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Re-designing Infrastructure as a Strategy for Crafting Coherence Across Three Networks

Focused on the Implementation of the Next Generation Science Standards

Coherence has been defined as the process by which stakeholders (e.g., district leaders, schools, departments, teachers) work together to craft or iteratively negotiate the fit between larger visions of teaching and learning articulated in educational standards or policy documents and the goals and strategies employed in daily work in districts, schools, and classrooms (Honig & Hatch, 2004). Within the US where the Next Generation Science Standards (NGSS; NGSS Lead States, 2013) or state-level science standards aligned to the *Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (subsequently referred to as the Framework; National Research Council [NRC], 2012) have been adopted, increased attention has been given to the notion of coherence. In this context, systemic coherence has received more attention in educational systems and relates to the alignment between curriculum, instruction, teacher preparation, professional development, and assessment (e.g., National Academies of Sciences, Engineering, and Medicine [NASEM], 2015; NRC, 2012). However, while discussions of systemic coherence can be found in the Framework and recent National Academies documents (e.g., NRC, 2012, 2015), these discussions mainly focus on the material alignment of NGSS-designed resources (e.g., curriculum, assessments) in place of describing translational aspects of how educational actors (e.g., teachers, administrators, state assessment leaders) re-design and organize resources and think about associated instructional changes in coherent ways as they seek to engage meaningfully in their daily work. As an example, limited attention has been paid to how teachers might work to understand, adapt, assemble, and coordinate the myriad NGSS-designed resources (e.g., talk activities, equity strategies, curriculum units, three-dimensional assessments) being developed by and in collaboration with external experts at the

national level in coherent ways. These efforts could address how educational actors go about accomplishing their day-to-day priorities of directly (i.e., teachers) or indirectly (e.g., district science curriculum directors) engaging students in relational and consequential three-dimensional sensemaking daily and across an academic year. For those few researchers who have oriented to the translational aspects of the coherence-focused work of various educational actors (e.g., Bell, 2019; Penuel, 2019), the re-design of infrastructure has emerged as an important focus for enabling educational actors to negotiate the complex terrain of crafting coherence. Here, infrastructure can be understood simply as a system of common working practices or routines and material resources that a community of professional actors (e.g., teachers, district science coordinators) collaboratively use to accomplish their work (Star, 1999).

Given the lack of attention to how educational actors coherently negotiate the translational aspects of their work through re-designing infrastructure, we sought to examine this in the context of three networks at different levels of the educational system (e.g., classroom, school, district). We believe this focus is particularly important in the current context of NGSS implementation since needed infrastructure did not accompany the dissemination of the standards. Consequently, we recognized how providing rich case descriptions and visions for how educational actors from different levels within the educational system engaged in re-designing existing infrastructure was centrally important to the implementation of the NGSS.

While more about the networks that served as the context for this research is shared in the Methods section, it is important to understand that this context involved long-term collaborative focus on the implementation of the NGSS by actors at different levels of the educational system. Consequently, the multilevel networks provided a context for illuminating and investigating the varied constructed audiences, foci, and emergent infrastructural re-design of NGSS

implementation undertaken by educational actors at different levels of the educational system and how they worked to collaboratively craft coherence through the re-design of infrastructure. As a result, the following research question was investigated: *For the different networks, who were their constructed audiences and how did this influence their foci and emergent infrastructural re-designs?* More details about the research question are provided in the Methods section, but first consideration is given to the theoretical and research literature within which this research is situated.

Conceptual Framework and Literature Review

Crafting Coherence

As already alluded to, our conception of coherence was informed by Honig and Hatch (2004) who viewed it as the processes through which network actors (e.g., teachers, district leaders, science specialists) within the educational system collaborate to iteratively negotiate the fit between larger visions of teaching and learning articulated in educational standards and strategies employed in the daily work of schools at various educational levels. In broad terms, networks have been conceptualized as actors who are interdependent and who value collaboration (Van Waes et al., 2016). Actors within these networks decide on a continuum between building bridges and buffering the external demands placed on them (e.g., policy mandates, external initiatives). Their decisions about how to respond to external demands depend on the needs, available resources (including administrative support and external services), skills, and beliefs of the network actors of local settings. Honig and Hatch explained that strategic groups use "simplification systems" that allow them to take complex external visions and systematically re-form them to make possible, and in the best cases enhance, their current operations (p. 19). In a sense, these groups simplify the broad vision to their context so they can

accomplish their operations while not becoming overburdened by new or mounting demands in the context of their day-to-day tasks. The individual networks under investigation aimed to embody the vision of the Framework through their daily goals and strategies in local districts, schools, and classrooms. Understanding this process of crafting coherence entails consideration of those foci that warrant attention because they are connected to the opportunities or challenges that beset the actors in the varied contexts of their individual networks. The process of crafting coherence is exemplified in the work of Bryk, Gomez, Grunow, and LeMahieu (2015). Within this work, the authors describe how networks of professionals collaborated to respond through simplification systems to external policy advocates who demanded that large schools become more personalized for students from disadvantaged backgrounds. In these accounts, understanding the process of crafting coherence was beneficial because networks learned how to articulate common problems, implement timely responses to these problems, identify measures for assessing the effectiveness of these responses, and build a system of sustainability to continue their meaningful work of improvement.

A guiding factor in Bryk et al. (2015) simplification systems was how the actors constructed audiences. The concept of constructed audiences has been discussed in the marketing and mass communication literature (Ettema & Whitney, 1994; Turow, 2005). In the current research, we drew on this notion to analyze how network actors focused on their work. From this lens, constructed audiences are built by the actors based on the perceived goals and needs of their audiences. For example, teachers could construct their audience of students as learners who need experience reasoning about real-world phenomena with science and engineering practices. School leaders could see teachers as their audience and understand them as facilitators of the classroom who need opportunities to learn more about the NGSS by engaging in experiences as

both teachers and learners. The perceived goals and needs of constructed audiences affect how

individual networks select, adapt, and re-design their work for their specific contexts. For our

study, we used the conception of crafting coherence to analyze how individual networks

constructed their audiences, which we recognized led network actors to re-design infrastructure

to meet the goals and perceived needs of these audiences as part of implementing the NGSS at

their specific level within the educational system. Beyond thinking about crafting coherence, we

also drew on the notion of infrastructure (Bell, 2019, Penuel, 2019, Starr, 1999) as a conceptual

tool to enhance the power of our analysis.

Infrastructure

Lipponen, Lallimo, and Lakkala (2006) and others (e.g., Starr, 1999) have noted how a

building's plumbing system can be a powerful metaphor for infrastructure. They note how

plumbing serves as an essential function in making a building useful and that when infrastructure

is working efficiently it largely goes unnoticed. Likewise, the infrastructure of educational

systems rarely arrests the attention of educational actors until problems arise or changes are

proposed (e.g., the implementation of transformational visions of teaching and learning) that

challenge the usefulness or function of existing educational infrastructure. Consequently,

surfacing infrastructure so that its components can be observed and analyzed clarifies the

important mechanisms involved in the process of crafting coherence (Star, 1999), especially in

the context of educational change like the implementation of new educational standards.

Furthermore, foregrounding infrastructure supports schools in responding to external visions

(e.g., policy demands) through strategic appropriations of materials and development,

modification, and maintenance of organizational structures. For this research, we adopted

Penuel's (2019) conception of infrastructure that operationalizes Star's (1999) ideas within the

context of educational systems. Penuel highlights the important infrastructural components of educational systems as positions, organizational routines, policies, relationships, and resources that support the practices of a community in which collaboration occurs to implement daily practices to advance the community's goals. Thus, infrastructure is entangled in relational negotiation and material organization and appropriation. The alignment and accountability of this system affect how network actors respond to external mandates and policies (e.g., visions of teaching and learning in the NGSS as the state adopted curriculum standards, which was the case in this research). When made explicit, infrastructure can provide a conceptual framework for understanding and potentially supporting its maintenance and refinement to meet the needs of the various educational actors within educational systems whose work influences teaching and learning.

Methodology

This was a qualitative, multi-case study nested in a larger project guided by the design-based research (DBR) paradigm. The purpose of the multi-case study method is to examine a contemporary phenomenon using multiple sources of evidence to develop cross-case conclusions (Yin, 2018). This methodology was useful in examining three different networks that engaged in infrastructure re-design and generating themes from cross-case analysis. Situated within this methodology, the DBR paradigm guides educational researchers to progressively refine an innovation while simultaneously building a better understanding of learning and the factors that affect it (DBR Collective, 2003). We identified DBR as a useful paradigm within which to situate our work because of the ontological commitments of DBR that recognize the interconnections between designs and the messiness of educational contexts as real-world amalgams of the social and material where educational actors work and the need to take flexible

stances toward ongoing iterative design in situ (Barab & Squire, 2004; Brown, 1992; Collins, 1992). In alignment with the DBR Collective (2003) we viewed, "both the design of the intervention and its specific enactments as objects of research" (p. 8). Here, since DBR is a conjecture-driven endeavor, our work was based on the following high-level conjecture (Sandoval, 2004, 2014) about how to support the collaborative work of networks at the various levels of the educational system seeking to implement the NGSS: Re-designing infrastructure as a form of crafting coherence can support the productive negotiation of pressing problems of practice that networks encounter. Consequently, our conjecture led to the theoretically informed coding of our data whereby we sought to understand each network's process of iteratively re-designing infrastructure for NGSS implementation. To do this our research focused on how the re-design of the infrastructure as part of each network's attempt to craft coherence played a role in each network's implementation of the NGSS. More specifically, this current research examined one re-design cycle as a snapshot in time of selected networks with the aim of better understanding and illuminating the complexity and variability of the work various actors within the educational system undertook in their attempts to support the implementation of the NGSS.

Research Context

Over the last three years, the second author has established networks of actors across contexts and levels of the educational system to focus on a more systematic approach to NGSS implementation. We describe three of those networks here: mentor teachers, district specialists, and interim assessment specialists. These were formal networks consisting of voluntary actors employed in different districts and organizations. The second author initiated a mentor teacher group of 14 in-service secondary teachers with a wide range of 2-30 years teaching experience and experiences with the NGSS. This group (subsequently referred to as the mentor teacher

network) was examined previously in Campbell, McKenna, Fazio, Hetherington-Coy, and Pierce (2019) and was established to ensure a more coherent learning experience for preservice science teachers across university science teaching methods courses and clinical or student teaching experiences in K-12 classrooms. While the mentor teacher network did consider ways to support preservice science teachers they were hosting or might host in the future, the majority of this network's attention was directed toward their professional learning in connection to the NGSS since this was seen as a foundational way that coherence across the university and school settings could be achieved. Additionally, the second author initiated a district leader and science specialists working group (subsequently referred to as the district specialist network) in the Spring of 2015 made up of leaders from five school districts in the New England state where this research took place. This network was initiated to identify ways in which cross-district collaborations might be supported so that districts could learn from and with one another about NGSS implementation. Finally, the second author initiated an interim assessment working group (subsequently referred to as the interim assessment specialist network) made up of a former state science specialist from a neighboring New England state who was also an NGSS writer, two state science assessment specialists, a local district science specialist who was also a member of the district leader and science specialist group, and a teacher academy leader from the state science center of the New England state where the research took place. The interim assessment specialist network began as a way to address a lack of resources related to NGSS-specific state- and district-level interim assessments in the New England state where this research took place. The composition of these networks did not include authoritative or evaluative relations. Also, the researchers who engaged in the infrastructure re-design work with the networks (first and second authors) were not in positions of authority and did not evaluate the networks' NGSS

implementation efforts. Therefore, collegiality and persuasion were essential in collaborating with different educational actors in re-designing components of infrastructure. More about each network, including their foci, infrastructural work, opportunities, and challenges, is shared as part of the Findings section.

Data Collection

Data were collected through the following three data sources: semistructured interviews and focus groups, recordings of professional learning sessions, and analysis of artifacts of the networks. These data were collected during spring 2019. Table 1 summarizes the data that were collected from each network, as well as the sample sizes of each network.

Table 1

Participants and Data Sources

Network	Recordings of Professional Learning Sessions	Focus Groups and Interviews	Network Artifacts
Mentor teachers (n = 14)	Two in-person meetings, each approximately three hours in length	One focus group with three mentor teachers and a one-on-one interview, each approximately one hour in length via video conference	Unit lesson plans
District specialists (n = 5)	Three in-person meetings, each approximately two hours in length	Two one-on-one interviews, each approximately one hour, one in-person and the other via video conference	Principles of NGSS instruction
Interim assessment specialists (n = 4)	Three video conference meetings, each approximately one hour in length	One focus group with three interim assessment specialists, approximately one hour in length via video conference	Practice brief on interim assessments

The interview protocol was constructed to understand the foci of each network and the emergent infrastructural re-design components (See Supplementary Material for full interview protocol).

Interviews and focus groups were audio recorded and conducted by the first and second authors. Below are some of the questions that were asked:

- What is your main focus in implementing the NGSS?

- What opportunities and challenges do you face in regards to implementing or supporting the implementation of the NGSS?

- Can you describe an experience that exemplifies how your focus, opportunities, and challenges might potentially overlap with other networks (e.g., mentor teachers, district specialists, interim assessment specialists)?

Data Analysis

In connection to our high-level conjecture that re-designing infrastructure as a form of crafting coherence can support the productive negotiation of pressing problems of practice that networks encounter, data analysis of all the recordings of the interviews and professional learning sessions followed the direction of Colaizzi (1978) and Sanders (2003). As such, data analysis began by listening to the audio files, transcribing data from selected sources, and gaining a sense for each transcript by reading it. Next, each network's constructed audience was coded based on its goals and perceived needs (Ettema & Whitney, 1994; Turow, 2005). In addition, each network's foci were explored through descriptions of how simplification systems were used in each case (Honig & Hatch, 2004). The emergent infrastructural re-design of each network was coded based on the following constructs from Penuel's (2019) framing of infrastructure as a system of standards for student learning: positions, organizational routines, instructional techniques and routines, relationships, and resources (see Supplementary Material for an outline of the codebook). These themes were then embedded into a narrative for each network (Yin, 2018). We also collected artifacts to triangulate themes from the data.

Triangulating data supports the trustworthiness of findings (Creswell, 2013; DBR Collective, 2003) and provided examples of themes. We triangulated the forms of data between interviews, recordings of professional learning sessions, and network artifacts by cross-checking themes that emerged across each data source. All three authors cross-checked each other as themes emerged as another measure of upholding the trustworthiness of our findings. From the themes, narratives were developed by adding context.

Findings

The findings are organized by network so that the research question is answered for each of the following networks: mentor teacher, district specialist, and interim assessment specialist. Then, the constructed audiences and the focus of each network connected to opportunities or challenges and the infrastructural re-design they considered important in connection to their constructed audience and focus are elaborated. During coding for positions and organizational routines, collegial working norms emerged as a salient mechanism for focusing each network's work on important issues. Little (1982) described norms of collegiality in the school context as teachers and administrators engaged in increasingly concrete discussions about their work. Moreover, collegial norms mean that teachers and administrators collaborated in planning, designing, studying, evaluating, and preparing teaching materials, which gave them opportunities to teach each other. These collegial norms were coded by descriptions that revealed the sharing of leadership to focus efforts on issues that were relevant to the local circumstances of the members in each network. After the three cases are presented, similarities and differences between them are discussed to better understand the relationships of the foci and emergent infrastructural re-designs.

Mentor Teacher Network

Table 2

Mentor Teacher Network Re-designing Infrastructure Scheme

Theme	Description	Example quote
Constructed audience	Students who need engaging lessons to develop skills that are useful in both academic and nonacademic settings	"For students, it gets them to start thinking more rather than just being the—regurgitating what was either in the book or the handout that people gave them. They are starting to take more risks in thinking. Although at first, it's difficult because they don't trust the system yet. They just want the answer. It's helping them build—take risks and building their thinking and being able to, at the end of it, when everything's always figured out, kind of have that pride like, yeah, I did that, but we did that together."
Foci	Developing the knowledge and skills to facilitate student learning in the form of NGSS instruction	"I think the different approaches that I've learned, the different skills that I've learned in the implementation of NGSS has helped me be better at communicating the holistic part of science, which is always—I've never liked teaching science in little segments or in little bins and little boxes."
Emergent infrastructural re-design	Lesson plans, instructional approaches, and relationships that facilitate NGSS instruction	"Well, what I'm doing is I am developing lessons or modifying lessons that already have been designed either by me, a co-worker, or somebody else and setting them up in a way that will allow for the NGSS model. This has been a trial-and-error effort. I've been doing this for over two years, so I have improved a little bit."

The mentor teacher network constructed their audience, had specific foci, and employed specific infrastructural re-design (see Table 2). Their constructed audience was science students who would benefit more from student-centered instruction that engaged them in representations of scientific activity like constructing and critiquing explanations of real-world events. Teachers believed that this type of instruction would stimulate interest and promote the development of

skills (e.g., critical thinking, analytical) that are useful in both academic and nonacademic

settings. Mentor teachers believed that implementing NGSS instruction provided a coherent path

to addressing these needs and goals. One mentor teacher network member explained it this way:

> It's [NGSS instruction] just now systematically organizing them in a process that is
>
> probably more cohesive and I think more realistic and more life driven than theoretically
>
> driven because when you're—and way back when you taught based—and it was all
>
> theory.

Through collegial conversations and ongoing working relationships with mentor teachers, we

came to understand that they had varying degrees of knowledge and experiences in learning

about the NGSS and working with NGSS-designed materials. As an example, one mentor

teacher network member described his experiences learning about the NGSS as follows:

> I think before [my university science teaching methods course] . . . I had never seen this
>
> style of teaching before, so I think . . . through my methods program, that was the first
>
> time that I was introduced to what NGSS was.

Another teacher described his experiences learning about the NGSS through summer

participation on a nationally recognized NGSS-design team:

> As a part of the . . . program, I got to work on one of the storylines, like revising the
>
> storyline. It had already been piloted by some teachers throughout the US, and then they
>
> were trying to—the goal was that we got all the results back to make revisions. . . .

While some teachers described external professional development opportunities, other teachers

in the mentor teacher network did not have such opportunities outside of the work of the

examined networks. Because there were collegial working norms in place, the authors prioritized

focusing the working sessions on building a collective understanding and language of what

NGSS implementation could look like in their classrooms. This was important in terms of how

they might interact with students or support student-to-student interactions and organize student

learning experiences across the arc of a unit of instruction. To work toward a collective

understanding and language concerning the NGSS, the network read and discussed chapters of

Ambitious Science Teaching (AST; Windschitl, Thompson, & Braaten, 2018). These readings

and discussions began to support the network by providing a well-articulated rationale and

framework for NGSS implementation with accompanying instructional supports, such as

summary tables (understood as collaborative, class-specific public representations that are

completed after unit activities) and proposed classroom routines (e.g., eliciting students initial

ideas) that could be used to help students refine their ideas over time. This was the beginning of

the infrastructural work that represented one of the simplification strategies undertaken by the

mentor teacher network as they made sense of new classroom norms and pedagogical practices

they could use in their classrooms and, importantly, in the mentor teacher network meetings to

rehearse and further negotiate productive strategies for engaging students in moment-to-moment

sensemaking experiences in their classrooms. More specifically, just after the mentor teacher

network read the AST chapter "Planning for Instruction with Big Science Ideas," groups of two

to three teachers used a researcher-created planning template. This template supported them to

think about and work to re-design a unit. One member of their group thought they would benefit

from revisions so that they could both use the revised unit in their classrooms once refined and in

the mentor teacher network as they worked to improve how they facilitated sensemaking

opportunities for students in their classrooms (see Figure 1). Here, as a form of crafting

coherence and another representation of collegial norms, mentor teachers revealed how time was

needed to reshape the existing curriculum (i.e., infrastructure) so that real-world phenomena

anchored their instructional units and science practices like modeling were used as a way to support student sensemaking across their revised units. One mentor teacher explained, ". . . but I think developing science units in this new way of thinking and a new way of learning where it is so student driven, it just takes an incredible amount of time to plan and prepare in the first place." In the end, developing the planning templates represented the way that the mentor teacher network unpacked the vision of the Framework and the NGSS and repackaged or simplified it in a way that supported them in translating the standards vision for teaching and learning into a usable classroom curriculum.

Part 1. Practice 1-Identifying Big Ideas

STEPS --- Movement of the earth's crust --- Energy Transfer

1. *Identify the important ideas for the unit you selected and list them here*

    Radioactive Decay - Primary sources of heat & Energy transformations

2. *From those ideas listed in STEP 1, cluster all ideas that are related*
    Cluster 1: Evidence of energy transformations
    i.   *Earthquakes and Volcanoes, Seismic waves (P and S), Earth's layers*
    ii.   *Seafloor spreading*
    iii. *Mountains, Trenches*
    iv.   *Earthquakes and Volcanoes*
    v.   *Earthquakes happen in patterns*

    Cluster 2: Mechanics of Earth features (How it works)
    vi.   *Convection Currents*
    vii. *Density*
    viii. *Radioactive decay*
    ix.
    Cluster 3: Characteristics of the System:
    x.   *Plate boundaries-oceanic and continental*
    xi.   *Density*

3. *Identify ideas with the power to explain. Within each cluster of ideas, which idea(s) have the greatest explanatory power*
    Cluster 1: *Energy transformations that occur within the earth cause e-quakes, mountain building, and mid-ocean ridges.*

    Cluster 2: *Heat from when the planet formed and accreted, which has not yet been lost and the radioactive decay of isotopes within in the earth are the primary cause of heat that results in density changes creating convections currents within the mantle to drive plate movement.*

    Cluster 3: *The earth's crust is broken up into plates of varying densities impacting the way they interact with each other.*

Figure 1. 'Planning for Instruction with Big Science Ideas' unit and rehearsal template.

The mentor teacher network drew on the units they developed with the planning templates to engage in rehearsals to re-design infrastructure. This supported them in learning about refining specific classroom routines and teaching scaffolds they could use with their students, while also supporting them in making additional revisions to their units as needed. Mentor teachers using the researcher-designed template is another representation of collegial norms within the network. These norms facilitated researcher understanding of mentor teachers' pressing issues (limited time and a need for instructional units) so researchers could respond accordingly. Here, as part of each of their monthly meetings, one group of mentor teachers figuratively donned *teacher hats* to lead their peers, who donned *learner hats* in learning experiences. These rehearsals supported collegiality in working sessions as they supported teachers in collectively identifying ways to work through challenges that they experienced in the classroom when implementing NGSS lessons. As an example, the network focused on rehearsals derived from their midunit Supporting Ongoing Changes in Thinking planning templates, describing the use of summary tables as public representations. They discussed the challenges they faced, including using summary tables across multiple classes daily and framing summary tables as a useful structure for students. As summary tables were class specific, mentor teachers grappled with logistics for managing them across multiple class periods. The following conversation exemplified how co-planning with a common language and ways of thinking about and supporting learning led to teachers learning with and from one another, especially in connection to summary tables:

> Mentor Teacher 1: I have a summary table question because it seems like we need to use summary tables a lot. So, the other thing that I am struggling with, well number one is to do it all the time right? So, you run out of time all the time, right? So, do you do

summary tables after every activity? After every grouping of activities? Certain

activities? Like how do you figure out how often you use them? Beginning class, after

class? Like do you have a routine?

Mentor Teacher 2: It would be nice to have a routine.

Mentor Teacher 3: It depends on what your ideas are under your big ideas. It depends on

what you are doing . . . I try for every single one [activity]. It becomes kind of

cumbersome and sometimes. . . . Ideally, you do the activity and the last 15 minutes is the

summary table. But sometimes, you run out of time, and then it's kind of awkward to

start the next class with a summary table of the previous class, especially when not

everyone was there.

Mentor Teacher 2: Right, in middle school it can take three days to do an activity.

Mentor Teacher 3: Right. But, at least it keeps me on track, and it sort of recaps for

everybody. So, what did we do this for? I like this in the elementary school example. It

says, "So what?"

Several Mentor Teachers: Yes

Mentor Teacher 3: And that I think is the most important thing for the kid, "So what?"

"We did Punnett squares, so what."

For mentor teachers, having colleagues who understood the challenges they experienced and

helped them troubleshoot these challenges was important for helping them realize a vision for

how this infrastructure could work for them and their students day-to-day in their classrooms.

Beyond the advantages of collaborating with other mentor teachers as part of rehearsals, the

mentor teachers were afforded important authentic learning experiences (i.e., learner hat

experiences) that gave them an appreciation for the possibilities of the NGSS, especially when

compared to traditional forms of instruction that focused more on supporting students to learn about content without regard for context. The following excerpt from a mentor teacher exemplifies the mentor teachers' enthusiasm for the sensemaking version of science learning envisioned in the NGSS:

> Yeah. I'm so jealous of the questions that my students ask sometimes 'cause I almost wish that I had had the chance to ask that cool of a question. I think that when my students are given a really challenging complex phenomenon, even one that is smaller but equally complex, I think the biggest opportunity, the coolest opportunity I see is when they're trying to ask the questions that they know they'll need to answer to figure it out.

Teachers recognized how NGSS instruction could motivate their students to ask meaningful questions as they make sense of a phenomenon. In the end, with the AST readings and planning templates as infrastructure to facilitate NGSS instruction, mentor teachers saw the benefits for both themselves as teachers engaged in professional learning and their students as learners getting more authentic experiences engaging in science.

District Specialist Network

Table 3

District Specialist Network Re-designing Infrastructure Scheme

Theme	Description	Example quote
Constructed audience	Teachers with different simplification systems who need professional development on how to re-design their existing infrastructural materials toward the vision of the Framework while respecting their existing workload	"I think that giving teachers time to figure things out on their own is a challenge because you're up against having to perform, but needing time to learn just like kids."

| Foci | Supporting teachers with different simplification systems due to local contexts in re-designing their infrastructure | "We were tryin', as a group—that's what I hope we can do here—to come up with, what would our four things be that distinguished what NGSS implementation was and not—we should say it broad enough that it doesn't take away from the work you've already been doing with your teachers in your district. At the same time, maybe it gives a heightened focus that we could start collaborating around to build like she built, he built, started to build." |
| Emergent infrastructural re-design | Three principles of NGSS instruction that would guide district specialists' professional development for teachers who are re-designing their pedagogies toward NGSS instruction | ". . . I think that's interesting because these three main points can be the bedrock that shifts to different settings. That's what I like about that. The crosswalks that go in-between." |

The district specialist network constructed their audience, had specific foci, and employed specific infrastructural re-design (see Table 3). As alluded to already, the focus of the district specialist network (i.e., leaders and science specialists from five school districts) in the New England state was situated in the larger context of the unique organization of more than 200 school districts operating somewhat autonomously under the auspices of local control within the state. Consequently, all of the five participating districts had unique needs that resulted in the use of different simplifying systems aimed at crafting coherence to meet the needs of each district's local contexts. Additionally, because of the somewhat shortened timeline between when the New England state adopted the NGSS (i.e., November 2015) and when districts would be held accountable through state-administered and publicly reported standardized assessments (i.e., Spring, 2019), districts made decisions independently about how best to ready their teachers and students for the dramatic shifts in teaching and learning inherent in the NGSS. Operating with no

external guidance, schools began using varied instructional frameworks (e.g., the 5E

Instructional Model, Next Generation Science Storylines), which made it challenging for district

specialists to collaborate. Exacerbating the difficulties of cross-district collaborations that came

with different frameworks used by the different districts, some districts purchased locally

developed curriculum, while others worked instead to support their teachers in collaborating to

develop their curriculum. Among these differences between district specialists, a commonality

was that all actors constructed their audience as teachers who needed professional development

on how to re-design their existing infrastructural materials to better align with the vision of the

Framework while respecting the teachers' existing workload. One member alluded to this

audience construction by asking, "How do you keep that balance of focus on the NGSS and what

it means—and the practices and the skills that we're teaching—just for that, and the leveraging

of them for everything else that teachers do?"

Through collegial conversation and work history, the second author understood the

challenges that collaborating across districts presented and proposed the identification of

commonly negotiated principles the districts could commit to in their NGSS implementation

efforts. These principles were to be specific enough to facilitate cross-district collaborations,

while at the same time flexible enough to provide space for variations across local settings that

would allow districts to build on work they had previously undertaken in their early district-level

NGSS implementation efforts. To accomplish this, the district specialist network began by

collegially negotiating four principles (which was later consolidated to three) of NGSS

instruction that all district specialists could use in supporting teachers. Here, the second author

suggested the following:

> If we agree on our four things, we could look at that and say, "Can we build something
>
> like this that's just a map for teachers to get oriented to do this?" The one thing I loved
>
> about this idea—if . . . I just only found those four, I would use those four and say, "I
>
> could pick up any 5E lessons that are the most current 5E lessons that have been
>
> reformed—I could pick up a 5E lesson, storylines, Ambitious Science Teaching, model-
>
> based learning, and every one of those would allow me to focus in those areas [the four
>
> principles].

As a result of negotiations around three resources for learning, the district specialist network

created the following three principles for NGSS instruction they believed they could

productively apply with teachers back in their local districts:

1. The facilitation of learning experiences anchored in phenomena that are relevant to students,

   elicit initial ideas and explanations, and set goals or problem spaces for learning.

2. The purposeful use of investigation (broadly construed), discourse (whole class and small

   group), and argumentation to develop a central model or explanatory account that is

   incrementally revised over time to explain the phenomenon or solve the problem.

3. The intentional use of routines and tools to facilitate sensemaking and making student

   thinking visible to incrementally build and refine student understanding of a phenomenon or

   problem.

In this scenario, the leadership hub acted as collegial brokers in providing the framework and

structure based on scholarship (Ko & Krist, 2019; Manz, 2019; Windschitl et al., 2018) that acted

as resources for the district specialists, while the district specialists negotiated and decided on the

principles. In the end, the district specialist network concluded that these principles were flexible

enough to allow them to build from work they had already begun with teachers in their districts

before the network's efforts examined here, while also being common enough so that resources

(e.g., curriculum materials, teaching scaffolds, pedagogical routines) that were subsequently

developed, refined, and found to be useful in one district might also be useful in other districts,

especially as these resources were mapped to the different commonly used principles for NGSS

instruction. This was not only seen as a way to craft coherence in how NGSS would be

implemented across districts but also within districts as frameworks were consistent with

instructional resources. Further, once the principles of NGSS instruction were established,

district specialists began to reflect on how they thought using these with teachers in their districts

would work.

> Second Author: If I was Matt [pseudonym] and I had a group of high school teachers how
>
> do you think this would work?
>
> District Specialist 1: And I worry about number one [i.e., anchored in phenomena that are
>
> relevant to student]. Back to the conversation about places. I want to make sure that
>
> there's room for this to happen in different places. . . .
>
> District Specialist 2: Well, in a lot of or some of the work out there now is about bending
>
> the storyline and then go to a related phenomenon.
>
> District Specialist 1: Right. I have looked at that. With third-grade teachers have
>
> struggled with that and we have almost offered a menu of phenomena.

As can be seen in this excerpt, these principles provided an important focus for reflection

whereby district specialists reflected on how the new infrastructure could be used in their day-to-

day work, especially based on experiences they already tried with teachers in their districts. In

their conversation about using phenomena in instruction (i.e., Principle 1), the district leaders

shared how they did this. In the end, the three principles were useful as infrastructure supportive

of the network's NGSS implementation efforts because they provoked meaningful conversations

and conjectures focused on improvement among district specialists who had begun to move

away from talking about the broad differences in their local contexts toward talking about

promising approaches that might be useful across districts.

Interim Assessment Specialist Network

Table 4

Interim Assessment Specialist Network Re-designing Infrastructure Scheme

Theme	Description	Example quote
Constructed audience	Teachers, professional development providers, and district leaders across the nation who need infrastructure to implement NGSS interim assessments	"Probably the best opportunity we've had with NGSS is the fact that we share these standards in common with other states. There's been a lot more collaboration that's occurred and a lot more taking advantage of resources, of experts—not only in assessments, but through other work that the department does with supporting professional development and curriculum work and all of that."
Foci	Developing and sharing a framework for NGSS interim assessments	"So, I think what that tells us is that there's a lot of different ideas to what interim assessment is. So, I think if we can think about some of the takeaways that people will have from researching this practice brief is a. . . . If not a definitive definition of interim assessment, at least a formative definition that people could come away and understand that where it is. . . . We are talking about interim assessment within an assessment system and how it connects to the classroom formative and summative. . . ."
Emergent infrastructural re-design	Practice brief on NGSS interim assessments	"Like I am trying to think about if this brief is to introduce or orient teachers and leaders to interim assessments. Would it be possible to give them something that

would be a resource to get them started?"

The interim assessment network constructed their audience, had specific foci, and employed specific infrastructural re-design (Table 4). The interim assessment specialist network was initiated by the second author when in discussions with the state department of education officials. It was recognized that very few interim assessment resources were available either locally or nationally. Additionally, it was also apparent that funds were not available within the New England state where the majority of members of this network were located to support the development of interim assessments. A focus on interim assessments was especially important since Perie, Marion, and Gong (2009) and recent National Academies documents (NASEM, 2015, 2017) emphasized the importance of a balanced assessment system. For supporting NGSS implementation, this assessment system can include classroom-level formative assessments, interim assessments (e.g., school- and district-level assessments administered across classrooms), and state-level standardized assessments. The interim assessment specialist network recognized that a dearth of interim assessment resources existed and that there was a lack of clarity related to how both members of the network and others (i.e., statewide and nationally) thought about interim assessments. Therefore, the interim assessment specialist network engaged across the period of this current research in developing a practice brief focused on interim assessments that aimed at clarifying the following: what interim assessments are, common issues associated with interim assessments, ways to attend to equity when developing and using interim assessments, and recommended actions that teachers and district leaders could take to implement interim assessments as part of NGSS implementation (Campbell et al., 2020). Thus, the constructed

audience of the interim assessment network was the broadest among the three cases. They

worked with teachers and state-level administrators and served on committees. Here, one

member discussed his different roles as he explained the challenges of his position:

> I wear a lot of hats. I do a lot of coaching [of teachers], but I also evaluate teachers.
> Their evaluation, though, what I do is—again—on pedagogy. It's just good classroom
> instruction. Right now, I'd say struggles are—as with most districts—I have teachers who
> are very strong. We've written some curriculum units, and they want more. There's not a
> wealth of good NGSS units available. Then I have teachers who are really struggling with
> still just the shift in instruction. It's a wide, wide range that I deal with. I also work at the
> state level, so I'd still do NGSX [Next Generation Science Exemplar Program] training.
> I'm on a variety of committees. . . .

Members of the interim assessment specialist network saw their broad audience as needing

resources and professional learning to implement NGSS interim assessments. The practice brief

was intended to assist this broad audience in drawing on interim assessments as a basis for

professional learning that members of this network could use to facilitate professional learning

for teachers and district leaders. The need for the practice brief became apparent early in this

network's work as members were unable to identify clear and concise practitioner-focused

resources that helped define interim assessments and outline the important role that interim

assessments could play in supporting NGSS implementation. One member of this network

shared,

> It recalled back to me when I was at the Department of Education in [neighboring New
> England state] and one of my assignments was to find out and research as much as I

could find out about interim assessments. So that had to be 2014, [or] 2013 . . . and there

was very little. So, I mean nothing really defining what an interim assessment is. . . .

Given the aim of the completed practice brief, it was seen as infrastructure that, once completed,

could help district leaders and teachers craft coherence, especially as the interim assessments

supported teachers in recognizing and improving the extent to which students experienced

equitable opportunities to engage in three-dimensional instruction.

The coauthoring of the practice brief also served as a productive focus for the interim

assessment specialist network that supported their professional learning. Using a collegial

process, they worked to make decisions about how to think about and guide others in thinking

about interim assessments. For instance, the interim assessment specialist network deliberated

about whether interim assessments should incorporate all three dimensions of the NGSS,

especially since they recognized that some dimensions (e.g., disciplinary core ideas) were more

familiar to teachers and local leaders than others (e.g., science and engineering practices,

crosscutting concepts). An example of this type of deliberation can be seen as one member of

this network (i.e., former state science assessment specialist from a southern state) shared the

following related to how his state chose to think about interim assessments in their earlier work:

> So, I think one of the reasons why there is such an emphasis on practice and cross-cutting
>
> concepts is because that wasn't an intentional part of the assessed curriculum before.
>
> Right? So, it's not what we needed . . . if we were going to wind up an army and go out
>
> and do professional development, we didn't need to wind up a content army and go do it
>
> because, you know, they've got access to a huge amount of resources that are very
>
> content heavy around any particular PE [performance assessment] you are going to find.

For the interim assessment specialist network, these discussions and their work focused on coauthoring and refining the practice brief and having all members contribute collegially. These discussions were part of the simplification process they engaged in to consider how the broader vision of the Framework and the NGSS could be translated into essential components of interim assessments.

Additionally, the members of the interim assessment specialist network recognized that the practice brief would bring resources and an inherent message about interim assessments and their possible role in supporting NGSS implementation to a broad range of actors within the educational system, including teachers and school leaders within the New England state and in other states that had adopted the NGSS as the practice brief was disseminated more broadly after its completion. Consequently, they realized how important it was to examine critically how interim assessments had been used by different actors previously and what could be done to improve upon this use in the future. For example, members of this network agreed that interim assessments have commonly been used as a form of teacher evaluation, a use this network thought detracted from the role they envisioned for interim assessments in supporting NGSS implementation. A district specialist explained it this way, "Not to harp on the negative, but from what I've seen . . . there are administrators, there are school leaders that will use interims, or use any assessment data incorrectly or really evaluative in terms of teacher practice." As part of this work, the interim assessment specialist network believed interim assessments could be a key lever for helping teachers build coherence, especially across classes, schools, and perhaps even across regions. They thought they could also be used as formative assessments to guide instruction as one district specialist explained, "But, they [district leaders and teachers] miss the

bigger picture about how it [interim assessments] can also ensure coherence, especially within a district, maybe within the region."

Furthermore, district specialists agreed that interim assessments could be used to support more equitable science instruction. A member of the interim assessment specialist network explained,

It [interim assessment] gains a lot of information and more importantly it gains information that districts can use to leverage their budget to be able to be more equitable. So, I think that would be really helpful for teachers to understand that it's not about doing more to. . . . It's about helping all the teachers within your district be colleagues to be able to gain more leverage and more equity.

Discussions like these emerged as part of the monthly network professional learning sessions that were focused on developing the interim assessment brief. Like other network actors, members of the interim assessment specialist network reported valuing these monthly meetings because the time was spent learning from one another and resulted in something (i.e., infrastructure) they thought would be useful in their future work with district leaders and teachers. Furthermore, because the NGSS were being implemented by many other states, members of this network recognized how "probably the best opportunity we've had with NGSS is the fact that we share these standards in common with other states. There's been a lot more collaboration that's occurred and a lot more taking advantage of resources." In the end, the ability to collaborate across states, as was done to some extent in this network, afforded future opportunities for the broader use and refinement of the interim assessment practice brief as infrastructure that could be used for crafting coherence across classrooms, schools, districts, and possibly regions.

Comparing and Contrasting Networks

All three networks engaged in the process of translating the broader vision of the Framework and the NGSS into infrastructure that could support their day-to-day work. For example, the mentor teacher network reflected on how teaching practices outlined in AST were being used in their classrooms. As a community, they were building capacity for a new infrastructural component (e.g., teaching routines) by working together to better understand the usefulness and refine how they used these components (e.g., summary tables). The district specialist network negotiated a framework for NGSS instruction that distilled it into three guiding principles that teachers could use as a compass for their day-to-day work. These three principles were the infrastructure component they developed. They represented organizational routines that the network believed could support professional development and resource development for teachers they supported. Finally, the interim assessment specialist network engaged in theoretical and practical conversations about how to think about interim assessments and what resources might embody this thinking that could be included in their practice brief. Their discussions drew on their lived experiences and knowledge of scholarship to influence their development of infrastructure, the practice brief. They all engaged in activities that required some understanding of the Framework and then worked to productively attend to how it applied to their work.

One difference between networks was how the leadership hub facilitated working sessions with different networks. Work with the mentor teacher network included discussions about readings from AST and support for applying the ideas from AST through the use of a template developed by the second author (as seen in Figure 1). Work with the interim assessment specialist network was less structured when compared to the mentor teacher network. This was

because the leadership hub often planned the majority of working time for loosely structured

conversations aimed at outlining and refining the practice brief that often amounted to theoretical

conversations about what should be included in interim assessments. Work with the district

specialist network was less structured than work with the mentor teachers and more structured

than with the district specialists. Conversations during the first and second meetings were based

on open conversation to identify the specific infrastructure focus most important to and needed

by members of the network. Later meetings were guided by literature shared by the leadership

hub.

Another noticeable difference between each network was the breadth of the constructed

audience that each network supported. This difference is described beginning with the broadest

audience served by the interim assessment specialist network to the narrowest with the mentor

teachers. The work of the interim assessment specialist network affected a wider range of actors

across the education system as it had the potential to support local leaders, teachers, and students

across the New England state where the study took place as well as in other states. Members of

the interim assessment specialist network needed to know the experiences of all of these

audiences so that their work was relevant and useful to them. This required insight into a wider

range of challenges to build infrastructure that was relevant and useful. Because the district

specialist network worked more closely with teachers, their simplification process was more

attuned to the experiences of teachers than was the process used by the interim assessment

specialist network, whose audience included teachers but also district leaders and science

supervisors, among others. Therefore, the district specialist network's focus was closely attuned

to the challenges of teachers. Finally, the work of the mentor teachers had immediate

consequences for students so they focused deeply on how instructional approaches worked in the dynamics of the classroom.

Discussion

The Framework and recent National Academies documents (NRC, 2012, 2015) call for coherent implementation of the NGSS that will facilitate three-dimensional learning. For the most part, the most recent National Academies documents have focused on material coherence by, among other things, being attentive to how curriculum and assessment align (NASEM, 2015; NRC, 2012, 2015). Given this, and our desire to complement what we believed was mainly a concern for material coherence in these most recent National Academies documents, this current research focused on describing translational aspects of how educational actors re-designed and organized myriad resources in their attempts to craft coherence at the intersection of the broad vision of the Framework and the NGSS and their day-to-day activities and work. In our work across the three networks, foregrounding infrastructure, the often unseen yet important components of the educational system (Lipponen et al., 2006; Starr, 1999), paved the way for helping us better understand the process of crafting coherence to advance goals across a range of contexts and, we believe, helped reveal the negotiation and decision-making that actors at various levels across the system (i.e., those in our various networks) must participate in as they engage in this work. Given this, the Discussion section is organized by the following salient themes that we believe best capture what we learned as we engaged in design-based research and collaborative sensemaking as part of our networks' interactions and supportive efforts to implement the Framework and the NGSS: Foregrounding infrastructure provided a meaningful pursuit as a focus of collaborative group work, and collegial workspace was beneficial for institutionalizing networks' foci.

Foregrounding the Work on Infrastructure Provided a Meaningful Pursuit as a Focus of Collaborative Group Work

Penuel (2019) proposed that engaging in the act of developing infrastructure involves focusing on ". . . activities that aim to re-design components, relations, and routines of school districts that influence what takes place in classrooms" (p. 1). In this research, we found that engaging in the development of infrastructure provided a meaningful pursuit for structuring the collaborative group work at the multiple levels in which the various actors worked. This pursuit was aimed at re-designing components, relations, and routines involved in the specific kinds of work each network undertook in their realm of influence to help positively shape student learning experiences in classrooms. Here, it is reasonable to conjecture that without foregrounding infrastructure that could serve as a focus of their pursuits that related to the networks' opportunities and challenges and directly impacted their day-to-day work, the meetings of the networks may have meandered and led to less engagement and commitment from the various network members over time. For each network, work involved both the development of material resources (e.g., lesson plans, NGSS instructional principles, a practice brief) and a focus on translational work, which we understood as the development of instructional or professional learning routines necessary to productively implement the material resources in day-to-day interactions with teachers and students.

While researchers like Penuel (2019) have begun to provide illustrative examples of what infrastructure work might look like, to date there exists only a limited amount of research that provides empirical case studies to exemplify and unearth the complexity of developing infrastructure that is connected to the NGSS implementation work of various actors in the educational system. In other words, while research has begun to reveal the complexity of NGSS

implementation for teachers in connection to different forms of infrastructure (e.g., Bell, 2019; Penuel, Harris, & DeBarger, 2015) and some research has begun to reveal the complexity of supporting administrators with NGSS-designed infrastructure (e.g., McNeill, Lowenhaupt, & Katsh-Singer, 2018), few studies have brought to light the complexity of NGSS implementation in connection to the beneficial role infrastructure development can play in the work of actors across the educational system.

Beyond revealing the infrastructure that each network focused on, our findings also helped nuance what rich versions of foregrounding infrastructure to support meaningful collaborative work might entail. More specifically, Penuel (2019) explained that engaging in the act of developing infrastructure ". . . involves a kind of mangling of innovations within varied educational contexts" (p. 12). Here, "mangling of innovations" can be likened to Honig and Hatch's (2004) notion of various actors within the educational system creating simplification systems to help them navigate the implementation of externally mandated policies in their various roles and pursuits in their local contexts. Our research helps exemplify how richer versions of foregrounding infrastructure go beyond implementing novel external innovations. As an example, the district specialist network re-formed Ko and Krist's (2019) description of NGSS instructional material features by simplifying the system in ways that accounted for previous work done with teachers and allowed for that work to be honored and connected meaningfully to innovations. Beyond this, for the district specialists, developing the three principles of NGSS instruction was integral to moving beyond the struggle of conceiving how cross-district collaboration might be possible in the context of local control and the expedited roll-out of NGSS implementation to engaging in conversations about how the principles could guide work within their district settings in ways that could potentially lead to the local development and

refinement of resources (e.g., instructional materials and routines) that could travel amongst districts.

In the end, Penuel (2019) argued, "it takes coordinated activity--across organizations and levels of an educational system--to bring these different components into being and into relationship with one another, that is to make them into a working infrastructure for teaching" (p. 5). Through this research, we identified how actors of the three networks engaged in the work of developing infrastructure that Penuel described. Furthermore, each network's reflective engagement on the work they undertook led them to further examine and critique the external vision of the Framework and the NGSS in ways that supported their sensemaking about their various roles across the educational system. This reflective engagement helped them see how new infrastructure could be applied to achieve their work, especially as they undertook the task of mangling this infrastructure to meet their needs in local contexts.

Collegial Workspaces Were Beneficial for Institutionalizing Networks' Foci

Bell (2019) indicated that infrastructure is a collaborative effort, writing, "[Infrastructure] as a shared collaborative design practice is [an] inherently complicated endeavor, but it has a strong potential for productively working toward equity across networks of teachers, community members, and researchers" (p. 682). This collaborative quality is important because it supports collegiality in working sessions so that they are productive and equitable by surfacing all actors' experiences, challenges, and needs (Little, 1982). Consequently, collegial workspaces go hand-in-hand with the institutionalization of infrastructural work that has meaning to local actors by better connecting emerging infrastructure to the actual problems that the network members encountered (Bevan & Penuel, 2018; Bryk et al., 2015). For productive and collegial workspaces to occur, the leadership hub took a brokering role instead of a directing role. Davidson and

Penuel (2019) showed that the work of the leadership hub could be analogous to a broker, which is an intermediate between research and practice. This brokering role of translating research and practice into innovative spaces that were coordinated to refine infrastructure was seen in each case. As an example, in the district specialist network, the leadership hub suggested research that provided a path (i.e., developing common principles for NGSS instruction) for addressing their challenge of engaging in collaborative work.

Help-based interactions that assist in the process of building trust (Kallio & Halverson, 2020) also characterized the three networks. This facilitated the process of trust development and supported colleagues in being honest with and critical of each other. The findings demonstrated how working session activities provided opportunities for colleagues to help each other develop infrastructure, while also creating opportunities for engaging in reciprocated actions. An example of reciprocated actions occurred when mentor teachers helped each other in building unit lesson plans and, as demonstrated in the Findings section, suggested solutions to challenges that their colleagues experienced when implementing summary tables. Here, as Bell (2019) suggested, establishing collegial working relationships that value equity in the contexts of collaborations between researchers and teachers is complex, especially given the normative hierarchical positions of power that have historically been exerted by researchers engaging with school leaders and teachers. However, if working relationships can be collegial, the benefits, among others, can be seen in how pressing problems of practice are connected to co-negotiated and re-formed infrastructure that is institutionalized as it is implemented and iterated in the varied contexts, like those that were the focus of the various networks in this research.

Conclusion

By examining the constructed audiences, foci, and emergent infrastructural re-designs of multilevel networks in the current research, a more nuanced understanding of what it means to craft coherence as part of NGSS implementation for the various actors in networks across the educational system was illuminated. From this, similar to what others have noted, it can be seen that a significant amount of work (Anderson et al., 2018) and coordination (Bell, 2019; Penuel, 2019) was required to go beyond envisioning NGSS implementation as merely the acquisition of coherent materials. The work on infrastructure across the various networks not only meant identifying useful NGSS-designed resources and frameworks, it meant considering how to translate these into meaningful supports or scaffolds that could ultimately lead to productive forms of engagement for either supporting teacher professional learning or student learning. In the end, we believe that the networks' collaborative focus on infrastructure may have also challenged the notion of doing things the right way (i.e., implementing the NGSS correctly) because the perspective of using infrastructure to craft coherence could be understood as a more fluid, local, and context-dependent path to NGSS implementation.

Finally, when this shift toward crafting coherence with infrastructure is coupled with a commitment within a network to more collegial and equitable forms of participation, the practical experiences of teachers and leaders in schools can be foregrounded to attend to the most pressing problems of practice (Penuel, Bell, Bevan, Buffington, & Falk, 2016). In the case of the networks in this research, this meant focusing on curriculum and instructional routines for mentor teachers, focusing on NGSS instructional principles for district leaders, and focusing on the development of an interim assessment practice brief for state assessment leaders—foci identified as central to and immediately applicable in the day-to-day work of the respective network members. Here, not only are the experiences and expertise of teachers and leaders

recognized (Bell, 2019), issues with flawed assumptions about how research findings can simply

be transitioned from contexts of development to new sites for subsequent implementation are

circumvented as the context in which infrastructure is developed and will be implemented are the

same (Tseng, Fleischman, & Quintero, 2018).

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