

**School System Leadership and Elementary Science Education: Managing Dilemmas in
Education System Building for Elementary School Science**

James P. Spillane

Northwestern University

Emily Rose Seeber

University of Michigan

Xiaoyu Yin

Will Quan

Christa M. Haverly

Northwestern University

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Address correspondence to James P. Spillane, Northwestern University, 2120 Campus Drive, Evanston, IL 60208, USA. Email: j-spillane@northwestern.edu

Introduction

Reforming elementary science education, as the cases capture, is challenging for system leaders for several reasons. We argue that some of the core challenges that system leaders construct are not problems that lend themselves to technically rational conceptions of problem solving but rather are dilemmas. Although problem definition and problem solving are an important part of system leaders' work, we argue that attending to dilemmas is also critical though mostly ignored in current writings about educational leadership and instructional reform.

A dilemma refers to a situation where the alternative solutions are roughly equally desirable (or undesirable), either of which necessitates compromising on some fundamental values: Choosing one alternative over the other is difficult, if not impossible. Moreover, these situations rarely rest solely on the personal or professional preferences of the individual system leader but rather are conditioned by structural arrangements. Public school systems, for example, operate in pluralistic institutional environments where they must attend to the diverse and sometimes conflicting demands of different stakeholders. Parents, community members, local and state policymakers, teachers, students all place demands on education systems that system leaders cannot ignore easily as they depend on these stakeholders for resources, including legitimacy, critical to the operation of their systems. Hence, system leaders' choices are constrained by the structural arrangements in which they work. To confront a dilemma then is to face alternative solution pathways that are more or less equally desirable, any of which requires some compromise among closely held values.

Several scholars have documented the centrality of managing dilemmas in the education sector. Magdalene Lampert's (1985) work on classroom teaching practice frames teaching as dilemma management. Larry Cuban's (2001) work on school leaders and educational

administrators also surfaces key dilemmas of leadership practice (see also Spillane & Sun, 2020; Spillane & Lowenhaupt, 2019). Michael Lipsky's (1980) work on the public sector more broadly captures the dilemmas of street level bureaucrats. Our analysis here focuses in on system leaders' efforts to lead improvement in elementary school science education and the dilemmas they confront and construct in doing that work (Peurach, Yurkofsky, & Sutherland, 2019).

In this paper, we identify and describe some core dilemmas, linked to the privileging of mathematics and ELA relative to science, that system leaders grapple with as they work at reforming elementary science education. Consistent with our framing for the research, our account focuses on system leaders' education system building work and how this work interacts with their efforts to manage their institutional environment, both currently and historically (Peurach et al., 2022). Analyzing these dilemmas of educational system building, we show how the preferential treatment of ELA and mathematics over science is fundamentally structural and how system leaders have to manage, rather than solve, the resulting dilemmas. The sidelining of science in elementary education is embedded in school systems' core structural arrangements, such as organizational routines and formal positions, that often cut across system levels (e.g., classroom, school, system) and shape everyday practice from teacher evaluation to professional development. Further, system leaders developed these structural arrangements over time, often in response to their efforts to manage their environments. The sidelining of elementary science as embedded in systems structures also captures how efforts to redress inequities in students' opportunities to learn science are fundamentally structural in origin and nature. Ensuring equitable access to science learning, including getting it taught in the first place, will require attention to the structural arrangements that sideline science as they shape everyday practice in school systems. While system leaders' work involves solving problems, it also necessitates

managing dilemmas of education system building. We argue for attention to dilemma management as a central, if mostly ignored, aspect of educational system building and system leadership practice in an era when problem-solving and evidence-based decision-making have come to dominate the discourse about educational reform.

Our paper makes three contributions. First, in embracing the subject specific nature of teaching and focusing on elementary school science we show how the dilemmas involved in education system building are school subject specific. Second, while capturing how the school subject is an important and critical consideration in education system building, we also document how the dilemmas encountered by system leaders in one school subject – elementary school science – emerge from interactions with other school subjects and education system building therein. While the school subject matters to education system building work, it matters in interaction with and in relation to education system building for other school subjects. Third, our analysis extends the literature on dilemma management in education by theorizing how these dilemmas emerge at the intersection of different domains of education system building work including school systems' efforts to manage their environment. In doing so, our account shows how the dilemmas that system leaders deal with are fundamentally structural in origin and nature.

Conceptual Framing

We frame our analysis by combining, synthesizing, and engaging three separate literatures in conversation with one another. More specifically, we extend theorizing on dilemma management in education by combining it with research on how the school subject shapes efforts to reform teaching to examine how the work of education system building is school subject specific and shaped by structural arrangements. We bring work on education system building

into conversation with these other two literatures and, in doing so, frame our analysis around the core domains of work involved in education system building.

LEAVING BLANK FOR AERA BUT WILL WRITE FOCUSING ON THREE ITEMS:

- 1) DILEMMAS AS THEORIZED IN THE EXTANT LITERATURE;
- 2) THE IMPORTANCE OF ATTENDING TO THE SCHOOL SUBJECT IN RESEARCH ON TEACHING AND EDUCATION SYSTEM BUILDING
- 3) THE NEED FOR A STRUCTURAL ANALYSIS AND THEN SOME VERSION OF OUR CONCEPTUAL FRAMEWORK FOR EDUCATION SYSTEM BUILDING - A) MANAGING ENVIRONMENTS; B) BUILDING EDUCATIONAL INFRASTRUCTURE AND SUPPORTING ITS USE; C) MANAGING PERFORMANCE; D) DEVELOPING SYSTEMWIDE DISTRIBUTED LEADERSHIP.

Findings

We organize our findings as follows. First, we identify some core dilemmas tied to the preferential treatment of ELA and mathematics relative to science that system leaders grappled with in their efforts to reform elementary science education. Second, analyzing the origins and nature of the preferencing of mathematics and ELA over science, we show how the dilemmas that system leaders manage in their education system building efforts are fundamentally structural, embedded in the formal organization. Third, we examine system leaders' efforts to manage dilemmas emerging from the preferential treatment of ELA and mathematics over science.

Education System Building for Elementary Science and The Privileging of ELA/Mathematics

For system leaders, as the three preceding cases capture, leading and managing the reform of elementary school science education poses an array of challenges. Some of the challenges identified in these cases constitute a particular type of problem – “wicked problems” or “dilemmas” (Cuban, 2001, p. 10; see also Lampert, 1985, Lipsky, 1980; Spillane & Lowenhaupt, 2019; Spillane & Sun, 2020). Based on our ongoing analysis, in this paper we identify and define some core dilemmas that system leaders grappled with in their efforts to reform elementary science, all connected to the preferential treatment of ELA and mathematics relative to science in elementary schools. While we observe these dilemmas at the system level (i.e., based on system leaders’ accounts of their work), they are rooted in work at the intersection of system, school, and classroom levels and the institutional environment in which school systems operate.

Across 11 of the 13 school systems, system leaders struggled with getting attention on, and resources for, supporting and reforming elementary science education. Though the challenges were specific to elementary science, they emerge from the differential valuing of elementary school subjects in system, school, and especially classroom work. North Valley, an affluent school system and among the highest performing in the state, was one school system in our study where the system leaders did not talk about the privileging of ELA and mathematics relative to science as a challenge in their reform efforts. In 11 other systems, ELA and mathematics commanded more, or even most, attention; not only at the system level but also, according to system leaders, at the school and classroom levels. As a Silverbay¹ leader summed up, “ELA really tends to drive the bus.” A Jasper¹ leader expressed a similar sentiment, noting,

“I think one area that I constantly battle with [is] the focus on literacy is continuing.” A Brookeport system leader explained:

The biggest challenge when we talk to teachers is time. It’s really not time! It’s what their priorities are, and especially in first grade, second grade, their priority still really has to be on literacy. We got to get those kids learning how to read. Time spent in the classroom doing literacy, foundational literacy skill stuff, *[laughter]*, is always going to be their priority. Often people just don’t have the time to set up a science experiment because it’s so materials-heavy too. It’s messy. People don’t always love that ... but I would say that’s the number one reason why teachers still say that they can’t do science is because they just don’t have time to do it.

For this system leader, teachers prioritizing of literacy, especially in early grades, coupled with the time required to set up for science lessons, especially the sort of science teaching advanced in NGSS, contributed to teachers not teaching science. These circumstances created a dilemma for system leaders intent on improving elementary science education as they worked at balancing their efforts to create time and space for elementary science while coping with teachers and school leaders’ prioritization of ELA and mathematics. After all, it is impossible to improve the quality of science teaching, if science is not taught in the first place.

Another dilemma for system leaders, also tied to the prioritization of ELA and mathematics over science, concerned procuring essential resources for improving science education, including time for teacher professional development about science teaching. System leaders grappled with getting essential resources such as time for improving elementary science teaching. System leaders reported that, for the most part, school leaders and teachers were less

comfortable and less prepared to teach science compared with ELA. As a Jasper system leader noted:

I think one thing is just the teacher's comfort level in the content. Depending on the teacher training program that they've gone through, some may only have spent one class on elementary science. That doesn't get into the breadth of the content that teachers will be expected to address. ... I think, really, it's just the teacher comfort level compounded with time. The time to make them comfortable with those concepts.

This perceived lack of preparation in teacher education programs was then compounded by privileging of ELA and math in providing resources for and uptake of professional development.

A Fairby leader reported that:

in terms of math and science, teachers don't feel confident enough. We have to build their confidence in both. That's similar. The difference is that they do need to know how to teach math. We can get them to come to PD [for math]. Science is harder to get teachers to come to PD.

Despite the need for professional development being greater in science, teachers and school leaders were more likely to devote time for professional development and school improvement more broadly on either ELA or mathematics. Moreover, system level resources for supporting elementary science teaching, including staff, were much scarcer relative to ELA and mathematics adding to the challenge of building an educational infrastructure for elementary science. Hence, recognizing that most teachers had limited capability for and comfort with teaching science, system leaders struggled with whether and how to invest scarce professional development time in science relative to ELA and mathematics.

To summarize tentatively, in documenting the subject specific nature of education system building and the dilemmas therein, we also capture how these subject specific dilemmas are deeply tied to education system building for other school subjects. The school subject matters in education system building work, but at least in the case of science it matters in interaction with education system building for other school subjects.

Anatomy of A Dilemma: The Sidelining of Elementary School Science

To better understand the nature and origins of the dilemmas that system leaders dealt with in their efforts at building educational infrastructures to support elementary science, we analyzed the preferential valuing of ELA and mathematics relative to science. Rather than assume that science is somehow inherently less important for elementary school children to learn, we situated the preferential treatment of ELA and mathematics over science as a social construction at the intersection of system leaders' efforts to manage their institutional environments and their school systems structural arrangements. In turn, these structural arrangements can be traced to school systems' efforts to manage and adapt to past environmental pressures. Specifically, as school systems rely on their environments for critical resources, including their very legitimacy as 'real' school systems, they embed in their organizational structures (e.g., organizational routines such as principal and teacher evaluation routines) their efforts to manage their environment over time. In doing so, we argue that the dilemmas faced by system leaders' intent on reforming elementary science are not only a function of the individual preferences of educators but fundamentally structural in nature. We focus on three *interrelated* structural arrangements rooted in the efforts of school systems to manage their environments historically, that contribute to the dilemmas they grapple with in reforming elementary science, all anchored in the privileging of mathematics and ELA over science in elementary education.

First, system leaders across all three systems pointed to how test-based accountability, linked mostly to ELA and mathematics, posed a major challenge in their efforts to reform elementary school science education. A King Park¹ system leader explained:

whether or not that's right or fair is not the purpose ... I think it makes it very challenging for schools even when they are invested [in science reform], and like the curriculum, and think the coaching is good, and all of those things to when it gets close to a test and not freak out, and be like, 'We're not going to do this. We've got to go all in on math and ELA.' That's just a hard reality I think we have to face. I think our [system] leaders—we have put a stake in the ground around math and ELA.

As this leader explains, even in schools that are working to improve science teaching, maintaining the focus on science was difficult, especially as student testing season got closer. Even in states where science is tested and figures in the accountability mechanisms, it is often weighted much less than ELA and mathematics. As a Hartwell system leader described:

In elementary, our biggest priority is just getting science education to be included ... school administrators want to concentrate in literacy and mathematics. They will spend all of their time on that because you have the high-stakes testing. It doesn't include, or includes very little, science education. In [state], we use Aspire Testing ... I would estimate that less than 10 percent of the questions have to do with science. As a result, we're on the backburner.

As policymakers hold school/system leaders and teachers accountable for their performance usually on a handful of performance metrics tied to student achievement in mathematics and ELA, these subjects tend to command most of the attention of teachers and school leaders often crowding out attention and time for science. System leaders in turn hold school leaders and

teachers accountable using the same metrics in the performance of core organizational routines (see below). System leaders could not afford to ignore these environmental pressures and if they did school leaders and teachers were likely to remind them about how these pressures were embedded in core organizational routines that were central to the operation of the school system and consequential for their performance as educators.

Performance metrics tied to test-based accountability connected with and informed other structural arrangements; especially the performance of organizational routines for evaluating teachers and school leaders' performance and by extension their retention. A North Valley system leader, Kendrick, explained that if given a choice, teachers were more likely to opt for teaching an ELA or math lesson rather than a science lesson when being evaluated. They noted that:

for whatever reason, when we do teacher evaluations, it is agnostic of curriculum and instruction focus, in the sense ... they've [teachers] gotten to choose when they've been evaluated ... our K through 6 people generally don't pick to be evaluated while they're teaching science unless they spend the bulk of their day teaching science. Safely, K through four, no one's picking science.

The situation was similar with respect to the evaluation of school leaders as a King Park system leader explained in describing the dilemma faced by Farrah, the system's science leader:

[Farrah is] in a really hard spot, because she's an advocate for science, which I totally understand. It puts the school year in a hard spot when someone who's like, "Why aren't you doing more science?" When they're like, "I have to stay—I'm up for renewal." It's a really tricky balance and I think one that we have not figured out. I don't really know that we will any time soon. That's the other challenge I'd say specific to science.

As this leader points out, because science is not a primary consideration in evaluating school leaders for renewal it contributes to putting system leaders with responsibility for reforming science in a ‘really hard spot’, one that they do not think will be figured out any time soon.

Farrah, King Park’s science leader, explained the challenge noting, “my biggest frustration is the conversation that I have to have every spring to defend why we should teach science and why we should continue to dedicate the same, if not more, time to teaching science.” In turn, the sidelining of science in the performance of these routines contributed to the dilemmas that science system leaders struggled with in their efforts to reform elementary science.

Still, the sidelining of elementary science in school systems was not only a function of the relatively recent high stakes incentives tied to performance metrics for ELA and mathematics. The availability of data about student performance *in and of itself* may also have contributed to privileging ELA and mathematics creating a dilemma for school systems striving to get attention on elementary science. Readily available and easily accessed data for literacy and mathematics meant that it was easier for system and school leaders to demonstrate progress with reference to these school subjects. The absence of such accessible data for science, contributed to making the marshalling of evidence to demonstrate progress with science more difficult and, in turn, its sidelining as a school system priority. System and school leaders could more easily give an account for their work and its contribution with performance metrics for ELA and mathematics that were not as readily available for science. These arrangements in turn were rooted in state policy environments that school system leaders must manage and, that not only assess student performance in science less frequently, but also don’t include science or include it less prominently in their accountability regimes. Readily-accessible, and user-friendly data – in the form of performance metrics – were more likely to be the focus of both system and school

organizational routines. A Brookeport system leader explained that readily available data in the form of performance metrics contributed to focusing school leaders and teachers' attention and time in the performance of school level organizational routines:

It really depends on what the priority of the school is. I know that there's a lot of data collected around literacy, especially in the early childhood grades, like literacy and communication, so that's how a lot of leaders look at what's happening in schools. That's the surface level. They can see the data. They can see how much progress has been made in the year. That's why it's a priority because it's easy to show progress.

Incentives and sanctions aside, the mere availability of data in itself, contributed to privileging ELA and mathematics in the performance of school and system level organizational routines.

The incentive structures prioritizing ELA and mathematics over science, however, extended beyond professional educators and the structural arrangements that shaped their practice, to include other stakeholder groups such as parents and the broader community. A Silver Bay system leader explained, "standardized testing has been how we view schools as being successful and principals as being effective for a long time. ... The schools that perform well on standardized testing are celebrated. Those that don't have not been." In this system leader's view standardized test results, typically tied to ELA and mathematics, were not only a metric for evaluating the worth of school principals but was also one that parents and the broader community used to gauge the worth of their schools and identifying which schools merited celebration for success.

Second, the dilemmas that system leaders grappled resulting from the preferential treatment of ELA and mathematics over science had more widespread structural roots linked to the historical treatment of elementary school subjects in local, state, and federal education policy.

Our analysis suggests that the privileging of ELA and mathematics preceded the emergence of high stakes accountability policies focused on ELA and mathematics and must be situated, at least in part, in the preferential treatment of these two subjects historically by other state federal programs (e.g., Title 1). Overtime, the historical preferencing of ELA and mathematics was embedded in organizational structures such as organizational routines, standard operating procedures, and formal school and system positions. School systems, like other organizations, learn from managing their environments and this learning goes beyond individuals. The federal Title 1 program, for example, was organized and used by local school systems and schools to support the creation of system and school level structures such as formal positions tied to ELA (e.g., reading teachers) and more recently mathematics as well as entire subunits within school systems (e.g., Title 1 offices) that were not focused on elementary school science. As one Silverbay leader explained:

ELA has always been the driver, mathematics second to that. Math, you can imagine, has much more staffing. For science, we've ... had one individual that [was] supposed to support science TK through 12 and without a lot of resources do that job. It's pretty daunting ... to roll out new standards, new trainings without a lot of resources as one person to represent *[laughter]* 6,000 teachers or 5,000 teachers.

In this account, the sidelining of elementary school science is not just a function of a quarter century of high stakes accountability centered on ELA and mathematics, but must be situated historically in the preferential treatment of these two subjects (Peurach et al., 2022).

Further, state legislation in some states mandated time for ELA and mathematics but not for science. A Norhaven system leader explained, "there is some legislation that affects the amount of time for ELA and math have to be taught. There's not that same legislation for science

... the way we negotiated time was based on we put in those legislated times and then added to.” So, while the NGSS pressed ambitious demands with respect to instructional time for elementary science, these instructional time demands were not embodied in state law, even in states that had adopted the NGSS. At the same time, instructional time for elementary ELA and mathematics was mandated in state law in several states, something that teachers and school leaders were aware of, creating a dilemma for system leaders to manage as they worked to find time and resources for the teaching of elementary science and efforts to improve that teaching and do so in the absence of the backing of state legislation.

Third, the structural roots of the dilemmas faced by system leaders striving to reform elementary school science, go deeper still reflecting the school subject specializations of elementary school teachers and leaders, in particular school principals. As a Silverbay system leader explained:

We have a lot of leaders that come from, especially an early literacy background, so as literacy specialists, and we have a lot of principals across our system that specialize in literacy. It’s safest to go with what you know [*laughter*], and it’s easiest for you to coach and to implement around things you know.

These specializations of elementary school staff, especially those who get selected for leadership positions such as school principals, contributes to the preferential treatment of ELA and/or mathematics over science and the sidelining of science. As a result, system leaders striving to create space and time for science have to manage what school leaders and teachers feel “safest with” and comfortable with – ELA and mathematics – and at the same time engaging them with what they may feel less safe and comfortable with – science. We are all more comfortable with engaging with domains that we feel we have some expertise in and engaging with the unfamiliar

and uncertain can be daunting. For system leaders, these circumstances create a dilemma about how to convince teachers and school leaders to devote time to a subject they feel uncomfortable with and believe they have limited capability rather than subjects where they feel they have both capability and comfort.

To summarize tentatively, the availability and regular use of performance metrics based on student achievement in ELA and mathematics assessments contributed to prioritizing these two subjects relative to science across 11 of our school systems. Our account documents how relatively recent performance metrics advanced in the institutional environment through state and federal policy privilege ELA and mathematics over science for educators from the classroom to the school system level. Still, the preferential treatment of ELA and mathematics must be understood historically, especially, in relation to how school systems in managing their environments, learn and embed their learning in their organizational structures. To dwell only on the preferences of individual school and system educators, is to fail to recognize how environmental constraints interact with organizational arrangements and fundamentally shape the work of education system building. The dilemmas that system leaders face in reforming elementary science are fundamentally structural in nature and origin. Structural arrangements, such as core organizational routines that serve evaluative and agenda-setting functions, reinforce the privileging of ELA and mathematics relative to science in practice from the classroom to the system level. This contemporary and historical privileging of elementary school subjects in organizational structures such as organizational routines, formal positions, and standard operating procedures legitimized the privileging of ELA and mathematics over science that in turn contribute to a series of dilemmas for those system leaders involved with reforming elementary school science. The challenge is systemic, not just individual.

Dilemma Management in Education System Building for Elementary School Science

Recognizing dilemmas is one thing, understanding how system leaders manage them is another if related matter. System leaders manage dilemmas as distinct from solving them. Indeed, trying to solve a dilemma, as Larry Cuban notes, can make matters worse (Cuban, 2001). In this section we focus on system leaders' efforts at managing the dilemma of reforming elementary science considering the preferential treatment of ELA and mathematics in their school systems' structural arrangements and their broader environments. Based on our analysis of the data, we describe how system leaders strive to manage the dilemma and in doing so we avoid being evaluative as our study was not designed to evaluate results.

One means that system leaders used in managing the dilemma of the privileging ELA and Math over science was to argue for integrating science instruction with ELA, and in some case mathematics. In eight of the 13 school systems, system leaders explicitly mentioned this integration approach in their efforts to get attention and time for elementary school science education. Specifically, system leaders spoke about working to persuade school leaders and teachers about the importance of teaching science by making the case that it could improve literacy skills. A Norhaven system leader noted that "any time I can double count minutes for science and ELA, I call that a benefit. Maybe that's something we need to look at that we haven't looked at before." A Silverbay system leader elaborated on this dilemma management strategy noting:

What we've tried to do is not butt heads with that, but also show that we can tie content into the literacy period by pulling in texts that are tied to the projects and the phenomena that we're trying to explore. We've actually seen a lot of teachers learning how to integrate inquiry throughout the day and then also using science texts.

System leaders sought to persuade schools and teachers about teaching science as a means of improving literacy and numeracy skills. A Silverbay science system leader explained how they argued for elementary science at the system level by trying to persuade colleagues of the benefits of teaching science for literacy and numeracy:

I've just really been trying to advocate with our core leadership team for science as about how science supports literacy and numeracy and how ... there's articles from Carnegie Mellon about engagement and what engagement does for students. Plus, I had experience in middle school seeing students coming into sixth, seventh grade that hated math and science.

Hillman system leaders also note how integrating science into literacy and mathematics as well as equity related projects was one approach to managing the dilemma of science being sidelined in the elementary curriculum. Hartwell system leaders also worked at integrating science with ELA and mathematics, both tested subjects, by encouraging both the teaching of science in ELA as well as using ELA to teach science.

In some systems, such as Hillman, system leaders also changed the marketing and messaging about science professional development to avoid directly mentioning science in the hope of engaging elementary teachers in science professional development. A system leader explained that "we got some feedback around our science literacy day tomorrow where people said, "Oh, you shouldn't call it science literacy. You should call it non-fiction literacy because then, people will be more excited to learn about that." While this system leader noted that her "jaw kind of dropped" at this advice, she went along with the recommendation in the hope that it would persuade more teachers to participate in professional development related to elementary science. At the same time, these efforts to manage dilemmas associated with the sidelining of

elementary science, surfaced new dilemmas for system leaders. In Bartlett, for example, getting attention to elementary science by creating cross-curricular projects linked with ELA, surfaced concerns about whether science learning goals were being addressed.

Ideally, ... [cross-curricular inquiry projects will include] the science perspective on, say, weathering and erosion, or natural disasters, and then the social studies aspect will be, “How did society respond to that?” ... The struggle is that we have [legislated reading time]. That means that ... we can’t have them do a lot of the reading and writing in ELA time that they would usually be able to do, so they do a little bit of it, but it’s more ELA-directed than us directing it. Even the conversations they would have about it are about the literary part. The teachers actually have different groups for [science and] social studies and for ELA, different groups of kids at different times.

School systems’ approaches to managing the dilemma of the sidelining of science, however, were not uniform. In at least one system, Jaspar, the science system leader worked to avoid the integration strategy that was common in other systems. Jasper’s science system leader, Trinity, tried to minimize attention to the integration strategy by buffering members of the science adoption committee from publications that focused on integrating the teaching of science into reading teaching. She explained that she:

choose carefully the articles ... that talk about the doing of science because there's so much pressure to spend so much time in reading that not everybody is committed to the power of the doing part of science and then layering on the learning. Maybe we'll read something together, but the doing [of science] is as important. ‘We are going to read science and respond to questions at the end of the chapter.’ We're not going to go back to

doing that. Even if your day is stretched with trying to get everything in, we're going to do science with our students because this is what sparks commitment to learning.

Recognizing the pressure on teachers to focus on reading during science instruction or at the expense of science instruction, especially due to the state's Reading Recovery Act, Trinity tried to ensure that the materials her school system's science adoption committee read did not center on this integration approach. At the same time, Trinity recognized that some compromise was likely necessary, so in selecting the Twig program the system also purchased the leveled readers that come with the program. She explained:

I bowed to a little bit—I wouldn't say it's pressure, desire—the Twig program comes with leveled readers. Now, fifth and sixth grade [teachers] did not want them, but K-4 wanted them, but we are not using them during science. We are using them during the reading block, or as an inquiry project and they're available to dip into, to grow, whatever you're researching for your inquiry based on investigation.

Compromise is central in managing dilemmas as system leaders attempt to balance competing values.

School and system leaders' efforts to manage the dilemmas related to the preferential treatment ELA and mathematics as they worked to improve elementary science education created other dilemmas. For example, grappling with a shortage of resources for science education system leaders often turned to boutique offerings to help them support their elementary science reform efforts. As a Jasper system science leader summed up it up, “we are not a state that has a reputation for funding education well” and whatever limited funding is available is unlikely to go to a school subject that is not prioritized in the state's structural priorities. As a result, school systems like Jasper turn to the ‘extra system’ of NGOs to fund the

reform of elementary science. For example, Jasper's STEM labs were primarily funded through the Jasper Community Foundation that worked to fund STEM labs in every elementary school. Additionally, the River Valley STEM Ecosystem offers a STEM classroom grant, grants for professional development, and bus grants for getting kids to their events. Still, these boutique offerings often engage some schools but not all schools in the education system. Doing so creates another dilemma, as a Jasper science system leader explained:

When we think about science instruction, we really try to approach it from the district approach, rather than there's this great program and then there a handful of classrooms that get to be a part of it. One example of this might be the Global Gardens and the Global Gardens club. They're amazing educators, and they really teach students how to not only plant their own gardens but also how to use them and how to cook with what they've planted. I know that with many of those groups that are really phenomenal and instrumental, it's hard to scale it for a district that's our size. That's why, like I said, we normally rely on larger threads that we can tap into rather than trying to pool a number of resources to address our district.

Working under resource constraints, system leaders turn to boutique programs that they can make available to some schools but whether and how they address their systemwide agenda for improving science education is not always clear. A coherent and equitable system wide agenda for elementary science education can be undermined by the reliance on different boutique programs that are available to some schools, rather than all schools.

Discussion and Conclusion

Our account documents how managing dilemmas, as distinct from solving problems, is fundamental to not only the practice of teaching and leading teaching in the schoolhouse, but

also to the practice of education system building therein. While our analysis here focuses on system leaders *and* their efforts to improve elementary school science, we document how these efforts are situated not only on the values and expectations of school leaders and teachers but more broadly in the broader institutional environment and school systems' structural efforts to manage and adapt to these environments. In doing so we show, how the school subject matters with respect to the dilemmas that system leaders grapple with as they engage in education system building for elementary school science, but how it does can only be fully understood in relation to system level efforts to manage other elementary school subjects, especially ELA and mathematics. The subject matters for the work of education system building, but it does in relation to and interaction with managing other school subjects and the competing demands for attention and resources on educators across the system. These competing subject matter demands reside not only in the preferences of individual educators but are embedded, over time, in school systems' educational infrastructures that shape the everyday work of system and school leaders and teachers. Hence, the dilemmas involved in education system building for elementary school science are anchored in not only institutional environment but also in school systems' structural arrangements. These structural arrangements contributed to reproducing the privileging of ELA and mathematics over science and the resulting dilemmas for system leaders' intent on reforming elementary school science.

Our contributions to the literature in this paper are three-fold. First, in focusing on elementary school science we show how the dilemmas involved in education system building are school subject specific. Second, while capturing how the school subject is an important and critical consideration in education system building, we also document how the dilemmas encountered by system leaders in one school subject – elementary school science - emerge from

its interaction with other school subjects and education system building therein. While the school subject matters to education system building work, it matters in interaction with and in relation to education system building for other school subjects. Third, our analysis extends the literature on dilemma management in education by theorizing how these dilemmas emerge at the intersection of different domains of education system building work and in interaction with systems leaders' efforts to manage their institutional environment. In doing so, we move beyond locating dilemmas only in the competing preference and demands of individual stakeholders, to show how these dilemmas are structural in origin and nature, embedded in the organizational structures that fundamentally shape the work of teachers, school leaders, and system leaders. The dilemmas we document are not a product of system leaders' (limited) capability or lack of will to reform. Rather, these dilemmas emerge at the intersection of the environments in which education systems operate, the structural arrangements school systems create to manage their environments historically, and the technical core of schooling – teaching – which is subject specific.

While several scholars have documented the centrality of managing dilemmas in the education sector from the classroom to the school and education system (Cuban, 2001; Lampert, 1985; Spillane & Sun, 2020; Spillane & Lowenhaupt, 2019), our account documents how managing dilemmas is also central to the practice of education system building (Peurach, Yurkofsky, & Sutherland, 2019) and how these dilemmas associated with education system building are school subject specific. With the rise of technical rationality over the past quarter century in education policy and education system building, technically rational notions about school improvement have privileged problem solving and in so doing undermined attention to the dilemmas that educators deal with in their everyday work. While problem definition and

problem solving are important parts of system leaders' work, in this paper we make the case for attention to dilemmas also and for appreciating the complex work of managing dilemmas.

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