Teacher-Reported</u> <u>Individual Teacher</u> <u>Focal Practices</u>	<u>Classroom</u> <u>Observations - AST</u> <u>[Sub]Practices</u> <u>Observed</u>	<u>Classroom</u> <u>Observation</u> <u>Average AST</u> <u>Practice Scores*</u>	<u>Average Annual</u> <u>Per Teacher</u> <u>Hours of</u> <u>Collaboration**</u>	<u>Data & Planning</u> <u>Meetings - Times &</u> <u>Focus</u>
<i>Source</i>	<i>Y3&4 Studio Day</i> <i>Logs</i>	<i>Y3 Teacher Survey</i>	<i>Y3 Teacher Survey</i>	<i>Y3 Classroom</i> <i>Observations Logs</i>	<i>Y3 Classroom</i> <i>Observations Logs</i>	<i>Y2 & Y3 Teacher</i> <i>Surveys</i>	<i>Y3&4 Data Meeting Logs</i>
Lincoln MS	3.6 (3)	N=5 5 - Standards-based lesson planning (also a first year teachers' focus on classroom management)	N=5 1 - evaluation of student data 1 - modeling 3 - structured talk	52% lessons w/AST N(obs)=27 N(teachers)=6 14 - Structured Talk 13 - No AST practice observed	3.2	N=5 & N=5 164 & 2387	2 Y3 meetings * after school, lunch, occasional PCT time * high data focus; loose AST focus * meetings disconnected * Y4 little traction
Douglas MS	3.6 (3)	N=5 5 - structured talk [to support explanations] (also some mention standards/rubrics; plus one first year teachers' focus on classroom management)	N=5 5 - structured [partner] talk [to support scientific explanations]	91% lessons w/AST N(obs)=34 N(teachers)=6 31 - role-based discussions (related to peer feedback) 3 - No AST practice observed	3.8	N=4 & N=5 1057 & 1272	6 Y3 meetings * shared planning time * high data/AST focus *Y3 meetings built on each other * dropped off in Y4

<u>Data</u>	<u>Studio Day</u> <u>Average (and</u> <u>Minimum) AST</u> <u>Practice Scores*</u>	<u>Teacher-Reported</u> <u>Focus of Work with</u> <u>Science Coach</u>	<u>Teacher-Reported</u> <u>Individual Teacher</u> <u>Focal Practices</u>	<u>Classroom</u> <u>Observations - AST</u> <u>[Sub]Practices</u> <u>Observed</u>	<u>Classroom</u> <u>Observation</u> <u>Average AST</u> <u>Practice Scores*</u>	<u>Average Annual</u> <u>Per Teacher</u> <u>Hours of</u> <u>Collaboration**</u>	<u>Data & Planning</u> <u>Meetings - Times &</u> <u>Focus</u>
<i>Source</i>	<i>Y3&4 Studio Day</i> <i>Logs</i>	<i>Y3 Teacher Survey</i>	<i>Y3 Teacher Survey</i>	<i>Y3 Classroom</i> <i>Observations Logs</i>	<i>Y3 Classroom</i> <i>Observations Logs</i>	<i>Y2 & Y3 Teacher</i> <i>Surveys</i>	<i>Y3&4 Data Meeting Logs</i>
Washington HS	2.8 (2)	N=6 4 - writing to explain 2 - without clear focus 1 - focused on lesson planning and assessments	N=6 1 - peer feedback 1 - structured talk and peer feedback 2 - peer feedback & writing to explain 1 - writing to explain 1 - "unfocused"	11% lessons w/AST N(obs)=28 N(teachers)=7 2 - Peer feedback 1 - structured talk 25 - No AST practice observed	2.4	N=7 & N=6 294 & 119	5 Y3 meetings * Wednesday formal meeting time, inconsistent * low data/AST focus * meetings disconnected from one another * none in Y4
Adams HS	3.7 (3)	N=5 2 - lesson planning and assessment 2 - no reported focus 1 - big ideas and MYP (pre-IB work)	N=5 1 - modeling, mapping claims with evidence to content standards 1 - modeling, causal explanations 1 - HOW/WHY explanations & reading supports 1 - HOW/WHY causal explanations 1 - unspecified	38% lessons w/AST N(obs)=24 N(teachers)=9 9 - Modeling based on anchoring phenomenon 15 - No AST practice observed	2.6	N=4 & N=5 206 & 599	0 Y3 meetings * more opportunistic meetings - after school, some shared planning * loose data/AST focus * no official Y3 meetings * Y4 meetings inconsistent

<u>Data</u>	<u>Studio Day</u> <u>Average (and</u> <u>Minimum) AST</u> <u>Practice Scores*</u>	<u>Teacher-Reported</u> <u>Focus of Work with</u> <u>Science Coach</u>	<u>Teacher-Reported</u> <u>Individual Teacher</u> <u>Focal Practices</u>	<u>Classroom</u> <u>Observations - AST</u> <u>[Sub]Practices</u> <u>Observed</u>	<u>Classroom</u> <u>Observation</u> <u>Average AST</u> <u>Practice Scores*</u>	<u>Average Annual</u> <u>Per Teacher</u> <u>Hours of</u> <u>Collaboration**</u>	<u>Data & Planning</u> <u>Meetings - Times &</u> <u>Focus</u>
<i>Source</i>	<i>Y3&4 Studio Day</i> <i>Logs</i>	<i>Y3 Teacher Survey</i>	<i>Y3 Teacher Survey</i>	<i>Y3 Classroom</i> <i>Observations Logs</i>	<i>Y3 Classroom</i> <i>Observations Logs</i>	<i>Y2 & Y3 Teacher</i> <i>Surveys</i>	<i>Y3&4 Data Meeting Logs</i>
Kennedy HS Campus (aggregated)	3.7 (3)	N=4 2 - lesson planning 2 - peer feedback	N=4 3 - structured talk & peer feedback 1 - peer feedback	24% lessons w/AST N(obs)=25 N(teachers)=6 5 - Peer feedback protocol/template 1 - Constructing models 19 - No AST practice observed	2.9	N=6 & N=4 140 & 158	6 Y3 meetings * mostly after school, but some "job alike" PCTs * high data focus; loose AST focus * meetings built on previous AST practice learning * increased shared leadership for meetings in Y4
Cleveland Academy	NA	N=1 1 - lesson planning, rubrics	N=1 1 - structured talk & peer feedback	0% lessons w/AST N(obs)=9 N(teachers)=2 9 - No AST practice observed	3.0	N=2 & N=1 87 & 46	campus-wide
Roosevelt Academy	NA	N=2 2 - peer feedback, and improved discussions/questio ning	N=2 1 - structured talk & peer feedback 1 - peer feedback	38% lessons w/AST N(obs)=8 N(teachers)=2 3 - Peer feedback protocol/template 5 - No AST practice observed	3.0	N=2 & N=2 222 & 178	campus-wide
Wilson Academy	NA	N=1 1 - lesson planning	N=1 1 - structured talk & peer feedback	38% lessons w/AST N(obs)=8 N(teachers)=2 2 - Peer feedback protocol/template 1 - Constructing models 5 - No AST practice observed	2.8	N=2 & N=1 82 & 228	campus-wide

<u>Data</u>	<u>Studio Day</u> <u>Average (and</u> <u>Minimum) AST</u> <u>Practice Scores*</u>	<u>Teacher-Reported</u> <u>Focus of Work with</u> <u>Science Coach</u>	<u>Teacher-Reported</u> <u>Individual Teacher</u> <u>Focal Practices</u>	<u>Classroom</u> <u>Observations - AST</u> <u>[Sub]Practices</u> <u>Observed</u>	<u>Classroom</u> <u>Observation</u> <u>Average AST</u> <u>Practice Scores*</u>	<u>Average Annual</u> <u>Per Teacher</u> <u>Hours of</u> <u>Collaboration**</u>	<u>Data & Planning</u> <u>Meetings - Times &</u> <u>Focus</u>
<i>Source</i>	<i>Y3&4 Studio Day</i> <i>Logs</i>	<i>Y3 Teacher Survey</i>	<i>Y3 Teacher Survey</i>	<i>Y3 Classroom</i> <i>Observations Logs</i>	<i>Y3 Classroom</i> <i>Observations Logs</i>	<i>Y2 & Y3 Teacher</i> <i>Surveys</i>	<i>Y3&4 Data Meeting Logs</i>
Madison HS Campus (aggregated)	4.3 (3)	N=4 1 - lesson planning + assessment 2 - lesson planning 1 - assessment	N=4 1 - selecting & sequencing & ELL supports 1 - accountable talk 1 - formative assessment	25% lessons w/AST N(obs)=20 N(teachers)=5 5 - Modeling in various instantiations (1 with sequenced share out) 15 - No AST practice observed	2.9	N=2 & N=4 798 & 629	4+ Y3 meetings * "Team" PCT Fridays * strong data focus; loose AST focus * meetings built loosely on past AST learning, but somewhat inconsistent * Y4 greater traction from teacher pairings
Jefferson Academy	NA	N=2 1 - lesson planning & assessments 1 - lesson planning (plus some notes about other strategies like GLAD)	N=2 1 - selecting & sequencing & ELL supports 1 - accountable talk	29% lessons w/AST N(obs)=14 N(teachers)=3 4 - Modeling in various instantiations (1 with sequenced share out) 10 - No AST practice observed	3.1	N=2 & N=2 798 & 667	campus-wide
Hamilton Academy	NA	N=2 1 - lesson planning	N=2 1 - formative assessment & feedback 1 - nothing reported	17% lessons w/AST N(obs)=6 N(teachers)=2 1 - Modeling in various instantiations 5 - No AST practice observed	2.8	N=0 & N=2 NA & 552	campus-wide

*AST proficiency was measured for 4 overarching AST practices on a scale of 1-5 and averaged across all practices & all observations.

**Teacher collaboration hours were extrapolated based on frequency of teacher-reported participation in a collection of activities.

All schools but one demonstrated capacity to engage AST practices with proficiency during reform professional development days. Teachers at the different schools demonstrated similar levels of working with AST practices during studio days and with coaches, with a couple of exceptions. At five of the six campuses, in studio days held during the third and fourth years of the science reform initiative, participants' collective level of engagement, as assessed by researchers for each studio day, registered on average, above 3.5 out of 5 on the teacher learning progression tool (Thompson et al., 2013; AST, 2017) and did not score below a 3 (out of 5) in any of the four science teaching practices assessed during any studios. One school, however, Washington HS, received multiple scores below 3 on the learning progression and averaged below 3 (nearly a point lower than the second lowest score among the other sites). This lower level of engagement by Washington HS teachers with reform practices was consistent with researcher qualitative observations of participants' conversations about instruction during the studio days. When compared to talk observed by researchers at other sites' studio days (Thompson et al., 2017), researchers found that participants at Washington HS talked less about theories of student learning or how to measure success in their teaching practice. They seldom made clear connections between their teaching practices and the evidence of student learning; rather, they focused primarily on activities and materials used on studio days. When given the option to employ AST tools and approaches versus more traditional approaches and tools, they often opted for the latter. In the context of studio day embedded professional development for AST reform work, when actively supported by science coaches and researchers, teachers at Washington HS actively resisted working with the reform practices unless they were able to reframe the practices within their own expectations of instructional activities.

Teachers within schools often aligned their focal practices with reform practices or with colleagues or with their work with a coach, but only one school in the study demonstrated teacher alignment of instructional practices across all of these dimensions. Beyond studio days, teachers' descriptions' of their work with coaches and of their individual instructional focus for the year varied among teachers at each school, with the exception of one school, Douglas MS. In the survey conducted at the end of the third year of the project, teachers were asked to identify the instructional practice on which

they were each focused, and to identify what instructional practices they were each working on with the science coach that year. At the two middle schools in the study, both of which had five of six science teachers respond to the survey, all of the responding teachers within each school reported working on the same individual practice with coaches – Douglas MS teachers all reported working on the AST practice around structured talk to improve student construction of evidence-based explanations of scientific phenomena; Lincoln MS teachers all reported working with their coach on standards-based planning. Additionally, when asked on this same survey what practices each teacher was working on that year, teachers at each campus listed a mix of different practices, many but not all of which reflected AST practices; notably, only one school, Douglas MS, reflected all teachers focusing on AST related practices and sharing a consistent focal practice. The teachers shared this practice among each other, as a personal focus, and it anchored their work with their coach. While teachers within a school often aligned some portion of their practices with one another, this alignment across multiple dimensions—the reform practices, individual focus on a particular instructional practice, individual work with coaches, and instructional work with colleagues—was not replicated at any of the other schools.

Only one school demonstrated high frequency application of AST focal practices with enactments that built on previous enactments of the practices; other schools demonstrated more occasional enactments of AST practices at a range of proficiencies. Schools varied in how often teachers engaged specific AST focal practices in their daily instruction, with one school significantly exceeding others in its teacher-driven application of the science reform across classrooms. In the third year of the initiative, researchers visited most teachers at all participating schools a minimum of three times. Specific AST-derived focal practices were observed to be at play in as low as 11% (Washington HS) and as high as 91% (Douglas MS) of observations, with schools averaging about 40% and all but one campus demonstrating AST practices in roughly one quarter or more observations. Researchers also used the AST learning progression to characterize the levels of general AST practices observed in the classrooms during these visits. For all but one school, average scores of the AST practices were lower (by roughly half a point) than what was observed on studio days. At Douglas MS, teachers scored an

average of nearly one point (out of five) above the average for all schools. Because these visits represent teachers' day-to-day instruction, these comparative scores suggest that the teachers at Douglas MS not only engaged AST practices more often, but did so with greater proficiency than teachers at other schools. Consistent with studio day performance, Washington HS scored lowest in classroom observation scores, further reinforcing that site's lower engagement with AST practices. Teachers at other schools also engaged the practices to varying extents, but their lower average observation scores on the learning progression suggest that the practices were at play less consistently and with lower proficiency.

Science teachers at different schools reported spending markedly different amounts of time on instructional collaboration, with two schools standing out, reporting consistently higher amounts than others. Two schools demonstrated consistently high amounts of instructional collaboration time among science teachers over the second and third years of the project; while three schools showed substantial increases in science teacher collaboration time and three showed drops from the second to the third year of the project. Researcher observations and teacher self-reports of the extent of instructional collaboration among teachers at each school further reinforce findings of higher levels of engagement by Douglas MS teachers and the inconsistent levels of engagement by teachers at other schools. Particularly during the third year of the program, researchers attended meetings intended for science teachers at each of the six campuses to engage collaboratively with each other around specific student data and related instructional planning. Douglas MS was one of the first and most regular schools to engage in this activity. In observations made by researchers attending meetings at different schools, researchers noticed that at Douglas MS, teachers consistently co-planned both lesson activities and instructional approaches. Conversely, at Washington HS, teachers chose to use their planning time to identify activities and standards they wanted to cover in each unit with little attention to instructional choices; further, Washington HS teachers often chose to deviate from shared unit plans. Teachers at the remaining schools collaborated on instructional planning to varying extents and with varying points of focus.

In the teacher surveys conducted at the end of years two and three of the reform initiative, teachers also self-reported on the frequency of their collaboration times around nine instructional

elements. These data were used to calculate average total number of hours of instructional collaboration time reported per teacher for the year. Data from both years 2 and 3 reflected consistently high participation in instructional collaboration by science teachers at Douglas MS, who averaged over 1100 hours of individual teacher time per year. Jefferson Academy teachers also reflected higher collaboration time (798 hours in year 2 and 667 hours in year 3) than other schools which ranged from an average individual teacher collaboration time of 46 hours per year to 2,387 hours. Lincoln MS, Adams HS and Wilson Academy all experienced substantive increases in science teacher instructional collaborations from the second to the third year, while Cleveland Academy, Roosevelt Academy and Washington HS experienced decreases. Both Douglas MS and Jefferson Academy demonstrated both high commitment to working on AST practices and put in the time to support that commitment; and Lincoln MS, Adams HS and Wilson Academy all demonstrated an increasing investment of time in instructional collaboration.

In summary, these contextual findings revealed trends in how different schools engaged with reform practices, including two schools that demonstrated particularly high and low levels of reform enactment, respectively. With these contextual findings in place about each school's comparative engagement with science instructional reform practices, I was better able to explore differences in the ways that principals engaged their sense-making and the sixteen leadership practices, and how those differences revealed trends in principals' influence on science instructional reform enactment. Specifically, Douglas MS consistently engaged the reform to a greater extent than other schools and Washington HS consistently engaged to a lesser extent. Particular inconsistencies reported above across schools offered grounded points of comparison for examining how differences in principal's leadership practices may influence various aspects of teachers' engagement (frequency, proficiency, collaboration, choice of focal practices, etc.) with the reform practices at those schools. Additionally, these findings about teacher enactment of reform practices seem to relate consistently to three emergent categories, described in the following findings sections, that capture the level to which principals make connections among priorities and practices.

Narrative Findings: Connections Among Principals' Sense-making, Leadership Practices and School Engagement with Ambitious Science Teaching Practices

In examining principals' sense-making and their leadership priorities, I uncovered three distinct categories (see Table 7) that described the extent of interconnectedness among multiple aspects of the ways principals approach their work. As part of setting direction for schools, one of the four categories of school leadership practices that I examined, principals identified various instructional priorities for their schools. The findings below attend to the extent to which principals identified connections among those different priorities (including science reform work), whether or not principals communicate with teachers about those connections, and to what degree principals link those school priorities and science reform to enactment of other leadership practices (related to developing people, redesigning the organization, and managing the instructional program). Principals ranged from holding priorities and practices that were very disconnected from one another, to maintaining loose alignment among priorities and practices, to integrating school priorities with one another, with the science reform, and with their other school leadership practices. Each finding exposes different types of connections at play in principals' sense-making and in their school leadership practices; and each finding identifies trends in how those connections are associated with different levels of school engagement with the science instructional reform.

In the first finding, I focus on what principals identified as school-wide priorities, and on how those priorities connected with each other and with science reform; I also examined how principals accounted for those priorities and the reform work in school leadership practices (including setting the vision, communicating the vision, fostering acceptance of a shared vision, and enacting other specific school leadership practices). In the second and third findings, I examine how principals brought their leadership practices to bear with respect to two very specific resources: coaches and shared collaboration time. Finally, in the fourth finding, I explore a specific school and the connections the principals and assistant principals there made among most categories of leadership practices in service of advancing the

reform practices. In the discussion section that follows, I further explore the leadership practices and connect them back to the conceptual model.

Finding 1: Most principals viewed science instructional reform efforts as consistent with but separate from their broader instructional priorities, and focused their leadership practices to advance their more generalized, school-wide priorities, leaving science teachers and/or coaches to define their own priorities for day-to-day instructional improvement.

Not surprisingly, secondary school principals identified instructional priorities for their schools that were broadly applicable across different disciplinary content areas (e.g., science, math, language arts, social studies, etc.). Whether principals developed these school-specific priorities themselves or with the input of others, the instructional priorities of each school echoed aspects of the district's 2013-2017 Strategic Plan. Some principals called out aspects related to the six student outcome goals (e.g., increasing graduation rates and decreasing suspensions), and most referenced the first of the four pillars of professional practices – “equitable access to rigorous, standards-based instruction” – that the district committed to apply in support of “effective instruction” and “higher levels of student achievement”. However, the degree to which principals explicitly recognized connections of their own school's work to the strategic plan varied, as did the level of explicit connections the principals made between their high level instructional priorities and the more granular initiatives (e.g., positive behavior intervention strategies (PBIS), setting learning targets, restorative justice, etc.), including the science reform (AST) practices.

This level of explicit versus implied connectedness seemed to impact the schools' capacities to shoulder multiple [supporting] initiatives at one time, particularly when principals foregrounded a particular initiative that they may have viewed as aligned with AST but that teachers did not experience as being entirely consistent with the particular AST reform practices they were exploring. I identified three sub-findings that further elucidate this claim.

Finding 1a: Generalized notions of instructional practices defined principals' instructional priorities, and principals varied significantly in how explicitly they recognized and communicated

connections among those priorities to teachers. Towards the end of Year 3 of the science reform initiative, we asked principals about their schools' instructional priorities. All but one principal explicitly called out promoting standards-based instruction as a top priority; and the principal who did not specifically name standards-based instruction identified specific practices related to it as her school's priorities. In addition, principals recognized an assortment of other priorities either in support of broader instructional and achievement goals or as more specific instructional priorities. Many principals identified priorities related to strengthening school culture and building relationships with students, specifically calling out initiatives like PBIS, restorative Justice, Sound Discipline, and generally helping "students to have a voice". Several principals referenced the Danielson teacher evaluation framework as guiding their schools' instructional pursuits. While there was some variation among the collection of priorities the principals identified, most were generally aligned with the district's strategic plan. The greater differences among principals' instructional priorities lay more in how, if at all, the principals connected multiple priorities to each other, and the degree to which principals made these connections explicit to their teachers. In particular, principals differed in how they enacted leadership practices of communicating the direction and fostering the acceptance of group goals. To illustrate these differences, I contrast two pairs of schools. I examined how the first pair of schools shared a high level instructional priority, but communicated about and fostered acceptance of that priority very differently from one another. In the second pair, I examined the consistency with which principals and assistant principals at the same school communicated about priorities and the extent to which these principals made connections among different priorities visible to teachers.

Contrasting two schools with shared instructional priorities: internal consistency among priorities and making connections among them visible to teachers was associated with greater instructional consistency and collaboration among teachers. The two schools on the Madison campus shared a principal and shared instructional priorities established by the cross-school leadership team (principal and two assistant principals, one from each school). These shared instructional priorities were anchored by two components in the Danielson Framework used by the district for teacher evaluation:

setting instructional outcomes and communicating with students. However, the two assistant principals communicated about these priorities very differently.

Jason, the assistant principal at Jefferson Academy, described how the leadership team established its instructional priorities to align with district and state goals:

My main focus is on, and was on, and continues to be on what our campus goals are. We've got New Pacifica School District goals and obviously when we develop our annual action plan and establish goals for our site, those are in alignment with New Pacifica School District goals and objectives, which are aligned with state goals and objectives.

When he initially identified the goals, Jason linked them directly to Danielson components “3a” and “1c”; and he described using staff meetings to focus on these Danielson components. He also used consistent language with the Danielson framework to describe these two components *and* the school’s instructional priorities. Jason appeared to extend the Danielson terms beyond a separated teacher evaluation tool and to apply Danielson as part of the day-to-day vernacular he used to frame and discuss instructional priorities with staff.

Additionally, Jason described how he actively linked the school’s top instructional priorities to other instructional concerns. "We also link those outcomes to common core standards and we spent time this year on curricular mapping and identifying what standards are being taught when and how." Over the course of our discussion, Jason connected the focus on learning outcomes to curricular standards and to the work of communicating with students. He also discussed a need for resources to support these efforts and he noted that he wanted to continue the teachers’ work with the science instructional coach *unless* the science teachers felt that “it creates work that's not aligned with the standards-based instruction." In short, Jason held an interconnected vision of the multiple instructional priorities; and he communicated the key connections to teachers, reinforced the anchoring aspects (standards-based instruction and the Danielson Framework) of those priorities, and engaged school leadership practices in support of those priorities.

In contrast, at Hamilton Academy, Assistant Principal Collette took a different approach with her school's leadership priorities. She described those priorities at a more granular level and did not offer an explanation for how they fit within the district's priorities, or the broader framework of standards-based instruction. She referred to the two goals as "student engagement" and "learning targets" that were "embedded in instruction." While consistent with the Danielson Framework components 3a and 1c, Collette expressed her priorities using different terminology. In my discussion with her, she did not acknowledge how these priorities linked to standards-based instruction. In describing her interactions with teachers around supporting these instructional priorities, she described focusing on them at a tactical level that she could observe and that her teachers could put into practice. For example, after a classroom visit to one science teacher's class, she described how she gave some positive feedback about student engagement and then mentioned, "I can see that there's a lot of rigor in your class. I didn't see the learning objective written down anywhere." Collette attended to the various instructional priorities, including the two around student engagement and learning objectives, and she also mentioned an additional instructional aspect of rigor in the classroom. She did not make links between these instructional aspects. Further, during our discussion, Collette described how one of her science teachers struggled to reconcile the AST approach of having students construct explanations with the school priority of including the day's objective on the board. Collette explained how she herself felt that the two were not in conflict, but she did not identify a role for herself in aligning those two instructional pieces for her teacher.

To better understand the implications of differences in how these two assistant principals communicated about instructional priorities, I considered the instructional engagements at each school as reported in the contextual findings above (see also, Table 6). Teachers at Jefferson Academy, where the assistant principal communicated a consistent focus and explicit connections among multiple priorities at the school, reported engaging in more instructional collaboration time than teachers at Hamilton Academy. Additionally, when teachers reported areas in which they worked with science coaches, teachers at both schools communicated lesson planning as a focus, but at Jefferson Academy, teachers also noted an additional connected practice at play (e.g., lesson planning *and* assessments, or, lesson

planning *and* GLAD strategies). Teachers from both schools joined together for AST-related professional development opportunities (e.g., studio days; data and planning meetings); yet in the combined situation, teachers at Jefferson Academy demonstrated more consistency with each other in how they engaged with AST practices than the teachers at Hamilton Academy. Researcher logs noted that, “even though teachers had common interest in scientific modeling, they were not on the same page.” The log further described how the teachers at Jefferson Academy took a common approach to modeling, but each of the teachers at Hamilton Academy approached modeling differently. Ultimately, the school with leadership practices that communicated more connections among priorities demonstrated instructional practices that were more aligned across both teachers and instructional priorities.

Contrasting two schools: coordinating priorities among multiple school leaders and forging connections among them for teachers. Principals and assistant principals at the same schools reported similar instructional priorities, rooted in the district’s strategic plan and aimed to address broad, cross-discipline aspects of instruction; however, the degree of alignment of instructional priorities among administrators at the same school varied. At both of the comprehensive high schools in this study, principals had regular contact with science teachers and supervised a subset of them; and one or more of the assistant principals at each school was responsible for supervising the other science teachers. During the third year of the reform initiative, leaders at these two schools illustrated contrasting degrees of connectedness between the two administrators sharing oversight of the science teachers.

At Washington HS, Cathi, the principal, and Laura, the assistant principal, communicated surprisingly different perspectives on the top instructional priority for the school. Cathi, the principal, identified the writing initiative as her top response for the school’s instructional priorities. Laura, the assistant principal who was responsible for evaluating most of the science teachers, identified standards-based instruction as the top priority for Washington HS, with particular attention to backwards planning and a need for students to understand what and why they are learning. When asked about any initiatives that positively or negatively impacted progress on key instructional priorities, Laura responded “I would say that something that is taking the most time away; that's negatively impacting would be the writing

initiative because teachers are...they just have so many different areas that they're focusing their time." Consistent with that sentiment, both Cathi and Laura identified multiple instructional priorities for the school, and they both referred to each as independent initiatives. They did not communicate connections between initiatives or describe any opportunities for teachers to reconcile multiple initiatives with one another.

The one shared exception was that both Cathi and Laura recognized the Danielson Framework as being consistent with their school's instructional work, and as having the potential to serve as an instructional tool; the assistant principal also called out the district's focus on using data to inform instruction as being aligned with Washington HS's instructional priorities. Cathi identified other instructional and related priorities including 95% graduation goal, "the effective teaching practices called out in the strategic plan", creating systems that can be maintained across turnovers in principal leadership, an upcoming focus on "student voice", a digital leadership core, and a future plan to get the science department to identify special instructional pathways (such as healthcare) that could be established for students to connect academic learning with possible local partner organizations (such as the nearby hospital). Laura called out fewer of the different initiatives, but did recognize the work science teachers were engaged in with the instructional coach. Laura suggested, "I just think that in our own building we have a lot of other initiatives going on that we are taking away from the instruction and we need to better focus". Teachers themselves also tended to view the initiatives separate from one another, talking about time they needed to spend on one versus the other. In some cases, they attempted to reconcile multiple instructional priorities with one another, but that was more the exception than the rule.

School leaders at Washington HS did not make connections for themselves or their teachers among the multiple initiatives at play, including their school-wide, cross-discipline writing initiative. Leaders at Adams HS demonstrated greater alignment in their view of instructional priorities, but varied in how they promoted those priorities in interactions with teachers. Principal Martha described Adams HS's instructional priorities in terms of standards:

I think overall, I think the past year we've been really focused on the standards-based instruction. What does it mean to teach to standards. How do you design a lesson with standards-based learning targets, and then also how to use assessment, especially formative assessment connected to those learning targets to really assess our kids making progress towards mastery or proficiency against a standard.

Independently, Irene, the assistant principal responsible for supervising several of the science teachers also identified the school's instructional priorities with respect to standards:

Our instructional goals are really around having people write strong learning targets and targets that reflect the standards so that they can ... There is that whole triangle about, if I have a good target and I am aligning my performance tasks to the target and my formative assessments are helping me measure that, then I am constantly in that cycle of assessment where I can be responsive to what students need in order to reach the goal. Our focus this year has really been a lot of learning how to write effective ones and then how to align my performance tasks to that and then how to assess that in a way that is effective.

Both principals focused not only on the idea of standards-based instruction, but also of how the different aspects of it fit together. Their work to foster acceptance of these priorities, however, was not as consistent, and reflected a lack of accessible connections among what teachers perceived to be competing instructional priorities.

Martha and Irene both endeavored to support science teachers in their instruction, and with respect to the school's priorities, and both focused disproportionately on teachers struggling with some aspect of their work; but their focus in those individual interactions varied. For example, walking through the science classrooms in the building, I regularly saw nearly every classroom with daily learning targets on the board for students to see, and I observed teachers giving students time to record, and sometimes, make sense of, the day's learning target. Martha described her interactions with teachers as focusing primarily on giving specific feedback about learning targets. However, when it came to the larger picture of instructional priorities, she admitted that she struggled with very different mindsets between the ninth

and tenth grade teachers and the upper (eleventh and twelfth) grade teachers. She expressed concerns that that upper grade teachers, who taught the International Baccalaureate (IB) program courses, seemed unable to see potential for using the standards-based approaches like grading that the lower grade teachers were enthusiastically adopting. While Martha believed that the instructional needs of IB could be reconciled with the broader school initiatives, she had not found a successful way to help the teachers see and explore those connections. Similarly, Irene described conversations with a teacher in which that teacher viewed the multiple initiatives at play (including the science reform, the standards-based work, the IB MYP work, etc.) as a list of separate items that he had to attend to and that he felt that he didn't quite have the bandwidth to fully do. Irene saw the various pieces fitting together but she hadn't found a way to translate those connections to her teachers. Additionally, when Irene worked one-on-one with the science teachers, she first worked to establish a focus with them for the year; and although she might have seen connections between the focus area and the school priorities, it was unclear if teachers were making those connections.

Overall, the school leaders shared prioritization of standards-based learning targets did translate to consistent classroom behaviors among science teachers, who all posted daily learning targets. However, the school leaders were not fully able to make connections they saw among instructional priorities fully accessible to teachers, and classroom instructional behaviors reflected significantly less consistency with adoption of related instructional priorities.

Interconnectedness: Finding 1a illustrates how generalized instructional priorities were not by nature adverse to the uptake of science instructional reform practices; however, the degree of connectedness that school leaders made for their teachers among general school priorities did impact teacher participation in reform practices. Principals' tendency to hold generalized instructional priorities was not inherently detrimental to advancing teachers' uptake of discipline-specific instructional reforms. However, the leadership practices of communicating direction and fostering shared acceptance of goals both impacted teachers' uptake of school priorities. When principals explicitly communicated to teachers, connections between the school's multiple instructional priorities, both the way they described

priorities and the way they planned professional development work, the schools experienced greater uptake of the priorities by teachers. Additionally, at schools with multiple administrators, when administrators communicated consistently about school priorities, teachers demonstrated greater enactment of those priorities. These different types of connections and alignment among aspects of school priorities and leadership practices converged and allowed me to characterize schools and their leaders into distinct categories that also related to the uptake of science reform at their schools.

I sorted schools and their leaders into one of three categories that reflected the degree to which different aspects of priorities and leadership practices were connected to one another: (1) disconnected, (2) loosely aligned, and (3) integrated. These categories, summarized in Table 7, were defined progressively as I clarified the characteristics of the connectedness relevant to each category of leadership practices. Finding 1 related primarily to leadership practices around setting direction—I observed trends in how different principals communicated direction, and how they fostered acceptance of group goals, that both related to the extent to which teachers enacted school priorities. Principals at schools in the disconnected category tended to hold multiple, distinct priorities that they promoted separately, and principals and assistant principals at the same school did not reliably express the same priorities for the school. Principals at schools identified as loosely aligned also held multiple priorities, and they saw connections between those priorities; however, they did not consistently articulate these connections to staff or design professional development plans that reinforced such connections. Principals at schools in the integrated category made explicit connections among their instructional priorities that they not only communicated to staff but also used to guide how they organized professional learning, made staffing decisions, and generally engaged in leadership activities. The more that principals connected school priorities to each other, the greater the traction that teachers demonstrated in implementing those priorities.

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Table 7 Three Categories of Connectedness among School Priorities and Leadership Practices, Summarized by Category of Leadership Practice

<u>Leadership Practices</u>	<u>Disconnected</u>	<u>Loosely Aligned</u>	<u>Integrated</u>	
Setting Direction	<ul style="list-style-type: none"> • Building a Shared Vision • Fostering the Acceptance of Group Goals • Creating High Performance Expecations • Communicating the Direction 	<ul style="list-style-type: none"> • Multiple distinct priorities, promoted separately • Inconsistent descriptions & promotion of reform among principal & AP(s) • Reform distinct from other priorities • Reform considered a support for school priorities, not a goal/priority of own • Take "hands-off" approach towards reform • Look for reform to shift to fit school priorities 	<ul style="list-style-type: none"> • Multiple consistent priorities w few explicit connections among them • Partially consistent descriptions & promo of reform among principal & AP(s) • Reform distinct from other priorities but viewed as consistent/supportig them • Refer to reform generally, not by practices • Do not promote reform; seek status updates • Do not shift view of school priorities in response to learning about reform 	<ul style="list-style-type: none"> • Explicitly connected instructional priorities made visible to teachers • Identify and cohesively promote same school priorities • Science reform a connected priority that informs how principals communicate about and foster acceptance of other priorities • Integrated professional learning plan, staffing, etc.
Developing People	<ul style="list-style-type: none"> • Providing Individualized Supports and Consideration • Offering Intellectual Stimulation • Modeling Appropriate Values and Practices 	<ul style="list-style-type: none"> • Professional learning plan promotes individual priorities separately & is disconnected from reform • Sometimes co-opts reform learning time to advance school priorities • Principal interactions with teachers focused on highly varied aspects of instruction, sometimes consistent with school priorities, not related to reform 	<ul style="list-style-type: none"> • Professional learning plan promotes school priorities; and is based on some assumptions about inherent connections between them • Professional learning plan disconnected from reform and some school priorities, though principals desired increases alignment with school priorities 	<ul style="list-style-type: none"> • Professional learning plan organized around integrated school priorities • Professional learning plan leverages reform practices • Individualized supports organized loosely around school priorities & coordinated across admin & coaches • Teacher leadership developed to advance school priorities aligned with reform
Refining and Aligning the School Organization	<ul style="list-style-type: none"> • Building Collaborative Cultures • Restructuring the Organization to Support Collaboration • Building Productive Relationships with Families and Communities • Connecting the School to the Wider Community 	<ul style="list-style-type: none"> • Provide little science teacher collaboration time • Often place requirements outside reform and school priorities when teachers do have time together 	<ul style="list-style-type: none"> • Collaboration time provided is largely allocated to advance broad priorities • Little or no time allocated for reform work outside scheduled studio days 	<ul style="list-style-type: none"> • Allocate time for instructional collaboration, including reform practices • Give teachers space to determine how to best use time & set dept priorities
Improving the Instructional Program	<ul style="list-style-type: none"> • Staffing the Program • Providing Instructional Support • Monitoring School Activity • Buffering Staff from Distractions to their Work • Aligning Resources 	<ul style="list-style-type: none"> • Expect coaches to drive science-specific work • Tell coaches needs • Ask coaches for info about teachers or reform; but do not adjust own approach • Push for highly individualized, disconnected support across teachers 	<ul style="list-style-type: none"> • Expect coach to drive science-specific work AND support other school priorities • Sometimes communicate expectations to coaches; • Listen to coach updates; rarely adjust own approach 	<ul style="list-style-type: none"> • Factor science reform and school priorities into expectations of coach • Engage in 2-directional communication with coach that may shift principal understanding & leadership practices • Expect individualized teacher support that advances shared priorities
Principal Participation in Reform Professional Learning	<ul style="list-style-type: none"> • Occasionally drop into reform professional learning events • Do not discuss granular reform practices • Make sense of reform practices without shifting their understanding of instructional priorities 	<ul style="list-style-type: none"> • Occasionally drop into reform professional learning events • Learn about reform practices but do not apply often in interactions with teachers • See connections to other priorities; do not shift other priorities in response 	<ul style="list-style-type: none"> • Active & regular participation in reform professional learning • Pro-actively talk with teachers about reform practices • Connect reform learning to advancing other school priorities & vice versa 	

Finding 1b: Principals treated Ambitious Science Teaching (AST) as separate from their active instructional priorities and most principals did not prioritize AST in their leadership practices and general decision-making. While principals varied in how they perceived AST practices, and in the support structures they provided to support AST enactment, principals generally described AST practices as distinct from school priorities and they did not recognize AST as any sort of intentional instructional reform to be implemented. Rather, to varying degrees, principals tended to treat AST as a support for other school priorities. In the findings outlined below, I first document how two principals described AST practices as effectively separate but consistent from broader school-wide priorities and manifested at most schools in a “hands off” approach by principals toward the science reform. Next I illustrate how the hands-off approach led to principals at many schools not attending or participating in science reform professional development activities at their schools, and at many schools, in principals dropping by but not participating. I discuss how these principals’ varying levels of participation in the professional development were associated with similarly varying inclinations to help teachers make connections between specific AST practices and general school-wide initiatives. Finally, I explore how those principals who participated more actively in AST professional development activities also tended to account for science reform work in other school leadership practices, particularly related to staffing and alignment of resources.

Treating science reform as being separate but consistent with school priorities allowed principals to take a largely “hands-off” approach to the science reform and was associated with less reliable and lower proficiency applications of science reform practices. Cleveland Academy and Wilson Academy are co-located on the Kennedy campus, but with separate principals leading each school. Principals at both schools believed AST practices were not only sound, but if adopted by their teachers, would improve science instruction at their schools in ways consistent with their expressed instructional priorities. However, both principals limited their discussion of AST to more of a generic approach to instruction and neither actively sought to promote the AST practices among their teachers.

Both identified misalignments among AST supports and their school-specific needs; and both saw limited AST enactments by their teachers, though Wilson Academy saw slightly more than Cleveland Academy.

Ana, the principal at Cleveland Academy, captured a common sentiment from principals at multiple schools:

Anytime I looked at the Ambitious Science Teaching practices, I always think, oh, this is good, this is what we're already doing, or what I'm aspiring to, so nothing feels like something over here that we can't do, right, it seems to all align with what we're wanting to work on as a school and a district, and align with Danielson, too.

She viewed the science reform, AST practices, as consistent with the instructional work of her school and of the district at large, and she acknowledged that AST was also consistent with their teacher evaluation framework (Danielson). However, she also talked about AST as if it were a black box of instructional practices that she had not unpacked to any significant extent. And she herself took a passive stance towards advancing the reform at her school, mentioning that she had not heard her teacher talk much about integration of AST practices this year. Researchers reported observing AST-specific practices at none of the nine classroom visits they made to Cleveland Academy's science classrooms during the third year of the science reform. Ana noted various potential reasons why her teachers were less engaged with AST practices this year than she expected, citing changes in coaches, less frequent AST studio days and touch points than in the past, and fewer opportunities for her teachers to collaborate with science teachers working on the same course subject. Ana expressed a sense of ownership for the quality of instruction in her building, noting, "I think, I mean, all instruction improvement in the building is, at the end of the day, my job; I feel responsible for it...I have some guilt about it too, because I feel like science hasn't gone well like I wanted it to this year." Despite holding a positive view of AST practices, Ana's leadership practices did not reflect pro-active promotion of AST reform work. She noticed that her teachers had not been talking about AST practices and instructional data validated that sense. During Y3 classroom observations, researchers did not observe particular AST focal practices at play in any of the observations

of either teacher's classrooms. Additionally, Cleveland Academy teachers engaged in the lowest reported average number of hours of instructional collaboration.

Similar to Ana, Marie, principal of Wilson Academy, explained that AST "really aligns with what we do and that's because my philosophy here is always a growth mindset." However, aside from purchasing structured support (part time support from a district science coach) from the district, her leadership practices did not actively promote AST practices. Marie described the studio days as "beneficial and helpful" because they gave science teachers "opportunities to come together with other science teachers...and also the opportunity to focus on the specific strategy, and come back and put it into practice, that they probably wouldn't have [otherwise done]." Marie recognized that despite her appreciation of the work, she did not provide opportunities for science teachers to engage AST practices, and she wished that the teachers could have additional studio days to work on AST practices. Teachers at Wilson Academy appeared willing to work with the reform. Researchers observed specific AST focal practices at play in three of eight observed science classes in year three of the initiative. Teachers' average instructional collaboration time increased from year two to year three; however the proficiency with which they engaged AST practices during observed lessons was below the average for observed lessons across all schools. In that vein, Marie looked to coaches to address the science-specific aspects of instruction by applying their "expertise to help my teachers with their curriculum, and wherever they're at with that." Yet, she also noted that she found the district-provided instructional coaches to be less useful than the site-based coaches because the district base coaches focused on the science curriculum-specific practices and did not support the larger set of school initiatives including "PBIS strategies, classroom management, setting expectations, standards-based grading." Overall, Marie was enthusiastic about the science reform practices, however, she maintained the science practices as separable from other core work, thereby limiting the time that teachers at Wilson Academy engaged with AST practices.

Principals' participation in AST professional development activities increased their likelihood of promoting specific AST practices and of connecting those practices to broader school priorities with their teachers. Very few principals actively participated in the science studio days or related professional

development and AST planning events. Those who did, discussed the reform practices at a more specific level and less as a singular [black box] item; and they were more likely to make specific connections for their teachers to the broader instructional goals. In the initial year of the reform program, of the five principals interviewed, only Harry from Douglas MS regularly attended and participated in the studio days. In addition to sending out an email highlighting particular next steps to his science teachers following a studio day, Harry explained that when giving positive feedback at the end of the day, he would “also try to connect it to some things that they’ve been working on in their practice, or things that we’ve been doing here in the building.” Anthony’s participation at Douglas MS studio days afforded him similar opportunities; and while his participation and follow up were different than Ted’s, he also tended to connect specific work the teachers were doing back to larger building initiatives. For example, when discussing the district’s data initiative, Anthony connected it to science teachers’ efforts using student work to dig deeply into how structuring of student talk to could help improve students’ written explanations. Anthony not only recognized that the AST work was relevant to the broader data initiative, he was able to link specific aspects of the AST work that teachers could leverage with the data initiative such that combined they helped teachers serve students better (specifically, with better designed unit planning that was responsive to student needs). Although neither Harry nor Anthony was able to attend entire studio days, they consistently prioritized making time to attend and participate in some portions of studio days during the course of the AST work. While school leaders at Douglas MS demonstrated the most consistent commitment to participating in science reform professional development with their teachers, leaders at other schools also made some time to attend studio days and also made some more specific connections between AST practices and broader school initiatives.

Principals at two other schools also participated in studio days and communicated specific connections between AST practices and more general instructional priorities. At Adams HS, during Year 2 of the AST reform initiative, Irene attended studio days and described how teachers subsequently sought to keep her abreast of their AST activities. She also remarked on how she was able to use her knowledge of the AST practices to help teachers with lesson planning. In one case, Irene described how

her knowledge of AST practices, specifically around student construction of explanations, gave her insight into how to help address one of her science teacher's struggles to allow students to take on the intellectual work to construct those explanations. Irene described how she hoped to apply an inquiry process looking at student work with this teacher to help them make progress (though she lamented not yet having had time to do so). Irene did not attend the studio days in years three and four, and as described above, she had more difficulty in Year 3 in helping her science teachers better connect and reconcile the multiple instructional initiatives at play, including AST.

At Lincoln MS, Olivia attended parts of studio days and related cross-school convenings of science teachers. However, she did not attend studio days in year three, and she lamented the fact that she had not prioritized AST for her teachers over the past year or so because she needed them to focus first on stronger backwards planning and other aspects of standards-based instruction. However, she felt like the teachers were at a point to re-engage more deeply with the AST practices and she was able to suggest a potential convergence between AST and backwards planning for that re-engagement – specifically around construction and evaluation of scientific models that are leveraged in AST. Even with limited attendance at studio days, principals made more specific references to and connections with AST practices, but did not seem to sustain those connections during years when they were not participating in the studio days.

Principals who attended but did not actively participate in studio days did not make as many specific connections between science reform practices and broader instructional priorities. At Washington HS, during the first year of the science reform, Principal James attended portions of multiple studio days, however, he did not participate in any of the professional development reflective or embedded activities, and he expressed frustration in reconciling the AST practices. He viewed students' initial activities to construct explanations of scientific phenomenon as being "elementary" and not reflective of a "grade-level-like expectation." Rather than forge connections between the reform practices, James actively looked to coaches and researchers to customize the AST work to reflect priorities at Washington HS. He wondered, "When are we going to get to actual strategies that will help create the conditions for students to learn?" Consistent with this disposition, during studio days, teachers

pushed back on implementing AST practices in their planning, their instruction and their reflections. Structured researcher notes from year one studio days at Washington HS explain that, “The LIN did not collectively problematize teaching/learning,” and, “Talk about [instructional] improvement seems to center on talk about which new strategies/practices [teachers] can apply in their classroom and not as much about individual teacher learning.” Additional researcher notes summarize one example of teachers reframing AST practices occurred during their third studio day in year one.

[Teachers] insisted on reframing [the AST what/how/why model of assessing the depth of student explanations] to fit their own partial understandings of the model - insisting on keeping what, how, why as a linear progression through which they expected to see students move sequentially in lessons...which tends to be more consistent with direct instruction dispositions of unrolling concepts to students in a sequential and organized fashion and is not entirely consistent with AST practices of supporting student reasoning around constructing explanatory models.

The assistant principal in Year 3 dropped in for a few minutes of various studio days, but also did not participate. Not unlike many reform efforts, teachers at Washington HS reduced AST instructional practices to activities that fit within their own notions of instruction and their scores on AST practices both during studio days and during independent observations were lowest among all participating schools. Both principal Cathi and assistant principal Laura expressed concern over the lack of rigor with which two of their teachers in particular were implementing general and focal practices, but neither made specific connections between AST practices and broader instructional priorities at the school.

At schools where principals did not attend any substantial part of studio days, principals generally did not discuss specific AST practices with researchers, even when asked; and while some made connections between AST and broader instructional priorities in conversations with me, neither they nor their teachers reported them drawing these connections in their interactions with science teachers. For example, Jason at Jefferson Academy did not identify specific aspects of AST practices when interviewed, but during the science learning walk he shared his appreciation of the anchoring events used to provide students a shared exposure to a scientific phenomenon at the beginning of a unit. He explained

that the real-world and relevant nature of those events aligned well to his school's focus on citizenship and Jason wondered how that aspect of the AST lesson might be further exploited in service of the citizenship focus of the school. So while Jason did connect broader school priorities with the AST-based lesson, he did not promote the AST practices. Teachers at Jefferson Academy engaged enthusiastically in the science reform work, but they were not entirely consistent in their instructional focus (as described in contextual findings) and, when observed by researchers, employed AST focal practices less than a third of the time, demonstrating an average proficiency of practice. Collette had seen AST work at play in her schools for three years (two at Hamilton Academy and one at Cleveland Academy) and she described how she made sense of the practice of students constructing explanations to reconcile it with a need to provide students with a learning target for the day without giving the students the explanation they were supposed to construct. She suggested that sometimes learning targets could foreground science *skills* rather than *content*. Despite making this connection for herself, Collette did not report discussing this connection with her teachers who were struggling to reconcile these very initiatives with each other. Overall, principals who did not participate in the reform professional development opportunities were less likely to discuss specific AST practices and were unlikely to make explicit connections between AST and broader instructional initiatives in their interactions with science teachers.

Principals who were more likely to communicate connections between specific AST practices and broader school priorities were also more likely to make staffing and resourcing decisions that actively supported the science reform. In addition to making fewer direct connections between AST practices and the school's direction (i.e., instructional priorities), most principals did not take AST into account when making staffing decisions in the science department. Although principals did not seek to undermine the science reform, they did not actively consider the implications their staffing choices would have on the enactment of the reform. Only one school in the study, Douglas MS, proactively considered the science reform in its staffing choices.

When Douglas MS elected to participate in the science reform initiative, the assistant principal, Harry, recognized that the middle school level program did not include instructional coaching support

from the district, and he negotiated with the principal at the time to invest in some part-time coaching support. Harry explained, “We can’t be doing all the studio work and there’s no follow-up coaching in the classroom. It can’t just exist in isolation.” Additionally, when new science teachers were hired at Douglas MS, Harry intentionally elected to hire them from the university teacher preparation program that was rooted in the same AST practices. At the end of year three, Eva and Anthony were faced with the need to hire two science teachers and they also chose to hire teachers experienced with the AST practices. Anthony considered their work to set a focused and connected vision for the staff as part of their way of protecting teachers’ time to focus on the right things. Anthony explained, “We try to stay as hyper focused on a few things that we want to do in the building so that we're not all over the place.” He characterized the level of trust that he and Eva put in their teacher leader as another contribution to helping the team have time to focus on consistent priorities, stating that the current department lead’s...

...strength as a leader of that [science] team, we just more or less let that ride, and I think it may end up paying off. You can only have so many bosses. You only have so many people tell you what direction to go.

In addition to making staffing decisions and aligning staffing and other resources, the principals at Douglas also buffered their science teachers from additional demands that would distract from their shared priorities. For example, Anthony explained that when the district required presence representing each school at particular district events, if the initiatives didn’t align with the science team’s priorities, he felt that the principals “have an understanding of what’s being asked of our teachers,” and if something was not a good use of their time, then he or the principal might choose to attend instead, which they did for a particular district-sponsored science initiative during year 3 of the reform work. Overall, Douglas MS school leaders actively considered the reform work both in how they communicated and fostered instructional priorities with the science team and also in how they conducted school leadership to support improving the instructional program; and the Douglas MS teachers invested considerably more time in enacting AST practices than any other school.

In making science-department related decisions around improving the instructional program, principals at other schools did not seem to bring science reform work to bear in their school's leadership practices. For example, at the end of year three, when Adams HS chose a new science department chair, rather than selecting a teacher who had prioritized AST practices, they knowingly selected a teacher that both Irene and Martha recognized as struggling to enact AST work. In Martha's words, "[This teacher] needs to work on less lecture, less control, not control, but she really manages her classroom and she's in control of every step in the classroom and she's highly organized and very smart." In year four, two different teachers stepped up to help lead the AST work, but they were not fully coordinated with the department chair and teachers at Adams HS continued to struggle to reconcile what they perceived as many different priorities, though they engaged enthusiastically with AST work during studio days in Year four.

School leaders at Washington HS displayed a similar lack of consideration of the science reform efforts when selecting teachers to participate in leadership opportunities. When they assigned their science department chair who would serve during the fourth year of the reform, they selected a teacher who had consistently pushed during studio days to restructure the AST practices to align with staff's existing approach to instruction rather than considering changes to their ways of thinking about instruction. In the third year of the program, when choosing a science teacher to serve on the school-wide literacy work group, Cathi and Laura chose a teacher who similarly reconfigured AST practices to align with his more traditional approaches to instruction. Consequently, teachers at Washington HS were not aligned in their instructional practice or even in their planning. A couple of teachers shared with the research team that they would like to engage more deeply with the AST practices, but they had so little support from their colleagues that they didn't have the capacity to figure out all the details and do all the planning on their own. AST focal practices were observed by researchers least frequently at Washington HS and proficiency with AST general instructional practices was lowest at Washington HS. The degree to which principals factored the science reform work into their school leadership practices around

improving the instructional program was consistent with the degree to which their teachers opportunities to work with AST practices were uncomplicated and leveraged.

Interconnectedness: Finding 1b illustrates how principals' tendency to disconnect the science reform from school-wide priorities not only created confusion among teachers reconciling the two, it also seemed to result in principals factoring the reform into fewer of their school leadership practices, thereby providing fewer supports for AST enactment at their schools. Finding 1b also reflected differences among how interconnected principal's priorities and practices were, particularly with respect to the broader reform initiative. As shown in Table 7, at more disconnected schools, principals took a "hands off" view towards the reform, tailoring few, if any, of their school's leadership practices to actively promote enactment of the reform. They did not leverage the reform work in their individualized instructional supports for teachers, focusing instead on highly varying aspects of instruction; and they did not actively participate in learning opportunities to better understand the reform itself or their teachers work with it. Principals at more loosely aligned schools considered the reform work as separate from other school priorities and did not actively promote it. They did express an appreciation for the reform work, referring to it in broad terms (e.g., the university work, or the "structured support" – the name by which the district referred to combination of the coach time and the studio days); and while they may have learned about particular aspects of the work, they rarely applied that learning to their instructional interactions with teachers or in their other enactments of school leadership. Principals who operated at schools with a more integrated approach participated in professional learning opportunities about the reform with teachers and applied their knowledge about specific reform practices to their building of a shared vision, construction of a professional learning plan, and other school leadership work. Overall, the more connected principals' treatment of the reform was with respect to the breadth of the school's leadership practices, the greater the teachers' enactment of science reform.

Finding 1c: Separate promotion of generalized instructional priorities unintentionally reduced engagement with science reform and sometimes caused confusion for teachers. Principals sometimes promoted particular school-wide learning foci (e.g., reading skills, writing skills, etc.) that they assumed to be generic and broadly applicable, but teachers often perceived conflicts between the generic instructional initiative and some aspects of AST practices. Beyond the treatment of AST as separate from other priorities, the act of promoting those other priorities isolated from the reform introduced teacher-perceived dissonance between enactments of the general priorities and AST practices that was left for teachers to reconcile, largely on their own. In such cases, particularly when principals did not make direct connections between the general initiative and the science reform work, teachers tended to opt to apply the generic, school-promoted priorities and to engage the AST practices less often, or with less proficiency. In the first comparison presented below, I illustrate how two school's different approaches to a school-wide writing initiative result in very different impacts to teacher enactment of AST practices. In the second comparison, I describe how two schools' attempts to leverage studio days in service of more generic school-wide initiatives diminished teachers' interactions with the science reform practices. Finally, I describe a selection of generalized instructional feedback that principals gave to teachers and I identify some complications that feedback provided with respect to teacher enactments of the science reform.

Reconciling school-wide initiatives with AST – foregrounding AST practices resulted in a higher proficiency enactment of the science reform than foregrounding the generalized practices. At some schools, principals sought to produce more targeted instructional alignment across the different disciplines at their schools, and the difference here also lay in the alignment, but this time in how principals addressed discipline-specific nuances of the instructional priority. During the third year of the reform effort, both Washington HS and Douglas MS distributed ownership for writing instruction across teachers of multiple disciplines. School leaders at the two schools made very different decisions about how to reconcile differences between the general elements of writing instruction and the discipline-specific elements of writing instruction.

As noted above, school leaders at Washington HS did not explicitly describe connections among their many school priorities; and similarly, while school leaders did endeavor to support teachers making connections among the common aspects of writing that cross disciplines, they did not make space for teachers to connect the writing initiative to discipline-specific aspects of writing. At Washington HS, principal Cathi acknowledged that, “Our school wide goal was that we would teach writing across the content areas.” She assembled a team of teachers from different departments to define a single cross-discipline rubric to support a school-wide effort to promote students “writing to explain”. Teachers in different disciplines were expected to support students as they learned to write and students were required to submit three writing assignments over the course of the school year to be graded with the shared rubric. During the development of the shared rubric, one of the district science instructional coaches provided feedback that the focus on “writing to explain” was very different from the student construction and writing of science explanations, and that, as presented, the cross-discipline rubric was more reflective of what we would consider in science to be descriptive writing. The feedback was not well received and school leaders communicated frustration to the district administrators that the science coach was overstepping her boundaries. Eventually, some minor changes were made to the rubric, but it remained focused on descriptive writing rather than construction and communication of evidence-based explanations. Despite this disparity, science teachers at Washington HS felt it was important to actively support the school-wide initiatives and they modified their own science explanations rubric and instructional choices to align with the school-wide more initiative.

As science teachers applied the cross-discipline rubric to their students’ work, they noticeably shifted their assignments away from student-constructed, evidence-based explanations of scientific phenomenon and turned to assignments that better leant themselves to more descriptive level writing. When the instructional coach engaged in planning with the teachers, she pressed them to present students with opportunities to construct evidence-based explanations, but most science teachers, with a couple of exceptions, chose to present writing assignments that, while they did ask students to explain their thinking about particular scientific questions, these assignments offered students fewer opportunities to construct

complete scientific explanations. During Washington HS studio day professional development conversations, when teachers scored student work, they applied a different set of criteria from the AST reform criteria and their scoring pressed students for less rigor and less accountability for connecting evidence to their claims. So while the cross-school writing initiative aimed to help establish consistency in writing across subjects, that prioritization resulted in an implementation that was not only not aligned with discipline specific instructional work, but that actively resulted in science teachers moving away from reform practices to accommodate the school-wide instructional priority.

School leaders at Douglas MS took a different approach to promoting cross-discipline instruction for writing by staging the roll-out across disciplines, beginning with specific disciplinary teams to identify strong implementations that apply to that discipline. Eva, the principal at Douglas MS, explained the writing instructional priority in this way:

My picture, my vision, as we move forward is to understand that our whole school had the responsibility to the reading and writing of non-fiction. That cannot be carried by a language arts department, so understanding what reading, and writing, and non-fiction looks like is a whole school's responsibility. (Eva)

Eva indicated that Douglas MS was beginning this effort only in social studies, and she recognized that they “haven’t got to science yet, and health yet, and art yet...” She went on to explain how the social studies group was looking at how to apply the literacy themes, first ensuring that students have a purpose for reading particular text, that they are writing every day, and that they are identifying central ideas. She recognized that there are many different types of writing and that it is important for teachers and students to share a common vocabulary to distinguish among them. She further recognized differences in the extent to which different disciplines employ the different types of writing, noting, “I think in science you tend towards a smaller set of those pieces of writing, whereas in literature and the language arts places you’re going to actually hit a few more of those types of writing.” While all this was in progress, she and the assistant principal also continued to acknowledge and encourage the writing work being done in science.

Both the assistant principal, Anthony, and the principal, Eva, at Douglas MS recognized some of the very specific aspects of the writing work being done in science classes and noticed elements of it that would be productive to share across disciplines. For example, when discussing how science teachers would determine how they can design units of study, Anthony noted:

If they're staying hyper focused on explanations and what students are writing and what they're saying and really teasing out because that's where it's at. The questioning and discussion and to that extent writing is the heart of what our kids are really able to do.

Similarly, Eva recognized that she wanted to see science teachers continue the work they were already doing around student writing, specifically:

What I don't want to stop doing is the questioning and discussion, and how does questioning and discussion turn into writing, so how do you build questioning and discussion so that you are again practicing the skills, these big ideas, through oral, and then how do you turn that into writing.

Although these aspects of writing – the questioning and discussion and the providing explanations for big science ideas – are not what they were working on with the social studies literacy work, both Eva and Anthony noticed these practices and wanted to see the teachers continue them. Both the seventh and eighth grade science teachers not only did continue to examine this work in their classrooms for the course of the entire third year of the reform effort, they were creating rubrics to help call out the key components of this scientific writing for their students, they elected to use their data meetings to examine how different approaches to talk were effecting students writing by comparing writing about a topic both before and after specific talk with peers. And they were spontaneously applying different ideas about writing both in their classes and even in their “advisory” periods working with students from across the school outside of classes. One teacher created an elements of explanatory writing chart that, when Eva heard about it, she made an explicit note to share the material with teachers in other disciplines who were working on writing skills. She was explicitly leveraging the discipline-specific work and sharing across the school. Anthony took similar actions previously to share work the teachers were doing with structured partner talk with teachers trying out similar instructional practices in the math department. In

parallel, these two school leaders consistently acknowledged successful instruction from the science teachers (and teachers in other disciplines) and shared relevant parts across the school to benefit all teachers/students and to create common instructional and skills-based vocabulary to be shared by teachers and students. They did not work from a single, generic model, but instead, looked from each discipline and then identified sharable ideas in way that respected teachers' discipline-specific work and provided them new instructional ideas that they could connect back to their disciplines.

When principals actively prioritized general instructional initiatives over AST practices: Two cases of schools where teachers unintentionally co-opted some of their studio days to serve broader school-wide priorities. As discussed in previous sections, principals at both Lincoln MS and Washington HS intentionally chose to prioritize advancing more generalized instructional work with their teachers (backwards planning in support of standards-based instruction at Lincoln MS and cross-discipline rubrics for explanatory writing at Washington HS). When presented with the opportunity, teachers at these two schools similarly chose to plan one or more of their studio day embedded professional learning opportunities to enact more generalized instructional priority of their schools. The embedded classroom lessons that teachers experienced on these days produced student work samples that made it challenging to assess students' depth of participation in reasoning about science ideas and in constructing explanations, both fundamental aspects of the AST reform that the studio days were designed to advance.

Lincoln MS teachers chose to focus one of their studio days in Year 1 on blended learning (an approach of running multiple simultaneous and related activities, including one technology-centric activity, all in service of a particular area of learning, that students cycle through over the course of one or two days of instruction). While providing multiple activities connected to a single phenomenon generally aligned with the AST practice of providing students with multiple sense-making activities anchored around a scientific phenomenon, the activities themselves did not reflect a deep consistency with AST practices. As the researcher logs reflect, "There were opportunities for students to think about the how and why, but they were somewhat limited in number and were not deeply supported in the way questions and worksheets were structured." Further, the researcher log explains that "While the unit was focused on

a model, the activities were not tightly connected to the model.” Teachers were able to observe students during the studio day, but students did not have many opportunities during the lesson to explore the deeper scientific levels of “how” and “why” the scientific phenomenon had occurred; this was particularly true with respect to the vocabulary exercise that students completed on their laptops. The teachers’ choice to reframe studio days to promote their school’s other priorities resulted in reduced sense-making opportunities for teachers about AST practices.

In Year 1, Washington HS teachers chose to focus aspects of multiple studio days on a school-wide, cross-discipline initiative to provide reading supports to students. In such studio days, lessons were created that prioritized use of a piece of text from which students were asked to find evidence that could be applied to explaining a larger scientific phenomenon. Researcher structured logs from studio days reported that “Discussions focused more around evidence and less around explanation.” On another occasion, researcher logs reflected that “The activity componentized aspects of the explanatory model [such that] student responses to each component tended to stay in the what zone with a little bit of talk about how, but not connected to the core explanatory science principles associated with the model.”

When coupled with Washington HS’s tendency to reframe AST practices within their existing instructional models, this focus on the reading initiative detracted from opportunities that otherwise might have used to more deeply explore AST practices in a context that better supported their application. In using the readings, teachers also seemed to spend less time discussing the science of the lesson.

Researcher logs and as well as comments made by teachers, suggested that teachers held a conception that they already understood the science so they did not need to spend time talking about it. However, “the team did not come to a common consensus about the scientific explanation for the relevant aspects of global warming” which led to inconsistencies in assessing student work. Overall, Washington HS experienced less frequent and lower proficiency instantiations of AST practices both within and outside of studio days. The school’s approach of foregrounding their school’s priorities and their own conceptions of instruction mirrored that of their principal and continued to define their limited approach to AST work into the fourth year of the reform.

Principals' more generalized instructional feedback to science teachers, in absence of conversations about science-specific practices, sometimes led to teacher confusion about how to reconcile general instructional priorities with AST practices or about which to prioritize if the teacher perceived them as separate work. When principals interacted with science teachers, they tended to provide generalized instructional feedback, sometimes linked to their school-wide priorities, but usually not grounded in AST practices. While in many cases, the result was that the interactions reinforced and prioritized instructional practices other than AST for teachers to tend, sometimes, the feedback introduced teacher-perceived conflicts with AST that teachers struggled to reconcile. The principals did not always recognize these introduced conflicts, and even when they did recognize them, they struggled to help teachers reconcile the conflicts because the principals did not share the teacher's perception of conflict. One of the most common areas in which principals provided direct instructional feedback to teachers that was separated from discipline-specific reform practices was in the area of classroom management, an issue particularly salient at schools with newer science teachers. Although usually not in direct conflict with AST practices, the shifted focus for the teacher introduced complications. For example, even in a highly integrated approach school like Douglas MS, when supporting a struggling new science teacher, Anthony moved into the space of classroom management separate from science instruction and learning. In one instance, as this teacher struggled to regain the attention of her students, she focused all her attention on recognizing student attention behaviors, praising students who were quiet and ready to listen; but when one student offered a response to the science question this teacher had posed, rather than capitalize on the response, this teacher ignored the science response and continued to focus attention on the other students. In the end of this particular class, the teacher had garnered little participation in the science work, losing the attention of those students who were ready to participate while she stayed focused instead on the other students. This teacher's approach to the classroom management strategy was likely not quite what the assistant principal, Anthony, intended, however, it was how the teacher applied his isolated feedback about implementing a classroom management strategy. At Lincoln MS, Olivia also focused some isolated attention on classroom management practices, and recognized that this focus,

combined with some other school priorities, did take the attention of the teachers and reduce their capacity to engage with the reform practices. While these instances were not designed in any way to diminish teachers' interactions with and advancement of AST practices, they did just that.

Isolated promotion of other instructional practices similarly diminished teacher's focus on AST, presenting instead unsupported work needed to reconcile what they perceived to be competing instructional strategies. In one case, as noted above, Collette at Hamilton Academy was pressing a teacher to publish daily learning targets, but the teacher struggled to understand how she could publish at the beginning of class what the students were supposed to learn and still spend the lesson allowing students to construct an explanation for a scientific phenomenon – she was afraid the learning target would give away the end point. While Collette internally solved this in her own mind by considering other dimensions of learning, such as skills, around which one might create a learning target, the teacher did not see that perspective, and consequently struggled to sort out the two practices – providing learning targets and facilitating students' construction of evidence based explanations (a fundamental piece of AST). Hamilton Academy was not the only school where teachers needed to reconcile AST with principal promotion of more general instructional priorities.

At Adams HS, Irene encountered other teacher-perceived instructional conflicts. Above I described issues one of her teachers raised about reconciling multiple instructional priorities; here, I cite her promotion of class meeting space as a tool for teachers to utilize in their classrooms. While the idea of gathering students into a meeting space to introduce a new skill or concept, then release them from the space to do independent work, and still maintain a reform approach to learning, was not problematized for Irene, it was for her teachers. Construction of evidence-based explanations implies that students do not first master a skill and then repeat application of that skill in independent work, so Irene's description of the practice of meeting space conflicted directly with teachers' understanding of the AST practices; yet they felt compelled to apply the meeting space approach because their evaluator was promoting it. I watched the teachers apply this approach on multiple occasions and I saw them evolve their way of using the meeting space time. On the first occasion I observed this practice in one teacher's classroom, he had

the students writing chemical formulas in meeting space and he held them there until they had successfully completed a set of problems, then he released them to work at their desks. But the next time I observed that teacher use meeting space, he used the time to orient the students to a particular science phenomenon and some data they had collected about it, subsequently releasing them from the space to go and make further sense of the data. The second application was more aligned with a reform-based approach, but it took this teacher multiple months to reconcile for himself these seemingly competing practices. And several other teachers did not make the same leaps in reconciling the two approaches, consequently reducing the proficiency of their applications of the AST practices. Similar to principals' more broad and isolated promotion of school priorities, their instructional feedback that was isolated from reform introduced hurdles for the teachers as they tried to reconcile with and stay focused on reform practices.

Interconnectedness: Finding 1c illustrates the potential for general school priorities to undermine the progress of reform practices when the two are segregated from one another. Again, this finding further illustrates the varying degree of connectedness between the reform and school leadership. (See Table 7.) As illustrated in finding 1C, principals operating in a disconnected manner provided widely varying instructional feedback to teachers that was seldom associated with reform practices, and sometimes conflicted with it. Further, reform learning opportunities at these schools were sometimes repurposed, and AST practices were often reframed, muddying teachers' designated opportunities to learn and apply reform practices in a supported context. At schools where connections between reform and other leadership work were loosely aligned, reform was also treated as mostly separate from other priorities. Professional learning plans generally did not integrate aspects of AST, and principals' feedback to teachers, regardless of principal participation in any reform learning events, tended not to leverage specific AST practices. Further, any learning the principals at loosely aligned schools did about AST did not appear to guide any changes in priorities or school leadership practices. At schools where principals took a more integrated approach, science reform practices were actively connected to school

priorities and were leveraged in service of them. Individualized supports for teachers were loosely organized around school priorities and were coordinated across multiple administrators and any coaches. Teacher leadership was intentionally developed and was partially anchored by reform practices; and principals actively and regularly participated in reform professional learning. The more integrated the reform practices were into school leadership practices, the less reform efforts were undermined by promotion of broader school priorities; and often promotion of the school priorities also supported enactment of the AST practices.

Finding 2: At schools that allocated greater time for science teacher collaboration and flexibility for how teachers used collaborative time, teachers planned for and enacted AST practices more often and in ways that built upon teachers' prior learning about the practices.

Schools that chose to build collaborative cultures and to restructure the organization to support collaboration (two categories of school leadership practices) in ways that prioritized collaboration within individual departments generally demonstrated the most engagement with AST practices. Science teachers at some schools were able to compensate for a lack of department planning and collaboration time by organizing meetings after school or during rare opportunistic times. Teachers' likelihood of leveraging the department meeting time in service of AST work was also constrained by the degree to which school requirements or implied expectations constrained department meeting time, effectively reflecting the degree to which the school chose to buffer staff from distractions to their [AST] work (a leadership practice). Two additional factors impacted the utilization of shared time in service of AST reform enactment, particularly during collaborative data and planning time: the presence of an AST "expert" (e.g., coach or researcher) who actively oriented discussions around AST practices, and, in some cases, the ability to work with teachers from other schools on a shared campus. I describe these factors in the following paragraphs by outlining relevant school-based narrative summaries.

When school leadership practices made more department collaboration time available to science teachers, they engaged more often in reform practices and in ways that built more on ongoing teacher learning about the practices. Despite having collaboration time built into the overall

school structure, science teachers struggled to find times to work together to plan and refine enactment of AST practices. School principals held different views about the extent of control they could exert over formal collaboration time, and consequently school leadership practices varied accordingly in allocating and organizing collaborative opportunities for teachers. The New Pacifica School District certificated teacher contract allotted ninety minutes of professional collaboration time (PCT) “for the purpose of promoting student learning” on most Fridays during the contracted calendar year for a total of roughly 32 days each year. One quarter were allocated for individual teachers to use at their own direction (“individual” PCT days); one quarter were allocated, again at teacher direction, for “collaborative work by small teams of teachers/specialists on building or district priorities” (“team” PCT days); and half were “determined by the building principal”. Of the half the principal directed, half of those were fully left to principal discretion (“building” PCT days) while the other half were required to be “identified and reserved” for collaboration by cross-school groups with similar job responsibilities (e.g., PE teachers, music teachers, librarians, etc.) – the latter were referred to as “job alike” days. Schools varied considerably in how they applied school leadership practices to coordinate the use of these days. Some principals, like Collette at Hamilton Academy, felt like they had no say in how any of these times were applied. She explained, “We don’t control any of it. The only thing the principal can control is the principal initiated days. That’s only a quarter of how many days there are.” Alternately, others actively coordinated staff to organize how they would use all but the individually directed PCT days, or at least the “building” PCT days.

Ultimately, only three schools regularly and reliably provided science department collaboration time to their teachers: Douglas MS, Jefferson Academy, and Hamilton Academy (in conjunction with Jefferson Academy). Interestingly, Douglas MS and Jefferson Academy were also the only two schools that made a concerted effort to provide common planning time to their science teachers. In Year 3, two of the three Jefferson Academy science teachers shared a planning time, and in Year 4, all three shared a planning time. At Douglas MS, all science teachers shared two consecutive planning periods, one of which was intended for individual planning time and the other for collaborative planning time. During

the collaborative planning time, the entire department met at least once a week as a department (though that declined later in the year) and at least once a week in content teams (teachers who were teaching the same course). In Year 3, teachers in the eighth grade science team reported meeting with each other almost daily as part of their planning for class.

Teachers from both the seventh and eighth grade science teams at Douglas MS remarked on how much they valued their common planning time. A seventh grade teacher commented, “I think for sure the department meetings move us forward when we get to work together as a group and we have a team goal in mind.” An eighth grade teacher described the informal touch points that the content team shared on a daily basis, noting that they were, “always talking about...how's it going? Like, how's the lesson going? At lunch. There's always a check-in there. Like, where are kids struggling? What are they saying that's like oh, didn't expect them to say that. That's cool. Or, even in the hallway. Just ... did you guys get stuck on number ten? Us too.”

This pervasive culture of collaboration built up over time, with these teachers reporting the highest number of average hours per year engaging in instructional collaboration in Year 2, and the second most in Year 3. Rather than decrease their out-of-school planning time, this culture seemed to encourage that as well. Another teacher from the group described how, “We would meet on Saturdays or Sundays to plan out the whole next unit. At least figure out our skeleton outline, what we’re going to do.” With strong instructional plans and materials in place, Douglas MS teachers were able to discuss not only preparation and delivery of activities and materials, but also reflect on how students reacted to the lessons. The eighth grade teacher’s above comment expose this, and so did the teacher’s monthly data and planning meetings held during the shared planning period in Year 3. Researcher logs reflect that Douglas teachers consistently examined student data (e.g., written and oral explanations and feedback) and applied learning from the data to their lesson planning, including both the development of materials and the selection of reform-consistent instructional strategies. From one monthly data and planning meeting to the next, despite sometimes examining seventh grade student data and other times examining eighth grade student data, the science teachers were still able to focus on a single AST focal instructional practice

around using structured peer feedback to improve written explanations, and to build on their learning about that practice from one meeting to the next.

Teachers at Jefferson Academy experienced a similar phenomenon of being able to utilize regular data and planning meetings, held during PCT time, to focus their learning about a shared AST focal practice. However, they held a common data and planning meeting for their entire campus, including science teachers from both Jefferson Academy and Hamilton Academy. In Year 3, two Jefferson Academy teachers shared a common planning period with each other, but Hamilton Academy teachers did not report shared planning times with each other or cross campus with Jefferson Academy teachers. Jefferson Academy teachers had the opportunity during the school day to continue conversations about their modeling practice in times outside the data and planning meetings. Researcher logs indicated a disconnect among the Jefferson Academy and Hamilton Academy teachers in Year 3, and stated, “Even though the teachers had common interest in scientific modeling, they were not on the same page.” The research log described how the two teachers with common planning executed most of their lessons rooted in the AST practice of modeling, while the third Jefferson Academy teacher also focused on regularly revising models and the two Hamilton Academy teachers attempted to apply modeling, but with less success, “[The two Jefferson Academy teachers with shared planning] did most of their lessons with models, [the third Jefferson Academy teacher] tried modeling (focusing on model revision), [one Hamilton Academy teacher] was struggling with teaching itself, and sometimes tried to develop model scaffolds with researchers or coaches, but often felt that they did not work, [and the second Hamilton Academy teacher] connected modeling with engineering.” The Hamilton Academy teachers did not have additional opportunities to work with the group on AST practices outside of the studio days and these data meetings. So while the data meetings did afford them some opportunity to work on the reform, in the absence of time to process that work with their peers on a more frequent basis, they struggled with both the proficiency and the frequency of their reform practice enactments.

In stark contrast to Douglas MS and Jefferson Academy, teachers at Washington HS had very little time to plan with their departments or their content teams. PCT time seemed to be taken up by a

host of other requirements and the flexibility for teachers to meet as departments during the official Wednesday after school meeting time was unpredictable. In attempting to join teachers for this meeting, I arrived on more than one occasion to find that the time was not available to departments or content teams after all and the teachers were expected to participate in another activity at that time. Teachers expressed frustration that the schedule for when they would be able to meet was sometimes late in coming and often changed. This Wednesday time, was intended to focus on creating content team professional learning communities (PLCs), however, both teachers and principals acknowledged problems with its execution. The principal noted that, “One of the things we're going to change next year or have mandated regularly pre-scheduled department meetings for our teachers in all departments because that's been missing. That's full departments but we will also have content team PLC work that is expected and regularly scheduled.” Teachers also did not have shared planning or other regular collaborative time with one another. On the occasions when they did have this time available, teachers were not inclined to apply the time to explore reform practices, but instead wanted to collaborate on the set of activities they would use for the next unit, how they might order them, and the logistics of who could create and share which materials.

Washington HS typified how in schools where collaboration time was not readily available, in the irregular instances when such time occasionally became available, teachers were not well positioned to apply that time to work on AST practices. For example, at Washington HS, when collaborative meetings occurred, the science coach regularly attended the occasional biology content team meetings in Year 3. She tried to bring teachers’ attention to AST practices, at least in terms of the opportunities their activities would give students to engage in revising models or constructing evidence-based explanations. However, she primarily worked to support the teachers address their pressing need to plan the unit, identify standards, and select accompanying activities. In Year 4, the teachers similarly had little time to work together and did not show capacity to take on deeper exploration of AST practices. The coach described working with teachers during limited common planning times in Year 4.

Their collaboration structures are just so minimal this year than they have been in the past that people just don't feel like they ever have time to collaborate or plan together, and even when they

do, they have these factions: These two people are going to plan together, and these two, instead of all four. So they just both never feel like they know what's going on. They don't feel like they have enough support to feel ... Like, when I go to plan with them, they just want to think about, "What am I doing tomorrow?" or they need somebody to just tell that they are overwhelmed.

Washington HS teachers did not engage with AST practices to any great extent. Despite that, they did try to take up some of the reform, by trying out focal practices like structured talk, or by organizing some of their instructional units around an anchoring scientific phenomenon. For example, the coach described one teacher who consistently tried to implement AST practices.

She will do initial model. She'll ask the kids to revise. She'll have them do a final model. She'll have them usually do some sort of feedback or something along the way and thinks about the kinds of evidence that kids would need further along. I think in general ... I think that's ... She's implementing really what she thinks is Ambitious Science Teaching and thinks that the part about really being responsive to student ideas, and ... she still also operates with, like, what's the right idea. She'll even tell me ... Like pressing for students, she's still not quite sure how to ask students questions or press their understanding. It's more about what's right or wrong, and it even makes its way into the rubrics and stuff. Like, a previous version of the rubric that we created, I tried to get rid of all the things that said it's incorrect or thorough and was more like ... it was just didn't include those kinds of things and they ... She was like, "Oh, I need them back. I put them back in." So I think she's very consistent with her implementation of what she would say is Ambitious Science Teaching, and I think it's ... probably she does it the most out of anybody.

But with a lack of time to make sense of these instructional practices together, the Washington HS teachers have consistently implemented them with low levels of proficiency and lower frequency than other schools.

Though less extreme, other schools with significantly limited collaboration time showed similarly lowered engagement with reform practices. Due to the lower number of teachers in each department, smaller high schools on the Kennedy Campus tended not to organize their "team" PCT days around single

departments, but instead chose to organize around cross-discipline teams (e.g., Wilson Academy) or combined teams (e.g., math and science together at Cleveland Academy). Thus, mostly only those teachers able to commit personal time after school had the opportunity to engage in collaborative data and planning days, yielding highly variable engagement of teachers with AST practices. Even at a comprehensive high school, like Adams HS, it was difficult for teachers to find time to collaborate. Some teams had common planning periods, but by Year 4, that was limited to only the tenth grade science team, who felt pressed to use that time to advance their day-to-day needs and broader school priorities. A science coach described how that not only limited Adams HS teachers' opportunities to collaborate with one another, but also constrained Adams HS teacher leader opportunities to collaborate with teachers from other schools.

One of the weaknesses here is that [the Adams HS teachers] never have time to meet as a department. So when we have the teacher leader days and [the Adams HS teacher leaders] come and the conversations are around collecting data and discussing with your department. Well you heard them today talk about like, "Well this is really great ..." 'Cause this is only probably the second time they've met the whole group. And the first time was the first studio day. So they don't have that built in time for the department to meet or to look at work. So when [the Adams HS teacher leaders] don't really have much to contribute, or when you guys are talking about things, I always feel like, "Oh they don't really think...there. They can't make this connection." Compared to [Madison Campus], who have just run with it, are taking it on, and bringing the new teachers sort of under their wings and having day-to-days, and getting them together, and now they're going to start looking at student work. Like they're actually making the attempt to take those days and they have that time built in during PCT time to do it."

Despite this fact, researchers did observe Adams HS teachers enacting the AST focal practice of modeling in their classrooms. With little time to collaborate outside of working individually with the coach, their proficiency with the overall AST practices in Year 3 was observed to be below the average (scoring an average of 2.8 out of 5; average score across schools was 3.0). Schools with greater opportunities for

teachers to collaborate, particularly in relation so AST practices, like Jefferson Academy and Douglas, scored an average proficiency of 3.1 and 3.8, respectfully.

When teacher collaboration time was less tightly controlled, via required products or specific expectations of outcomes, but was anchored in a strong alignment between reform practices and instructional priorities, teachers' engagement with reform practices increased. When science teachers had regular opportunities to collaborate, in cases in which they were given flexibility to define use of their department or content team collaboration time, they engaged more extensively with AST practices. Collaboration time at Lincoln MS represents this in extreme fashion – the teachers there collaborated regularly with one another, yet they intentionally chose to use that time to advance other school priorities and not reform practices. Consequently, they held only two data and planning meetings during Year 3 (in contrast to the four to six meetings at most locations). Further, Lincoln MS teachers did not build on their learning across data and planning meetings, but instead looked at learning from only one meeting at a time. That said, when Lincoln MS teachers did choose to engage with AST practices, their regular meeting time seemed to ensure that such engagements involved most teachers such that researchers observed AST focal practices at play in Lincoln MS classrooms in half of their visits. Setting expectations for the shared planning time, if aligned with reform practices, may increase teacher engagement with the practices; however, in most cases that expectations or structures were established around collaboration time, they were not aligned with AST practices.

Contrary to the expressed belief of the Washington HS principals, the need to impose external structures on science teacher collaboration time did not lead to greater traction with AST practices. Cathi, the principal at Washington HS explained that she believed, “Then the PLCs, we have a lot to do to define, to help teachers make the most of the time they spend in their PLCs.” Laura, a Washington HS assistant principal, reinforced that sentiment adding her own belief that in addition to structuring the teachers' time, the school leaders should be present to facilitate that time. She explained, “If I structure time for them then there isn't somebody then helping to facilitate or to coach or then what are they ... you know. Then they don't have the support base either.” However, at Cleveland Academy, Ana did provide a

structure for her teachers to use during their designated collaboration times. At Cleveland Academy, the math and science teams were assigned to meet together during their “team” PCT days.

So the PLCs have kind of been a challenge, I would say. Right now what's worked well for our math and science team is that they are pretty much working independently on different things, but it's all related to rubrics and backwards planning, and they're all in the same room. They do a check-in to start with some of our science coaches, math coaches, what's everyone working on? They all fill out this Google form, or spreadsheet, whatever, that says what they're doing, questions that they have, and they go work for a little bit. I've seen them, they'll ask each other questions and work with the coaches. At the end they come back together and say, "Here's what I accomplished, here are my next steps." They record it in the form and they ask each other questions, clarifying questions, comments on what each other are doing, and I've seen the work in the classroom, right?

Rather than focusing PCT opportunities on building a collaborative culture (a leadership practice), Ana chose to organize PCTs to provide more individualized supports to teachers (another leadership practice) in a collocated space where teachers and coaches could be resources to one another. She also chose not to use the “team” PCT to align resources (another leadership practice) to instructional practices, but instead to align them around a meeting protocol that also provided individualized supports to the teachers. Teachers at Cleveland Academy were not observed enacting any AST focal practices during any researcher observations during Year 3.

In contrast, Jefferson Academy teachers were observed enacting focal practices in Year 3, just under a third of the time and Douglas MS teachers over 90 percent of the time. Unlike the aforementioned schools in this section, Jefferson Academy and Douglas MS maintained an instructional practice focus during Year 3 data and planning meetings such that they \increased their depth of engagement with particular reform practices. In Year 3, both schools not only chose to provide additional time, beyond PCT, that helped build a collaborative culture and structured the organization to support collaboration (both leadership practices), they allowed teachers freedom in defining exactly how to use

that time to support their work, allowing teachers to more organically align resources (another leadership practice) to their existing instructional priorities, which included attention to and grounding in reform practices. Such freedom did not imply an absence of structures or expectations, rather it allowed for such constraints to be established by the teachers (and coaches and researchers) who attended the meetings. The principals at Douglas MS recognized and appreciated how well-structured the science department meetings were. Anthony, their assistant principal explained, “There's clearly a leader in the group and a respected leader in the group, who comes prepared when they meet and who is hyper focused all the time that they spend together, and on outcomes. Outcomes are so incredibly important. It makes no sense to sit down with a group of people who haven't identified what the purpose of that meeting is.”

Douglas MS maintained a very consistent meeting structure that pressed its teachers to stay on task and to respect one another's needs. They also employed a researcher provided protocol when looking at their data, adjusting the balance of time allocated to each aspect of the protocol, to favor data reflection or follow-up planning time based on their given needs at any given meeting. Such teacher-imposed processes freed Anthony to focus on his perceived role which he described as, “My role is to make sure everybody is aligned. The second one was support, to find out what it is that they need to achieve their goals as a department.” The science teachers at Douglas MS echoed these sentiments, indicating that not only did they value their time together, but also the freedom with in it. One of the seventh grade teachers explained, “I think for sure the department meetings move us forward when we get to work together as a group and we have a team goal in mind ... I feel like we have that freedom to do what we want as a department, but of course we have the constraints of what standards were gone be teaching to. But nobody ever told us how.” Like the assistant principal, and several other teachers, she recognized that alignment among the teachers and administrators around the department's priorities were an important factor.

Shared goals and expectations were helpful to Douglas MS in advancing AST practices in Year 3, but less so in Year 4. As the priorities for the school became more focused on standards (as alluded to by the teacher quoted above), the teachers shifted much of their time away from an AST focus, and spent

their collaborative time tending to anchoring lessons around the standards. This tension between standards and facilitating student construction of evidence-based explanations for scientific phenomenon was present in Year 4 studio day planning and discussions. In one instance, a new teacher to Douglas MS resisted organizing a lesson around the group's ongoing focus on structured peer feedback to improve explanations until first spending the majority of allocated planning time grappling with which standards that day's lesson should take into account. While mapping a lesson to standards is important and not inherently orthogonal to AST practices, the shift in balance of how collaboration time was used substantially reduced the amount of time during which the group was able to reflect on, learn about, and apply reform practices. In May of Year 4, another teacher summarized the Douglas MS's attention to data and planning meetings, which had been an anchoring point of their department-wide collaboration in Year 3, as not being very present in their collaborative practices.

We did not really do any data days this year. We have been putting most of our energy into making new rubrics based on NGSS standards and tweaking our practice to fit the new standards...It's been harder to do gapless explanations, unless the standard is "construct an explanation..." or something similar. The performance tasks in the standards just dictate a bit more of what exactly we end up doing in class.

The expectation that teachers would spend collaboration time attending to standards mapping, and the lack of clear alignment of that school priority with the science reform practices reduced the school's engagement with AST practices.

When science department or content team collaboration time was attended by a science coach or university researcher who actively guided the work and conversations around AST principles and strategies, teachers engaged more extensively with AST practices. When principals chose to invest in coaching supports (part of "staffing the program"), they substantially increased the coaches' impacts on the school's leadership practices when they coupled the coaching with science teacher collaboration time (assuming the collaboration time exceeded a minimum threshold to enable meaningful collaboration around reform practices). Although district coaches spent the majority of their

time at specific schools working to provide “individualized supports” to teachers, when given the opportunity, they helped build collaborative cultures and align resources (specifically teachers) around as AST framework for science instruction. Additionally, they appear to have contributed to direction setting as well, but helping science teachers build a shared vision that was rooted in AST practices, in fostering acceptance of those group goals when time was available, and in consistently communicating the direction to science teachers.

In Year 3, at those schools who met to collaborate about data and planning work, coaches, researchers, or sometimes both, committed to attend the work sessions. When teachers used their own time to engage in this work, or they felt that they were provided enough collaboration time to address building priorities and reform practices, the presence of a coach (or researcher taking on a coaching role) at their meetings increased their engagement with AST practices. In these instances, teachers seemed to value the support of the coaches and be open to their suggested direction. However not all schools maintained an open disposition to coaching direction. As discussed above, at Washington HS, teachers felt a need to take advantage of their infrequent collaboration opportunities to simply plan units and activities, and the coach felt obliged to support this focus, though she did so from an AST-rooted instructional framework. Similarly to the situation with an individual Washington HS teacher in which the teacher simply rejected the coach’s inputs because she could not reconcile them with her own perceived needs, the Washington HS content teams treated coach input similarly, taking up those items they could easily reconcile but rejected those ideas they could not. A lack of planning time offered little opportunity for teachers to revisit those decisions with each other (and the coach).

In contrast, the Jefferson Academy teachers did have regular time to collaborate and they particularly valued input from the coach. One of the Jefferson Academy teachers explained how she felt supported by her assistant principal (who supervised the science teachers), but relied primarily on the science coach for instructional guidance. She summarized, ““I feel like [her] feedback, my science coach, is the one that drives my instruction the most. She's the one that impacts it far more than any other one. I think [the assistant principal’s] is like a little bit, but [the science coach] is definitely the one that has

helped me grow as a teacher the most.” This teacher also expressed an appreciation for the studio days and the university supports for the reform work. She explains that she finds the studio days more useful than other professional learning opportunities, “...cause it's our kids. I just find them humble, I always take something away from it, where other PD, I'll sit there and be like okay...” The university researcher, sometimes in partnership with the science coach, facilitated the Year 3 data and planning meetings, and some in Year 4 as well. The teachers were very receptive to this, and even the teachers from Hamilton Academy, attending with the Jefferson Academy teachers, attempted aspects of the AST practices, anchored in work they did in the data and planning meetings.

Douglas MS exposed a more complicated story, but that is consistent with the finding that coach presence in collaborative meeting times increased teacher engagement with AST practices. The school began its engagement with AST practices with support from a district coach, which was discontinued after Year 1; however, the school invested in a part-time science coach in Year 2, but then shifted that investment to all-STEM coach in Year 3. During Year 3, the researcher (myself) stepped in to play a coach-like role in data and planning meetings as well as studio days; and teacher engagement with AST practices was particularly high. But in Year 4, I was unable to continue that role, and the school did not replace their science coach. As described in more detail above, in Year 4 at Douglas MS, teacher engagement with AST-practices declined. In contrast, despite a lack of collaboration time, teachers across the Kennedy Campus who chose to use their own after school time to meet, supported by a coach, demonstrated increased collaboration rooted in the AST framework. The coach seemed to play a key role in “fostering acceptance of the group goals” and “communicating [consistent] direction” based on reform.

Teachers at smaller schools on shared campuses sometimes increased their engagement in AST compared to what they might have based on opportunities at their own school alone, when they were able to meet and collaborate regularly with teachers from other schools on the campus. When schools did not provide adequate collaboration time for teachers to regularly engage in AST-rooted collaborative planning, teachers on multi-school campuses were sometimes able to compensate by investing their own time in collaborating with teachers from different schools across the same campus.

Effectively, the leadership that the teachers took to forge these relationships yielded additional capacity to build collaborative cultures, build a shared vision around AST-related practices, at least among a subset of colleagues, foster the acceptance of group goals related to AST, and align resources (the teachers themselves) around a shared vision of instruction. This situation was observed at both Kennedy Campus and Madison Campus. In Year 4, at Madison Campus, teachers from Hamilton Academy connected with Jefferson Academy teachers during studio days and data and planning meetings, but then extended their work by using their own time to meet in content team pairs (one member from the more AST-experienced school, and one member who was less AST-experienced and yielded from the more “disconnected” school). Research logs described how teachers in Year 4 often made common tools to gather data.

Before, they had common interest in modeling, but their instructional practices were not aligned. But in Y4, the teachers often developed common tools to gather data (e.g., teachers' checklist for the structured talk opportunities, exit tickets, peer feedback rubric). Furthermore, before, they sometimes shared their model scaffolds but did not plan together to make ones. In Y4, the teachers sometimes worked in Jefferson Academy-Hamilton Academy pairs according to the grade level that they teach, and had time to co-design model scaffolds for their lessons. All the Jefferson Academy teachers have some experiences in modeling but all the Hamilton Academy teachers are new to the team & the teaching profession. In the early days, the Hamilton Academy teachers depended on Jefferson Academy teachers to get some instructional materials and advice, and this promoted their grade level collaboration across schools.

As noted above, the initiative of teachers in creating additional collaboration time also connected those teachers and their work to more leadership practices that established the context for their work, and helped align those practices, at least in some instances, with the reform efforts.

Kennedy Campus teachers also took leadership initiative to meet outside of school scheduled time. In that case, not all teachers participated, but those who did engaged more with AST practices. In Year 3, teachers held data and planning meetings mostly on their own time (though they were given “job-alike” PCT for a couple of meetings). Of their six meetings, three teachers attended four or five meetings.

Not only did these teachers engage in AST-framed reflections on student data and subsequent instructional planning, they focused on a common practice and built on their learning across meetings. In Year 4, when teachers were invited to participate in a science teacher leadership program organized around the reform, three teachers, one from each school on the Kennedy Campus, signed up and they all attended and participated regularly. The research logs described how these teachers have built a more collaborative culture across the schools in Year 4. While the impact on classroom practices was not measured, the logs also note that more teachers are pro-actively participating to facilitate studio days, which are rooted in AST practices. The research logs noted:

They have definitely been collaborating more [in Y4], but I am not sure if that has translated to a difference in their classroom practices. They have been more actively co-planning for biology together and using and adapting each other's materials...I am not sure if they had *more* data meetings than previously, but it seems like they've had better attended data meetings that they co-plan for as well. One thing that is noticeable to me from having attended studios at the school is that they split the facilitation intentionally and have started adapting some of the studio day practices. For example, rather than co-planning for the host teacher's subsequent lesson or by content area (which is what has historically happened at [Kennedy Campus]), [one teacher] helped the group identify various aspects of the feedback practice that they would like to improve, and then planning was devoted to developing group resources. While I'm not sure how much of the practice has been showing up in classrooms, it felt like [Kennedy Campus] had a practice thread more this year than in previous."

In contrast to other schools that had little collaborative meeting time available, those at Kennedy Campus were able to build collaborative opportunities among peers across their campus. This appeared to develop an increasingly "collaborative culture" that was also aligned with reform practices, and consequently, it seemed to lead to increased participation in AST-related work by science teachers across the campus. Leadership practices particularly relevant to an interconnected stance towards school leadership and reform adoption included those linked to setting direction, establishing collaborative cultures and aligning

resources. Conversely, schools that were more disconnected tended to constrain collaboration opportunities to impacts related to leadership practices around providing more individualized supports and very few other categories.

Interconnectedness: Finding 2. As discussed in the previous finding, teachers at schools whose leadership practices were more interconnected to each other and to the reform, showed greater engagement with reform practices. More disconnected schools tended to make decisions that limited the impact of teacher collaboration opportunities while those schools in the integrated category made decisions that magnified the impact of collaborative work to advance reform enactment. Schools in the loosely aligned category demonstrated a mix of magnifying and limiting leadership choices related to the reform. Further, schools' interconnected dispositions also influenced the extent to which collaborative time was leveraged to promote AST practices. For example, in schools where school priorities and reform practices were more aligned, a lack of imposed structure on teacher collaboration meetings yielded high levels of AST-promoted work. The presence of a coach or other expert also helped to enhance the impact of collaboration time on advancing AST practices. And teacher-initiated leadership for AST work also enhanced impact of collaboration on creating more lasting structures to help reinforce the enactment of AST practices.

Finding 3: Principals relied on science coaches to provide discipline-specific support, but most principals reduced coaches' impacts on reform practice enactment by also directing coaches to promote other, more generic, instructional priorities and by limiting coach participation in school leadership.

Most principals provided direction to coaches that aligned with the “separate but consistent” view principals held around science-specific versus generic instructional priorities. The resulting disconnect in instructional coaching between reform practices and general instructional issues manifested from multiple factors, including principals' sense-making about and direction to coaches, coaches' own views of their roles, and the extent to which coaches participated in or had influence over school leadership practices. All principals viewed science coaches as content experts and looked to them to provide science-specific

instructional feedback, but they differed in how they expected and directed coaches to provide that expertise. Coaches themselves reinforced some of the disconnectedness between reform practices and other aspects of instruction. Further, principals took widely varying approaches to integrating coaches' expertise into school leadership practices that influenced enactment of the science instructional reform. Ultimately, coaches provided valuable instructional supports to individual teachers, and sometimes to teams of teachers, but those supports did not coherently or explicitly advance development of a common teaching and learning framework intended by the reform. In the following sections, I explore the aforementioned factors in more detail.

With few exceptions, principals' directions to coaches diluted coaches' impacts promoting science instructional reform. Principals tended to rely on science coaches to provide science-specific instructional feedback to teachers but also communicated other instructional priorities to coaches to address. Additionally, most principals, in an attempt to individualize the supports provided to teachers, encouraged coaches to allow teachers to guide the direction of their work with coaches. This combination of effectively competing priorities – AST, principal direction about working with teachers, and teachers' own input about their needs – reduced the proportionate time and attention that teachers and coaches paid to reform practices in their work together. In the following sections I describe first, how these competing priorities manifested at four schools, and second, how principals' sense-making about coaches' work differed even more than its execution.

Only one school took an approach that fully integrated the work of the principal, the work of the coach, school priorities and AST into a coordinated effort, while other schools aligned only a subset of these. At Douglas MS, Anthony described how the school's entire approach to individual coaching work is coordinated among both staff and with building priorities. In looking for the teacher to help establish a focus for their work with the coach, Anthony explained,

Ideally, a teacher and a coach would identify areas of the teacher's practice that needs some observation, first of all. Some teachers know what they want to look at and in doing so, the coaches are not only going to look for what the teacher wants the coach to observe but also

identify anything that we see as ... Especially when we think about our initiatives here but anything that we know is going to support teaching and learning in the classroom especially as it relates to the initiatives in the building.

Anthony further explained how teachers, coaches and principals can have their “blind side,” so they need to be able to keep each other in check and be honest about what they observe and believe is needed.

Teachers at Douglas MS consistently focused on the same instructional practice both for their own work and in their work with a coach (as reported in the teacher survey from Year 3). Researchers found the teachers at Douglas MS to be engaged in AST focal practices on over 90 percent of their Year 3 visits. Conversely, most other schools in the study exhibited less cohesion tying their coaching work together across teachers and with school priorities and reform practices. The following paragraphs describe three schools – Wilson Academy, Jefferson Academy, and Lincoln MS – that illustrate the partial alignment of resources with respect to coaching work.

At Wilson Academy, Marie’s sense-making about coaches and her direction to the district science coach at her building typify these tensions, viewing one role for the coach, but then also asking the coach to take on an additional role. On the one hand, Marie noted that, “The curriculum piece is where I reach out to my science coaches and my math coaches because that’s their specialty. I need them as expertise to help my teachers with their curriculum, and wherever they’re at with that.” Yet, Marie also explained that she needed coaches to support individual teacher needs, which did not tend to relate to AST practices. “[The principal told the coach,] ‘I really need you to just spend your time with [one particular teacher], helping her lesson plan, and getting her down, feeling confident that she can write a lesson plan on her own without staying here until 9:00 o’clock at night.’ Through that work, that teacher really grew because they were only focusing on one thing, but then I was able to support her with the things that we have in our own PD, like PBIS, classroom management stuff.” Marie saw a role for herself and one for the science coach, and she saw those as loosely aligned with one another, but only with respect to her own priorities and not with respect to any goal of advancing AST. Consequently, teachers at her school did

engage with reform practices intermittently, but not consistently, with researchers in Year 3 reporting observed lessons that applied AST focal practices only about 38 percent of the time.

At Jefferson Academy, Jason described a similar division of roles between the individualized supports he provided teachers and those provided by a coach, however, unlike Marie at Wilson Academy, he did not directly add to the coach's role. Jason explained, "I feel strongly that our science teachers have progressed in their instruction thanks to the outside coaching that they've received. More so than the coaching that I've been able to ... I've been focused on our site-based goals, but the real science and how students learn science I think comes from the science experts." He maintained that division of labor, but he did ask that the science coach pay heed to the needs of the teachers. As the Year 3 teacher survey indicates, each teacher reported holding a different individual focal practice for the year – one focused on selecting and sequencing of share-outs as well as providing English language learner supports in their lessons, while another focused on accountable talk among her students. Additionally, in their work with coaches, these two teachers both reported working on lesson-planning, but they each added a different element along with the lesson planning – one worked on assessments while the other addressed GLAD strategies. While these teachers did converge on points of common professional learning, they also chose to work on multiple non-reform rooted aspects of practice with their coach. Researchers in Y3 observed AST focal practices at play in Jefferson Academy classrooms on 29 percent of their visits.

At Lincoln MS, the coach and principal were very aligned about their work with teachers. They made decisions together about where they would focus their efforts, they communicated with each other, and they both actively participated in providing individualized instructional supports to science teachers. However, they chose to not align their work with the science reform. Olivia, the principal explained how she and the science coach worked with the new science teachers, "The coaching was on classroom management, it was not on deeper work." Olivia also noted how the coach allowed experienced teachers to set their own area of focus with the coach. The coach shared a similar view of her work with the teachers, explaining, "There's a lot of work that I'm doing with teachers that is not necessarily...it's not misaligned, it's just additional work that's not part of AST." She went on to identify a number of

different areas in which she worked with individual teachers, including: encouraging teacher to circulate more among students and ask questions that will help students be successful with their exit tickets at the end of class; being strategic about student leadership opportunities and classroom routines; classroom management; and checking for understanding during class. Teacher-reported data interestingly do not report their work with the science coach from the same perspective – all teachers reported working with the coach on the same practice – standards-based lesson planning, which although not entirely antithetical to reform practices, is not entirely aligned with those practices. Teachers did, however, report multiple individual focal practices for the year, including evaluation of student data, modeling and structured talk. These individual focal practices do align with the science reform, and teachers were observed by researchers as putting these practices in action in about half their lessons in Year 3.

Schools differed more in how principals made sense of, and how they aspired to apply, the individualized nature of instructional coaching than in how the coaching work was conducted. In all but two schools, individualized coaching supports were applied to each teacher at a given school independent from other teachers, from reform practices, and even from school priorities. All principals leveraged coaches to provide individualized supports to their science teachers, but few utilized them to help build collaborative cultures, build a shared vision, align resources or foster acceptance of shared goals. Yet, many principals recognized the potential for coaching work to provide these other supports. When asked to describe their idealized version of coaching, more principals expressed an aspiration to have their coaching work more focused and aligned, across all science teachers, and with their school priorities. At one of the two schools where coaching work was most integrated across teachers and with school priorities, Eva at Douglas MS, recognized the potential of coaching to do more than provide individualized supports. She said, “I think coaching is one of the most effective ways of supporting a team plus a single person with improving practice.” The following paragraphs describe how principals whose schools were using coaching primarily to support individual teachers, desired to adjust that coaching to do more; and they capture sentiments from a few schools that did not look for coaching to extend beyond that individualized support.

Two high schools observed potential for coaches to play an expanded role that not only tended to individual teacher's needs, but that also advanced school priorities in a more targeted way. Martha at Adams HS explained how she wanted to see the coaches more assertively press teachers in their practices beyond ways in which the teacher is asking to be pressed, more effectively advancing particular instructional approaches, such as AST. She described this ideal in terms of a math consultant who works with teachers and "...does a lot of coaching, of pushing coaching. I think the [district] coaches take the appropriate role of what teachers are willing to do, and are comfortable with. To me, ideally, it would be, I think coaches need to be attached to a building [so they can press more deeply with teachers]. It's really hard when they're hear a couple of times..." Marie at Wilson Academy noticed a similar issue, but for a different reason. She explained:

What I've noticed is my in-house coaching for my humanities seemed to have a bigger impact, and it was probably because she was here throughout the day, and knowing a lot of the work that we're doing, instead of just coming in once a week. The math coaches and the science coaches are really good for helping support my teachers for understanding the curriculum, lesson planning, aligning with standards in that kind of work, but a lot of our system-wide strategies come from our PD for the whole staff.

Both Martha and Marie wanted to see coaches have an opportunity to spend more time with the science teachers and in the school. Marie hoped that would better align coaching work with more general school-wide priorities. Martha hoped that more time would allow coaches to press towards a more aspirational approach to instruction that the coach provided.

At three of the schools operating from a more disconnected stance, on the other hand, principals did not tend to want coaching to be more consistent across teachers; and while they recognized that coaching could sometimes promote school goals, they did not look for it to focus on promoting reform practices. At Washington HS, the assistant principal presented an inconsistent aspirational view of science coaching, leaving both the actual implementation and the desired direction of coaching without direction beyond providing individualized supports. Laura lamented that coaching at Washington HS

supports everything from teaching strategies to writing to explain to packaging curriculum units; and she wished it would instead focus on helping all teachers focus on school priorities around assessments and backwards planning. However, she also stated that “Meeting them where they’re at and what they need and working with individual teachers rather than as a group towards the same thing, and they’ve really liked that, because they know that some teachers need more support than others in different areas.”

Similarly the latter sentiment, principals at Hamilton Academy and Cleveland Academy express aspirations limited to using coaching to provide individualized supports. Collette at Hamilton Academy believed that school priorities can be at play in coaching work to fill a vacuum when the teacher doesn’t have an alternate area of focus. She explained, “I think that the teachers having access to a coach and working on what they feel they need to work on I think is very helpful for the teacher. If the teacher doesn't know what to work on I think the coach taking what the school is focusing on and I know that they have. I know [the coach] has taken a role focusing on engagement and learning objectives.” Ana, the principal at Cleveland Academy, cited an example of a task related to a school-priority, identifying standards for lessons, that the coach could help teachers address, but more as a tactical response than a leadership strategy for fostering acceptance of shared goals.

Coaches’ own approaches were only partially aligned to reform practices and were intentionally oriented towards being responsive to principals’ expressed needs in a way that was only loosely aligned to reform practices. This tension appeared in both the way that coaches themselves described their work, and in how principals described both coaching work and their satisfaction with it. While AST reform practices were intended to be the foundation for the science coaching work in the district, disconnected nature of AST being separate from most schools’ priorities pervaded the coaches’ approach to working with teachers at schools as well. In the following paragraphs I begin by describing how coaches themselves defined AST and its role in their work. I illustrate how that created tensions between coaches’ choices to focus their time with teachers on planning compared to principals’ desires to have coaches provide full coaching “cycles” to teachers. And I summarize how coaches’ limited time in buildings impacted not only their capacities to interact with teachers, but also to

interact with principals. The disconnected nature of coaches' approach complicated their opportunities to advance the enactment of AST reform practices.

Coaches' definition of their role was conflicted due to competing expectations from principals, the research-practice partnership, and school and district goals. AST instructional reform practices provided a context for the work of science coaches but that context was reinforced by very few systemic structures and was compromised by competing priorities. The first year of the project showed the greatest focus on AST as a comprehensive instructional approach. The senior district science coach described AST as, "ambitious science teaching to me is a ... framework to ... I mean science teaching framework. And, has been our preferred practice of the district for the length of [this reform initiative] and [for] working toward implementation of NGSS." This coach further described the work of the district coaches in the first year of the program as focused on implementing AST practices.

So I think when we really started the work, that [the other district coach] and I both felt like our kind of role, and mission was to help teachers implement ambitious science teaching. So to, organize their units around models, and big ideas. Have to, have a model that they use with students, or add a unit ... and work on revising ideas, things that like. And, that is what we did most of our initial coaching on, especially that first year. That also formed a lot of the work that we started that first year. So, that's the 2013-2014 school year. We've created frameworks, and engaged some teachers in thinking about creating frameworks.

Studio days also reflect the shift of coaches from looking at the broader AST framework to focusing on particular practice. For example, in Year 1, at Jefferson Academy, the log describes observations in a studio day with respect to the larger AST framework in which the lesson was situated: "Students referenced the slinky activity to help make sense of waves and energy, but they did not reference other activities to help them make sense of the phenomena. However they were making a lot of sense about the lecture/demonstration that [the teacher] did about the electron movement." A log from a Year 3 studio day at Jefferson Academy reflects this move away from explicitly working in as much detail with the

overarching AST framework and focusing more on specific practices, “The share-out is planned so that students can engage in reasoning about their own ideas.”

In that same Year 3 studio day log, the AST idea of models is referenced, but only in the context of that day’s activities, “The models incorporated observational evidence (activity and videos).” In fact, throughout the studio logs, references to “models,” a fundamental anchor for AST, dropped substantially from Year 1 to Year3 (appearing in roughly half as many Year 2 and Year 3 descriptive comments as in Year 1). Because the curriculum materials at use in the schools were not organized around AST, anchoring instructional units around models required coaches to invest unit and lesson planning time with teachers. For example, the senior science coach reported spending roughly half of her time in Year 1, including the majority of her individual support of teachers, planning with teachers. This inclination towards planning support, although appreciated by teachers, did not always meet with principal expectations.

Principals at five schools all expressed an interest in coaches extending their work beyond primarily planning to working with teachers on full coaching cycles that included planning components, but also observation, possible co-teaching or modeling, and debriefing. Whether principals hoped these cycles would center on reform practices, school priorities, or independent needs of individual teachers was not always clear; but the principals seemed to convey a notion that such an approach to coaching would provide stronger individualized supports to teachers. Few principals linked these cycles to other school leadership practices, with the exception of an implied desire for increased staffing/resources to support science. After Year 2, only one school, Lincoln MS, continued to invest additional funds that supported more than one day per week of science coaching in their building. Olivia at Lincoln MS used some of this time to engage in full coaching cycles with a science coach at her school.

Other schools did not have these full coaching cycles in effect, but communicated a desire to have them in place. At Washington HS, Cathi described her perspective on coaching cycles, “One thing that’s lovely is when you’ve got...[building based teacher] leadership [that] can really go in depth because you’ve got coaching cycles taking place continuously with the coach who’s in the building and then the

district person can be coaching that coach plus they can be working with different content areas for PLCs. It's just another level of support.” At Adams HS, similar to Martha’s desire for coaches to press more on teachers’ instructional practices, Irene described why she believes full coaching cycles can help with that.

The one thing I would change with them is doing more of a full cycle so instead of a day of planning, it is like how could we do a day of planning where you are planning and then in the classroom doing some push and coaching and then doing a debrief. I think there needs to be a complete cycle. I think teachers would benefit from that a great deal. I think it would help the two coaches...see more clearly where teachers' strengths and weaknesses are because people can talk I am going to say a good game and I don't mean it like that.

Irene echoed sentiments from both Martha at Adams HS and Anthony at Douglas MS that it is not sufficient for teachers alone to identify opportunities for their instructional growth. They look for both principals and coaches to help play a role in that process. At Douglas MS, coaching work is organized around that premise, but Douglas MS cut back investments in science coaching, moving from a part-time dedicated science coach to a full-time shared math, science, engineering and technology coach. With the STEM coach stretched thin, Anthony did acknowledge that at Douglas MS, “I do believe that they need more coaching cycles, but again, based on their needs not based on any agenda or initiatives that we may have.”

While coaches did seek to promote adoption of AST practices, they were also sympathetic to meeting the expressed needs of the principals. The initial district science coaching positions were funded by the research-practice partnership grant. As the research grant released responsibility for funding the coach positions to the district, the district passed that cost on to the individual schools, requiring that principals elect to purchase “structured support” (a.k.a., district science coaching time for their buildings) as a choice item from their building budgets. That shift in funding responsibility introduced an accountability tension for the senior district science coach, which she described here.

Over time as that kind of funding in part became...more of a partnership, like direction of work versus partnership and work, we've had to shift a little bit more to implement, to let principals and

other district initiatives shape work as well. So, I remember when we first learning about coaching, [the university principal investigator] would always say, she would only coach about the rows of the [AST] performance progression. So like if it was anything else that's not what she would give feedback on.

This coach further described how, as time shifted, not only did she begin to focus on more granular instructional practices with teachers (and less on the AST framework), but she also felt an increased need to attend to principals' particular asks. "I believe that here is where we also, our work was fully funded through structured support and so we were ... really needing to be at the service of the administrations who are paying for our coaching as well."

The second district coach, who had shifted to work as a school-based coach at the middle schools in Year 2, also described feeling compelled to help schools address district-wide priorities around standards. She explained.

I want to see students performing well on the MSP, but I wanted to convince teachers that measuring students on their MSP was not contradicting the ambitious science teaching. I think I wanted them to see how they could work together...Science is science and the science ideas are still necessary, may not be to the depth of ambitious science teaching but I really wanted to convince teachers that ... using tests and online tools to give the tests and to pull the data to make instructional decisions, to be done with ambitious science teaching and can help improve student performance on the MSP [state science exam used in middle school].

At Lincoln MS, this coach and the principal were very aligned in this goal, and consequently, the teachers focused substantially on standards-based planning work and intentionally delayed further direct work on AST practices. Science teachers themselves took up this stance as well, feeling a need to first address what was perceived as a large number of school-wide goals before they would have capacity to work on AST practices. During a Year 4 monthly leadership meeting, one of the teacher leaders from Lincoln MS explained how she believed their team first had to deal with a "mountain" of other priorities before they could focus on AST practices. When pressed by fellow teacher leaders, coaches and researchers to

consider working on AST practices in concert with her school's other instructional work, this teacher expressed hesitation. Referring to the underpinnings of AST as "inquiry," she posed the question "What does it mean to add inquiry to the mountain?" While researchers did observe teachers at Lincoln MS enacting AST practices in their classrooms during half their visits, researchers also observed that Lincoln MS teachers did not use data meetings to build on previous learnings about AST practices, but instead, investigated isolated instances of the practices without attention to cumulative learning across different instances.

All principals did not share this view that AST practices needed to be deferred until other priorities had been addressed, but they did, some intentionally and some unintentionally, make coaches feel obligated to spend some of their time with teachers working on general school priorities. At Adams HS, a coach new to the program in Year 4 described how the principal "talked about her sort of push was around and what she's looking for around learning targets and formative assessment. And so I brought that back to the teachers." This coach also noted about that principal, "I don't know if she really understands AST at all yet. And I don't know, I haven't had enough conversations with her to know, when she is observing or walking through [science classrooms], if she's noticing some of those practices." This coach did strive to attend to AST practices in her work with the teachers, as noted by the work she did to support one teacher who created a new tool to help students incorporate evidence into their explanation as late as May of Year 4. The Year 3 Coach at Adams HS, when working with the ninth grade teachers, benefited from the teachers having a shared planning period, which they no longer had in Year 4. She described getting some traction with two of the three teachers in implementing more model-based curriculum, but getting particular traction with one teacher.

They tried using some summary tables, and then they used models for phenomena for all of their work, and [one teacher] was great. [That one teacher] was really receptive. [A second teacher] was receptive too, but [with the first teacher], I would, if I had extra time, I'd say, "Hey, [the third teacher] canceled, so I can come out and work with somebody if you just want some feedback on

class," and [the second teacher] never really took me up on that, but [the first teacher] always did, so that was very positive.

However, in Year 4, the shared planning period for the ninth grade team had been lost, and the new coach's work with the team was somewhat constrained to working with single teachers due to a lack of collaboration time available for course teams (e.g., biology, integrated science).

At Cleveland Academy, another school this coach supported, the principal's lack of focus on any particular aspect of instruction pressed the coach in her meeting time with the principal to talk about broad aspects of activities that were happening in the classrooms. The coach described her meetings with the principal.

At Hamilton Academy, I meet with [Collette, their assistant principal] and now we have sort of a regular meeting on the calendar. I basically fill her in on what each teacher's been working on and the things they've been trying on in their classroom. I would say that things do come up around AST but it's not the only thing...When we talk, it's not as though she's particularly asking me about AST, she just sort of wants to get a feel for what they're working on."

The coach was responsive to this principal's expressed desire to discuss happenings broadly, and in reflection, she commented, "Now that we're having the conversation, I'm realizing that I, instead of talking about the activity I should talk about their practices." Her work with teachers at the school was similarly responsive and supported a variety of needs, including scaffolding procedure writing, increasing the number of students participating in classroom talk, and observing student presentations. These teachers did engage with AST practices. And in Year 4, they partnered with science teachers at Jefferson Academy who were teaching the same courses, and benefited from the Jefferson Academy teachers knowledge of and learning about AST practices. But their work with the coach did drift based on their own perceived needs and the implicit press from the principal to support the teachers in general.

At all but two schools, principals' school leadership practices did not appear to change in response to reform-practice-related information gathered from coaches. Principals at only two schools described proactively leveraging coaches' reform-related expertise to inform the course of their

science teachers in enacting school-wide priorities. At other schools, principals primarily leaned on coaches to provide individualized supports to teachers and to help principals monitor school activity by providing updates about what the coaches observed and worked on with science teachers. Yet, despite most principals finding value in the work of the coaches, there was little evidence of coaches, or their updates to principals, impacting school leadership practices with respect to direction-setting, refining the school organization, or improving the instructional program. In one particular case, coach feedback related to a school-wide initiative was actively rejected by school leadership. This isolation of coaches' work seemed to reinforce the principals' inclination to separate discipline-specific reform work from other school priorities.

The two schools that actively solicited coaches to participate in defining work to advance school-wide priorities did so by inviting input from these coaches outside of their individual work with teachers. At Douglas MS, in Year 1 of this project, Harry made extra efforts and expended additional budget to hire a part-time science coach. He consulted this coach to help him understand the reform practices and to guide his own perceptions of science teachers' instruction in his building, but also to understand the learning targets the coach wanted for the science teachers. He described pressing the coach to explain, "What is the thing that you want our teachers to walk away with as a result of this instruction? And just as if I want my teachers to have really clear instructional goals for their students I want you to have really clear instructional goals for my teachers as a result of this PD that you're giving them." He then followed up with his teachers in email and in person, to reinforce these professional learning and practice goals, thereby involving the coach in building the shared vision for instruction at Douglas MS. As discussed previously, and in the next finding, Douglas MS teachers demonstrated extensive engagement with reform practices.

At Jefferson Academy, Jason was more tactical about his inclusion of the science coach in the work of the building, but he was attentive to recognizing opportunities where the science coach could add value to advancing school priorities. Like many principals, Jason looked to the science coach to keep him informed, to provide science expertise, and to support school-wide needs. Jason described meeting with

the coach every few weeks. “She'll let me know what various teachers are working on and what their focus is, and [I'll let her know] if there's anything building-wise that we would like them to look at.” However, when asking her to support school priorities, he included opportunities to engage with those priorities in the school-wide context.

For example, our last discussion was, “[Coach], will you join us at one of our staff meetings as our teachers are working through their curricular maps specific to state standards and help our teachers work on identifying which standards are being taught and which lesson,” and so forth. So, she's able to come in and do that and work with our teachers on that.

This approach differed from principals who asked science teachers to work on standards-based instructional supports with teachers in that it gave the coach an opportunity to work in a school wide environment where she was part of an exercise related to building a shared vision and fostering the acceptance of group goals. Her participation was included interactions not only by the individual science teachers, but also with other teachers and school leaders in the context of their own priorities. Thus, through the coach’s representation, reform practices had an opportunity to shape the alignment of resources and the building of collaborative culture at the school. Teachers at Jefferson Academy reported consistently high numbers of hours collaborating on instruction, and in Year 4 in particular, demonstrated leadership in partnering with new science teachers at Hamilton Academy to share their expertise, experience and instructional materials.

At other schools, as described above, principals generally looked to coaches to provide science-specific instructional support, updates to principals, support for individual teacher needs, and in some cases, support for school priorities. However, with the exception of the two schools described above in this Finding (Douglas MS and Jefferson Academy), and Lincoln MS, coaches did not actively participate in or influence other aspects of school leadership. Irene, an assistant principal at Adams HS, was formerly a coach herself. While she enjoyed the work, she believed that coaching is undervalued at the district level. “I sort of saw the writing on the wall that instructional coaching, I think, is a critical position but in terms of how it is seen at the district office, it is sort of considered frosting and not the

base and so it is something that is easy to get rid of.” This observation was consistent with data that showed a lack of integration of coaches into the fundamental priorities and leadership practices at the schools.

At one school, Washington HS, the overall school culture was even hostile towards attempts by the science coach to connect with school-wide work. As described in Finding 1b above, as a cross-school team at Washington HS developed a cross-discipline rubric to evaluate students’ written explanations, the science coach provided feedback that the rubric seemed to be based more on descriptive writing than explanations. Recognizing the cross-disciplinary nature of the work, rather than press the group to meet needs specific to science, she suggested utilizing common core standards related to explanatory writing, but she encountered strong resistance from both the group and the school principal, who rejected her suggestion.

It was not received well, and I probably didn't say it the best way, but it's true. [the principal] argued that she needed to start somewhere and it's easier to get everyone on board with something that's easier, basically...so I had to kind of back off and just try to work within what they had decided because they weren't willing to change. That was already decided and not flexible. I think I was able to slightly influence it, but it really was more about what maybe science teachers would interpret as writing the procedure or conclusion and less about ... More formulaic than what we'd like to move toward for actually writing the explanation, for what we call an explanation in *Ambitious Science Teaching*.

As discussed above, this decision reduced the science teachers’ engagement with AST-rooted explanations. It also marginalized the role of the coach at the building and reduced any incentive for teachers to engage more deeply with reform practices, as she described.

I think this made it challenging at [Washington HS] because they tend to really simplify things. So if we're working on writing to explain and this is a school initiative, then I want to work on the thing that's simple to do within those boundaries. And so I think we've been able to support that. I've been able to support them and try to push on it, and I think some people can't take that push.

Some people are more susceptible to a press, and so I think a lot of people though aren't. So I think that's ... If I had to summarize what the story is, it's just that generally their satisfaction with practice and not really ... There's not an urgency there to change.

Coaches echoed principals' concerns that the current implementation of the coaching role in the district may contribute to the perceived lower level of coach integration into the broader school community. Principals across the district acknowledged different concerns related to coach presence. Ana at Cleveland Academy and Collette at Hamilton Academy both lamented not having met more often with the coaches. Irene at Adams HS and Marie at Wilson Academy both described a desire for coaches to have time to run full coaching cycles; and Marie further noted that lack of building-based coach presence limited the coach's ability to support school-wide priorities. Under the current design of the system, at the high school level, principals who purchased the "structured support" [coaching time] received only one day of coach presence at their campuses each week. This made it challenging for coaches to consistently meet with principals, to regularly engage in full cycles of coaching with multiple teachers, and to become more familiar with building-specific priorities and needs. The senior district science coach explained that in the future, they may consider adjusting their support model to retain the current cost structure, but to visit building for a full week of time, but potentially only one week each month.

Interconnectedness: Finding 3: Coordination between the principals and coaches was limited and generally led to coaches doing their best to accommodate principals' priorities at the expense of coaching teachers towards deeper enactments of AST practices. As with previous findings, schools tended to fall into one of three categories with respect to how interconnected principals' work with coaches was to their broader school priorities, to reform practices, and among different teachers. Schools where principals took a more integrated approach tended to include coaches, directly, or indirectly through their inputs, in a wider array of school leadership practices. They also tended to organize coaching activities around shared priorities, though they did individualize some aspects of coaching work to address independent issues with particular teachers' instruction. The difference

between schools in the “disconnected” and “loosely aligned” categories was less in how principals actually conducted their approach to coaching of individual teachers, and more in how they *aspired* to conduct that work. Principals at the “loosely aligned” schools tended to look to better align coach’s work with individual teachers to more cohesively advance particular school priorities; and principals at the “disconnected” schools tended to remain interested in coaches working with individual teachers on independently determined needs. Additionally, principals operating at schools with a more “disconnected” stance tended to be less satisfied with the feedback they received from coaches and wanted more. Overall, the more integrated the school’s approach, the more the teachers were able to engage with reform practices with the coach (with the exception of Lincoln MS, where the principal and coach agreed to defer more focused work on reform practices until first completing some particular work advancing school-wide priorities).

Finding 4: When principals pro-actively sought to understand science instructional reform practices and their teachers’ related learning, they were more likely to make explicit connections between their schools’ broader leadership practices and the science reform – and these connections appeared to increase science teachers’ engagement with reform practices.

While teachers at all the schools in this study reported growth in their understanding of and proficiency with many of the instructional practices, teachers at one school in particular not only reported such growth, but also reported multiple times the investment of other schools in collaborating with each other on their instructional work. The frequency and proficiency of their enactment of practices, coupled with the cumulative nature of their engagement with the practices, collectively exceeded other schools in the study. The leadership story at this school is similarly distinct in both the ways school leaders made sense of AST practices and, in the ways that they connected that work with school leadership practices and their interactions with teachers. Douglas MS was the most distinctive example of a school where principals explicitly made connections between broader school initiatives and AST. In the following sections, I explore how principals at Douglas MS both made sense of and applied their understanding of reform practices to leadership decisions at their school.

When principals sought specific understanding of reform practices, they were more likely to factor that understanding into direction setting leadership practices, and to communicate priorities to teachers in a way that aligned with reform practices. Douglas MS was the only school in this study where principals participated regularly and deeply in teacher reform professional learning opportunities. The story of Douglas MS's involvement in the project stemmed from a problematized interaction between the principal and a teacher. This motivated the principal, as he sought to "build a shared vision" for high quality instruction with his science teachers, to seek out both information and resources for the science teachers at Douglas MS. It also established his role as a "lead learner" alongside the teachers from the very beginning of the reform effort. Harry, the Douglas MS principal during Year 1 of the network reform initiative, described an instructional interaction he had with one of his teachers the year prior to Year 1. "Last year she and I kind of had a...I won't say, not toe-to-toe. We had a...um...I don't know. "Heated" is not the word. We had a conversation where she was disagreeing with me around some discourse stuff." This made him seek more information about a pilot of the reform project that was being conducted at a different middle school in the district.

So going back to last year I went to...I wanted to find out more about it because I heard [Lincoln MS] had it and I'm like, "Man, I want to get that over here at [Douglas MS]." So I went last year to one [studio day] there and I spent the whole day. And yeah. I'm about as involved as...like I don't think you could get much more involved. Like I went to the summer. You know, [researcher] did a summer training for all those secondary science teachers around some of these practices in August? I think it was a three—a two or three day institute. I went to one full day because I also had to go to some math stuff and some other PBIS—some other ones. You know, they're all happening on the same days and stuff. So I went to that. I've been to all the studio days. The last one I was only there for part of it...I just couldn't spend the whole day in there. I spent half the day.

Following the implementation of the reform at Douglas MS, this principal continued to attend the Year 1 studio days, setting an example for then Dean, who became the assistant principal in Year 3, and who also committed to attending the studio day experiences regularly.

Harry described three inter-related reasons that he sought to participate actively in the teachers' professional learning about the reform: (1) to provide himself credibility and a vocabulary that would allow him to communicate more effectively with his teachers; (2) to be a "lead learner" to participate with teachers and later to help them connect their learning to follow up actions; and, (3) to enable him to function as an effective instructional leader who can connect the work of the teachers with the broader plan to "move this whole department over the course of a year. Or two or three years." He described some of this motivation in the text below.

I felt that I was being somewhat dismissed in the past by some science teachers because, you know, "Science is different than math and you need to blah blah blah." And I was—and I was trying to explain to them, "No, some of these things are very similar," right? Around...and just some things around how do you introduce a lesson? And how do you create closure? And what's around a clear—what's a clear teaching point? And so there was pushback around, "You don't understand how we plan our lessons. And you don't understand the inquiry process." Sort of stuff. And I wanted to immerse myself a little bit and find out, well, what are some things that I might not be understanding? And what's some of the language that I need to be able to speak? And I also wanted to be able to present myself as like a lead learner also. I don't know everything. You know? I want to be there side-by-side as a support and a learner with you on some things.

After studio days, Harry reflected on the work and followed up with teachers via email and conversations to summarize key points. Following the Year 1 November studio day, he sent a message that concluded a commitment to follow up on the studio day work. "At our next department meeting on Wednesday Nov. 20th you will discuss how it's going with your personal goals from yesterday's Studio Day. Be prepared to present what initial first steps you took in recent days to implement those goals, highlighting successes, challenges and any needed supports. Together we can support each other in implementing our goals..."

Harry's approach to the way he engaged in professional learning with his teachers connected the reform work across numerous leadership practices, including building a shared vision, fostering the acceptance of group goals, creating high performance expectations, communicating the direction, providing individualized supports, building a collaborative culture, aligning resources, monitoring school activity, and even buffering staff from distractions to their work.

While the principal and assistant principals who preceded Harry at Douglas MS did not invoke the same breadth of leadership practices in their engagement with reform professional learning, they still connected multiple aspects of leadership through their learning about reform practices and about the their teachers' applications of the those practices. Anthony, the current assistant principal, continued to reflect a portion of these sentiments in his own approach to participation in studio days and related teacher learning. "I'm just going to go with listen and take notes and take whatever nugget I can take away for the professional development myself. I just wait to see, when do I have to lead, where do I have to speak because that is a lot to live in your head especially when it's written down." Although less directive than Harry in "communicating direction," Anthony did allow reform learning to shape the vision that he, the principal and the science teachers held for science instruction and teacher priorities at Douglas MS. Additionally, Anthony's participation in studio days, science team meetings, and classroom visits helped himself and Eva to develop an understanding of the AST work teachers were enacting with respect to structured peer feedback, student talk, revision of models, and construction of written evidence-based explanations. As described in previous sections, that common understanding not only created a shared vision for science instruction, it also helped the work in science to contribute to the shared vision for cross-discipline initiatives like the writing initiative, and better aligned staff across the school.

The work of Douglas MS school principals persisted across leadership turnover in its integration of reform work with setting direction for the school. Many other principals, as reported in previous findings, attended portions of studio days. But none reported engaging in instructional discussions with teachers about the reforms on a persistent basis or in a way that connected back to building a shared vision for science instruction in their buildings. As described above, Olivia, Irene, Collette, and James all

discussed attending studio days and the latter three also described how they made sense of particular practices they observed during those days. Irene and James both described interacting with teachers about the practices, but neither used those discussions to foster acceptance of group goals or to build a shared vision. Among these, only Olivia established a shared vision for science instruction at her school, but it was aligned around standards-based instruction and was not connected to reform practices.

When principals aligned direction setting with science reform practices, they were more likely to connect the reform to decision-making with other related leadership practices that influenced teachers' opportunities to engage with reform practices. Douglas MS's decision to participate in the science reform work influenced the school's approach to a host of leadership practices associated with impacts on learning. Douglas MS principals' approaches to staffing and collaboration shifted over time, in some cases, increasing teachers' engagement with reform practices, and in other cases, reducing it. Despite this, Douglas MS teachers demonstrated the most sustained engagement with reform practices, but evidence suggests that engagement may have begun to decline in Year 4.

Douglas MS's approach to collaboration was rooted in Harry's desire to co-construct a shared vision for high quality science instruction with his science teachers. Harry's work focused less on providing shared time, and more on helping teachers leverage the shared time they had in pursuit of the shared goals they were developing through their reform professional learning. In a quotation above, Harry explained how he felt compelled to understand the work that his science teachers were doing and to apply that understanding to creating short- and long-term plans to "move this whole department". He further clarified that he felt the need to "...give them what the expectations are, what they're supposed to be doing in their common planning or departmental time..." He strived to ensure that "...next steps need[ed] to be tied back to some PD...[because] it need[ed] to connect to what you've been working on." The protocols and meeting approaches that science teachers described using in later years of the project reflect how this initial foundation leveraged a host of leadership practices to advance this reform work, using collaborative time to build shared vision, to build a collaborative culture, to foster acceptance of

group goals, to create high performance expectations, to provide individualized supports, and to align resources.

The new administration, Eva and Anthony, took a further step and restructured the organization to support collaboration. They introduced the double period of department-oriented, collaborative planning time. Finding 2 above further explicates how the availability of shared time and the latitude teachers were given to use that time forged connections among more leadership practices and further advanced the teachers' engagement with reform practices. However, the reduction over time in principal attention to collaboratively and intentionally setting more comprehensive direction with the science teachers around a vision for high-quality science instruction in particular may have contributed somewhat to the reduction in teacher engagement in Year 4 with data and planning meetings focused on particular AST practices and related student work.

Shifts in Douglas MS's approach to staffing the program similarly may have contributed to a perceived reduction in teacher engagement with the reform practices. When Harry initiated the reform with his teachers, he began Year 1 with by hiring a new teacher who was trained in the same program as the teacher with whom he had the "disagreement" that marked his active problematizing of the school's lack of a shared vision around high quality science instruction. He described why it was valuable to him to have hired a second teacher from the same program.

So I mean it really aligns. Like what [the principal researcher] is doing [in studio days] and what they [the teachers] just learned [from their teacher preparation program]. And they're newer teachers. One's in his first year and the other one is in her third year. So I think because of that it really align to the collaboration. In the past our science department was a lot of lone wolves out there. And so I've really tried pretty hard to bring some structure and some expectations of how they should be using their common planning time and our departmental planning time. But you know honestly the one that just seems to—or just aligns so perfectly is when they come out of that same program together and they're getting some of the similar PD and then they already have

a similar way that they plan lessons and think about...thinking about that. So that's a big plus that's happening, especially at 8th grade.

Harry continued this work by hiring an additional teacher from the program at the end of Year 1 (to start in Year 2).

Eva and Anthony also respected and appreciated this staffing alignment with the reform practices. When faced with a need to hire two teachers at the end of Year 3, they selected two teachers from within the district who had AST experience, one from the same teacher preparation program and one who had worked as a science coach advancing the AST practices. However, in this case, the two teachers came from the one school in the district that had developed very strong collaborative alignment, but had done so while also deferring their work on AST practices so they could focus more on standards-based instruction. That change introduced complexity to the collaborative opportunities in which the teachers engaged this year. In the first studio day, as described in Finding 2 above, one of the new teachers refocused the discussions in a way that reduced teachers' time to engage with AST practices. With Eva's and Anthony's reduced focus on a shared vision of high quality science instruction, a reduction in resource alignment was introduced with departure of two experienced science teachers and the introduction of two teachers with different priorities and visions about how AST fit into the work.

Additionally, Eva's and Anthony's decision to discontinue their investment in a dedicated part-time science coach further diluted staffing of the program by reducing overall staff expertise in reform practices. As described in Finding 2, Douglas MS science teachers reported a lack of engagement in Year 4 with the data and planning meeting aspects of AST. The absence of a coach, or a researcher serving in the coach capacity, removed some leadership capacity from the group; and teachers, when faced with a need to reconcile conflicting views about AST and standards-based instruction, privileged the latter over the former rather than integrating into a more seamless shared vision.

Overall, while Douglas MS saw some decline in teacher engagement with AST practices in Year 4, the school demonstrated substantially more integration of AST with the school's leadership practices than any other school in the study. Table 8 indicates overall interconnectedness of each school/campus.

Figure 5 depicts a comparative look at the degree to which each school connected AST to the four categories of leadership as well as the degree to which the school’s broader priorities were interconnected with one another. Schools in the disconnected category showed low levels of integration not only with AST practices, but also among the school’s broader priorities. Schools in the integrated category showed consistently mid-to-high levels of interconnectedness in all categories. Schools in the loosely aligned group tended to display interconnectedness between AST and some leadership practices, but not consistently across the breadth of leadership practices.

Table 8

Overall School/Campus Connectedness among Priorities and between AST and Leadership Practices

<u>Disconnected</u>	<u>Loosely Aligned</u>	<u>Integrated</u>
<ul style="list-style-type: none"> • Washington HS • Cleveland Academy (@ Kennedy) • Hamilton Academy (@ Madison) • Lincoln MS 	<ul style="list-style-type: none"> • Wilson Academy (@ Kennedy) • Adams HS • Jeffereson Academy (@ Madison) • Kennedy HS Campus • Madison HS Campus 	<ul style="list-style-type: none"> • Douglas MS

*Roosevelt Academy was not categorized as an individual school due to insufficient data.



Figure 5. Level of Connectedness between Reform and School Leadership Practices at Each School. This figure depicts the degree to which multiple school priorities were connected to one another and the degree to which the science reform was connected each category of leadership practices.

In Summary: The More Interconnected Schools' Leadership Practices were with the Science Reform, the Greater the Teachers' Engagement with Reform Practices

Overall, while Douglas MS saw some decline in teacher engagement with AST practices in Year 4, the school demonstrated substantially more integration of AST with the school's leadership practices than any other school in the study. Table 8 shows the overall level of interconnectedness observed at each school and campus. Figure 5 depicts a comparative look at the degree to which each school connected AST to the four categories of leadership as well as the degree to which the school's broader priorities were interconnected with one another. Schools in the disconnected category showed low levels of integration not only with AST practices, but also among the school's broader priorities. Schools in the integrated category showed consistently mid-to-high levels of interconnectedness in all categories. Schools in the loosely aligned group tended to display interconnectedness between AST and some leadership practices, but not consistently across the breadth of leadership practices.

Discussion

Findings from this study help make connections not only between school leadership practices and instruction, but also between the related bodies of research. These findings help to explain how and why particular school leadership practices reinforce or reduce the barriers of influence caused by loose coupling (Elmore, 2000) between leadership practices and instruction. In-so-doing, these findings provide additional insight about how Leithwood's (2012) distinct leadership practices influence one another and why Fullan & Quinn's (2016) focus on direction setting is so critical. In particular, this study exposes the ongoing cycle of direction setting that all leadership practices, regardless of intent, contribute to, by reinforcing, connecting, supporting or marginalizing particular priorities. This study provides further evidence into why Fullan & Quinn's (2016) push towards focusing on advancing the learning and practices of the group, and not just the individuals in it, further contributes to the cycle of direction setting. Additionally, it reinforces the need for school leaders to participate as lead learners, particularly with respect to the impact of such co-participation on establishing a more coherent system to promote instructional change. This work also sheds light on how particular leadership practices promote or detract

from the different aspects of scaling a reform. Finally, this study builds on Spillane's (2015b) initial components to offer a further developed conceptual model for evaluating the influence of leadership practices on instruction (and the converse). These implications are discussed in the following paragraphs.

As I considered these findings, I was struck by the marked fragility of reform enactment across this system. My initial question, "Why does reform implementation look so different at different schools in the same district that are invested in the same professional development opportunities and same regional professional network?" assumed that reform that I was studying was rooted in a strong *network* of teachers and coaches *across a system* to advance and sustain the reform work. Yet the contexts of the individual schools shaped the reform enactment in consequential ways. In revisiting Coburn's (2003) work, I recognized connections between the fragility I had observed and the scalability of reform implementations. I was able to further unpack the elements of "scalable" reforms in light of not only the instructional context, but also the administrative context of the schools, and perhaps more importantly, the degree of overlap between those two contexts.

Perhaps the reason that schools where instructional priorities were integrated with one another, and with the science reform, engaged more extensively with reform practices, is that the reform practices become part of the shared instructional vision that was built at the school. I hypothesize that both the act of co-constructing such a vision, and the direction that it provided, contributed to a greater intersection of leadership and instructional contexts in the school that increased the scale of reform enactment. This overlap allowed teachers and principals to engage in more coordinated and shared reconciling of different priorities to yield a more cohesive, evolving, and shared instructional vision that accounted for school priorities in the context of the AST principles and practices. Additionally, the intersection of administrative and instructional contexts exposed principals to more opportunities to engage a broader set of leadership practices to intentionally support reform enactment and to minimize conflict of reform work with other priorities. In short, this alignment among priorities, reform and school leadership practices contributed to the "coherence" described by Fullan & Quinn (2016). In the following paragraphs, I examine how principals' sense-making and their school leadership practices, influenced the depth,

sustainability, spread, and shift in ownership – Coburn’s four elements of reform scalability. I applied Leithwood’s (2012) categorization of leadership practices that are linked to learning to better uncover *how* principals, in their school contexts, influenced reform implementation and scalability. I unpacked consistencies between my findings and elements of Fullan & Quinn’s coherence framework for leadership rooted in instructional change to better understand why particular leadership practices might contribute to greater coherence. Finally, I updated my conceptual model to reflect the collection of learning from this study about how school leadership practices influence instruction.

How do principals and assistant principals make sense of and interact with discipline-specific instructional reform initiatives?

Principals made sense of the AST reform initiative in two related ways, both rooted in “setting direction” for their schools. First, principals made sense of AST as a whole: some considered AST to be an instructional priority while others viewed AST as a support to help advance other, more school-wide priorities. Second, principals made sense of specific AST practices and principles via their participation in AST professional learning experiences. Both these aspects of sense-making influenced the degree to which principals considered reform practices in their direct interactions with teachers and in how they participated in other school leadership practices. I summarized this level of connection that principals made between the reform and their school leadership practices using the categories described in the findings. Figure 5 depicts the extent to which each of the four categories of leadership practices was connected to AST at each school (described in greater detail in Table 7). “Disconnected” scores identify a relationship in which reform activities and particular school leadership practices were pursued independently of one another (i.e., one did not inform the other). “Loosely aligned” scores reflect when principals recognized connections between the reform and related school leadership practices, but did not explicitly communicate or apply those connections in the context of leadership practices. “Integrated” scores reflect when principals not only saw connections between the reform and leadership practices, but explicitly communicated relevant connections and applied them in the context of school leadership work. The two metrics for setting direction represent the degree to which principals connected the collection of

their schools' broader priorities to each other, and the degree to which those broader priorities were connected to the science reform initiative. The remaining three metrics reflect the degree to which the AST reform work was connected to Leithwood's (2012) other three categories of school leadership practices – developing people, refining and aligning the school organization, and improving the instructional program. Schools are grouped according to their overall level of interconnectedness among leadership practices and reform; and those levels were generally consistent with teachers' engagement with reform practices at a given school, with more disconnected schools seeing lower teacher engagement with reform practices, and more integrated schools seeing higher teacher engagement with reform practices.

Lack of explicit shared vision for high quality science instruction at most schools. Figure 5 shows that only schools that both identified some level of connectedness among their school priorities, *and* that connected the reform to those priorities, took the additional steps of linking the reform to other leadership practices. Unfortunately, as Finding 1a illustrated, at many schools, principals did not link schools' multiple school-wide priorities with one another much less with the science reform. And as Finding 1b revealed, principals generally did not treat the science reform as a school priority, thereby leaving it largely disconnected from the schools' shared instructional vision. Reinforcing the importance of creating greater coherence across a system enacting change (Fullan & Quinn, 2016), when principals did not at least loosely align their individual priorities with one another, they were unlikely to align those priorities with reform practices. Consequently, the reform, either in concept or in practice, was largely absent from any instructional vision, if there was one, guiding their school's direction. (See Figure 6)

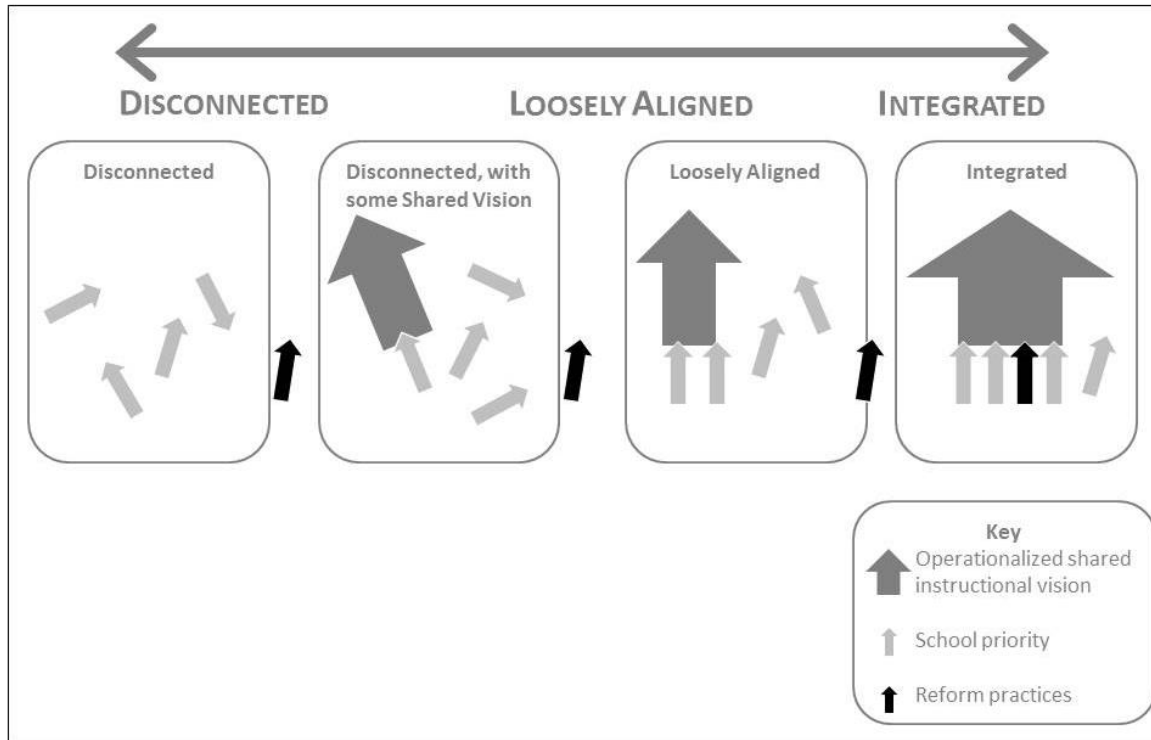


Figure 6. Setting Direction – Unpacking the Operationalized Shared Instructional Vision(s) Created by School Leadership Practices with respect to internal alignment and alignment with Reform Practices. This figure illustrates how school’s priorities and reform efforts connect to one another and to shared [instructional] vision(s) constructed through school leadership practices.

Hamilton Academy, Cleveland Academy, and Washington HS alike described instructional foci for their schools that allowed individual teachers to interpret each school’s vision for high quality instruction in multiple ways that did not necessarily align with one another. Although these principals did work to establish instructional priorities (e.g., backwards planning, social justice, use of learning targets, etc.) at their schools, by leaving those priorities disconnected from one another, they lacked coherence and failed to coordinate multiple priorities in order to create a shared vision for instruction. This left individual teachers to reconcile apparently competing priorities with one another, and to determine their own courses of action. In the absence of a shared school instructional vision that integrated the science reform, there was no clear and reliable path towards shifting ownership, to teachers or school principals, of a reform that was neither highly visible nor commonly understood among those teachers and principals at the school. Spreading the reform enactment among teachers at the school was also largely

unreliable as each teacher was left to interpret the priorities of the science reform for themselves. Such an approach left little opportunity to develop Coburn's (2003) "depth" of implementation that reliably yielded consistent enactment of reform practices. Similarly, in the absence of a consistent instructional vision that incorporated the reform, little foundation helped sustain such work over time. Cross-school collaboration among science teachers on shared campuses partially mitigated this lack of school-specific vision for Hamilton Academy and Cleveland Academy, and helped to foster more of a shared vision at least among participating science teachers. The impact was more extensive at Hamilton Academy because all of the science teachers participated in the cross-campus collaboration opportunities, whereas at Cleveland Academy, only one of the two science teachers participated regularly. This dependence on voluntary cross-campus collaboration to develop a shared vision did not provide a sustainable structure for supporting the reform work over time. Additionally, any vision that the collaborating teachers did develop was shared among the participating teachers and coaches, but not with the principals, further reducing the coherence, ownership, spread and sustainability of the reform.

Even Lincoln MS, although loosely aligned in connecting its broader school priorities to one another, did not connect the reform to those priorities, and consequently, limited both teacher engagement with the AST practices and the scalability of the reform at the school. While Lincoln MS aligned much of its work school-wide instructional work around standards-based instruction, it left other school-wide priorities (like blended learning) and the science reform separate from its shared instructional vision. Like the disconnected schools described above, this approach left teachers and the coach at Lincoln MS to reconcile these additional priorities (e.g., AST, blended learning) with the school's instructional vision, independent of one another, and usually independent of the shared school vision that was anchored in standards-based instruction. With few structures in place to help teachers build a convergent vision for high quality science instruction that included AST, there was little coherent substance on which to anchor the development of depth, sustainability, or even spread of a consistent vision of the reform. There was, in effect, no shared vision connected to the reform work of which anyone could assume ownership.

Similarly, “loosely aligned” schools lacked adequate integration among their multiple priorities and AST to allow them to build a coherent and shared vision for high quality science instruction. This positioned reform uptake to be more opportunistically linked to enthusiastic teachers and coaches, and left their work highly vulnerable to changes in both instructional and administrative staffing. At Jefferson Academy, for example, while the school shared a connected vision for school-wide priorities, AST was only loosely aligned with that vision. Although Jefferson Academy teachers engaged frequently and enthusiastically with reform practices, they did so with lower levels of proficiency and a less shared vision on a focal practice. I hypothesize that the lack of shared vision around high quality science instructional priorities, and the reform practices in particular, reduced teachers’ level of engagement with reform practices. Douglas MS, the only overall “integrated” school in the study, also supports my theory that a shared vision for high quality science instruction, including AST practices, is fundamentally necessary if a reform is to develop any sort of scalability. In the absence of that shared vision, there is nothing for anyone at the school – teachers, coaches or principals – to own, and there is nothing consistent that can spread, be executed at depth, and be sustained. In Year 4, as Douglas MS teachers shifted to a less integrated vision that tied AST practices less tightly to their school’s more highly prioritized push for standards-based instruction, they reported reduced engagement with the reform practices, as described in the findings above. Douglas MS’s current principal and assistant principal were less directly engaged with the reform practices than the Year 1 principal. This reduced level of connection between the school leaders and the science reform decreased the reform’s resilience to co-existing with other school priorities; with less integration, the leadership practices established reduced coherence around the reform, and the science reform became more vulnerable to competition from other priorities with respect to teachers’ time and attention.

These findings are consistent with Elmore’s (2000) assessment that in the absence of administrative leadership over core instructional work, reforms are only taken up through a process of “volunteerism” by those teachers whose values and predispositions align with reform principals. My study examined more closely why administrators did not engage more directly in what Elmore alluded to

as the “core”, and how principals made sense of being an instructional leader. More specifically, this study brought to light a particular issue with principals’ development of their own capacities to engage with core instruction.

Lack of building of principals’ capacities to engage more deeply and specifically with AST.

This study revealed the highest levels of reform enactment (in terms of frequency, cumulative learning/application, proficiency, and related professional collaboration) at a school in which the initial principal, Harry, engaged deeply, along with his science teachers, with the professional learning about AST practices at Douglas MS. That engagement with practices provided Harry substance around which he was able to begin to construct a shared vision of high quality science instruction with his teachers. It also enabled him to communicate key aspects of this vision to them, and to actively foster acceptance of the group goals by taking opportunities outside of the official studio days to further develop his teachers’ understandings of the practices as they began to build a shared instructional vision with each other and with Harry. I would argue that this shared instructional vision positioned Douglas MS as a truly “integrated” school around the science reform, and further, that it was Harry’s participation in regular and significant portions of the reform learning days that enabled him to establish such a shared instructional vision. This finding also reinforces Fullan & Quinn’s (2016) tenet that principals need to be lead learners.

Principals who do not take the "learner stance for themselves do not keep ahead of the curve; they gain years of experience but not necessarily knowledge and skill about what is required to implement deeply. Principals who visibly struggle in learning about the Common Core State Standards (CCSS) or digital innovations along with teachers build credibility, trust, and knowledge of both the innovation and what is needed by the organization to move ahead. Most of all, they learn, thereby becoming more and more effective. (p. 54)

Harry’s follow-up messages to teachers outlined specific aspects of AST practices and principles that had previously been unfamiliar to him. Additionally, Harry chose to highlight those strategies that his teachers had recently learned about and committed to put into practice in their classrooms, better connecting him to the situated work of his science teachers. I would further argue that such participation

with his teachers likely resulted in other less intentional reinforcements of the science reform practices, such as spontaneous conversations with teachers (some of which were described to me by teachers).

Beyond theory, Harry's knowledge of reform practices was local and relevant to his own science teachers. This discipline-specific, and teacher-relevant understanding, allowed Harry to address a key issue with reform implementations that Cuban (2013) highlighted: "Contexts matter." Specifically, Cuban's research revealed reformers' tendency to focus on the qualities or knowledge of the teachers themselves rather than the situation in which teachers were teaching and learning. Harry engaged in distributed leadership, with his teachers, that was rooted in the contextual, or situated, treatment of the reform. As Spillane, Halverson & Diamond (2004) described, "Distributed leadership practice is constituted in the interaction of school leaders, followers, and the situation" (p.3). Fullan & Quinn (2016) add support to this contention, noting that when principals take an active learner role, "Because they are immersed in action and tuned into learning, they recognize and mentor leadership in others" (p.54). Harry's approach reflected the integrated stance that Harry took toward leadership practices at Douglas MS. This situated integration among priorities, people and contexts inherently brought more leadership practices into play to support the reform – aligning resources, building collaborative culture, providing individualized supports – all in addition to work to build a shared vision, communicate that direction, and foster acceptance of shared goals related to that vision. The collection of these practices enhanced all four aspects of Coburn's (2013) scalable reform at Douglas MS. Teachers worked together, supported by the principal and coach, to spread common practices and engage in them at depth, leading to shifts in ownership across the science teachers and the principal, and contributing to a more sustainable context for enacting the science reform. However, Harry did not codify the shared vision he was building with the science teachers into any formal school priority or other norm. Consequently, like reform efforts at other schools, the Douglas MS work remained somewhat fragile and was similarly susceptible to competition from other school priorities that do not align as tightly with the science instructional reform.

The presence on an evolving shared vision for high quality [science] instruction seems integral to the sustainability of any discipline-specific reform effort. With no identifiable, articulated, and shared

instructional vision in place, Douglas MS teachers' adherence to the reform principles remained strong but lacked a shared grounding with later school leaders, and new teachers who joined the school in subsequent years. I hypothesize that when new leaders took over at Douglas MS, their comparatively decreased participation in the reform work diminished the coherence of the shared instructional vision. Further, I suggest that their lessened engagement with the teachers' reform enactments also led to a reduction in the number of leadership practices at play to support the science reform, and rendered the AST-based vision increasingly fragile over time. This disconnect between principals' participation in the situated instructional context embodies Elmore's theory of "loose coupling" (2000; 2004; 2007). This theory purports that the reason classroom instructional practices have been highly resistant to substantive change despite decades of attempts at reform (Cuban, 2000; Tyack & Cuban, 1995; Elmore, 2013) boils down to the design of schools that intentionally buffer teachers, who manage the technical core of instruction, from the new and challenging reform practices advocated by "outsiders" (including school leaders and the district). Attempts to breach the wall between teachers and organizational influences are compromised by the design of the very systems within they function. Principals in this study described school priorities that were rooted in instructional practice and a sense of personal responsibility for instructional quality and outcomes at their schools. However, very few of the principals reported engaging in activities that helped build their own capacities to operate in a shared context that was situated not only in the organizational activities of the school, but that overlapped into the instructional contexts of the teachers. By this, I do not mean simply addressing instructional strategies, but rather, situating their leadership activities in the actual instructional contexts where teachers must reconcile both general and discipline-specific strategies with their own expertise and the needs of their students. AST studio days provided such an opportunity, but did not design a clear space for principals to participate, and few principals took advantage of them.

Again, Douglas MS illustrated some of the nuanced ways in which principals participated in studio days and leveraged that work to develop more or less tightly coupled versions of distributed [and situated] leadership with their teachers. Anthony engaged with the science reform in many of the same

school leadership practices as Harry, but not all of them. While this still positioned Anthony to drive towards some level of meaningful coherence with respect to the reform work, my findings indicate this may have reduced Anthony's individual, and the schools collective, capacity to enact the science reform. Anthony, the new assistant principal, attended AST professional learning and connected with teachers about the different practices in which they were engaged; and he shared his knowledge with Eva, the principal. However, he did not continue Harry's work to develop a distinct shared vision for high quality science instruction, nor did he take responsibility for communicating such a vision. He and Eva did connect the science reform work to Douglas MS direction setting activities for the school. However, such connections were based on opportunistic knowledge when it connected well with a particular school priority (e.g., the writing initiative). So while Anthony and Eva enthusiastically leveraged connections between AST and school priorities, they did not deeply develop their own capacities to co-construct or lead a vision of high quality science instruction with their teachers. As the findings indicated, Anthony took more of a personal learning stance toward participation in the studio days, and did not recognize the importance of applying the context of those learning situations to engage in truly distributed leadership with the teachers. This lack of leveraging the shared learning context to continue to build a shared instructional vision reduced the extent to which Anthony was able to connect the reform to more leadership practices and the capacity he built in himself to be a leader in the reform's implementation. This also left the teachers' instructional practices highly vulnerable to shifts in school priorities and shifts introduced by new staff members joining the team, positioning their stagnant AST-based instructional vision as less relevant, and pressing them to construct an updated instructional vision that was less rooted in reform practices, and more loosely aligned with them, as the findings above describe happening in Year 4 at Douglas MS.

In another attempt to bridge the gap between organizational practices and instruction, several principals in this study embraced the formative, teacher-development-oriented teacher evaluation system selected by the district, and established school priorities rooted in particular components of the Charlotte Danielson framework (as described in the above findings). Although this work by principals was situated

arguably proximate to instructional practice, in absence of principals' deeper understanding of the science reform practices and their teachers' engagement with them, principals missed the opportunity to build shared instructional visions with their science teachers that connected general instructional practices and science-specific ones. Some principals, like Jason at Jefferson Academy, interacted with teachers and the framework in ways that integrated with other school instructional priorities, while other principals, like Collette at Hamilton Academy, limited their interactions with teachers to the framework components in more separate ways from other priorities. In both cases, however, the principals looked to coaches and teachers to determine how science reform practices should be integrated. Rather than sharing leadership for the science reform work with teachers and coaches, principals seemed to have unintentionally abdicated their role as instructional leaders with respect to discipline-specific enactments without recognizing that such enactments were situated in the core contexts for potential instructional change. As Elmore (2000) described, that shared context is critical to the successful distribution of leadership that has access to influence instructional practice. "It is the 'glue' of a common task or goal – improvement of instruction – and a common frame of values for how to approach that task – culture – that keeps distributed leadership from becoming another version of loose coupling" (p.15). Without that influence, teachers' enactments of AST practices remained fragile across the system, and school leadership marginalized its own potential to jointly influence a shared vision for instruction. Principals' decisions to disconnect themselves from discipline-specific instructional work not only reduced their own ability to influence instruction, it increased potential conflicts among school priorities, leaving teachers to develop visions for instruction that were less connected with the school and with each other. Even in schools in which teachers worked together on reform practices and occasionally tried to integrate broader school priorities into that work, the principal was largely absent from that context, again, leaving the loose coupling in place.

Ultimately, how did principals' school leadership practices impact enactment of instructional reform practices at each school?

As shown in Figure 5, principals in this study rarely engaged in more than two of the four categories of leadership practices in connection to the science reform. While setting direction was arguably the most important leadership category for principals to connect their support for AST, connections with additional categories increased the scale of the reform. The level to which principals connected these other leadership practices to the reform also impacted the longer term stability of the reform at each school. Beyond Elmore's "loose coupling" concern, principals' connections to a broader array of leadership practices impacted the school structures that reinforced teachers' participation in enacting the reform practices. The more AST was integrated with each of these categories of leadership practices, the greater the capacity for the reform to scale at the school. However, it was not sufficient to simply engage more practices if direction setting at the school was not at least loosely aligned among multiple priorities and with AST. Perhaps the most critical aspect of the direction setting was establishing a shared instructional vision that included AST and that provided a foundation on which the other leadership practices could build. In absence of a shared instructional vision that integrated multiple school priorities with each other and with reform practices, the structures and practices established by principals' enactments of other categories of leadership practices, did not have a clear shared direction to promote, and so provided less benefit to reform enactment. As Fullan and Quinn (2016) explain, focusing direction is fundamental to establishing coherence that includes clarity of strategy that all members of the organization can describe, learn about together, and enact. Hamilton Academy illustrated such a case in which leadership practices provided shared collaboration time and coaching support, both loosely aligned with the reform practices, yet remained a disconnected school with less engagement in reform enactment. The following paragraphs examine how different practices impacted science reform, looking closely at particular practices in each of the latter three leadership categories: aligning resources in improving the instructional program, providing individualized supports in developing people, and building collaborative

cultures and restructuring the organization to support collaboration in refining and aligning school organizations.

Aligning resources. Many principals chose to align instructional resources around a district focus on standards-based instruction, thereby unknowingly undermining science reform enactment. Findings in this study were consistent with multiple researchers who have found the movement promoting a standards focus in our schools often operates in conflict with reform initiatives (e.g., Cuban, 2013). This study sheds some additional light on this issue. At both Cleveland Academy and Lincoln MS, where leadership established standards as the primary direction for the school, teachers engaged less often with reform practices. In Year 4 at Douglas MS, when standards became a priority for the school, engagement with AST dropped. At Cleveland Academy and Lincoln MS, principals did not participate with teachers in reform learning activities; and at all three schools, principals did not consistently integrate AST into establishing the shared instructional vision at their schools. In this case, as described above, this lack of co-participation limited the principals' capacities to recognize the implications of their other leadership practices on AST – not only in terms of intentionally supporting AST but also in terms of recognizing the implications of their practices to AST. Similar to the instance at Hamilton Academy, where Collette found her teacher struggling to reconcile setting of standards-based learning targets with student construction of explanations, teachers at other schools either perceived conflicts between standards-based approaches and AST or simply found it easier to focus on the standards somewhat separate from AST practices. In either case, the result was the same – diminished engagement with AST practices at the school. In the case of Collette at Cleveland Academy, she believed she had a way of reconciling learning targets with AST, but she did not interact with her teacher in their core, science-specific instructional space, reducing her ability to help teachers reconcile the practices and maintaining a “loose coupling” between school leadership and instruction.

The reform effort made space for integrating next generation science standards (NGSS) into the work, but principals' low participation in AST learning opportunities and their lack of regular communication with teachers around AST practices maintained a separation between the leadership

context and instruction. This is consistent with what Spillane and Kim found in 2012, “Having a formal leader in a subgroup then was positively associated with subgroup members’ reports of alignment of school programs with external standards and with norms of trust.” By promoting the idea of standards-based instruction but not participating in its discipline-specific instructional context, principals left teachers to focus on implementing standards, but based on their current instructional practices. (Spillane, 1999) Research has shown that such approaches yield little change to instruction as teachers tend to use the standards as curricular resources only and not as the instructional resources they were also intended to be (Spillane, 1999; Spillane, Reiser & Reimer, 2002).

Consistent with this research, the Douglas MS teacher’s Year 4 description of only being able to apply AST practice of constructing student explanations to lessons where the standard explicitly calls for that type of explanation typify this notion of standards giving guidance for “what’ to do. In contrast, when Harry was principal at Douglas MS, he unpacked standards *with* his teachers, looking at both the *content and the instructional implications*. For example, in an email Harry wrote to Douglas MS teachers following a studio day, he summarized, “We started out with a lesson objective that essentially required students apply information (Use properties to describe what happened.) to justifying and hypothesizing what happened by using their knowledge of properties of matter.” Harry’s participation with the teachers in learning about the reform allowed him to not only connect the reform work with the standards work, but leverage AST practices around constructing evidence-based explanations to ensure that standards were considered with respect to instruction as well as content.

Providing individualized supports. Principals’ leveraging of coaches to support the science reform implementation was largely underutilized and missed a key opportunity to tighten the coupling between school leadership and instruction. As Coggins, Stoddard and Culter (2014) acknowledged in their research, coaches have the potential to bridge the distance between school leadership and instruction, and “In that sense, coaches address the problem of loose coupling and help change to reach the technical core.” I would argue that this study illustrates a caveat to that supposition – that it is insufficient for the coach to *reach* the technical core, and rather than simply carry messages between leadership and

instructional contexts, they must function in a way that brings greater situated overlap between these two contexts. Coaches in this study unquestionably “reached the technical core” in working with teachers to plan and carry out science instruction. However, they did that instructional work outside of the leadership contexts in which direction setting and other key practices were enacted; and the coaches themselves in most schools did not have a consistent role in helping to enact leadership practices. So the divide between instruction and leadership remained in place.

When coaches tried to enact leadership practices, such as building a shared instructional vision, with science teachers, they did so separated from other school priorities, principals and leadership practices. So any alignment in setting a vision remained disconnected from the shared vision the principals established school-wide with teachers. And as Martha, Ana, and Collette all acknowledged, the communication channel between coaches and principals was limited, leaving principal’s minimal insight into the reform practices their teachers were implementing, and giving coaches little opportunity to influence direction setting or other leadership practices at a given school. At Jefferson Academy, where there was greater engagement with AST practices, Jason actively invited the coach to participate in school-wide instructional activities, increasing the overlap between instructional and leadership contexts. At Lincoln MS, Olivia formed a core leadership team with the coaches, drawing significant overlap between instructional and leadership contexts, but without connecting the shared instructional vision explicitly to AST practices, thereby marginalizing any advantage the overlap might convey for advancing science reform enactment. Similarly, as discussed in the above findings, those schools that exhibited instructional visions that were disconnected or loosely aligned from the reform also reduced the impact of coaches in advancing the reform. At Wilson Academy, with a loosely aligned instructional vision, coaches opportunistically wove AST practices into work with individual teachers, but provided a variety of focal points for their individualized supports, further entrenching the isolated classroom model in the school’s operations and reinforcing a loose coupling between leadership and instruction.

Building collaborative cultures and restructuring the organization to support collaboration.

Available collaboration time was largely disconnected from reform practices, from instructional leaders,

and from other leadership practices, minimizing both its impact on AST enactment and its capacity to help form connections between the leadership and instructional contexts of the school. In this study, teachers at all the schools, by contract, were assigned regular small group, school-directed, and individually-directed collaboration opportunities. In all but two schools (Jefferson Academy & Hamilton Academy), none of this time was applied to supporting the enactment of AST (though at Douglas MS they had extensive alternate time for that collaboration). It was either applied to disconnected school-specified priorities outside the context of reform practices or it was leveraged for deeper instructional purposes separate from broader school priorities and school leaders. Consistent with research that shows collaboration time itself is insufficient and must be coupled with a culture that supports collaborative work (Elmore, 2000; Szczechsiul & Huizenga, 2014; Leithwood & Louis, 2012; Spillane, Reiser & Reimer, 2002), Leithwood (2012) identified two distinct leadership practices related to collaboration: restructuring the organization to support collaboration *and* building collaborative cultures. Both of these demonstrated potential in this study to help tighten the coupling between leadership and instruction; but in most cases were underleveraged.

Three schools in this study made an effort to restructure their organizations to support collaboration: Douglas MS, which provided science teachers with two shared planning periods; Jefferson Academy, which provided science teachers with a shared planning period; and Adams HS, which provided a subset of science teachers a shared planning period. However, in only one of these schools, Douglas MS, was there an integrated and shared instructional vision that included reform practices. In absence of that vision, activities during the shared planning period were grounded primarily in the instructional context, leaving instructional decisions to be made with little overlap with the leadership context, thereby further reinforcing the gap between instruction and school leadership. Beyond providing time for teachers to collaborate, schools did little to help build collaborative cultures rooted in reform practice, contributing to a shared instructional vision, or being guided by a shared instructional vision. Although some principals lamented the lack of direction they provided to teachers to utilize available collaboration time, organization of the time was less critical and sometimes even detrimental to its

productivity. For example, Ana's organization of science/math collaboration time at Cleveland Academy was highly structured, but was oriented around individual teacher planning with collaborative resources available, reinforcing the theoretical walls around classrooms buffering from overlap with school organizational direction and leadership. Counter to this, collaboration at Douglas MS was not structured by administration, but was oriented around a shared instructional vision that was built through regular interactions between teachers and principals (and coaches and other experts), particularly during Year 1, but continuing to some degree after that. In the case of Cleveland Academy, collaboration time had minimal effect on advancing teacher engagement with and enactment of AST practices, while at Douglas MS, the time had a much more significant contribution to AST work.

At schools like Hamilton Academy, Wilson Academy, Washington HS, and to some extent, Adams HS, in which collaborative practices were primarily conducted during teacher's own time, AST enactment was largely facilitated through "volunteerism" (Elmore, 2000). In these cases, AST engagement varied substantially among teachers, school structures provided no reinforcement for the collaboration, and principals did not participate in the work, further isolating the instructional context from the school leadership context and buffering the latter's ability to influence instruction. This reflects Robinson, Lloyd, and Rowe's 2008 finding, based on a collection of studies, that participation of school leaders in teacher professional development is strongly associated with improvements to instruction and student achievement. Overall, the general lack of formal science teacher collaboration time available translated to less time to develop the "depth" of the reform, to help it spread among teachers, and for teachers or leaders or to grow a sense of ownership towards the reform work. Further, principals' lack of participation in collaboration and the disconnection of collaboration from the school's shared vision provided little overlap between instructional and leadership contexts and reduced the sustainability of the reform due to a lack of reinforcing structures and collaborative operating norms. I would further caution that those adhering to Fullan & Quinn's (2016) framework for coherence must ensure that they drive this coherence not only around genericized and discipline-agnostic instructional practices, but that they attend to the discipline-specific instructional practices and nuances in the technical core of their work. In

absence of such attention, this research suggests that they will leave in place a loose coupling between their leadership drivers and the instructional practices such that teachers are left to make sense of the context-specific aspects of instruction in isolation from each other and the larger vision.

What implications did these findings have for constructing a stronger and more extensible conceptual model for considering leadership influence on instructional practices?

Spillane's (2015b) work captured the need for a more consistent model for researchers to apply to answer questions about the overlap of administrative and instructional operating contexts of a school. At the beginning of this study, I proposed a model that acknowledged the connectedness of administrative and instructional contexts and articulated the critical components of each. This study, for the most part has borne out the relevance of that model, with one key adjustment that I will propose regarding the movement of influence between contexts. Additionally, this study has revealed operational specifics that allowed me to further unpack and add to the key leadership practices, and their relative situating, in this model. In the following paragraphs, I briefly discuss each of these learnings and present an updated model.

A sound representation. The proposed initial model (see Figure 4) components accurately reflect key elements, from individual sense-making, to practice, to context, at play in instructional reform efforts at a school. First, and fundamentally, this study established that even in a cross-network, multi-school reform enactment, the context of the individual school plays a significant role in determining the extent to which teachers will engage with reform practices. So even in a district-wide reform effort, examining localized, school-based instructional and leadership practices provided insights into the influence of school leadership on instruction. Second, the presence of a cognitive element in this very situated model remained important. In particular, the way that principals made sense of how instructional reforms fit with respect to their other goals and priorities for their schools significantly impacted how the reform was considered in the context of the breadth of school leadership practices. Third, the inclusion of overlapping administrative and instructional contexts in which these practices were executed was highly

relevant, though it's potential for impact may have been under-represented by the initial instantiation (I'll say more about this below).

Perhaps the most striking example of contextual influence was how substantially the treatment of other school priorities, both with respect to each other and with respect to the reform work, became in setting direction and determining the level of overlap between administrative and instructional contexts. This critical contextual element of connectedness among priorities and to the reform provided substantive explanation for the extent to which teachers at each school engaged with the reform practices. Additionally, the instructional practices, AST-specific and related to other aspects of instruction, were key to the ways and situations in which teachers reconciled perceived conflicts in direction and experienced potential overlap with leadership practices, thereby opening spaces of potential influence. While this study identified a number of specific categories of relevant instructional practices, those practices were local to this study and this district's priorities, and the specific practices themselves did not further define the model.

Finally, Leithwood's (2012) four categories of leadership practices applied in this study did contribute to defining the model. All four categories factored into the extent of instructional reform enactment in this study, and together, they provided additional insights into how school leadership was exerting particular influences on reform adoption. Note that while Fullan & Quinn's (2016) leadership framework for coherence extends beyond the lists of practices that Leithwood (and others) offer, I retained Leithwood's practices in the model because they provided a more comprehensive list of practices, rather than a focused list of best practices, which was important for enabling research consideration both of intended leadership practices and their outcomes but also other leadership practices that contributed (sometimes positively, sometimes negatively) to desired outcomes.

Unpacking elements of, connections between, and situating of leadership practices. While Leithwood's leadership practices provided a strong foundation for a conceptual model, they did not fully capture the path by which leadership was influencing instructional reform enactments. In this section, I will introduce three ideas to help update the conceptual model to better consider not just what practices

are influencing instruction, but how and why those practices, as they are executed in context, are exerting influencing on teachers' levels of engagement with reform practices.

Among the four categories of leadership practices, one stood out as exerting particularly strong influence on the level of teacher engagement with reform practices. In setting direction at each school, the degree to which multiple priorities were connected to one another and to the science reform corresponded roughly to the extent to which teachers at each school engaged with reform practices in a breadth of capacities. I contend that in the work of coordinating, communicating about, and fostering acceptance of multiple priorities (including the science reform), a shared operationalized vision is constructed for each school and that vision drives execution of the priorities. As Figure 6 illustrates, when priorities are not well integrated with one another, only those that are reinforced through direction setting practices are likely to contribute to a shared vision across the school. And when priorities are left out entirely, like the reform often was, they are unlikely to be part of the shared operational vision. Such an operational vision may differ from a school's formal vision statement or even from the direction expressed by different staff members (as seen in discrepancies among principals at the same school in this study). These findings are consistent with Fullan & Quinn's (2016) leadership driver of focusing direction. As they put it, "We have shown...how successful systems have rallied around focused direction, and that focus is not just a matter of having uplifting goals. It is a process involving initial and continuous engagement around core goals persistently pursued...Finally, remember that "focusing direction" is never finished. It is always ongoing" (p.45). Beyond Fullan & Quinn's conception of focusing direction, this study identifies the importance of attending to the ways in which all categories of leadership practices contribute to setting direction. For example, providing time for collaboration or not can reinforce or marginalize particular priorities, as can the degree to which resources are aligned with the priorities, and so forth. A model for studying leadership influences on instruction must account for this alignment that occurs through direction-setting practices, whether intentional or not, and including engagement with the practices, and not just outcomes from them.

Even in schools in this study that exhibited alignment in their direction, the shared vision did not always provide adequate support or motivation for reform adoption. As shown in Figure 7, it was critical to pull the other leadership practices connected to vision setting deeper into the instructional context. When principals participated in instructional activities, such as examining data with teachers who were applying data to guide instruction, or participating in teacher learning activities linked to instructional reform work, shared visions were more likely to develop and be reinforced through other supporting practices. The act of participation itself helped the principal to forge more relevant connections to other leadership practices that could directly support or minimize conflicts with discipline-specific instructional work like reform implementation. In Figure 7, I propose the addition of a category of principal practices around co-participation with teachers (and other experts like coaches or researchers) in instructional contexts. This is similar to Fullan & Quinn's (2016) leadership driver of deepening learning, which includes a component of principals as lead learners but also addresses learning across the organization. I call this particular aspect of principal co-participation out as a separate set of practices because it attends to more than how principals conduct other practices and is itself an action that contributes to instruction, primarily by forging a greater intersection between instructional and leadership practices, so that shared engagement in leadership work will have higher potential to impact instruction. Further, by separating this co-participation practice out as a unique element, I can better indicate the importance of its extent of intersection with relevant instructional practices at the core of teachers' work, and not just with peripherally supporting instructional practices. As with many of the leadership practices, this one is likely to manifest to some extent in the ongoing development of an evolving, instructionally relevant, shared vision. That vision, and its centrality for bring different categories of leadership practices into greater alignment with one another, is also reflected in Figure 7.

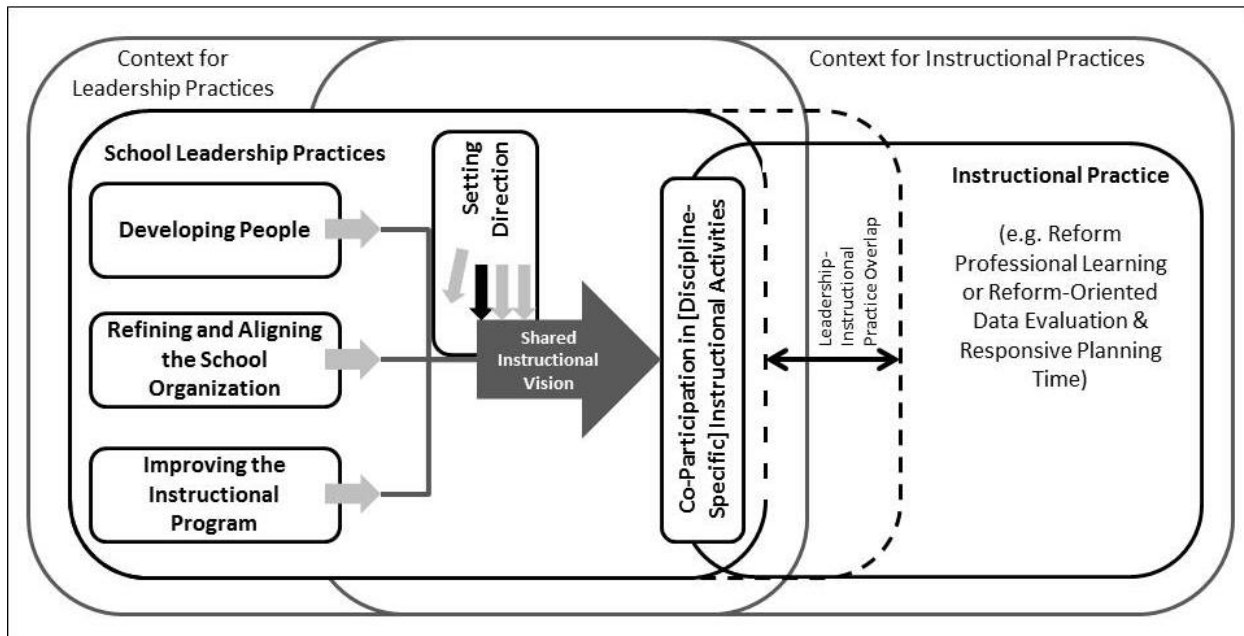


Figure 7. Updated Conception of School Leadership Practices – Adding to Leithwood’s (2012) 16 practices, Recognizing Connections, and Accounting for the Situated Nature of the Practices This figure applies learning from this study to recognize the potential for school leaders’ direct co-participation in instructional activities to lead to better alignment among multiple leadership practices with each other and with respect to particular instruction reforms.

Representing influence. The most powerful influences of leadership on instruction uncovered in this study were attributed to co-construction of a shared instructional vision by leaders and teachers together. Beyond any outcome of leadership practices (e.g., establishing a time for teachers to collaborate, or setting the priorities for the school, etc.), it was the operationalized, shared instructional vision that most effectively mitigated the buffering of organizational influence from instruction that is so entrenched in the loose coupling of school design. To draw attention to the importance of leadership practices taking place in the overlapping contexts of leadership and instruction, I present the updated conceptual model in Figure 8. This model adds the new category of leadership practices about co-participation. While data in this study were limited to co-participation in discipline-specific instructional practices (around the reform), I contend that is less the discipline-specific nature of the instructional context that is important and more its proximity to the actual instruction that a teacher will perform in their classroom. I hypothesize that the greater the overlap into the instructional context, the nearer this

work will be, and the less reconciling of competing priorities will take place independently, thereby leaving any shared instructional vision created from this work largely intact and relevant to the actual instruction, including any reform practices and principles at play. This updated model reflects the central nature of the operationally constructed shared vision and the importance of connections among leadership practices. Finally, I removed elements of the model that focused on the movement of objects between contexts and instead focused on the operational overlap of instructional and leadership contexts. In response to Spillane’s (2015b) call for a stable and extensible model, I offer this as a next step to establishing a conceptual foundation for evaluating the impacts of leadership on instruction, and particularly on the enactment of instructional reform.

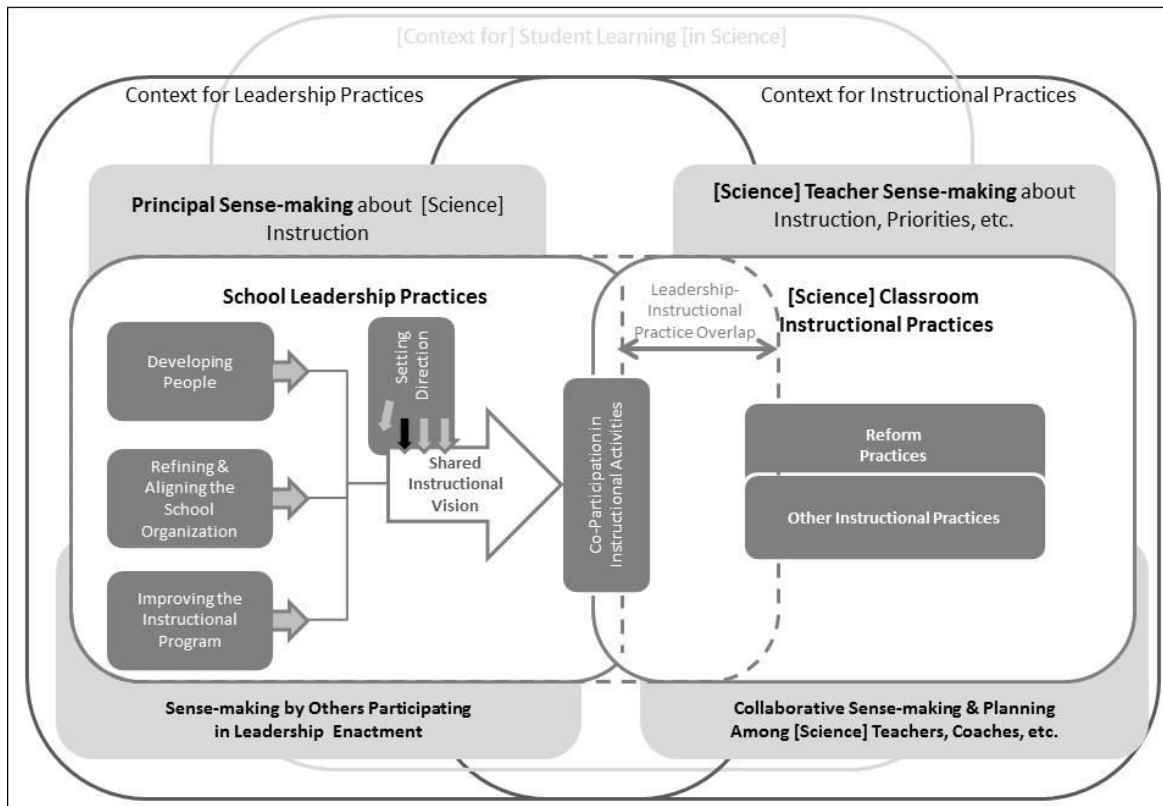


Figure 8. Updated Conceptual Model: School Leadership Influence on Instruction. This figure illustrates key elements involved in determining the influence of leadership practices on instruction. It acknowledges relationships among those practices, adds another category of practice and highlights the overlap between the instructional and leadership contexts.

Design Limitations

The strength of this study is also its greatest limitation. In an effort to bring together what have traditionally been separate areas of research and understand more deeply how principals may be influencing instruction, this study effectively represents a collection of studies from a breadth of perspectives. The necessarily higher level analyses conducted in each area likely missed nuances in those particular contexts that are worthy of additional attention. For example, I did not shadow the principals in their day-to-day work to observe how they engaged in leadership practices; but I did build a picture of those practices from a combination of teacher, coach and principal inputs through both interviews and surveys, and from my own and other researchers' personal experiences working in the schools. Thus, because of the breadth of data applied, and the ability to triangulate findings from multiple sources and perspectives, I am confident that the convergence of data provides a high level accurate representation of the different elements at play in the ways that school leadership practices influenced the enactment of this science reform. If a researcher were examining the implementation of a more incremental, rather than transformative, instructional change, it is also possible that different factors would come into play in different ways.

Researchers are another factor that this study did not directly address. The majority of researchers in this study, including myself, served roles as both researchers and participants in the study, collaborating with coaches, and sometimes working with individuals or groups of teachers directly, to support teacher learning, teacher planning, and teacher reflection about using AST practices. The nature of the network improvement community included a phasing of the project, and over time coaches took increasing responsibility for running professional development days, and teacher leaders also shifted their roles in teacher collaboration, working with data, communicating with administrators and facilitating teacher learning. However, researchers continued to play some form of supporting roles throughout the course of the time studied, making it more challenging to identify some potential constraints on scalability of reform should the researchers not have been in place. That said, the findings from this study did not reveal researcher participation to be a top limiting factor to the enactment or scalability of the reform.

This study is one of an accumulating number of studies that identify the importance for principals to participate with teachers in instructional work. Secondary principals have traditionally been cautious of such an approach due to a concern about scalability of immersing themselves in each discipline's work. I would suggest from this study that it is not necessary for principals to become experts in every discipline, but rather to become co-participants with teachers in setting and refining instructional direction that is relevant to the instructional core of classroom situations. Further studies can help to more precisely uncover the critical aspects of that participation and better define it in a manageable way for principals to execute.

Conclusion

Key findings from this study include the importance of principals attending to the ongoing process of setting, adjusting and reinforcing direction through all of their leadership practices in ways that help to align both vision and practices around instructional change. Arguably the most significant element in helping to align direction and practices with the reform efforts was ongoing development of principals' own capacities through co-participation in reform activities at the core of instructional practices. Additionally, collaboration time for teachers and greater alignment with instructional coach supports contributed substantially to more extensive and proficient reform enactments.

At all schools in this study, there was evidence supporting multiple types of teacher engagement (e.g., planning, teacher learning, classroom enactment, etc.) with reform practices. The network provided teachers with connections to coaches and colleagues outside their own school environment that helped support their reasoning about and application of AST practices. Yet the context of the schools seemed to be a more influential factor in determining the extent of teacher engagement with reform practices. In explicating the importance of principal participation in instructional contexts, this study helped highlight a frequently neglected aspect of discipline-specific instructional reform initiatives: identifying a participant role for the principal. While many of the principals in this study wished they could attend more of the studio day embedded learning opportunities with their teachers, most did not prioritize that attendance in their busy schedules. And the principal who made such attendance and participation an imperative part of

his practice, actually remarked that there was no clear role for him to play in studio days and outside of them, so he had to craft one for himself.

As future research-practice partnerships advance discipline-specific reforms, in secondary schools in particular, it would be useful to define participation structures for principals both during and outside of formal teacher learning opportunities. Such participation structures should strive to maximize the overlap of principals' school leadership contexts with the core instructional context to maximize the benefit of principals' engagement and to help break down the buffering between the school organizational and leadership influence on classroom instruction. In bringing together leadership and instructional contexts, these participation opportunities for principals should also help to align reform practices with teacher's core instructional work and with school-wide priorities. By bringing these elements into a common and relevant space for interaction, teachers and principals will have opportunity to coordinate multiple priorities, including the reform, into an operationalized, shared instructional vision that each can support through other interactions in their respective contexts.

Further, it is important that research models more consistently reflect the critical nature of overlapping contexts for direct participation by principals in activities related to the instructional core. Such models must reflect the situated relevance of interactions across context. They must also acknowledge the connections between different leadership practices, and the evolving operational constructs (such as the extent of alignment of multiple priorities in a system) that create real-time shared visions that inevitably drive actions beyond any more static formal goals and visions published about the system. Whether an instructional reform derives from an initiative from a partnership with an external organization, from a top-down or a bottom-up internal approach, or at a single school or across a district, the contextual elements captured in this conceptual model should help researchers better understand how and why school leadership practices are or are not influencing instruction to the extent observed. Despite the constraints imposed by loosely coupled administrative and instructional contexts, principals can and should play an active role as instructional leaders who collaboratively drive core instructional improvements with their teachers and other school leaders.

References

- American Association for the Advancement of Science (AAAS). (1989). *Science for All Americans*. Washington D.C.: 10: 0195067711.
- American Association for the Advancement of Science(AAAS). (1993). *Benchmarks for science literacy*. New York: Oxford University Press."
- Alozie, N. M., Moje, E. B., & Krajcik, J. S. (2010). An analysis of the supports and constraints for scientific discussion in high school project-based science. *Science Education*, 94, 395–427.
- Bass, B.M. (2000). The Future of Leadership in Learning Organizations. *Journal of Leadership & Organizational Studies*. 7(18): pp.18-40. doi: 10.1177/107179190000700302
- Bryk, A.S., Gomez, L.M., and Grunow, A. (2011). Chapter 7: Getting ideas into Action: Building Network Improvement Communities in Education. In M.T. Hallinan (Ed.), *Frontiers in Sociology of Education, Frontiers in Sociology and Social Research* (pp. 127-162). Dordrecht: Springer.
- Carnegie Foundation for the Advancement of Teaching. (2016, Dec 15, retrieved). *The Six Core Principles of Improvement* [Web page]. Retrieved from <https://www.carnegiefoundation.org/our-ideas/six-core-principles-improvement/>
- Cobb, P. & Jackson, K. (2011). Towards an Empirically Grounded Theory of Action for Improving the Quality of Mathematics Teaching at Scale. *Mathematics Teacher Education and Development*. v13(1): pp.6-33. ISSN-1442-3901
- Coburn, C.E. (2001). Collective Sense-making about Reading: How Teachers Mediate Reading Policy in Their Professional Communities. *Educational Evaluation and Policy Analysis*, 23(2), pp.145-170. DOI: 10.3102/01623737023002145 <http://epa.sagepub.com/content/23/2/145>
- Coburn, C.E. (2003). Rethinking Scale: Moving Beyond Numbers to Deep and Lasting Change. *Educational Researcher*, 32(6), 3-12. need URL ref here...
- Coburn, C.E. (2005). Shaping Teacher Sense-making: School Leaders and the Enactment of Reading Policy. *Educational Policy* 19 (3):476–509.

- Coburn, C.E., and Turner, E.O. (2011). Research on Data Use: A Framework and Analysis. Measurement. 9173-206. DOI: 10.1080/15366367.2011.626729
- Coggins, C.T., Stoddard, P., and Cutler, E. (2003). Improving Instructional Capacity through School-based Reform Coaches. Report to American Educational Research Association: Chicago.
- Cohen, D. K. (1990). A revolution in one classroom: The case of Mrs. Oublier. Educational Evaluation and Policy Analysis, 12, 327–345.Cohen
- Cohen, D. (2011). Teaching: Practice and its predicaments. Cambridge, MA: Harvard University Press.
- Cuban, L. (1984). Transforming the Frog into a Prince: Effective Schools Research, Policy, and Practice at the District Level. Harvard Educational Review, 54(2), pp.129-151.
- Cuban, L. (1988). The Managerial Imperative and the Practice of Leadership in Schools. Albany: State University of New York Press.
- Cuban, L. (2013). Inside the Black Box of Classroom Practice: Change Without Reform in American Education. Cambridge, MA: Harvard Education Press.
- Elmore, R.F. (2000). Building a New Structure for School Leadership. Washington, D.C.: The Albert Shanker Institute.
- Elmore, R.F. (2004). School Reform from the Inside Out: Policy, Practice and Performance. Cambridge, MA: Harvard Education Press.
- Elmore, R.L. (2007). Chapter 2: Building a New Structure for School Leadership. in School Reform from the Inside Out: Policy, Practice, and Performance. Cambridge, MA: Harvard Education Press. ISBN 978-1-89179224-3.
- Elmore, R.F. (2008). Leadership as the Practice of Improvement. In Pont, B., Nusche, D. & Hopkins, D. (Eds.). Chapter 3: Improving School Leadership: Volume 2: Case Studies on System Leadership. OECD Publishing: France.
- Engels, N., Hotton, G., Devos, G. Bouckenoghe, D., and Aeltman, A. (2008). Principals with a Positive School Culture. Educational Studies, 34(3), pp.159-174.

- Firestone, W.A. and Riehl, C. (Eds.) (2005). *A New Agenda for Research in Educational Leadership*. New York, NY: Teachers College Press.
- Fullan, M. (2001). *Leading in a Culture of Change*. San Francisco, CA: Jossey-Bass.
- Fullan, M. (2014). *The Principal: Three Keys to Maximizing Impact*. San Francisco, CA: Jossey-Bass.
- Fullan, M. and Quinn, J. (2016). *Coherence: The Right Drivers in Action for Schools, Districts and Systems*. Thousand Oaks, CA: Corwin.
- Gouvea, J. and Passmore, C. (2017). 'Models of' versus 'Models for': Toward an Agent-Based Conception of Modeling in the Science Classroom. *Science and Education*. 14(7-8). DOI 10.1007/s11191-017-9884-4
- Greeno, J.G. (1998). The Situativity of Knowing, Learning, and Research. *American Psychologist*, 53(1), pp.5-26.
- Greeno, J., Collins, A. & Resnick, L. (1996). Cognition and Learning. In Berliner, D. & Calfee, R. (eds.), *Handbook of Educational Psychology*, (pp15-46). New York, NY: Macmillan.
- Gronn, P. (2000). Distributed properties: A New Architecture for Leadership. *Educational Management, Administration & Leadership*. 28(3): 317-338. doi: 10.1177/0263211X000283006
- Gronn, P. (2002). Distributed Leadership as a Unit of Analysis. *The Leadership Quarterly*. 13(4): 423-451. doi: 10.1016/S1048-9843(02)00120-0
- Hallinger, P. (2003). Leading Educational Change: Reflections on the Practice of Instructional and Transformational Leadership. *Cambridge Journal of Education*, 33(3), pp.329-351. DOI: 10.1080/305764032000122005
- Hallinger, P. (2005). Instructional Leadership and the School Principal: A Passing Fancy that Refuses to Fade Away. *Leadership and Policy in Schools*, 4, pp.1-20. DOI: 10.1080/15700760500244793
- Hallinger, P. (2011b) Leadership for Learning: Lessons from 40 Years of Empirical Research. *Journal of Educational Administration*, 49(2), pp. 125-142.
<http://dx.doi.org/10.1108/09578231111116699>

- Hallinger, P. and Heck, R.H. (1998). Exploring the Principal's Contribution to School Effectiveness: 1980-1995. *School Effectiveness and School Improvement*, 9(2), pp. 157-191.
- Hallinger, P., & Murphy, J. (1985). Assessing the instructional leadership behavior of principals. *Elementary School Journal*, 86(2), 217-248.
- Harris, A. and Spillane, J. (2008). Distributed Leadership through the Looking Glass. *Management in Education*, 22(1), pp.31-34. DOI: 10.1177/0892020607085623
- Heck, R.H., and Hallinger, P. (2009). Assessing the Contribution of Distributed Leadership to School Improvement and Growth in Math Achievement. *American Educational Research Journal*, 46(3), pp.659-689. doi: 10.3102/0002831209340042
- Howell, J.M. and Avolio, B.J. (1993). Transformational Leadership, Transactional Leadership, locus of Control, and Support for Innovation: Key Predictors of Consolidated-Business-Unit Performance. *Journal of Applied Psychology*, 78(6), pp.891-902.
- Koh, W.L., Steers, R.M., and Terborg, J.R. (1995). The Effects of Transformational Leadership on Teacher Attitudes and Student Performance in Singapore. *Journal of Organizational Behavior*, 16, pp.319-333.
- Knapp, M.S., Copland, M.A., Honig, M.I., Plecki, M.L., and Portin, B.S. (2010). Learning-focused Leadership and Leadership Support: Meaning and Practice in Urban Systems. Commissioned by The Wallace Foundation. Prepared by Center for the Study of Teaching and Policy, University of Washington, Seattle, WA.
- Langley, G., Nolan, K., Nolan, T., Norman, C., and Provost, L., (1996). *The Improvement Guide*. Jossey-Bass: San Francisco
- Lasky, S. (2005). A Sociocultural Approach to Understanding Teacher Identity, Agency and Professional Vulnerability in a Context of Secondary School Reform. *Teaching and Teacher Education*, 21: pp. 899-916. doi:10.1016/j.tate.2005.06.003
- Lawrenz, F., Huffman, D. and Lavoie, B. (2005). Implementing and Sustaining Standards-Based Curricular Reform. *NASSP Bulletin*, 89(643), pp.2-16.

- Leithwood, K. (2012). Core Practices: The Four Essential Components of the Leader's Repertoire. In K. Leithwood & K.S.Louis (Eds.), *Linking Leadership to Student Learning* (57-67). San Francisco, CA: Jossey-Bass.
- Leithwood K., and Seashore Louis, K. (2012). *Linking Leadership to Student Learning*. San Francisco: Jossey-Bass Publishing.
- Leithwood K., Louis K.S., Anderson S., Wahlstrom K. (2004). How leadership influences student learning. *Learning from Leading Project*. New York, NY: Wallace Foundation.
- Leithwood, K.A., Mascall, B., Strauss, T., Sacks, R., Memon, N. and Yashkina, A. (2007). *Distributing Leadership to Make Schools Smarter: Taking the Ego out of the System*. *Leadership and Policy in Schools*. 6: 37-67.
- Leithwood, K., Patten, S., & Jantzi, D. (2010). Testing a conception of how school leadership influences student learning. *Educational Administration Quarterly*, 46(5), 671-706.
- LeMahieu, P. (2015, Aug 18). Why a NIC? [Web log comment]. Retrieved from <https://www.carnegiefoundation.org/blog/why-a-nic/>
- Lortie, D. (2002). *Schoolteacher: A Sociological Study*. 2nd Edition. Chicago: University of Chicago Press.
- Lortie, D. (2009). *School Principal*. Chicago: University of Chicago Press.
- Louis, K.S., Leithwood, K., Wahlstrom, K.L., and Anderson, S.E. (2010). *Learning from Leadership: Investigating the Links to Improved Student Learning: Final Report of Research Findings*. New York, NY: The Wallace Foundation.
- Neumerski, C.M. (2013). Rethinking Instructional Leadership, a Review: What Do We Know About Principal, Teacher, and Coach Instructional Leadership, and Where Should We Go from Here? *Education Administration Quarterly*, 49(2), pp. 310-347. DOI: 10.1177/0013161X12456700
- Achieve, Inc, on behalf of NGSS Lead States (NGSS). (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

National Policy Board for Educational Administration (2015). Professional Standards for Educational Leaders 2015. Reston, VA

National Research Council (NRC). (1996). National science education standards. Washington, DC: National Academy Press.

National Research Council (NRC). (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington D.C.; The National Academic Press.
http://www.nap.edu/download.php?record_id=13165

Portin, B.S., Knapp, M.S., Dareff, S., Feldman, S., Russell, F.A., Samuelson, C., and Yeh, T.L. (and assistance by Gallucci, C. and Swanson, J.) (2009). Leadership for Learning Improvement in Urban Schools. Commissioned by The Wallace Foundation. done by Center for the Study of Teaching and Policy.

Robbins, P. & Aydede, M. (2008). Chapter 1: A Short Primer on Situated Cognition. In P. Robbins & M. Aydede (Eds.), The Cambridge Handbook of Situated Cognition (pp. 3–10). Cambridge: Cambridge University Press.

Robinson, V.M.J. (2006). Putting Education Back into Educational Leadership. *Leading & Managing*, 12(1), pp.62-75.

Robinson, V.M.J., Lloyd, C.A., and Rowe, K.J. (2008). The Impact of Leadership on Student Outcomes: An Analysis of the Differential Effects of Leadership Types. *Education Administration Quarterly*. 44(5): 635-674. DOI: 10.1177/0013161X08321509

Rogoff, B. (1997). Evaluating Development in the Process of Participation: Theory, Methods, and Practice Building on Each Other. In Amsel, E. & Renninger, K.A. (Eds.), *Change and Development: Issues of Theory, Method and Application* (265-285). Mahweh, NJ: Lawrence Erlbaum Associates.

Rueda, R. (2011). Commentary: The Need for More Expansive Frameworks: A Practical Perspective. *Learning Disability Quarterly*, 34(3), pp.180-182. DOI: 10.1177/0731948711417554

- Sebring, P.B., Allensworth, E., Bryk, A.S., Easton, J.Q. and Luppescu, S. (2006). The essential Supports for School Improvement. Consortium on Chicago School Research: Chicago, IL.
<https://consortium.uchicago.edu/sites/default/files/publications/EssentialSupports.pdf>
- Spillane, J. (1998). Improving Teacher Practice: Can Policy and Peer Mentoring Help Teachers Do Better? in Enhancing Educational Performance: Three Policy Alternatives. Wisconsin Family Impact Seminar #11. School of Education, University of Wisconsin-Madison.
- Spillane, J.P. (1999). External reform initiatives and teachers' efforts to reconstruct their practice: the mediating role of teachers' zones of enactment. *Journal of Curriculum Studies*, 31 (2), 143-175.
DOI: 10.1080/002202799183205.
- Spillane, J. P. (2004). *Standards Deviation: How Schools Misunderstand Education Policy*. Cambridge, MA: Harvard University Press.
- Spillane, J.P. (2005). Distributed Leadership. *The Educational Forum*, 69(2), pp.143-150.
- Spillane, J. P. (2012). Data in Practice : Conceptualizing the Data-Based Decision-Making Phenomena. *American Journal of Education*, 118(February), 113–142.
- Spillane, J.P. (2015). Leadership and Learning: Conceptualizing Relations Between School Administrative Practice and Instructional Practice. *Societies*. 5: 277-294.
doi:10.3390/soc5020277
- Spillane, J.P. (2015b). Managing Instructional Quality and Leading Instructional Improvement: Engaging with the Essence of School Improvement. *AEL*. 37(1): 22-26.
- Spillane, J.P. & Anderson, L. (2014). The Architecture of Anticipation and Novices' Emerging Understandings of the Principal Position: Occupational Sense Making at the Intersection of Individual, Organization, and Institution. *Teachers College Record* 116(7) pp.1-42.
- Spillane, J. P., & Kim, C. M. I. N. (2012). An Exploratory Analysis of Formal School Leaders' Positioning in Instructional Advice and Information Networks in Elementary Schools. *American Journal of Education*, 119(November), 73–103.

- Spillane, J.P. & Thompson, C.L. (1997). Reconstructing Conceptions of Local Capacity: The Local Education Agency's Capacity for Ambitious Instructional Reform. *Educational Evaluation and Policy Analysis*, 19(2), pp.185-203. <http://www.jstor.org/stable/1164209>
- Spillane, J. P., Reiser, B. J., & Reimer, T. (2002). Policy Implementation and Cognition: Reframing and Refocusing Implementation Research. *Review of Educational Research*, 72(3), 387–431. doi:10.3102/00346543072003387
- Stein, M.K. and Coburn, C.E. (2008). Architectures for Learning: A Comparative Analysis of Two Urban School Districts. *American Journal of Education*, 114(4), 583-626. <http://www.jstor.org/stable/10.1086/589315>.
- Stein, M.K., & Spillane, J. (2005). What Can Researchers on Educational Leadership Learn from Research on Teaching? Building a Bridge. In W.A. Firestone & C. Riehl (Eds.), *A New Agenda for Research in Educational Leadership* (pp.28-45). New York, NY: Teachers College Press.
- Stein, M.K., Grover, B.W., and Henningsen, M. (1996). Building Student Capacity for Mathematical Thinking and Reasoning: An Analysis of Mathematical Tasks Used in Reform Classrooms. *American Educational Research Journal*, 33(2): pp. 455-488. doi: 10.3102/00028312033002455
- Supovitz, J. A. (2012). Getting at Student Understanding—The Key to Teachers' Use of Test Data. *Teachers College Record*, 114(11)."
- Szczesiul, S. and Huizenga, J. (2014). The Burden of Leadership: Exploring the Principal's Role in Teacher Collaboration. *Improving Schools*, 17(2), pp.176-191. doi: 10.1177/1365480214534545
- Thompson, J., Windschitl, M., & Braaten, M. (2013). Developing a Theory of Ambitious Early-Career Teacher Practice, *American Educational Research Journal*, 50(3), 574-615.
- Tyack, D. and Cuban, L. (1995). *Tinkering toward Utopia: A Century of Public School Reform*. Cambridge, MA: Harvard University Press.
- Valli, L., Croninger, R.G. and Walters, K. (2007). Who (Else) Is the Teacher? Cautionary Notes on Teacher Accountability Systems. *American Journal of Education*, _(), pp.635-662.

Vygotsky, L.S. (1997). Chapter 6: Development of Scientific Concepts. In J. Glick, R.W. Rieber, and Hall, M.J. (Eds.). *The Collected Works of L.S. Vygotsky v.4: The History of the Development of Higher Mental Functions (167-241)*. Cambridge, MA: Plenum Press.

Weick, K.E. (1976). Educational Organizations as Loosely Coupled Systems. *Administrative Science Quarterly*. 21(1): pp.1-19.

Wenger, E. (1998). *Communities of Practice: Learning, Meaning, and Identity*. Cambridge: Cambridge University Press.

Windschitl, M. & Calabrese Barton, A. (2016). Rigor and Equity By Design: Seeking a Core of Practices for the Science Education Community. In Lederman, N.G. and Abell, S.K. (Eds.), *Handbook of Research on Teaching, 5th Edition*. American Educational Research Association.

Windschitl, M., Thompson, J., Braaten, M., & Stroupe, D. (2012). Proposing a Core Set of Instructional Practices and Tools for Teachers of Science, *Science Education*, 96(5), 878-903.

Appendix A

Early Guiding Research Questions

The following reflect the initial set of research questions, and one additional question, that helped define the scope of the investigation. They were rooted in the overarching question, “*How might principals’ sense-making about science instructional reform work & their leadership practices be influencing teacher uptake and advancement of these reform-based instructional practices?*”

- Sense-Making
 - How do principals and assistant principals make sense of discipline-specific instructional reforms to be taken up by their teachers?
 - How do principals and assistant principals make sense of the relationship between these reforms and school/district level initiatives/policies?
 - In what ways do principals and assistant principals apply their sense-making about science reform work when they establish and implement operational goals and plans for their schools (e.g., school-wide goals, professional development plans, school-specific enactment plans for district-initiatives, use of data, etc.)?
- Interactions
 - Direct: How do principals and assistant principals interact with teachers and coaches around issues of instruction, including discipline-specific instructional reform work?
 - Indirect: How do school and district level initiatives/policies established/promoted by principals and assistant principals appear and interact with science specific instructional reform work, especially during structured times of professional learning for teachers?
- Influence
 - How are outputs from principals' leadership practices transformed (if at all) by teachers and coaches in the system and applied to instruction with respect to reform practices?

Appendix B

Interview Questions

Appendix B.1 – Principal/Assistant Principal Interview Questions

INTERVIEW QUESTIONS: PRINCIPAL/ASSISTANT PRINCIPAL

Thank you for taking time to talk with me today. The goal of this conversation is for me to gain greater understanding of how the science instructional work fits into the larger work of your building and to get your feedback about how we can adjust/evolve this work to support this school's specific needs in science instruction.

Demographic Info – need to keep very brief, but important to collect up front

- How long have you been a principal/AP? How long have you been at this school?

Connections between School Foci and AST/NIC Work (Q: 1b + 1c + 2b)

- What are the instructional goals you've held for your school this year?
- Can you list the different agendas or initiatives (from district, state, school, teachers, etc.) that impact your ability to improve instruction this year? E.g., Danielson, district data initiative, new science curriculum?

Interactions with Science Teachers around Science Instruction & Science Instructional Improvement (Q: 2a + 3a)

- Tell me about ways that you most often interact with teachers about issues of instruction or instructional improvement. (Press for consistency/frequency around interactions.) Can you describe a particular interaction you've had this year with a science teacher regarding instruction or instructional improvement?

Making Sense of Science-Specific Instructional Reform Work (Q: 1a)

- What do you think the real changes are that NGSS is trying to accomplish? What problems is AST trying to solve?
- How long have you been involved in ASTP work and in what ways?
- How do your overall school goals and data focus connect to the ambitious science teaching (AST) instructional work that your science teachers are doing with studio days & coaches?
- What do you think the strengths and challenges have been for your science department this year?
- What do you think moves your science teachers forward in meeting challenges and what holds your science team back from improvement?

Interactions with Science Coaches around Science Instruction & Science Instructional Improvement (Q: 2a)

- What role has the science coach played for your school? Is there anything additional you wish they had done or would do? (Press: Which of those see to be of the highest value to you? OR How do those things show up when you visit classrooms? OR Can you give an example of something the science coach has accomplished this year?)

- In what ways and how often do you interact with the science coach? Describe a particular interaction you've had this year with a science coach regarding instruction or instructional improvement? How would work with the coach look if it were ideal?

Roles in Science Instruction and Science Instructional Improvement (Q: 1c + 2b + 3a)

- How would you describe your role in supporting science instruction and instructional improvement? How do you share instructional leadership responsibilities [for science] with other building leaders? Is there anything you would like to do differently if you could?
- How does the district support your efforts to improve science instruction in your building? For example?
- How do you organize professional development opportunities for your teachers? How do district PD, school-based PD and other specialized PD opportunities connect to and impact one another? Where does the science PD (studio days, coaching, etc.) fit into this picture?
- What changes and/or additions to the AST supports (e.g., coaching, studio days, class visits, student work analysis, etc.) would you like to see to make them more effective/ accessible for your science teachers? (Possible press: What do you value most about ASTP? What do you find most frustrating about ASTP?)

Appendix B.2—Science Instructional Coach Interview Questions

INTERVIEW QUESTIONS: COACHES

Thank you for taking time to talk with me today. The goal of this conversation is for me to gain greater understanding of how the context of the different schools is influencing your work with ambitious science teaching practices with teachers, to understand how this fits into your overall work, and to learn more about how principals and assistant principals support your instructional work. Your participation is entirely voluntary. And you can choose not to comment on anything that makes you uncomfortable for any reason.

Demographic Info – need to keep very brief, but important to collect up front

- How long have you been a coach? How long have you been in your current position?
- Over the past 3-5 years, which schools have you supported with respect to science instruction and in what capacity?

Overarching question(s)

- What is ambitious science teaching (AST) and what role does it play in your work as a district coach? What are the other responsibilities of your role and how do they connect with AST?
- For each school you've supported, please tell me about how the implementation of ambitious and equitable science teaching practices has progressed over the years you have been involved. Please include your observations and experiences about each of the following:
 - To what extent have AST been adopted by the school as a whole and by individual teachers within it?
 - What parts of AST have the most traction at the school and by whom?
 - What holds the school back from implementing AST practices?
 - Do you believe the teachers at the school are generally on a productive path of professional growth with respect to their instructional practice? Why do you think that?

- How are AST efforts integrated with other [instruction-related] work at the school? What have been the science teachers' professional and team goals and AST focal practices and how have those related and changed over time?
- What has your role been at that school in supporting adoption of AST and how has it changed over time? What have your other goals/responsibilities been at that school?
- What role have principals and assistant principals played at the school to support this work and to support you? How has that changed over time?
- What have been the [instructional] goals and focus areas for the school in general and how have those changed? Have those goals/focus areas had much impact on science teacher professional learning and/or changes in instructional practice?
- Describe the collaborative lesson planning and collaborative learning about practice at the school and any changes in that over time.
- In better understanding how principals and assistant principals and their work influences science teachers' professional growth, particularly in terms of growing/changing instructional practice over time, what other things have you noticed and wondered about?

Reflective question

- When you talk about instructional practice at each school, are there any particular ways of talking or points of focus or priorities that you hear similarly prioritized or spoken of with consistent language by the principal/APs and the science teachers? How have such consistencies evolved over time?

Appendix B.3—Science Teacher Interview Questions

INTERVIEW QUESTIONS: TEACHERS *—with mapping to principal research questions*

Thank you for taking time to talk with me today. The goal of this conversation is for me to gain greater understanding of how ambitious science teaching practices fit into your overall teaching, including with respect to other responsibilities and initiatives, and to understand impacts of different supports for your instructional growth.

Demographic Info *— need to keep very brief, but important to collect up front*

- How long have you been a teacher? How long have you been at this school?

Contextual Demands/School Foci (Q: 1c + 2b + 3a)

- What do you view as the overall instructional goals for your school this year?
- Can you list the different agendas or initiatives (from district, state, school, teachers, etc.) that impact your ability to improve instruction this year? E.g., Danielson, district data initiative, new science curriculum?

Interactions with Principals/Aps around Science Instruction & Science Instructional Improvement (Q: 2a)

- Tell me about ways that you most often interact with your principal and/or assistant principal teachers about issues of instruction or instructional improvement. (Press for consistency/frequency around interactions.) Can you describe a particular interaction you've had this year with a principal regarding instruction or instructional improvement?

Making Sense of Science-Specific Instructional Reform Work with Respect to Other Obligations/Goals (Q: 2b + 3a)

- How would you describe what you are working on in terms of your instructional practice this year? What outcomes have you seen?
 - How have other science-specific goals and initiatives are you responsible for this year impacted your work on your practice (both helping and/or hindering; e.g., NGSS, updated curriculum...)
 - How have broader (non-science-specific) school goals & initiatives impacted your work on your practice?
- How did formal professional development opportunities at your school this year support your work on practice? How did they detract from it (if at all)?
- What moves science teachers in your school forward in their advancing their practice & what holds them back?

Interactions with Science Coaches around Science Instruction & Science Instructional Improvement (Q: 2a)

- What role has the science coach played for you this year? Is there anything additional you wish they had done or would do? How would work with the coach look if it were ideal?

Opportunities for Collaboration and Professional Development (Q: 1c + 2b)

- As you reflect on this past year, can you tell me about a single instance or a set of related instances when you have collaborated well with your colleagues? Why was this instance important to you? What was the object of your shared work and how did different colleagues (including yourself) contribute to that work? What were the outcomes? Is this a regular form of collaboration or was this more of a special occasion?
- How often do you meet formally & informally with your science teacher colleagues and what do you focus on? How does this work fit in with the larger professional development plan for your school?

Specific Experiences with Ambitious Science Teaching work (Q: 1c + 2b)

- How long have you been involved in AST work and in what ways?
- As you reflect on the past year, can you tell me about a productive studio day experience for you? Why was this experience meaningful to you? What particular outcomes from this experience did you take away? How did it impact your practice (if at all)?
- In comparison to other professional development opportunities, what do studio days mean to you? How do studio days overall impact your practice (or not)?
- What would make studio days and network convenings even more useful to you in advancing your practice?

Appendix C

Survey Questions

Appendix C.1a – 2016 Principal/Assistant Principal Survey Questions

- ❖ Which school are you assigned to this year?
- ❖ What is your role at the school?
- ❖ How long have you been working as an educator? (Total, not necessarily consecutive years.)
- ❖ What is your experience with STEM learning and teaching? Check all that apply.
- ❖ Do you currently serve as the evaluator for the science teachers at your school?
- ❖ Which THREE would you like your science teachers to spend more time on?
 - ❖ none
 - ❖ studio days
 - ❖ cross-district science teacher convenings
 - ❖ finding and using new online instructional strategic resources
 - ❖ using social media to connect and share with other teachers
 - ❖ creating/updating classroom tools
 - ❖ creating/updating planning tools
 - ❖ exit tickets and student data work
 - ❖ new district science curriculum
 - ❖ new teacher evaluation system
 - ❖ research about best practices
 - ❖ Next Generation Science Standards
 - ❖ district focus on data
 - ❖ working with science instructional coach
 - ❖ training time with the other science teachers
 - ❖ standardized tests
- ❖ Choose THREE learning activities that would be most important for the improvement of your science teachers' professional practice.
 - watching a colleague teach
 - revising a lesson/tool and immediately seeing its impact
 - evaluating student explanations
 - co-planning science explanations (what they would like to get from students)
 - learning about research on best practices
 - seeing how other schools implement the practices
 - sharing resources and practices across schools
 - collecting data on student participation
- ❖ In your opinion, what kinds of data matter most for adapting science classroom instruction?
- ❖ This year, approximately how much time has been provided at your school for the science department meet to work together? (Please do not count Studio Days and convenings.)
- ❖ To what extent do you agree with the following statements regarding the administrative team at your school?
The administrative team at my school...
 - communicates a clear vision for our school.
 - sets high standards for student learning.
 - is supportive of the changes teachers are attempting to make in teaching science.
 - sets high standards for teaching in science.
 - actively monitors the quality of science teaching in the school.
 - understands how children learn science.
 - presses teachers to implement what they have learned in Studio Days.
 - carefully tracks student academic progress in science.

- knows what is going on in the science classrooms.
- participates in instructional planning with teams of science teachers.
- shares a similar instructional vision (to coaches and university facilitators) for science teaching.
- understands and supports what teachers are trying to accomplish in Studio Days.
- provides feedback that is aligned with the instructional practices teachers aim to develop in Studio Days.
- asks teachers about their work with the science teacher network (i.e. Studio Days, Convenings).
- has attended Studio Days or Convenings this year.
- ❖ During this school year, approximately how often have you and your science teachers interacted in the following ways?
 - I was made aware of new materials, strategies and resources for teaching science.
 - I observed my science teachers teaching (for at least 10 minutes).
 - I provided feedback to improve teacher instruction after observing their teaching.
 - We talked about the work done in Studio Days & Convenings.
 - We collaborated on non-science school or district initiatives.
 - I made science teachers aware of non-science specific school or district initiatives.
 - I helped the science team to secure instructional resources.
 - I discussed teaching/instructional practices with science teachers.
 - I discussed professional goals with one or more science teachers.
 - How did this differ during the last (2015-2016) school year?
 - Were there particular interactions that happened more or less frequently last year? Please comment.
- ❖ Please share any final comments, questions or concerns in the text box below

Appendix C.1b – 2015 Principal/Assistant Principal Survey Questions

- ❖ Which school were you assigned to this year?
- ❖ What is your role at the school?
- ❖ How long have you been working as an educator? Number of total years
 - How long have you been assigned to your current school?
 - How long have you been an administrator in the K--12 system?
 - How long were you a teacher?
- ❖ What is your experience with STEM learning and teaching? Check all that apply.
 - I was a mathematics teacher.
 - I was a science teacher.
 - I was a technology teacher.
 - I have worked on STEM programs as an administrator.
 - I have worked closely with STEM teachers and departments.
 - Other (please specify)
- ❖ Which THREE would you like your teachers to spend more time on?

My priorities for science teachers:

 - none
 - studio days
 - cross-district science teacher convenings
 - finding and using new online instructional strategic resources
 - using social media to connect and share with other teachers
 - creating/updating classroom tools
 - creating/updating planning tools
 - exit tickets and student data work
 - new district science curriculum
 - new teacher evaluation system
 - research about best practices
 - Next Generation Science Standards

- district focus on data
- working with science instructional coach
- training time with the other science teachers
- standardized tests

Comment on any of the above

- ❖ Looking ahead to next year, choose THREE learning activities that would be most important for the improvement of your teachers' professional practice?
 - watching a colleague teach
 - co--planning science explanations (what they would like to get from students)
 - seeing how other schools implement the practices
 - evaluating student explanations
 - learning about research on best practices
 - collecting data on student participation
 - sharing resources and practices across schools
 - revising a lesson/tool and immediately seeing its impact

Comment on any of the above.

- ❖ What kinds of data matter most for adapting classroom instruction?
- ❖ This year, approximately how much time was provided at your school for the science department meet to work together? (Please do not count Studio Days and convenings.)

Other (please specify)

- ❖ To what extent do you agree with the following statements regarding the administrative team at your school? The administrative team at my school...

- Strongly disagree
- Disagree
- Agree
- Strongly agree

- communicates a clear vision for our school.
- sets high standards for student learning.
- is supportive of the changes teachers are attempting to make in teaching science.
- sets high standards for teaching in science.
- actively monitors the quality of science teaching in the school.
- understands how children learn science.
- presses teachers to implement what they have learned in Studio Days.
- carefully tracks student academic progress in science.
- knows what is going on in the science classrooms.
- participates in instructional planning with teams of science teachers.
- shares a similar instructional vision (to coaches and university facilitators) for science teaching.
- understands and supports what teachers are trying to accomplish in Studio Days.
- provides feedback that is aligned with the instructional practices teachers aim to develop in Studio Days.
- asks teachers about their work with the science teacher network (i.e. Studio Days, Convenings).
- has attended Studio Days or Convenings this year.

Comment on any of the above

- ❖ During this school year, approximately how often did you and your science teachers interact in the following ways?
 - Never
 - 1--2 times
 - 3--5
 - 6--10
 - 11--20

- >20 times
- I was made aware of new materials, strategies and resources for teaching science.
- I observed my science teachers teaching (for at least 10 minutes).
- I provided feedback to improve teacher instruction after observing their teaching.
- We talked about the work done in Studio Days & Convenings.
- We collaborated on non--science school or district initiatives.
- I made science teachers aware of non--science specific school or district initiatives.
- I helped the science team to secure instructional resources.
- I discussed teaching/instructional practices with science teachers.
- I discussed professional goals with one or more science teachers.
- ❖ Please share any final comments, questions or concerns in the text box below:

Appendix C.2 — 2015 & 2016 Science Teacher Surveys, Sample Questions

- ❖ Of those things above, which THREE would you like to spend more time on? Which THREE do you think your administrator would want you to focus on?
 - none
 - studio days
 - cross-district science teacher convenings
 - finding and using new online instructional strategic resources
 - using social media to connect and share with other teachers
 - creating/updating classroom tools
 - creating/updating planning tools
 - exit tickets and student data work
 - new district science curriculum
 - new teacher evaluation system
 - research about best practices
 - Next Generation Science Standards
 - district focus on data
 - working with science instructional coach
 - training time with the other science teachers
 - standardized tests
- ❖ Which practices have you been working on this school year, like structured talk for how & why explanations, peer feedback, modeling to support scientific explanations, EL support for communicating science, or others? Please name the most prevalent ones and describe briefly HOW you have been working on these practices.
- ❖ What kinds of data matter most for adapting the practice you mentioned above?
- ❖ How are the practices you've been working on similar to and/or different from what your science colleagues at your school have been working on this year?
- ❖ To what extent do you agree with the following statements regarding ONE administrator? The administrator...
 - communicates a clear vision for our school.
 - sets high standards for student learning.
 - is supportive of the changes we are attempting to make in teaching science.
 - sets high standards for teaching in science.
 - actively monitors the quality of science teaching in this school.


- understands how children learn science.
 - presses teachers to implement what they have learned in Studio Days.
 - carefully tracks student academic progress in science.
 - knows what is going on in my classroom.
 - participates in instructional planning with teams of science teachers.
 - shares a similar instructional vision (to coaches and university facilitators) for science teaching.
 - understands and supports what we are trying to accomplish in Studio Days.
 - provides feedback that is aligned with the instructional practices we aim to develop in Studio Days.
 - asks me about my work with the science teacher network (i.e. Studio Days, Convenings).
 - has attended Studio Days or Convenings this year.
- ❖ During this school year, approximately how often did you and your administrator interact in the following ways?
- I made my administrator aware of new materials, strategies and resources for teaching science.
 - S/he observed my teaching (for at least 10 minutes).
 - S/he provided me with feedback to improve my instruction after observing my teaching.
 - We talked about the work we do in Studio Days & Convenings.
 - We collaborated on non-science school or district initiatives.
 - S/he made me aware of non-science specific school or district initiatives.
 - S/he helped me to secure instructional resources.
- ❖ How often this year has this person helped you or interacted with you in the following ways? (Use N/A for those things you have not experienced with this person.)
- This person has shared (existing) materials with me (e.g., a lesson, activity, learning unit, probe, tool, etc.).
 - We have collaborated to create, plan or modify instructional materials (e.g., lesson, tool, activity, etc.).
 - This person has helped me to better understand some science content.
 - We have discussed student learning.
 - This person has helped me to better understand learning and teaching.
 - We have analyzed examples of student work.
 - We have co-taught lessons or parts of lessons.
 - This person has given me feedback on my practice (e.g. teaching, coaching, mentoring, etc.).
 - We have collaborated on improving instruction specifically for ELL students.

Appendix D

Scales Used to Discuss and Evaluate Learning Opportunities

Appendix D.1 – Teachers’ Learning Progression for Ambitious Science Teaching Practices – 4 Core Science Practices and 1 ELL Practice

Ambitious Science Teaching (with practices for supporting EL students)

Ambitious Practices	A progression for analyzing attempts at Ambitious Science Teaching				Aim for practices in this direction >>>
<p>ST Practice 1</p> <p>1) Selecting big ideas, treating them as models</p>  <p>Selecting major academic language to be developed, practiced, and used in relation to the big idea/model.</p>	<p>Missing science content</p> <ul style="list-style-type: none"> Teacher has built unit on topics that are not connected to phenomena in the natural world. 	<p>Focus on topic or “things”</p> <ul style="list-style-type: none"> Teacher has selected concrete or abstract entities (things) to learn about in varying degrees of detail. Students asked to describe, name, label, identify, using correct vocabulary. 	<p>Focus on observable processes</p> <ul style="list-style-type: none"> Teacher has selected as focus a natural system and “what is changing” in a system or how conditions affect a naturally occurring event. Teacher has focused on logical relationships among concepts. 	<p>Focus on observable-unobservable</p> <ul style="list-style-type: none"> Teacher has focused on <i>unobservable</i> processes, events, or entities, and how these relate to <i>observable</i> natural phenomena. Unit framed around complex, situated phenomenon to be explained. 	<p>Explanation as model</p> <ul style="list-style-type: none"> Teacher has emphasized links between observable and unobservable in order to develop an explanatory model that students will make sense of over time. Students make links between observable and unobservable content. Unit framed around complex, situated phenomenon to be explained. For EL students, Teacher has identified, selected, and explicitly taught key academic language to be developed and used in the lesson(s). Teacher focuses on the purposes of using the focal scientific language and related complex language structures, in addition to content-specific vocabulary.


ST Practice 2

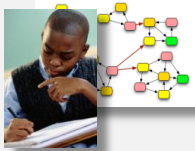
2) Attending to students' ideas and experiences



Attending to the language of students' ideas and experiences

<p>No access to students' ideas</p> <ul style="list-style-type: none"> • No discourse interactions between teachers and students or among students—students' ideas inaccessible to teacher. 	<p>Monitoring for correctness of students' ideas</p> <ul style="list-style-type: none"> • Teacher starts by presenting information, then monitors language students use to see if students are developing "correct" conceptions. • Teacher uses IRE in whole class conversations to present more correct conceptions to students. 	<p>Eliciting students' initial & unfolding understandings</p> <ul style="list-style-type: none"> • Teacher elicits students' initial and on-going hypotheses, questions, or conceptual frameworks about a scientific idea. 	<p>Referencing students' ideas</p> <ul style="list-style-type: none"> • Teacher listens for and acknowledges partial understandings as well as alternative conceptions (without presuming students need to precisely replicate the teacher's line of thinking). • Students' thinking is made visible by teacher through re-voicing or public representations 	<p>Using students' ideas and experiences to adapt instruction</p> <ul style="list-style-type: none"> • Teacher elicits and uses students' language, partial understandings, and experiences as building blocks to shape the direction of classroom conversations. • Teacher pursues students' lines of thinking by making their ideas visible and weaving students' lines of reasoning together with scientifically coherent ideas. • For EL students, Teacher clearly differentiates language, according to purpose and register of task For example, in weaving students' lines of reasoning together with scientifically coherent ideas, Teacher points out the difference in language between a more "conversational" or "classroom" language used in students' lines of reasoning and the change in language use when referring to "scientifically coherent ideas." • Teacher makes explicit to the students the language choices (s)he makes for which task and why.
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<p>ST Practice 3</p> <p>3) Using activity to support on-going changes in reasoning</p>  <p>Using activity to support content comprehension and academic language development in the science classroom</p>	<p>Students not engaged in activity</p> <ul style="list-style-type: none"> • There are no observations made, use of 2nd hand data, simulations, or lab work to develop a concept. • Teachers presentations or readings substitute for engagement with science practices. 	<p>Primarily focusing on procedure</p> <ul style="list-style-type: none"> • Teacher asks students to describe procedures for activities or experimental set-ups. • Science concepts are played down to allow time to talk about designing observations. • Talk with students is about how to do an activity or about error, validity, reliability, 	<p>Discovering or Confirming Science Ideas</p> <ul style="list-style-type: none"> • Teacher has students “discover” science concepts for themselves without guidance OR has students use an activity as a “proof of concept.” • Science is about acquiring accepted facts, principles, or laws. Students collect information to recognize or prove patterns, but not to make sense of 	<p>Linking concepts within and across investigations</p> <ul style="list-style-type: none"> • Teacher seeds students’ thinking with new science concepts (not explanations) and asks students to use these ideas to shape and/or make sense of an investigation. • Science ideas are up for discussion. Public representations of students’ ideas change in response to findings from each day. • <i>For EL students, Teacher uses visuals, charts, and other comprehensible input supports to share new science concepts.</i> 	<p>Model-Based Inquiry focus</p> <ul style="list-style-type: none"> • Teacher or students highlight gaps in tentative explanatory models as the motivation for investigations. • Teacher builds in background knowledge of underlying (unobservable) science ideas and models before, during, and following an inquiry, but without doing the reasoning for the students. • Students derive explanatory language from activity and use it to reconsider their models. • Science activity is about revising and testing models to synthesize ideas and explain problems. • <i>For EL students, Teacher is explicit about the purpose and register of the language used for a particular task as well as the vocabulary the students are using or can use (e.g. what is “explanatory language?”)</i> • <i>Teacher provides multiple English language development supports, such as a number of sentence stems, to support EL students in explaining problems and their models, and synthesizing ideas.</i> • <i>For EL students, teacher explicitly teaches students’ language for explaining problems and their models and synthesizing ideas.</i>
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		recording data.	underlying causes		
<p>ST Practice 4</p> <p>4) Pressing for explanation</p>  <p><i>Pressing for explanation and attention to academic language/language of the science classroom</i></p>	<p>No press for a scientific explanation</p> <ul style="list-style-type: none"> Teacher does not ask students to provide any form of explanation; or teacher uses “explain” to mean “justify” as in justify the existence of an entity or accepted fact. There is no event or process that is subject to explanation. 	<p>“What happened” explanation</p> <ul style="list-style-type: none"> Teacher asks students to describe relationships between variables, differences between experimental groups, trends over time, or qualitative observations. “Explain what you see in the data.” 	<p>“How/ partial why” something happened explanation</p> <ul style="list-style-type: none"> Teacher asks students to hypothesize about reasons for relationships among variables or observations, and how these predict the ways some natural system will behave. 	<p>Causal explanation</p> <ul style="list-style-type: none"> Teacher has students use unobservable events, processes, and entities to construct a causal story of why something happened. (may mean first supporting students through “what” and “how explanations” with goal of working toward “why explanations”) Teacher unpacks learning about the nature of scientific explanations with students, and about “what counts” as evidence. <i>For EL students, Teacher begins with an open-ended question, slows down the pace of the dialogue and allows more turns by the student to explain or clarify thinking before the Teacher evaluating/recasting. Teacher questions are aimed at understand the meaning of what the EL student is contributing. When recasting EL student responses, Teacher models language use.</i> <i>If needed, Teacher invites the EL student to reference or draw a visual to represent thinking.</i> Teacher makes explicit what language the students are using and for what purpose. 	<p>Arguing from evidence about an explanatory model</p> <p>Teacher asks students to use evidence to support key parts of the causal story.</p> <ul style="list-style-type: none"> Teacher unpacks learning about “what counts” as evidence with students and scaffolds their use of it. Students supported in engaging in scientific argument with peers, evaluating their own arguments and those of others. <i>Teacher creates and makes explicit to the EL students multiple language supports, such as sentence stems, for the students to use in framing and sharing their ideas.</i> Teacher makes explicit what language the students are using and for what purpose (i.e. language functions). <i>Teacher explicitly teaches language of explanation to EL students</i>

Appendix D.2—Rubric for Evaluating Student Work based on Depth of Explanations and Use of Evidence to Support Explanations

Standards-based rubrics for written scientific explanations

Dimension	Beginning (1)	Approaching (2)	Meeting (3)	Exceeding (4)
Depth of explanation	<i>“What” explanation</i> Describes what happens. Focuses on observations without suggesting cause.	<i>“How” explanation</i> In addition to describing what happens, focuses on processes – how something happens. Starts to include cause-effect relationships and unobservables.	<i>“Why” explanation</i> In addition to describing what happens and how, explains why something happens or works the way it does. Includes chains of causes and effects and unobservable or theoretical ideas.	<i>“Why+” explanation</i> “Why” explanation plus: <ul style="list-style-type: none"> • Application to related phenomena or situations
Integration of evidence	<i>Refers to data, observations, activities</i> Cites observables or activities without reasoning that connects them to aspects of the explanation. May be part of a description of what happens.	<i>Connects to evidence</i> Uses specific evidence as support for specific aspects of the explanation, but reasoning connecting evidence and explanation is limited or unclear.	<i>Justifies with evidence</i> Uses specific evidence as support for specific aspects of the explanation, with clear connective reasoning that draws on scientific principles.	<i>Justifies+</i> Justifies with evidence plus: <ul style="list-style-type: none"> • Triangulates evidence from multiple sources to support a claim • Use of evidence to compare multiple possibilities and/or refute alternate ideas

Aligned with/in support of:

- CCSS.ELA-Literacy.W.9-10.1: Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
- NGSS Practice 6: Constructing Explanations
- NGSS Practice 7: Engaging in Argument from Evidence

Appendix E

Principal Learning Walk Supporting Materials

Appendix E.1 – Principal Learning Walk Protocol

Protocol for Science Teaching Learning Walks with Principals Purpose: To promote productive conversations about instruction and NOT intended for evaluative purposes.	
3-5 min <i>pre-walk</i>	Review the Practices <ul style="list-style-type: none"> • <u>HOST</u>: Briefly summarizes ASTP practices (e.g., NGSS shift to skills not just content; constructing explanations not reiterating them; foregrounding student thinking; ASTP in cycles, but not always). • <u>ALL</u>: Take 2-4 minutes to look over the ASTE description (page one of observation tools handout)
4-6 min <i>pre-walk</i>	Discuss the Instructional Practices & Concerns <u>PRINCIPAL & ASSISTANT PRINCIPAL(S)</u> : Each comments briefly (2 min total) on these questions: <ol style="list-style-type: none"> 1. What have you seen that is interesting to you in your science classrooms? 2. What have you seen (or not seen) that concerns you in your science classrooms? 3. Do you have any reactions or questions about the ASTP summary?
3 min <i>pre-walk</i>	Choose a focus for the instructional walk <ul style="list-style-type: none"> • <u>COACH</u>: Briefly (1 min) summarize teachers’ current focus for instructional practice development • <u>HOST</u>: Introduce observation tools and describe how we can use them to focus today’s visit. Suggest: <ul style="list-style-type: none"> ○ Use Tool 1 as individual reflection after each visit. ○ Use Tool 2 or Tool 3 to record particular observations in 1 or 2 quadrants during each visit. • <u>PRINCIPAL/ASSISTANT PRINCIPAL(S)</u>: Choose Tool 2 (engagement) or Tool 3 (rigor)
~8-10 min each	Visit Classrooms <ul style="list-style-type: none"> • <u>PRINCIPAL/ASSISTANT PRINCIPAL</u>: Identify the 2-5 science classrooms that you would like to visit and choose an efficient route for the learning walk. • <u>ALL</u>: Enter each classroom and plan to stay for 8-10 minutes. If students are working in smaller groups, each observer should choose a table group or pair of students to observe. Make notes on observation Tool 2 or 3. At end of visit, use Tool 1 to check off observed student/teacher interactions. • <u>ALL</u>: After visiting each classroom, each person in the group should briefly share a comment about something they noticed during the visit to that classroom. • <u>HOST</u>: Between classroom visits, answer any questions for principal/assistant principal(s).
10-15 min <i>post-walk</i>	Debrief Classroom Visits <u>PRINCIPAL & ASSISTANT PRINCIPAL(S)</u> : Each respond to the following questions: <ol style="list-style-type: none"> 1. What is one take-away that you have about science teaching in your school from today? What helped you think about that? 2. In what ways do you think you can best support your science teachers as they develop their instructional practices to best serve their students? 3. How can the research team and/or coaches better support you to connect with, leverage and support this work? <u>HOST</u> : Briefly respond to questions. Invite comments from researcher(s) and coach as needed.
3 min <i>post-walk</i>	Debrief Overall Learning Walk <u>PRINCIPAL & ASSISTANT PRINCIPAL(S)</u> : Each respond to the following: What did you like about the learning walk and observation tools, and what would you change?
2 min <i>post-walk</i>	Next Steps <u>HOST</u> : Identify dates and upcoming events (studio days, data days, convenings, learning walks, etc.).

Appendix E.2—Principal Learning Walk Tool with Space for Targeted Observation Notes

Observing Science Classes: Looking for and Recognizing Best Practices

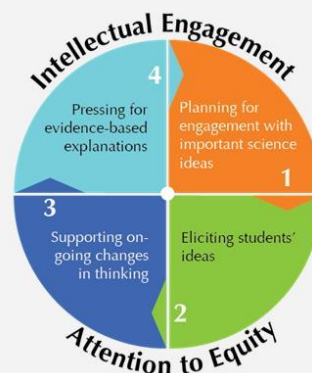


This set of observation tools brings together best instructional practices in science, Next Generation Science Standards (NGSS) and relevant practices from the Danielson framework. NGSS has fundamentally shifted science instruction to elevate science and engineering *practices* (e.g., asking questions, developing & using models, planning & carrying out investigations, analyzing & interpreting data, constructing explanations, engaging in argument from evidence, and obtaining, evaluating and communicating information) to equal footing with disciplinary *content* and crosscutting *concepts*. Similarly, the Danielson Framework (particularly in domain 3, which covers instruction) elevates the role of students as active learners by recognizing the need for strong intellectual engagement from students who learn via questioning and discussion with one another as well as with the teacher.

These tools group observations into four ambitious science teaching practices that occur, sometimes in a cohesive cycle, sometimes as independent elements. Depending on the focus of the class you are observing, one area may serve as a better focus for that day. Tool 1 can be used during an observation or just after leaving a classroom. Use Tool 2, the engagement tool, to tally particular student engagement behaviors during an observation. Similarly, use Tool 3, the rigorous talk tool, to make notes about student talk during an observation. Use notes areas to script student conversations, record questions or make other notes.

Ambitious & Equitable Science Teaching Practices

Research about teaching and learning in science broadly converges on the importance of student engagement with scientific practices (Windschitl & Barton, 2014). To engage meaningfully, students must have opportunities to make their thinking visible, to reason about new information and ideas, and to actively change and add to their understanding over time. Research shows that students can only engage rigorously with scientific ideas if instruction is responsive to their ideas and questions (Thompson et al., 2016). The following research-based instructional practices promote responsive talk and activity in science classrooms.



Planning for engagement with important science ideas – a big question or observable scientific event (a.k.a., phenomenon) is used across a unit of study to help tie different science principles and activities together in a meaningful way.

Eliciting students' ideas – occurs when a major new idea is introduced. Research shows that for students to shift and add to their understanding, their thinking must be made public. Such lessons focus less on “correct” science ideas and more on helping students to articulate their own thinking open questions.

Supporting ongoing changes in students' thinking through opportunities for student sense-making – occurs during particular activities/lessons in the middle of a unit. Research shows that learning from material activities is most effective when the activities are accompanied by sense-making talk during and after the activity.

Pressing for evidence-based explanations – providing students opportunities for argument and reasoning – occurs at the end of a unit or later in sense-making lessons. Research shows that allowing for variability in student explanations helps promote comparative reasoning & construction of stronger explanations.

These practices are intended to be used in progressive cycles over the course of a unit of instruction; but teachers may iterate on them in different ways. The tools provided here do not assume any particular cycles of science instruction. These tools focus on particular aspects of instruction that tends to be present in each of the these practices. For reference, connections are made between in the observation tools between the ASTP and NGSS as well as Danielson (CD). You can find additional supporting tools and more information about these particular instructional practices on ambitiousscienceteaching.org.

Tool 1: Observing Instructional Practices—Identifying Key Teacher & Student Interactions

Choose one or two of the following “look for” areas to focus a short visit to a science class. For each area, you will look for one particular aspect of student talk (and other expressions such as writing and drawing). Both student and teacher actions are identified. These observations can help identify classes in which teacher and student talk practices are still developing or beginning to emerge and those in which practices are proficient or more advanced. This tool is intended for promoting productive discussions and not for evaluation.

Look for: Reasoning with Evidence

For students to understand bigger science questions or phenomena, they must apply multiple sources of information to construct scientific explanations. (CD 3b & 3c)

- Developing/Emerging**
- Students describe processes.
 - Teacher asks students to answer questions without pressing them to explain their reasoning.
 - Students make claims and cite evidence without fully explaining how/why the evidence supports the claim.
 - Students explain individual science concepts without connecting them.
 - Students explain larger phenomena/questions using scientific facts without using evidence to reason.
 - Students reconstruct models from their text or notes without evidence or reasoning.

- Proficient/Advanced**
- Students compare/contrast different ideas.
 - Students combine ideas and add to explanations.
 - Teacher (or other students) asks students to explain their reasoning when they cite evidence and make claims & arguments.
 - Students create visual/written models that link observable evidence to explanations.
 - Students explain how/why non-occurred or answer larger scientific questions using evidence to back their reasons.

Look for: Connections to bigger questions/phenomenon

Classroom talk and activities should help students develop their understanding of a science question or phenomenon that is bigger than individual science facts or principles from a single lesson. (CD 3a & 3c)

- Developing/Emerging**
- Teacher focuses on single topics without significant ties to larger questions or scientific phenomena.
 - Students are asked to describe, name, label, and identify, using correct vocabulary.

- Proficient/Advanced**
- Lesson connects to a complex real-world science question or phenomenon to be explained.
 - Students make connections between observable and unobservable science content.

Look for: Making Sense of Data & Information

For students to add to and modify their understanding of a scientific concept, they need new information AND opportunities to make sense of it (CD3b&3c)

- Developing/Emerging**
- Lesson focuses on a science skill (procedure, observation, etc.) separate from the science concepts.
 - Teacher asks students to describe relationships between variables, differences between experimental groups, trends over time, or qualitative observations. “Explain what you see in the data.”
 - Students use activity or reading to collect information or recognize patterns about a single concept and do not connect it to a larger science question or phenomenon.

- Proficient/Advanced**
- Students identify trends and relationships and form hypotheses about reasons for relationships.
 - Students discuss science ideas and don't just state them.
 - Students make connections between data or information and larger scientific questions/phenomena
 - Students use evidence from the lesson to more fully develop an explanation for a larger science question/phenomenon.
 - Teacher and/or students update/change public representations of students' ideas in response to findings from the lessons.

Look for: Connections to students' experiences

For students to build understanding about a scientific concept, they need to connect it to their own relevant experiences and thinking. (CD 3c, 3d & 3e)

- Developing/Emerging**
- Teacher elicits students' initial ideas and evaluates them for “correctness”.
 - Teacher references real-world events that may be relevant to students and that connect to current unit without eliciting connections directly from students.
 - Teacher revises and/or records student ideas without building on them during the lesson/unit.

- Proficient/Advanced**
- Teacher elicits students' language, partial understandings, and experiences to shape talk and activities.
 - Teacher makes student ideas visible through revising and/or public representations and references/builds on them during the lesson/unit.
 - Students talk/write about why they think something happens.
 - Students draw on their observations of science phenomena and their personal experiences to hypothesize about why something happens or to predict what might happen.

Intellectual Engagement

1 Planning for engagement with important science ideas

2 Eliciting students' ideas

3 Supporting ongoing changes in thinking

4 Pressing for evidence-based explanations

Attention to Equity

Tool 2: Observing for Equitable Engagement—Data Snap Observation Tool

This observation tool can help identify which and how many individual students, and groups of students, are participating in particular areas of talk/work. It can also help identify how often students are engaged with deeper levels of science talk during a class.

Based on what is happening in the class you are observing, choose one or two of the following “look for” areas to focus observations during a visit (~8-10 min or more) to a science class. For each area, you will look for one particular aspect of student talk (and other expressions such as writing and drawing) by tracking three questions. Add a tally mark or note in the appropriate box each time you observe a representative instance/student/group.

These observations can help identify who is participating in particular areas of talk/work and at what level they are participating.

NOTE: This tool is intended to promote productive conversations about instruction and is NOT intended for evaluative purposes.

Look for: Reasoning with Evidence

(connects to CD 3b & 3c + NGSS asking questions, developing & using models, analyzing & interpreting data, constructing explanations, engaging in argument from evidence, and obtaining, evaluating and communicating information)

	<i>How many times do students identify specific evidence in their talk/writing?</i>	
	<i>How many different students identify evidence in talk/writing during class?</i>	
	<i>Which groups of students (e.g., ELL, special needs, struggling, girls/boys, other) identify evidence in talk/writing during class?</i>	

Look for: Connections to bigger questions/phenomenon

(connects to CD 3a & 3c + NGSS asking questions, developing & using models, engaging in argument from evidence, & obtaining, evaluating and communicating information)

	<i>How many times do students refer to how one science idea connects to bigger questions/phenomena?</i>	
	<i>How many different students reference big questions/phenomenon?</i>	
	<i>Which groups of students reference big questions/phenomena?</i>	

Look for: Making Sense of Data & Information

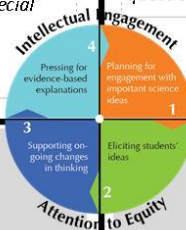
(connects to CD 3b & 3c + NGSS asking questions, planning & carrying out investigations, analyzing & interpreting data, constructing explanations, & obtaining, evaluating & communicating information)

	<i>How many times do students try to explain what data or particular scientific facts mean?</i>	
	<i>How many different students try to explain the meaning of data or facts?</i>	
	<i>Which groups of students try to explain the meaning of data or facts?</i>	

Look for: Connections to students' experiences

(connects to CD 3c, 3d & 3e + NGSS asking questions, developing & using models, constructing explanations, and obtaining, evaluating and communicating information)

	<i>How many times do students share relevant personal experiences about a science question/phenomenon?</i>	
	<i>How many times does the teacher revoice or publically record student ideas?</i>	
	<i>How many different students share experiences? Which groups share?</i>	



ADDITIONAL NOTES (e.g., noticing about student patterns of participation; questions, etc.)

Appendix F

Researcher Logs – Forms and Data Systematically Collected

Appendix F.1a – Studio Day Log – Years 1-3, sample section

5/25/2017

Science Studio Data (Official)

8. Notes about practice 2 during the studio (across lessons) and in comparison to previous studios

9. Practice 3) Using activity to support on-going changes in reasoning

1 (not engaged in activity), 2 (focused on procedure), 3 (discovering or confirming science ideas), 4 (linking concepts within and across), 5 (model-based inquiry focus)

Mark only one oval.

- 1
 2
 3
 4
 5

10. Notes about practice 3 during the studio (across lessons) and in comparison to previous studios

11. Practice 4) Pressing for explanation

1 (no press for explanation), 2 (what happened), 3 (how/partial why), 4 (causal explanation), 5 (arguing from evidence)

Mark only one oval.

- 1
 2
 3
 4
 5

Appendix F.1b – Studio Day Log – Year 4, sample section

8. Notes about practice 2 during the studio (across lessons) and in comparison to previous studios

9. Practice 3) Using activity to support on-going changes in reasoning

1 (not engaged in activity), 2 (focused on procedure), 3 (discovering or confirming science ideas), 4 (linking concepts within and across), 5 (model-based inquiry focus)

Mark only one oval.

- 1
 2
 3
 4
 5

10. Notes about practice 3 during the studio (across lessons) and in comparison to previous studios

11. Practice 4) Pressing for explanation

1 (no press for explanation), 2 (what happened), 3 (how/partial why), 4 (causal explanation), 5 (arguing from evidence)

Mark only one oval.

- 1
 2
 3
 4
 5

Appendix F.2a—Data Day Log – Year 3, sample section

2. Date

Example: December 15, 2012

3. Who was there?

4. Practice focus

Mark only one oval.

- Peer feedback to deepen written explanations
- Selecting and sequencing models for whole-class share-out
- Structured talk for how/why reasoning

5. What data was available, and what observations were made?

6. What next steps or takeaways did teachers identify with respect to the practice? (How did these relate to their data observations?)

Appendix F.2b — Categories of Reflective Notes about Years 3+4 (collected in late Y4)

- ❖ Y3 Month of First Data & Planning Meeting
- ❖ Rough approximation of number of Y3 Data & Planning Meetings
- ❖ Time Utilized for Y3 Data & Planning Meetings
- ❖ Y3 AVERAGE Characterization of the Degree of Using Student Data to Inform Instruction (HIGH MEDIUM LOW - SEE NOTE)
- ❖ Y3 Variation of Characterization from Meeting to Meeting (HIGH MEDIUM LOW - SEE NOTE)
- ❖ Y3 Level of connectedness/building (INDEPENDENT, LOOSE- PRACTICE, LOOSE-OUTCOME, PROGRESSIVE, OTHER - SEE NOTE)
- ❖ Y3 Average Number of Teachers Attending
- ❖ Y3 Consistency in Teacher Attendance - MOSTLY SAME TEACHERS; SOME VARIATION; INCONSISTENT
- ❖ Comments about data and planning meetings in Y3
- ❖ Comments about any changes or consistency observed in Y4 regarding data and planning meetings

Appendix F.3 — Class Observation Log – Year 3 – sample questions

8. When is the lesson occurring in the current unit? *

Mark only one oval.

- Early
 Middle
 Late

9. Briefly describe the lesson observed

Provide context for the lesson and identify different activities/elements of the lesson

10. Which, if any, focal practice was at play?

Mark only one oval.

- None
 Peer feedback: Role-based discussion
 Peer feedback: Argumentation discussion with white boards
 Peer feedback: Explanation-feedback discussion
 Peer feedback: Peer feedback protocol/template
 Modeling: Sequenced share-out
 Structured Talk
 Other: _____

11. If focal practice did not occur today, why?

Mark only one oval.

- Does not have focal practice
 Focal practice still under development
 Researcher constraints did not allow for observation of focal practice
 Supporting activities for focal practice were at play, but not the practice itself
 Part of focal practice was at play, but not all of it
 Teacher seldom applies focal practice
 Other: _____

Observations of AST Core Practices

Appendix G

Analytic Codes Applied in this Study

<u>Round</u>	<u>Leadership Practices</u>	<u>Instruction</u>	<u>Leadership-Instruction Interface</u>
Round 0: general read-through of interview text and notes from instructional walks and interviews			
	<i>no codes - open read</i>	<i>no codes - open read</i>	<i>no codes - open read</i>
Round 1: initial coding at broad stroke			
	Source: Leithwood, 2012 • Setting Direction • Developing People • Refining and Aligning the School Organization • Improving the Instructional Program	Source: focus of study • AST • NGSS • Other Instructional Issues	Source: focus of study + previous study + initial read of data • Working with [Science] Coach • Broad Instruction Related Initiatives • Professional Development Opportunities • Department Collaboration Time • Formal Teacher Evaluations • District • Principal Direct Instructional Interactions with [Science] Teachers and/or Studio Days • Challenges • Vision for High Quality [Science] Instruction • Vision for Instructional

<u>Setting Direction:</u>	<u>no new codes</u>	<u>no new codes</u>
Round 2: orienting to more detailed look at leadership practices		
Source: Leithwood, 2012	<i>no new codes</i>	<i>no new codes</i>
Setting Direction:		
<ul style="list-style-type: none"> • Building a Shared Vision • Fostering the Acceptance of Group Goals 		
Goals		
<ul style="list-style-type: none"> • Creating High Performance Expectations 		
Expectations		
<ul style="list-style-type: none"> • Communicating the Direction 		
Developing People:		
<ul style="list-style-type: none"> • Providing Individualized Supports and Consideration • Offering Intellectual Stimulation • Modeling Appropriate Values and Practices 		
Refining and Aligning the School Organization		
<ul style="list-style-type: none"> • Building Collaborative Cultures • Restructuring the Organization to Support Collaboration • Building Productive Relationships with Families and Communities • Connecting the School to the Wider Community 		
Improving the Instructional Program:		
<ul style="list-style-type: none"> • Staffing the Program • Providing Instructional Support • Monitoring School Activity • Buffering Staff from Distractions to their Work • Aligning Resources 		

<u>Round</u>	<u>Leadership Practices</u>	<u>Instruction</u>	<u>Leadership-Instruction Interface</u>
Round 3: iterating to include emerging codes around both instruction and those activities reflecting connections between the interface of instruction and leadership			
	<i>no new codes</i>	Source: list augmented with codes that emerged from data <ul style="list-style-type: none"> • AST • NGSS • Non-Science, Discipline-Specific • Standards Focus & Planning • Student Engagement • Behavior / Relationship Management • Assessment • Differentiation & Responsive Instruction 	Source: list augmented with codes that emerged from data <ul style="list-style-type: none"> • Working with [Science] Coach • Broad Instruction Related Initiatives • Professional Development Opportunities • Department Collaboration Time • Formal Teacher Evaluations • [Development of] Instructional Tools • Teacher Leadership • District • Principal Learning • Principal Direct Instructional Interactions with [Science] Teachers and/or Studio Days • Proactive Connection Between AST-Related Practices and Larger Context • Challenges • Vision for High Quality [Science] Instruction • Vision for Instructional Improvement
Round 4: finding points of connection between specific leadership practices and particular aspects of instruction or particular interfaces between instruction and leadership			
	<i>no new codes</i>	<i>created automated codes to</i>	<i>created automated codes to</i>
Round 5: reviewed data on a code-by-code basis and selected codes with particularly rich data to read through and summarize by principal/AP and sometimes aggregated by school (if multiple administrators)			
	<i>looked particularly at categories</i>	<i>looked particularly at categories</i>	<i>looked particularly at categories</i>
Round 6: identified emerging key events and circumstances that trended across schools and began to compare principal codes with instructional context findings			
	<i>no new codes</i>	<i>no new codes</i>	<i>no new code, but began to</i>
Round 7: added details to summaries of key events and circumstances using other data sources (e.g., researcher logs, coach & teacher interviews, surveys, learning walks notes, other researcher notes, reform engagement data, Year 1 principal interviews, etc.)			
	<i>no new codes</i>	<i>no new codes</i>	<i>no new code, revised findings and</i>
Round 8: identified trends in interconnectedness among multiple priorities and between AST and leadership practices			
	<i>no new codes</i>	<i>no new codes</i>	identified emergent
Round 9: Sought additional confirming and disconfirming data about findings from multiple data sources; checked with teachers, coaches, principals and researchers to get clarification or additional detail about particular events or comments			
	<i>no new codes</i>	<i>no new codes</i>	<i>no new codes</i>