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RESEARCH ARTICLE

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Administrators' capacity for supporting reform-oriented science instruction: An urban school district case study

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Abstract

Secondary school administrators play a vital role as instructional leaders, but little is known about their knowledge of science practices and perceptions of strategies for supporting reform-oriented science instruction. This multiphase, mixed-methods Q-Methodology study explored administrators' perceptions of instructional leadership and, in particular, high-quality science instruction. After a concourse of 40 items was developed through a review of literature and an expert panel, $n = 22$ administrators from one urban school district completed a Q-sort and a post-sort questionnaire in which they commented on a lesson excerpt. Principal components analysis with varimax rotation was used to assimilate the participants into three factors or groups explaining 40% of the variance. A subsample (n = 14) of administrators then participated in focus groups to engage in collective sensemaking. Although administrators consistently valued positive teacher-student relationships and had high expectations for all students over other managerial duties, perceptions of how to support teachers and their ability to detect evidence-based science pedagogy (NGSS), differed. Administrators with a science background or more experience as an

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administrator were more familiar with some of the evidence-based instructional strategies for science included in the sample lesson. Administrators without such a background tended to emphasize general pedagogical techniques. We discuss implications for the development of school leaders with varying disciplinary backgrounds as one component of building districts' capacity for high-quality science instruction.

KEYWORDS

administrators, high-needs populations, instructional leadership, science practices, urban schools

1 | INTRODUCTION

In recent years, scholars have proposed that models of effective administrative leadership should include more explicit connections with student learning outcomes (Myran & Sutherland, 2018). In science, leaders' focus on academic achievement is particularly important in districts with high proportions of historically underserved and economically disadvantaged students, as these youth are less likely to experience highly effective and engaging instruction in science or remain in course pathways that prepare them for study in STEM fields at the postsecondary level (Lochmiller, 2016). Compared to White students, course completion rates in STEM disciplines are far lower for African Americans and Hispanics, who tend to be enrolled in districts with fewer financial resources and less qualified teachers who may not deliver science instruction that reflects best practices (Cooper, 2009) or have access to discipline-specific instructional coaching (Jackson et al., 1983).

In parallel, scholars have noted that administrators are vital to the provision of high-quality science instruction through classroom observation and the provision of feedback to teachers (Cunningham & Lochmiller, 2020; Irwin, et al., 2021; Wenner & Settlage, 2015). However, to provide informative feedback, administrators must understand contemporary trends in disciplinary practices and possess sufficient knowledge of the local curriculum (McNeill et al., 2018; Wahlstrom & Louis, 2008). Given that recent science reforms emphasize discipline-specific feedback to teachers (Bybee, 2014; Hill & Grossman, 2013; National Research Council, 2012) but leaders' backgrounds vary, there is a need to understand administrators' perceptions of classroom practices and their approach to providing feedback aimed at improving student outcomes. This study marks a step towards building knowledge about the perceptions of administrators with varying disciplinary backgrounds and years of administrative experience, how they construct meaning when presented with multiple strategies for instructional leadership, and their primary areas of focus when giving feedback on a sample science lesson.

This study spans existing literature to examine in a single study the ways in which administrators characterize effective science teaching, what they notice when watching instruction, and how they conceptualize teacher feedback. Additionally, the study calls attention to similarities and differences among administrators across these three areas. To investigate, we used a multiphase Q methodology to reveal the different perspectives of administrators on instruction and instructional leadership (Q-sort), how they engaged in sensemaking when presented with multiple strategies (focus group), and what they focused on when giving feedback on a sample science lesson (survey). By triangulating these sources of data, we aimed to identify patterns and hone our perspective on potential areas of need for instructional leaders' professional development.

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2 | COMPONENTS OF INSTRUCTIONAL LEADERSHIP

Recently, scholars have drawn attention to instructional leadership as an important component of the overall role of an administrator (Leithwood et al., 2004; Myran & Sutherland, 2018; Shaked & Beoliel, 2020). While some have proposed that instructional leadership primarily involves setting the mission and conditions for learning within a school, others have proposed that effective instructional leadership requires a strong commitment to the well-being of students and staff, relationship-building skills, a focus on creating a supportive learning environment, an orientation towards the curriculum (Hallinger, 2005) and a focus on understanding how to promote equitable student learning (Wahlstrom & Louis, 2008). Some scholars have explicitly connected models of school leadership with tenets of learning that map neatly onto the assumptions underlying reform-oriented science instruction, such as viewing the learner as an individual who learns best through active, agentic, and social experiences (Grissom et al., 2021; Myran & Sutherland, 2018). For school leaders to exhibit effective instructional leadership in science education, administrators need a deep understanding of science content and reform-oriented science instruction, knowledge of pedagogical best practices in teaching and learning science, and strong communication skills (Grissom et al., 2021; Myran & Sutherland, 2018). Such a perspective clearly situates familiarity with teachers' classroom practices within the purview of the school leader.

2.1 | Teacher observations

Building and district level administrators are often called upon to observe and provide feedback as part of teachers' evaluation cycles, during the implementation of new initiatives such as curricular changes, or at the request of a teacher. For this reason, scholars have examined effective approaches that administrators can take. For example, Cunningham and Lochmiller (2020) reviewed leadership practices in mathematics and science instruction and noted the importance of regular observations and the use of classroom observation data to provide targeted feedback. Reinhorn et al. (2017) interviewed teachers and administrators in schools with large underserved populations and emphasized the importance of encouraging teachers to reflect on students' formative and summative assessment data in light of their lesson plans, while noting the disadvantageous effects of focusing on observation for accountability purposes. Others have underscored the importance of providing actionable feedback about general aspects of pedagogy (Brookhart & Moss, 2015; Leithwood et al., 2004) to build teachers' ability to communicate expectations and feedback to students on a regular basis, use effective classroom management strategies (Finley, 2014), assist students in making real-world connections to the content (Roth & Garnier, 2006), and create positive social relationships in the classroom (Brookhart & Moss, 2015; Marshall, 2009).

2.2 | Reform-oriented science instruction

Since our work is situated within science education specifically, we were also interested in examining the degree to which administrators align their perceptions of effective instructional leadership in science with reform-oriented science practices (McNeill et al., 2018) including investigating, student sensemaking, and critiquing, to include pedagogical strategies that emphasize inquiry, discussion, and reasoning from evidence (Duschl et al., 2007; National Research Council, 2012; Sampson et al., 2013). In general, reform-oriented science instruction is intended to include opportunities for students to collaborate and engage in scientific discourse, gather and process empirical data, create models and draw conclusions, and argue from evidence (Sampson et al., 2013). This often requires the use of technology such as probeware, computing devices, and other hands-on tasks (McNeill et al., 2018) but can also be accomplished in a virtual environment through demonstrations, individual at-home activities, and online

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discussions. National policy documents call for effective science instruction to include active participation and engagement from students (Duschl et al., 2007; National Research Council, 2012). Such activities may mean that in-person and on-line science instruction[1] may look, sound, and be managed differently from lessons that focus on other disciplines and the science classrooms of prior years—lessons may span multiple class periods to allow time to design, conduct and communicate experiments, and students may express tentative or incorrect ideas that are then examined by peers as well as the teacher (Sampson et al., 2013).

2.3 | Administrators' perceptions

The potential gap between the general pedagogical tendencies noted in instructional leadership and efforts to improve discipline-specific instruction in science leads to two objectives that the present study seeks to address. The first is how administrators might construct their own understanding of the components of effective instructional leadership. Few studies have used a quantitative approach to create an organized and refined understanding of administrators' perceptions of how to fulfill an instructional leadership role, yet scholars have emphasized the need to examine the organized "working" knowledge that contributes to administrators' interpretation of events (Coburn, 2005). The second objective pertains to science specifically as we investigate how administrators with varying backgrounds and years of experience might make sense of a science lesson and consider how to communicate with the teacher about its perceived effectiveness.

2.4 | Administrators' sensemaking

As noted, although instructional leadership has been conceptualized in a manner that is largely independent of disciplinary pedagogies (e.g., Wieczorek & Lear, 2018), the Next Generation Science Standards emphasize students' proficiency in science specific disciplinary practices including investigating, sensemaking, and critiquing (National Research Council, 2012). This shift away from traditional, teacher-centered instructional strategies towards student-centered, authentic, inquiry-based activities, requires administrative consent and support. However, administrators with little background in science may either struggle to identify high-quality science instruction or have difficulty offering specific feedback that is aligned with disciplinary best practices. Regardless of background, administrators will likely construct an understanding of what is happening and use that understanding to provide feedback. This process of drawing on background knowledge to guide action can be thought of as sensemaking (Thomson & Hall, 2011; Weick, 1995).

Sensemaking originates in leadership and management research; it refers to the way meaning making occurs and reflects the integration of perception, cognition, memory, and action (Carraway & Young, 2015; Evans, 2007; Weick, 1995). Since one aspect of sensemaking is the imposition of an individual's underlying conceptual framework on a phenomenon (Starbuck & Milliken, 1988), we propose that variations in administrators' perspectives on instruction may arise from clusters of perceptions that leaders bring to the situation to make sense of it (Thomson & Hall, 2011; Weiner & Woulfin, 2018). If so, it is important to understand the content of these implicit frameworks and how, over time and in response to direct experience as well as working with others in a professional social context, administrators construct an understanding of what it means to be an effective instructional leader, as well as their understanding of what they are witnessing in their environment and how to respond (Weiner & Woulfin, 2018, p. 215). Therefore, we seek to understand belief-related antecedent factors of sensemaking, how these may manifest during instructional coaching opportunities, and how these reflect administrators' overall perspectives on instructional leadership (Wieczorek & Lear, 2018).

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Research on administrators' sensemaking has found that individuals blend new information about best practices and policies with pre-existing understandings that vary in commitment to their importance, as well as memories of personal experience. In a landmark study, Spillane and Callahan (2000) emphasized a cognitive approach to understanding administrators' ability to support teachers during a time of reform. They found that, in the face of science policy change, many district level administrators drew on either prior knowledge about forms of pedagogy and beliefs about student engagement and motivation or on assumptions about the relation between classroom practices and students' learning outcomes. However, the study did not account for the ways in which leaders' professional social interactions may function as a context for sensemaking, nor did it connect administrators' understandings to their approach to providing feedback. More recent work has examined sensemaking among instructional leaders as a form of reasoning about ambiguous situations and has used a social constructivist approach (Maitlis & Christianson, 2014). In their review, Ganon-Shilon and Schechter (2017) emphasized that school leaders rely on an assemblage of prior understandings to make sense of ambiguous situations. However, they highlighted the relative lack of research on how such prior understandings are organized or could be leveraged to support learning and reflection among groups of leaders. Similarly, Gawlik's, (2005) qualitative study of school leaders also highlighted how leaders' sensemaking involved wrestling with prior understandings and new, policy related information that focused on accountability. Gawlik proposed that collective sensemaking could be used as a tool for administrators' professional development but did not offer a framework for gathering and representing leaders' understandings. This presents the opportunity to use the social context of focus groups to examine how collective sensemaking might proceed.

It is important for school leaders to work together to make sense of science instruction, understand best practices and strategies for implementation. Through effective leadership, administrators can strengthen their capacity to support meaningful and engaging learning experiences for students in science. The present study allowed for phases of individual and collective sensemaking. After soliciting administrators' beliefs individually using the Q-sort, we used focus groups as a context for creating shared understanding. The administrators were given the opportunity to actively engage in discourse, share their varied knowledge resources, collaboratively decipher what was happening in the science lesson, and provide comprehensive feedback for the teacher in the science lesson excerpt. This allowed multiple perspectives, types of background knowledge, and experience to be shared and discussed in a safe and structured way (Marshall et al., 2021) that also revealed similarities and differences to the investigators. Our use of focus groups mimics the practice of seeking out colleagues for discussion, which is often used to reduce uncertainty by leveraging professional social networks (Siciliano et al., 2017). Such networks increase collaboration and the exchange of ideas, and can foster improved educator self-efficacy and student performance (Siciliano, 2016; Siciliano et al., 2017).

3 | THE PRESENT STUDY

This study was conducted to both highlight a strategy for understanding leaders' constructions of instructional leadership components and connect such constructions to responses to a specific instructional setting. As such, its outcomes are intended to build on prior research on leaders' sensemaking in science (Ganon-Shilon & Schechter, 2017; Spillane & Callahan, 2000; Weick et al., 2005) and offer insights into needs that may arise, for example when seeking to create a culture of consistent feedback (Marshall et al., 2021) for science teachers (see Figure 1 for a visualization of the main components of the study).

Based on the review of literature there were multiple areas of importance for effective leadership in science: administrator's disciplinary background, need to provide instructional feedback to teachers, and understanding of the science practices and what they could look like in the classroom. In this study, we evoke sensemaking as an intra- and interindividual process linking perception—organized representations of prior

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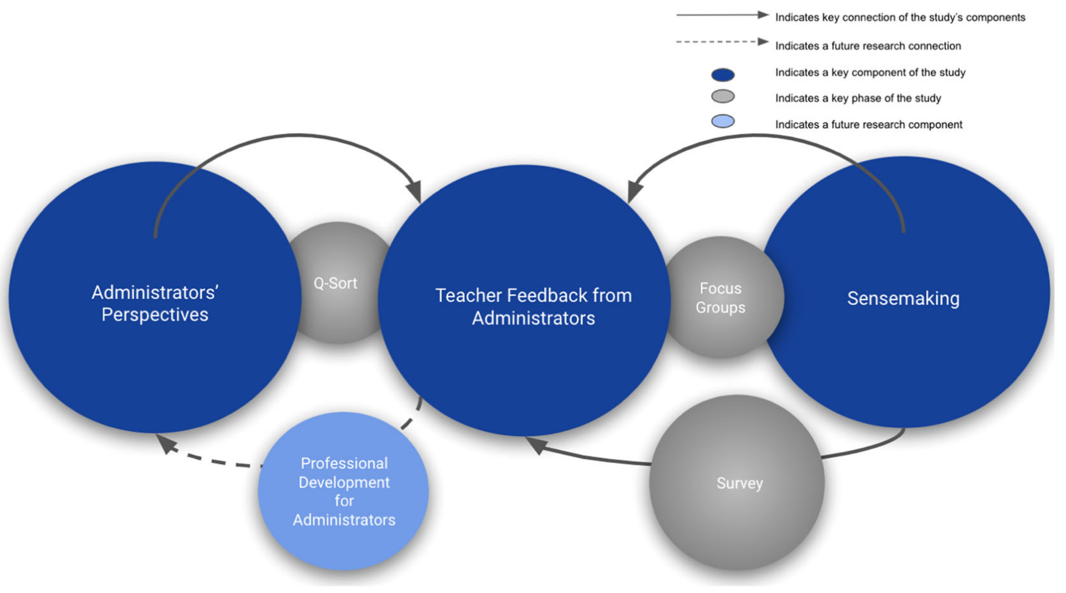

FIGURE 1 Administrators' perceptions on science practices conceptual framework.

beliefs and aspects of classroom instruction that administrators noticed—and action, through statements made when asked to provide feedback and conversations that took place in a small group setting (McNeill et al., 2018). The participants were all from the same school district and part of a social network, which provided more insight when they were grouped together for the focus groups. The Q methodology approach was used to derive a common set of statements about leadership and then group administrators according to their agreement with the statements (Militello et al., 2016). The set of prompts and the sort findings were anticipated to provide insight into variances and commonalities among leaders' perceptions. The following research questions guided the study:

1. How do secondary administrators with varying disciplinary backgrounds and years of leadership experience characterize effective teacher support?
2. What do secondary administrators notice when watching teachers deliver science instruction?
3. On what topics do secondary administrators provide feedback after viewing a science lesson excerpt?

4 | METHODS

4.1 | Context

The context for this study was an urban school district serving approximately 20,000 students in the eastern portion of the United States. At the time of the study, approximately 60% of the district's students were African American, 24% were White, 8% were multiracial, 8% were classified as Other; over half (55%) were economically disadvantaged as indicated by the state's student records data definition index. The district had recently achieved 100% accreditation (from 40% in prior years) through improved student achievement in English, mathematics, and science.

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4.2 | Design

This was an explanatory mixed-methods study that integrated quantitative and qualitative methods (Creswell & Plano Clark, 2007) by using Q methodology (Brown, 1980) followed by a survey and focus groups. Q methodology is a participatory method of collecting data on participants' values, attitudes, and beliefs (Brown, 2006). It is recognized as yielding statistically valuable results that group similar individuals using principal components analysis to examine patterns among the perceptions of participants (Yang, 2016). Q methodology differs from item-focused factor analysis, in that response patterns are examined using participants rather than variables (Militello et al., 2016).

A Q methodology study typically proceeds in phases (Zabala et al., 2018). Phase 1 involves developing the concourse or universe of opinion items; Phase 2 involves selecting a sample of statements from the concourse to create the Q sample that is sorted by participants; Phase 3 involves selecting participants who will make up the P sample; Phase 4 includes the participants completing a forced distribution card sort known as the Q-sort; and Phase 5 includes performing a principal components analysis and interpreting the findings in relation to the membership within each factor (group) and the most appropriate label for each group (Militello et al., 2016). In this study, these phases were extended to include focus groups for each affinity group (factor) and the opportunity to examine consensus statements that were rated similarly across each group.

4.3 | Participants and procedure

4.3.1 | Q sample development

The Q sample, a population or concourse of opinion statements, was generated in study Phases 1 and 2. The concourse of items was developed from two sources: an extensive review of the instructional leadership and science education literature, and a survey (Ferrell, 2021; see also Militello et al., 2016) that was sent to an expert group of $n = 24$ principals, assistant principals, lead teachers, district leaders, state leaders, and retired administrators.[2] The survey was on the topic of *effective actions for school leaders' support of instruction* and asked them to list five support actions they had received from an administrator or that they as an administrator had provided a teacher to improve their instruction. Then, three retired administrators, one district leader, and one state-level science leader served as an expert panel to revise the entire group of statements for clarity and remove redundant items (Militello et al., 2016). The panel approved the smaller Q-set of statements that was used by the P sample in their sort. Items are presented in Table 1.

4.3.2 | P sample characteristics

Phases 3 and 4 of the study involved a sort of the Q-set of statements conducted by the P sample of $n = 22$ administrators from one urban district whose roles included secondary level principals and assistant principals. As shown in Table 2, only seven participants had a formal background in science education. Six participants reported having taught secondary science before becoming an administrator. Of the six participants who were former science teachers, five were former middle school science teachers and one was a former high school science teacher. One of the participants previously taught elementary science before becoming an administrator. The other 15 administrators had different backgrounds. There were 5 administrators with an English or English Language Arts teaching background. There are 3 administrators with a math teaching background. There were 3 administrators with a history or social science teaching background. The remaining administrators were 2 former physical education teachers, a former elementary teacher, and a former school counselor.

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TABLE 1 Statements retained for the Q-sort.

Statement	Sources
Make suggestions and ask clarifying questions on my teachers' weekly lesson plans.	Pilot
Attend collaborative learning team (CLT) meetings with my teachers.	Survey: P1
Collaborate with teachers during the lesson planning process.	Survey: P1, P4
Conduct weekly observations and schedule timely follow–up conferences.	Lochmiller (2016)
Schedule peer observations of other teachers.	Survey: P1
Partner with culture/climate coaches.	Survey: P3
Partner with curriculum specialists/supervisors.	Pilot
Conduct weekly constructive debriefs.	Reinhorn et al. (2017)
Send my teachers appreciation notes as appropriate.	Brookhart and Moss (2015)
Use observation evidence in follow-up conversation.	Lochmiller (2016)
Offer opportunities for my teachers to demonstrate leadership or strength.	Hallinger (2005); Survey: P3
Support teachers in the implementation of division initiatives.	Pilot
Encourage teachers to bring real-life examples/situations in the classroom.	Roth and Garnier (2006); McNeil et al. (2018).
Encourage teachers to provide students with opportunities to collaborate and engage in academic discourse.	Sampson et al. (2013)
Expect teachers to move around the room to engage off-task learners, and re-engage them in the lesson.	Wahlstrom and Louis (2008)
Celebrate with my teachers over student growth and success.	Leithwood et al. (2004); Pilot
Encourage teachers to provide enrichment opportunities for their students.	Shaked and Benoliel (2020)
Encourage teachers to have positive teacher-student relationships.	Savran and Çakiroglu (2003); Survey: P5
Require teacher-led instruction to ensure content is introduced to students as indicated in the pacing guide.	Survey: P13
Expect teachers to use technology and hands-on activities with students.	McNeill et al. (2018); Windschitl et al. (2008)
Expect teachers to achieve higher than the division on common assessments and benchmarks.	Survey: P13
Encourage teachers to actively engage students in participation and discussion.	Evans (2007); Pilot
Encourage teachers to use a lot of hands-on activities utilizing student collaboration.	McNeill et al. (2018)
Encourage teachers to use and share new technology and resources.	Windschitl et al. (2008); Survey: P10
Attend trainings on new technology.	Survey: P9
Provide targeted professional development based on evidence obtained from data and classroom observations.	Lochmiller (2016)
Emphasize the use of effective instructional practices to teachers.	Wahlstrom and Louis (2008)
Encourage teachers to reflect on their lesson plans and adapt based on student feedback from formative assessments.	Reinhorn et al. (2017)
Ensure teachers provide formative and summative assessments to determine content mastery.	Reinhorn et al. (2017)
Encourage teachers to use a classroom management system.	Finley (2014)
Encourage teachers to create an atmosphere of safety/trust in their classrooms.	Wahlstrom and Louis (2008)
Encourage teachers to set high expectations for all students.	Marshall (2009); Survey: P11
Encourage teachers to provide feedback to students with suggestions for improvement.	Brookhart and Moss (2015)
Encourage lead teachers to facilitate collaborative learning in team meetings.	Survey: P2
Encourage teachers to take an active role in the implementation of the curriculum in my school.	Survey: P14

(Continues)

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TABLE 1 (Continued)

Statement	Sources
Expect teachers to follow the instructional pacing guide.	Survey: P15
Participate on the curriculum development team for the area that I supervise.	Wahlstrom and Louis (2008)
Conduct evaluations on my teachers beyond the division's expectations.	Reinhorn et al. (2017); Pilot
Attend professional development opportunities for content-specific areas.	Hall et al. (2016); Pilot
Use student data to help support my conversations with my teachers.	Survey: P12; National Research Council, 2015

Note: P = Pilot Group; NRC = National Research Council.

4.3.3 | Self-guided Q-sort procedure

Following recruitment and informed consent, participants used an online portal to conduct a Q-sort that elicited their perceptions about effective support actions for science instruction using the following Condition of Sort: *"What is the most effective feedback that your teachers need right now to help them move their classroom instruction forward?"* Participants dragged and dropped the 40 Q-set items using a forced-choice distribution from +4 (*strongly agree*) to −4 (*strongly disagree*) (Figure 2).

4.3.4 | Lesson excerpt

After completing the Q-sort, participants watched an 8-min clip of a video recorded science lesson that was conducted in an online environment due to the COVID-19 pandemic. The lesson, which was conducted in the participants' district, included a female eighth grade physical science teacher and her class of 28 students. The lesson excerpt included a review of the procedure and findings of a hands-on lab activity that was conducted synchronously but remotely by the entire class in their at-home settings during the previous class period. The topic of the lesson was heat transfer. In the lesson excerpt, the teacher reviewed the lab and asked the students to give authentic examples of conduction, convection and radiation based on their lab activity and other examples from their everyday lives. The teacher used an interactive slide presentation to solicit and evaluate students' individual understandings of the various methods of heat transfer and waited until each student had responded electronically before moving to the next question. The teacher then split the class into small breakout rooms. She visited each room and encouraged them to discuss their responses to questions with their peers, and to provide evidence to justify their statements about the direction of heat transfer between materials.

The lesson excerpt was chosen because it provided administrators with a number of opportunities to comment on an example of a teacher implementing hands-on pedagogy and student discourse in a virtual setting. For example, students used science vocabulary when summarizing the investigation that they conducted in the previous lesson (NGSS—investigating). Students made connections to their everyday lives when they used examples and terminology such as conduction, convection, and radiation. They were required to discuss a problem in their community that could be solved using one type of heat transfer, e.g. using a solar oven (NGSS—sensemaking). Finally, students used their data as evidence to discuss how heat energy flows out of a hotter substance and into a cooler one (NGSS—critiquing). Administrators were instructed to watch the excerpt and make notes about what they noticed.

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TABLE 2 Participants' demographics and factor placements.

Participant	Race	Gender	Subject(s)	Years taught	Years as Administrator	Highest degree	Factor (group)	Post–sort interview, focus group
1	W	M	History	14	3	Ed.S.	A	Y
2	W	M	P.E.	6	1.5	M.Ed.	C	Y
3	W	M	English	11	11	M.Ed.	[a]	Y
4	AA	F	ELA	7	8	M.A.	A	Y
5	W	F	Science	16	1	Ed.S.	A	Y
6	W	F	Social Studies	15	16	Ed.S.	B	Y
7	AA	F	Math	18	14	Ph.D.	B	Y
8	AA	M	All	5	21	M.Ed	B	N
9	AA	F	Science/ Social Studies	14	15	Ed.D.	B	Y
10	W	M	P.E.	10	16	M.A.	A	N
11	W	F	SPED/ History	5	12	M.Ed	A	N
12	AA	M	English	3	15	M.Ed.	A	Y
13	AA	F	Science	17	2	Ed.S.	A	Y
14	AA	F	Math	5	13	Ed.D	B	N
15	W	F	Science/ Social Studies	10	18	M.Ed.	A	Y
16	AA	F	English	13	10	MA	A	N
17	AA	F	Counselor	6	3	Ed.S.	B	Y
18	AA	F	English	14	16	Ed.D.	C	N
19	AA	M	Science	13	3	M.Ed.	A	Y
20	AA	F	Science	4	13	M.Ed.	C	N
21	AA	F	Science	9	9	M.Ed.	A	Y
22	AA	F	Math	4	14	M.Ed.	A	N

Note: W = White; AA = African American; M = male; F = female.
Abbreviations: ELA, English language arts; P.E., physical education.
[a]Removed due to anomalous (negative) factor loading.

4.3.5 | Focus groups with sensemaking exercises

The $n = 14$ administrators who submitted their lesson excerpt responses by the requested due date were invited to one of three factor-based focus groups (Factor A focus group $n = 8$; Factor B focus group $n = 4$; Factor C focus group $n = 2$). The purpose of the focus groups was to provide an opportunity for collective sensemaking about the Q-sort results and their approach to providing teachers with feedback (Marshall et al., 2021). In the focus groups,

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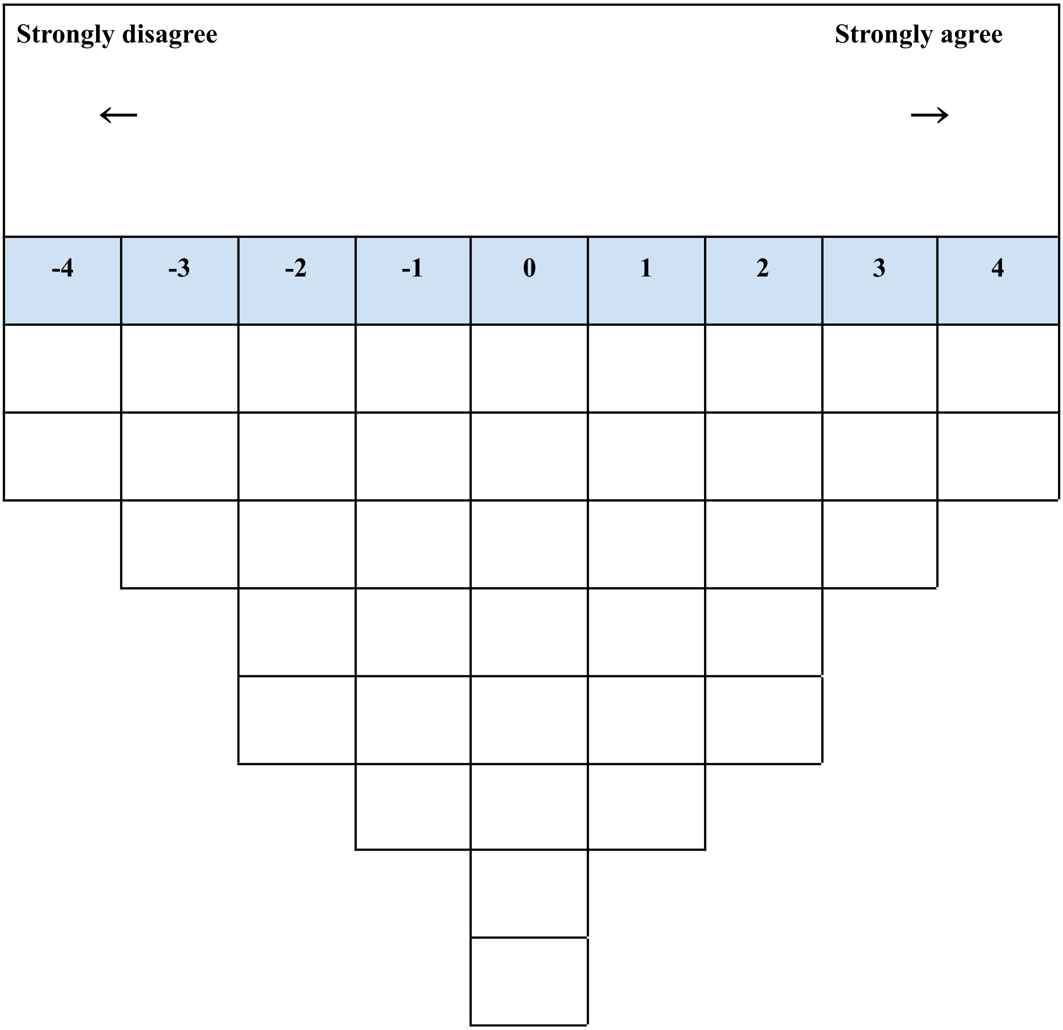

FIGURE 2 Q-sort distribution grid. Condition of Sort (keep this statement in mind as you sort the statements): "What is the most effective feedback that your teachers need right now to help them move their classroom instruction forward?".

participants were asked several questions to prompt their reflection on the sort and its apparent outcome (see Table 3).

In the focus group, administrators also viewed a model sort that represented the participants' respective factor and which provided a basis for generating a label to describe the factor (Watts & Stenner, 2012). An example of a model sort for Factor (group) A is shown in Figure 3 in the Findings. Participants then engaged in a sensemaking exercise where they discussed their perceptions of the science clip, listened to others' impressions, stated what they noticed, and articulated the feedback they would provide the teacher. Questions to the groups included "Who is in your group?," "Which statements best represent your shared perspective?," and "What name would you assign to represent the perspective illustrated by this model sort?" The exercise concluded when participants came to a consensus on their feedback for the teacher in the lesson excerpt and articulated common descriptors for their perspective that could be included when the researcher was generating the factor (group) label. The factor names were selected based on the statistical characteristics of the highly ranked statements, common themes that

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TABLE 3 Post-sort questions aligned with research questions.

Post-sort focus group questions	Research question
1. Who is in your group? Describe any similarities and/or differences (e.g., demographics, job, etc.). 2. What has had the greatest impact on how you sorted your cards the way you did? (E.g., past experience, administration training, content knowledge, etc.). Please explain your answers. 3. Which statements best represent your shared perspective? 4. What name would you assign that represents the perspective illustrated by this model sort? Explain why and the meaning associated with that name—use statements to provide justification.	1. What are the perceptions of effective teacher leadership among secondary administrators with varying disciplinary backgrounds and years of leadership experience?
5. What did you "notice" during the science lesson?	2. What do secondary administrators notice when watching science instruction?
6. Based on your perceptions of the most effective feedback, what feedback would you provide to this teacher regarding science instruction? Do you feel comfortable delivering this feedback or support to this teacher?	3. On what topics do secondary administrators provide feedback after viewing a science lesson excerpt?
7. Is there anything that was said that has triggered a different thought that you would like to share?	All

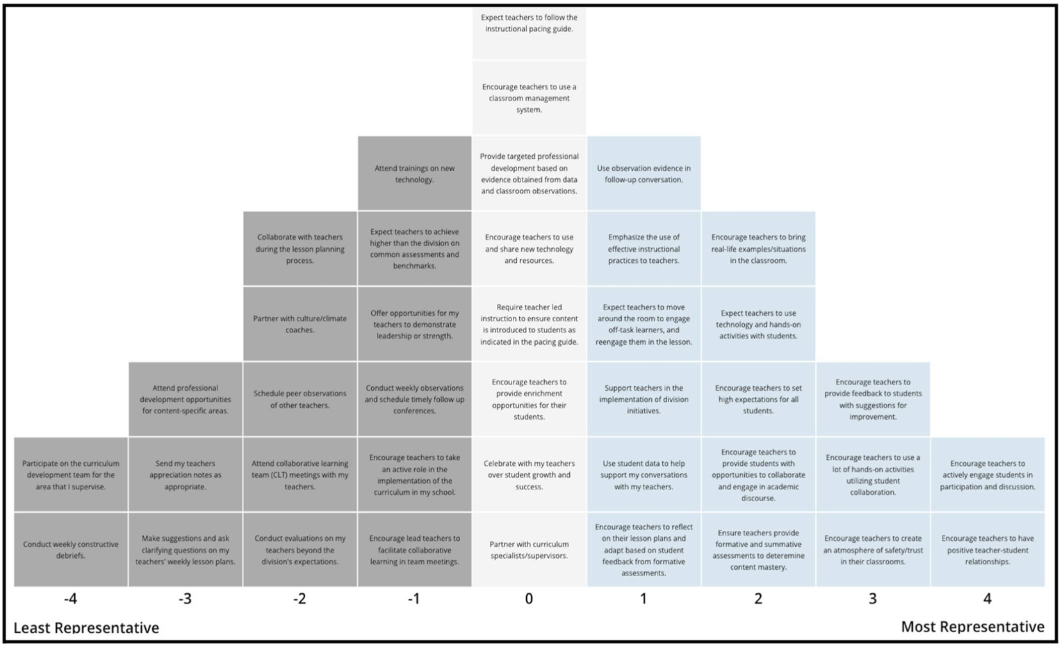

FIGURE 3 Model sort for Factor A.

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emerged from the post-sort survey questions, and the focus group interviews. The three factors are: Effective Encouragers (Factor A), R.E.C. League (Relationships, Encouragement and Curriculum; Factor B), and Eye in the Sky (Factor C).

4.4 | Data analysis

4.4.1 | Quantitative data

Participants' Q-sort statement ratings were subjected to principal components analysis using the Ken-Q Analysis web-based application (Banasik, 2016). The analysis grouped participants who shared similar views by factor and used Varimax rotation to minimize the correlations among factors (Wint, 2013). This resulted in a three-factor solution which accounted for 36% of the variance and to which 21 participants could be associated (Table 4).

TABLE 4 Factor matrix using participants' Q-sorts (loadings).

	Factor		
Participant	1	2	3
1	0.3409**	0.0214	0.1001
2	0.0831	−0.0383	0.3745*
3	0.1587	−0.1966	−0.3352*
4	0.5616*	0.2016	0.2917
5	0.3950**	0.1077	−0.2685
6	0.2082	0.5536*	0.0863
7	0.2203	0.5058*	0.1993
8	0.1727	0.3698**	0.1753
9	0.1940	0.4462*	0.4142
10	0.4727*	0.1936	−0.0479
11	0.6674*	0.0325	0.2174
12	0.6351*	0.3124	0.4751
13	0.5602*	0.2502	0.1421
14	0.2007	0.6929*	0.2090
15	0.7386*	0.1140	0.0432
16	0.4652*	0.0554	0.3291
17	0.0322	0.4317*	−0.0519
18	0.1612	0.2062	0.4458*
19	0.4305*	0.2671	0.1571
20	0.1524	0.1427	0.57638*
21	0.4938*	0.3446	−0.1153
22	0.7058*	0.3641	0.1131

Note: *$p < 0.01$, **$p < 0.05$.

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Twelve participants were grouped under Effective Encouragers (Factor A), six participants were grouped under R.E.C. League (Relationships, Encouragement and Curriculum) (Factor B), and five participants were grouped under Eye in the Sky (Factor C).

4.4.2 | Qualitative data

All interviews were recorded, transcribed, and thematically coded. This process is called InQuiry and it was used to provide a qualitative account of participants' perspectives (Militello et al., 2014). Data from the focus group participants provided insights to answer Research Questions 2 and 3. Field notes were collected during the focus groups. Notes were analyzed for word frequency and then reviewed to provide a source of emergent themes and individual and common perspectives in response to a prompt.

Administrators responded to two questions (pertaining to Research Questions 2 and 3) following the lesson excerpt: "After watching the science lesson, what did you notice during the lesson?" and "Based on your perceptions of the most effective feedback and support, what feedback and support would you provide to this teacher regarding science instruction?" Responses to these questions were coded in a top-down manner that referenced the science practices included in the National Research Council (2012) including investigating—references to asking questions, planning and carrying out investigations, collecting data, conducting an experiment, or observing phenomena; sensemaking—references to analyzing and interpreting data, developing and using models, and explaining how or why a phenomenon has occurred; and critiquing practices—including references to engaging in argumentation from evidence, evaluating information, or students questioning and evaluating each other's ideas. Responses were also coded in a bottom-up manner to capture emergent ideas and themes in the data, including comments about classroom management, use of technology, or instructional pacing. Similarly, the focus groups were recorded, transcribed, and thematically coded using inductive and deductive coding (Zhang & Wildemuth, 2009). The coding process used inductive coding to determine themes and accommodate spontaneous categories that emerged in participants' responses, and deductive coding to map participants' responses to the research questions (see Table 3) as well as map responses to NGSS science practices (Table 5). Dr. Ferrell and two independent raters coded the data to the point of consensus.

TABLE 5 Hierarchical coding scheme for administrators' qualitative responses.

NGSS practice	Categories of administrator feedback	Examples
Investigating	Asking questions regarding data, claims, evidence, and the design of the investigation; Planning an investigation; Collecting data; Conducting an experiment.	Participant 15 stated that the teacher and students discussed the popcorn lab that they conducted during the previous class, and the teacher asked the students to reference their data to respond.
Sensemaking	Analyzing or interpreting data; Constructing an explanation; Developing or using a model.	Participant 19 highlighted that the teacher gave the students the real-world examples of heat transfer.
		Participant 7 stated that the teacher gave the class the example of a slide in the summer and asked them to explain the type of heat transfer and why.
Critiquing	Engaging in argument from evidence; Obtaining, evaluating, or communicating information.	Participant 5 mentioned the teacher asking for examples of heat transfer in the chat and then having the class agree or disagree with the examples and their explanations.

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In addition to the top-down (deductive) approach that was used to address Research Question 2, administrators also shared additional perspectives regarding science instruction that did not fit the initial codes. In this case, inductive coding occurred by generating themes from post-interviews and questionnaire responses to fully capture what administrators noticed about the science lesson they viewed. Research Question 3, which focused on administrator feedback based on what they saw in the video and what constitutes good science instruction, used the deductive coding process. The three identified science practices (investigating, sensemaking, and critiquing) aligned with administrators' responses to the science clip.

Using deductive coding, Research Question 3 aimed to explore the feedback of administrators based on their observations in the video and how they define good science instruction. The deductive coding process involved developing a codebook that outlined the categories and subcategories of the analyzed. In this case, the codes were developed based on the three identified science practices. The responses of the administrators were then coded into these categories to identify patterns and common themes in their feedback.

4.4.3 | Q-sort?

The three groups' qualitative data were examined in turn. For each of the three groups, individual administrators' feedback was reviewed by multiple raters to decide on tone. The research team used data excerpts to ensure that all raters could interpret the codebook correctly. The questionnaire responses and the post-sort interview data were reviewed using line-by-line coding followed by a team meeting to discuss any statements or data that were not placed under the same code for all members. Discrepancies in coding were resolved through discussion. Administrators were asked to consider their perception of the most effective feedback and support actions and respond with the actions they would take with the secondary science teacher they observed in the video. They were also asked how comfortable they would feel giving their feedback and support to that teacher. Through the q-sort administrators shared their perceptions of effective leadership in science by ranking what they value higher than other actions (see Table 1). Through the individual feedback each participant shared for the teacher in the video, and their focus groups that were based on their q-sort their perceptions of effective leadership in the science classroom were revealed.

While reviewing the feedback portion of the questionnaire and the transcripts from the interviews, a characteristic emerged that was subsequently incorporated into the data analysis. This was the overall tone of the feedback (*positive*, *negative*, or *neutral*). A positive evaluation meant that the administrator's feedback was overall positive and evaluative in nature, with one or fewer areas for improvement given. A neutral evaluation meant that the administrator's feedback was overall more descriptive, with a balance of positive and negative comments given. A negative evaluation meant that the administrator's feedback was overall negative and evaluative in nature, with two or more areas for improvement given. Once again, feedback was discussed by the reviewers until consensus was reached.

5 | FINDINGS

In this study, we examined similarities and differences among administrators' perspectives on instructional leadership, as well as what administrators noticed during a science lesson, and how they might approach providing feedback. We draw on the findings of the Q methodology study to respond to the first research question, how secondary administrators with varying disciplinary backgrounds and years of leadership experience characterize effective teacher leadership, and then integrate the Q methodology findings with the focus group portion of the study to respond to the second and third research questions, which pertain to what administrators noticed when watching (and discussing) the lesson excerpt, and the priorities they identified for feedback.

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5.1 | Administrators' varying perceptions of effective strategies for instructional leadership

The principal components analysis resulted in a three-factor solution that included 21 participants.[3] The factor groups differed in the relative agreement ratings given to the Q-sort statements. Relative rankings of the statements according to each factor (group) are shown in Table 6, with the scale ranging from −4 (*strongly disagree*) to +4 (*strongly agree*). While there was variance in the participants' individual disciplinary backgrounds (Research Question 1) including history, science, and English, the majority ($n = 5$; 62%) of the individuals with a science background fell into Effective Encouragers (Factor A). The groups were not markedly different in years of experience: Effective Encouragers had an average of 9 years of administrative experience and 10 years of teaching experience compared to an average of 14 years of administrative experience and 10 years of teaching experience for R.E.C. League (Group B), and 10 years of administrative experience and 8 years of teaching experience for Eye in the Sky (Group C).

5.1.1 | Variation in the most and least strongly endorsed statements

Q-Methodology allowed the researchers to extract multiple distinct viewpoints from the sample. The three-factor solution with varimax rotation (Watts & Stenner, 2012) offered the best balance between high values for variance accounted for, the inclusion of more participants, and lower correlations among factors; this solution represented points of consensus among groups of administrators. The initial factors were rotated with the Varimax method. This method of factor rotation was used because it attempts to clarify the relationship among factors. The factors accounted for 36% of the variance, with Factor A representing 26%, Factor B representing 6%, and Factor C representing 4%. Based on the content background of the participants (Research Question 1) the expectation would be that those with a science background would load onto the same factor. The majority of the administrators with a science background loaded onto Factor A. The three factors that emerged from the data analysis consolidated the 40 statements and 22 participants into three perspectives.

A common theme for the 12 administrators in the Effective Encouragers group was *encouraging teachers and building relationships*. The most strongly endorsed statements for this group included "Encourage teachers to have positive teacher-student relationships, "Encourage teachers to create an atmosphere of safety/trust in their classrooms," and "Encourage teachers to provide feedback to students with suggestions for improvement." Administrators in this group also strongly endorsed *instructional strategies that promote student collaboration and discourse*, including "Encourage teachers to use a lot of hands-on activities utilizing student collaboration" and "Encourage teachers to actively engage students in participation and discussion."

The six administrators in R.E.C. League emphasized *encouraging positive teacher-student relationships and high expectations for students*. Statements most strongly agreed upon by this group also included "Encourage teachers to have positive teacher-student relationships" but differed from the prior group by endorsing "Encourage teachers to set high expectations for all students," "Attend collaborative learning team (CLT) meetings with my teachers," "Ensure teachers provide formative and summative assessments to determine content mastery" and "Encourage teachers to take an active role in the implementation of the curriculum in my school."

The four administrators in Eye in the Sky emphasized *high expectations for teachers and students through data-driven decision-making*. This group strongly endorsed statements of "Conduct weekly observations and schedule timely follow up conferences," "Conduct evaluations on my teachers beyond the division's expectations," "Use observation evidence in follow-up conversation," "Encourage teachers to reflect on their lesson plans and adapt based on student feedback from formative assessments," and "Use student data to help support my conversations with my teachers." This group was notably different from the other groups by the relative lack of emphasis on relationships.

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TABLE 6 Normalized factor scores for each group.

	Factor A: Encouraging teachers and building relationships		Factor B: Encouraging positive teacher-student relationships		Factor C: High expectations through data-informed decision making	
Statement	Grid placement	Z-score	Grid placement	Z-score	Grid placement	Z-score
Encourage teachers to have positive teacher-student relationships.	4	2.14	4	1.61	1	0.47
Encourage teachers to actively engage students in participation and discussion.	4	1.51	1	0.41	1	0.74
Encourage teachers to use a lot of hands-on activities utilizing student collaboration.	3	1.27	−1	−0.71	−1	−0.66
Encourage teachers to create an atmosphere of safety/trust in their classrooms.	3	1.22	2	1.14	1	−0.14
Encourage teachers to provide feedback to students with suggestions for improvement.	3	1.42	0	0.12	0	0.32
Encourage teachers to bring real-life examples/situations in the classroom.	2	0.98	−1	−0.41	1	0.58
Encourage teachers to provide students with opportunities to collaborate and engage in academic discourse.	2	0.74	−1	−0.73	0	−0.04
Expect teachers to use technology and hands-on activities with students.	2	0.86	0	−0.31	2	1.04
Ensure teachers provide formative and summative assessments to determine content mastery.	2	0.86	3	1.56	1	0.66
Encourage teachers to set high expectations for all students.	2	0.90	4	1.96	4	1.50
Use observation evidence in a follow-up conversation.	1	0.61	0	0.19	3	1.24
Support teachers in the implementation of division initiatives.	1	0.58	1	0.41	−3	−1.70

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TABLE 6 (Continued)

Statement	Factor A: Encouraging teachers and building relationships		Factor B: Encouraging positive teacher-student relationships		Factor C: High expectations through data-informed decision making	
	Grid placement	Z-score	Grid placement	Z-score	Grid placement	Z-score
Expect teachers to move around the room to engage off-task learners and reengage them in the lesson.	1	0.82	0	0.14	−1	−0.19
Emphasize the use of effective instructional practices to teachers.	1	0.64	1	0.70	2	1.00
Encourage teachers to reflect on their lesson plans and adapt based on student feedback from formative assessments.	1	0.62	0	0.17	3	1.21
Use student data to help support my conversations with my teachers.	1	0.86	1	0.64	4	1.31
Partner with curriculum specialists/supervisors.	0	−0.21	1	0.49	0	0.19
Celebrate with my teachers over student growth and success.	0	0.27	0	0.11	2	1.11
Encourage teachers to provide enrichment opportunities for their students.	0	−0.39	0	−0.37	0	0.122
Require teacher-led instruction to ensure content is introduced to students as indicated in the pacing guide.	0	0.22	−1	−0.74	−4	−2.18
Encourage teachers to use and share new technology and resources.	0	−0.27	−2	−1.03	0	0.11
Provide targeted professional development based on evidence obtained from data and classroom observations.	0	−0.36	2	0.98	−1	−0.20
Encourage teachers to use a classroom management system.	0	0.62	2	0.89	0	−0.03

(Continues)

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TABLE 6 (Continued)

Statement	Factor A: Encouraging teachers and building relationships		Factor B: Encouraging positive teacher-student relationships		Factor C: High expectations through data-informed decision making	
	Grid placement	Z-score	Grid placement	Z-score	Grid placement	Z-score
Expect teachers to follow the instructional pacing guide.	0	0.24	2	1.22	1	0.60
Conduct weekly observations and schedule timely follow up conferences.	−1	−0.87	−1	−0.47	3	1.33
Offer opportunities for my teachers to demonstrate leadership or strength.	−1	−0.36	−2	−0.93	−2	−1.14
Expect teachers to achieve higher than the division on common assessments and benchmarks.	−1	−0.61	−2	−1.08	−2	−0.70
Attend trainings on new technology.	−1	−0.62	−4	−1.78	−3	−1.59
Encourage lead teachers to facilitate collaborative learning in team meetings.	−1	−0.62	1	0.42	−3	−1.54
Encourage teachers to take an active role in the implementation of the curriculum in my school.	−1	−0.42	3	1.36	−2	−1.21
Attend collaborative learning team (CLT) meetings with my teachers.	−2	−0.81	3	1.56	2	1.04
Collaborate with teachers during the lesson planning process.	−2	−1.15	2	0.85	−1	−0.21
Schedule peer observations of other teachers.	−2	−0.86	−2	−0.94	0	−0.04
Partner with culture/climate coaches.	−2	−0.97	−4	−1.75	−2	−1.14
Conduct evaluations on my teachers beyond the division's expectations.	−2	−1.17	−4	−1.35	2	1.19
Make suggestions and ask clarifying questions on my teachers' weekly lesson plans.	−3	−1.40	−1	−0.44	−3	−1.71

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TABLE 6 (Continued)

Statement	Factor A: Encouraging teachers and building relationships		Factor B: Encouraging positive teacher-student relationships		Factor C: High expectations through data-informed decision making	
	Grid placement	Z-score	Grid placement	Z-score	Grid placement	Z-score
Send my teachers appreciation notes as appropriate.	−3	−1.35	−2	−1.03	−1	−0.60
Attend professional development opportunities for content-specific areas.	−3	−1.26	0	−0.36	−1	−0.34
Conduct weekly constructive debriefs.	−4	−1.80	−3	−1.29	1	0.58
Participate in the curriculum development team for the area that I supervise.	−4	−1.86	−3	−1.25	−2	−0.98

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Administrators also varied by group in the statements that they disagreed with the most strongly. In Effective Encouragers, administrators did not endorse the statements "Make suggestions and ask clarifying questions on my teachers' weekly lesson plans," "Send my teachers appreciation notes as appropriate," "Attend professional development opportunities for content-specific areas," "Conduct weekly constructive debriefs," and "Participate in the curriculum development team for the area that I supervise." Similarly, participants in R.E.C. League also rejected the statements "Conduct weekly constructive debriefs" and "Participate on the curriculum development team for the area that I supervise." They also disagreed with the statements "Conduct evaluations on my teachers beyond the division's expectations," "Partner with culture/climate coaches" and "Attend trainings on new technology." Administrators in Eye in the Sky disagreed with "Make suggestions and ask clarifying questions on my teachers' weekly lesson plans," "Partner with culture/climate coaches" and "Attend trainings on new technology." In addition, this group rejected the statements "Support teachers in the implementation of division initiatives" and "Require teacher-led instruction to ensure content is introduced to students as indicated in the pacing guide."

5.1.2 | Consensus statements

To identify areas of agreement among all three groups, statements that were placed in a statistically similar location on the distribution grid of each model sort for all three groups were presented as consensus statements. The three-factor solution used in this study generated three consensus statements: one reflecting agreement, one reflecting disagreement, and one in the middle of the continuum (see Table 7). Statement 27, "Emphasize the use of effective instructional practices to teachers" was judged mildly favorably by participants in all three groups, although participants in Eye in the Sky agreed with it more strongly than those in Factors A and B. Participants in all groups disagreed with Statement 21, "Expect teachers to achieve higher than the division on common assessments and benchmarks," although it was more strongly rejected by participants in R.E.C. League and Eye in the Sky. Statement 17, "Encourage teachers to provide enrichment opportunities for their students" emerged as a neutral statement for all groups.

5.1.3 | Administrators' reflections on their group membership

In homogeneous focus group settings, participants viewed a model sort, which is a group level representation of statement rankings that matches a particular factor (see example in Figure 3). This allowed for reflection and elaboration on group membership.

The model sort served as a prompt for participants to elaborate on their ratings. For example, in the Effective Encouragers group, participant 19, a male African American with a science discipline background and less than 5 years of experience as an administrator stated, "I'm a big relationship person so I think that once you start looking at positive teacher to student relationships, that's the most important thing." Also in the focus group Effective Encouragers, participant 12, a male African American with a humanities background and more than 10 years of

TABLE 7 Consensus statements.

Statement	Grid placement A	B	C
Emphasize the use of effective instructional practices to teachers.	+1	+1	+2
Encourage teachers to provide enrichment opportunities for their students.	0	0	0
Expect teachers to achieve higher than the division on common assessments and benchmarks.	−1	−2	−2

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experience, added, “I lean more so to really helping my teachers understand how to actively engage their students and how to build those relationships, so that they can teach students.” Participant 15, a White female administrator with a science and social studies background, added, “I agree with you all. I think we are not really touchy feely, but we all like to understand our personnel, and building relationships—that works.”

The focus group setting also offered the opportunity for participants to elaborate on why certain statements were not endorsed. Effective Encouragers Participant 19 clarified,

> There's a ton of duties and responsibilities that we [as administrators] have to monitor, and they are very time consuming. While we would love to conduct weekly constructive debriefs with our teachers, there is just no time in the day to do that. If you develop those relationships with your teachers, you will know which ones are most in need of those constructive debriefs.

In the focus group with R.E.C. League participants, the topic of high expectations for students was explicitly tied to the topic of having positive relationships. Participant 7, an African American female administrator with a mathematics background and more than 10 years of administrative experience, stated, “I was looking at teachers needing to have high expectations and relationships with their students. If you have those pieces and a safe environment, you can teach anything”. Participant 9, an African American female with more than 15 years of administrative experience and a background in both science and the humanities added,

> I also looked at the classroom environment, and the classroom management. If you have control of your classroom then there is no limit, but if [you] don't have control then everything you set out to accomplish isn't going to happen. The teacher will spend time dealing with stuff that is irrelevant.

Finally, in the Eye in the Sky focus group, participants compared the statements they had agreed about and those with which they had disagreed. For example, Participant 2, a White male administrator with a nonscience background and less than 5 years of administrative experience, noted,

> When I think about working with and growing teachers, I do not feel attending training on new technology is as important as conducting weekly observations and scheduling those follow-up conferences, because I think that that should be number one.

5.2 | What administrators noticed when watching a science lesson excerpt

Overall, what was noticed was not clearly tied to Factor (group), years of leadership experience, or disciplinary background. However, individuals with science expertise were more likely to include science concepts in their comments than individuals without professional preparation in science education.

5.2.1 | NGSS informed practices

More than one-third (35%) of the administrators noticed investigating practices and commented on the lab that the teacher referenced during the lesson. The majority of these individuals had a science background, but not all. For example, participant 15 (science and social studies background, 18 years of leadership experience, 3 years of administrative experience) noticed that the teacher asked the students to reference their data from the lab to

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respond to a question, and also noticed that the teacher asked the students to identify the type of heat transfer that they experienced during the investigation.

Approximately one in five (21%) of the administrators noticed sensemaking practices (see Figure 4): participant 19 (science background, 3 years of leadership experience) highlighted that the teacher discussed real-world examples of heat transfer, and participant 9 (science and social studies background, 15 years of leadership experience) mentioned that the teacher supported the students' processing of different examples of heat transfer from the lab investigation through the use of the chat function in the lesson. Five administrators (36%) mentioned students using evidence or data to support their conclusion (see Figure 4).

Only two (14%) of the administrators mentioned the practice of critiquing (see Figure 4): participant 5 (science background, 1 year of leadership experience) mentioned that the teacher asked for examples of heat transfer in the chat and then requested that the students register agreement or disagreement with examples and explanations, and participant 12 (English background, 15 years of leadership experience) stated that the students responded in the chat and the teacher instructed them to discuss and elaborate on their examples with the class. The results of the deductive coding process revealed that the administrators perceived good science instruction as incorporating the three practices of investigating, sensemaking, and critiquing. Based on their feedback, only 36% of the administrators in the study observed investigating practices, while 21% noticed sensemaking practices, and only 14% noticed critiquing practices (see Figure 4). In summary, through the deductive coding process, it was identified that administrators perceive good science instruction as incorporating the three identified practices to varying degrees and that the video illustrated these practices.

5.2.2 | Emergent themes

There were significant similarities and differences among the three factor groups. Participants in all factors shared similarities on setting high expectations for all students, emphasizing effective instructional practices to teachers,

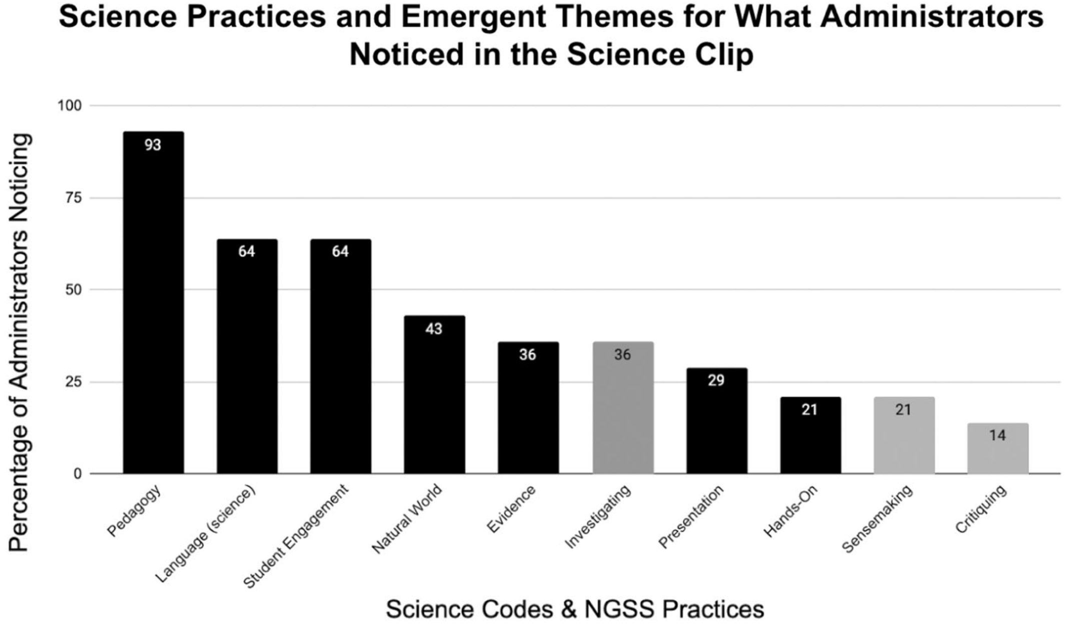

FIGURE 4 Science practices (gray) and emergent codes (black) that administrators noticed in the science clip.

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and encouraging positive teacher-student relationships (higher for Factors A and B). Emergent themes included comments about pedagogy, the use of science language, and the presence or absence of student engagement. Almost all (93%) administrators discussed pedagogy (see Figure 4). In Effective Encouragers, five individuals (Participants 1, 4, 12, 15, and 21) and in R.E.C. League three individuals (Participants 6, 7, 9) noticed the structure of the lesson, the success criteria and learning intentions, the use of an interactive slideshow tool as a formative assessment, how each student was placed in groups within the program, and how the teacher was able to control the content that the students saw on their screens.

The majority of administrators (64%) noted the use of science language (see Figure 4). In Effective Encouragers Participants 5, 15, and 19 (all of whom had science backgrounds) and in Factor (group) B participants 7 (math background) and 9 (science background) specifically mentioned conduction, convection, radiation, and heat transfer in their responses, and noticed that the teacher and students gave numerous examples of each concept during the lesson. By contrast, administrators without a background in science education most frequently commented on classroom management. One commented that the teacher was

> Monitoring the chat, addresses questions, background is appropriate for the virtual setting... gives verbal immediate feedback to students, she does not waste instructional time asking to see students' faces but checks to see who is participating by monitoring the check [sic; chat].

5.2.3 | Conflicting observations

Differences between the factors emerged in regard to participants' beliefs about the effective actions of administrators. Nine participants noticed and commented on student engagement although the perceived level of engagement was perceived variously. Some found attending collaborative learning team meetings effective while others felt that providing students with opportunities to collaborate and engage in academic discourse was more effective. Effective Encouragers, the group with the most administrators who had a science background felt that effective support for them would be encouraging teachers to use a lot of hands-on activities with student collaboration. These included participants from Effective Encouragers (Participant 5, science background; Participant 19, science background; and Participant 21, science background); R.E.C. League (Participant 7, math background and Participant 9, science and social studies background; and Eye in the Sky (Participant 2, English background), who all noticed and commented on students' engagement in the form of participating in discussions, submitting chat responses, or using the interactive board to respond. However, in Effective Encouragers participants 1 (History background), 12 (English background), and 13 (science background) discussed not hearing all students talk during the lesson and were concerned that this could be associated with a lack of engagement. Similarly, while one participant commented that "real-world examples were provided, examples were on the application level and not simply the "remember/understand level" for heat transfer review" and another noted that the "teacher asked for responses to keep students engaged," another administrator commented that "the questions were lower level. They were examples the kids had previously used so it's more memorization than application and the teacher gave the examples."

In sum, administrators with experience teaching science or those that had been an administrator longer than 10 years more easily noticed science practices, specifically the investigating practice. Administrators with a science background or more experience as a secondary administrator seemed to be more familiar with science practices, suggesting that whereas these individuals might benefit from professional development focused on sensemaking and critiquing practices the other administrators may benefit from support that targets their ability to detect all three types of science practices (investigating, sensemaking, and critiquing). These findings suggest that administrators need support to visualize what a classroom that engages in the science practices should look like,

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why instruction may differ from other disciplines or classrooms, and how to support their teachers to engage in these practices effectively (McNeill et al., 2018).

5.3 | Administrators' feedback to science teachers

The third research question was informed by administrators' responses to the postvideo prompt "Based on your perceptions of the most effective feedback and support, what feedback and support would you provide to this teacher regarding science instruction?" as well as their responses to a similar question that was asked during the focus groups.

5.3.1 | Tone

As noted, while reviewing the feedback portion of the questionnaire and the transcripts from the interviews, the overall tone of the feedback (*positive*, *negative*, or *neutral*) emerged as an important feature: a positive evaluation noted either none or one area for improvement; a neutral evaluation tended to be descriptive and balanced between positive and negative comments; and a negative evaluation tended to focus on two or more areas for improvement.

Participants loading on R.E.C. League (Factor B) sorted Statements 18, 32, 2, 29, and 35 on the +4 and +3 side of the distribution grid. The highest scoring statements in Factor B, contained language such as: "encourage teachers to have positive teacher-student relationships," "encourage teachers to set high expectations for students," and "encourage teachers to take an active role in the implementation of the curriculum." Common themes among these statements were relationships, encouragement, and curriculum. The R.E.C. League group's teacher feedback also included an endorsement of the statements, "the teacher created an atmosphere of safety/trust," "the teacher has a good relationship with the students," "the teacher is patient and acknowledges/responds to students questions," and "the teacher actively engages students to participate and use the chat feature when unforgettable about speaking on camera."

There were eight positive statements with only three areas for improvement given. Positive evaluations, which were gathered from individuals in the R.E.C. League and Eye in the Sky groups, included only one or two areas for improvement and were given by 28.5% of the administrators; the same percentage, which only included individuals in Effective Encouragers, gave evaluations that included five negative comments with only one or two positive statements. Just under half (43%) of the administrators, which included individuals in Effective Encouragers and B, gave neutral evaluations that included positive and negative comments. In summary, the feedback given by the administrators was congruent with the emphases in the various factor groups.

5.3.2 | Content

Notably, it was uncommon for the content of the administrators' feedback to be aligned with NGSS elements such as investigating practices, student sensemaking using data to explain scientific phenomena, and critiquing practices. Only two administrators suggested NGSS-informed sensemaking and critiquing practices; suggestions included putting the students in breakout groups and allowing them to engage in academic discourse about heat transfer. One participant noted that "my feedback would be to ask the students for a unique example of each type of heat transfer (best) or give examples that haven't been used during instruction for students to identify [the] type of heat transfer."

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Generally, the content of administrators' feedback was more likely to be focused on classroom management and methods for maintaining student engagement than on discipline-specific pedagogical approaches. Participant 2, a white male in the Eye in the Sky group, without a science background and less than 5 years' leadership experience, stated that he would ask the teacher what system they had in place to ensure that all students were being called upon in class. Participant 9, African American female in the R.E.C. League group, without a science background but with more than a decade of leadership experience suggested that the teacher establish a classroom management system that incorporates when it is appropriate for students to speak and when open conversations are acceptable. These participants were more focused on a system of calling on students or having a classroom management plan than in noticing that students were using scientific vocabulary to have a discussion about heat transfer. Participant 7, an African American female in the R.E.C. League group without a science background and more than a decade of leadership experience, also praised the teacher for providing students with opportunities to collaborate and engage in academic discourse. One participant blended a recommendation for assessment with content-related feedback: Participant 19, an African American male in the Effective Encouragers group with a science background and less than 5 years of leadership experience, suggested a different method for formative assessment to ensure that students were giving all original responses to the types of heat transfer to ensure every student understood the concepts.

6 | DISCUSSION

Science teachers make instructional decisions that affect what students learn in science, but school administrators make decisions about what effective science instruction should look like in their building, and this in turn influences teachers' instruction and students' learning of science (Wenner & Settlage, 2015). This study was conducted to gain insight into how school leaders view the task of leading the instruction of science teachers, and to what degree the school administrators vary in their preferences and priorities for teacher feedback. A mixed methods approach was used which involved administrators ranking statements about instructional leadership, providing qualitative examples, and discussing their responses in a focus group setting. Through this approach, we found substantial variations in administrators' endorsement of particular instructional leadership and science teaching practices. Furthermore, administrators' emphasis was found to be placed on general pedagogy, as opposed to being specific to the discipline and pacing of the science lesson. Given that this variability exists within one district's leaders, and in light of mandates to emphasize particular strategies in science instruction, the study raises questions about how to promote collaboration and consistency (or productive disagreement) among administrators, and how to manage the provision of meaningful feedback to science teachers.

Our first research question concerned the ways in which administrators with varying disciplinary backgrounds and years of leadership experience characterized effective teacher support. We found that leaders who were grouped as Effective Encouragers (Factor A, highest concentration of administrators with a science background) prioritized hands-on activities. This was seen in the Q-sort and during the focus groups. These secondary administrators tended to focus on pedagogy when observing science instruction, rather than offering specific feedback on science practices. Compared to the administrators in R.E.C. League and Eye in the Sky, those in Effective Encouragers, which also included a number of individuals with expertise in science education, were more likely to value and agree with statements that reflected NGSS-informed instructional strategies and practices. For example, those in Effective Encouragers gave high ratings to statements portraying the administrator's role as one of encouraging teachers to engage students in discussion, use technology, teach with hands-on activities, and implement collaborative activities.

In contrast, our findings suggest that administrators without a disciplinary background in science may need assistance to develop their capacity to effectively support instruction that reflects NGSS-informed practices. R.E.C. League and Eye in the Sky were aligned in their emphasis on administrators' role encouraging teachers to set high expectations for students, which was not as high of a priority for Effective Encouragers, but R.E.C. League administrators emphasized the more generic statement pertaining to teachers' use of assessment data to inform decision making, and Eye in the Sky administrators also emphasized more generic statements pertaining to formative assessments and teachers' use of reflection on lesson plans as a method for ensuring high quality instruction. Administrators in Eye in the Sky rated weekly debrief meetings much more favorably than participants in the other two groups, who expressed in their focus groups that other managerial tasks kept them from doing this. In essence, the three groups were focused either on instructional strategies, setting high expectations and measuring student performance and ensuring that teachers are leading curriculum implementation, or, in the case of Eye in the Sky, setting high expectations, measuring student performance, *and* conducting frequent observations and follow up meetings. The differences between the three groups' priorities suggest that science reform requires administrators without science backgrounds to prioritize pedagogical matters that are not familiar to them.

Under the current science reform efforts, students are encouraged to explore scientific phenomena in collaborative learning environments. Students are provided opportunities to collect and analyze evidence, construct models, draw conclusions, and defend their arguments supported by evidence (Sampson et al., 2013). However, students will only have these opportunities if teachers allow and encourage these practices in their classrooms. Teachers will be less likely to do so if their administrators are not focused on them during observations or do not encourage them during feedback.

Overall, the findings support prior research on sensemaking, confirming that it is an individual and somewhat idiosyncratic process that draws on the prior experiences of the professional (Ancona et al., 2011). In addition, the findings support the literature on instructional leadership in that many of the literature-derived statements included in the concourse of items were endorsed by the administrators in ways that reflected patterns. Q-methodology provided a way to analyze how administrator's subjective viewpoints of science instruction and support for secondary science teachers differ from one another. However, it would be misleading to state that the Q methodology process revealed commonalities among the statements administrators endorsed as being important for instructional leadership, since these styles could not be mapped precisely onto years of teaching or administrative experience, or disciplinary background. This opens up questions for future research about why administrators might subscribe to particular strategies for instructional leadership, and the degree to which individuals' school contexts, the experience levels or support needs of the teachers they work with, and their construction of other aspects of their role as an administrator might influence their approach.

The variability that was observed in administrators' priorities for instructional leadership and feedback to a single lesson excerpt serves as a reminder for district and state level science leaders as new areas of emphasis in the curriculum are communicated. It is common for updated curriculum standards and instructional practices to be introduced to teachers but generally, principals, assistant principals, and other administrators are less likely to participate in discipline-specific professional development. Instead, such individuals are likely to be exposed to professional learning opportunities that focus on general facets of instructional leadership such as attending to classroom culture, classroom management, and administrators' management of teacher observations (Rigby et al., 2019). This could inadvertently reinforce the focus on general pedagogy that was found in the present study, and potentially conflict with new strategies being implemented by the teacher. Some science education researchers have endorsed the use of classroom observation rubrics, such as the Reformed Teaching Observation Protocol (RTOP; Piburn, et al., 2000) as a means to help administrators attend to discipline-specific practices. While this approach may increase consistency, our findings suggest that administrators also naturally draw on other sources of professional knowledge to appraise the quality of instruction. Further research is needed to find ways to integrate these sources of knowledge into classroom observation to leverage the expertise of the administrator and empower the science teacher who is implementing discipline-specific strategies.

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7 | CONCLUSION

This study sought to examine administrators' perceptions of effective instructional practices, with a particular focus on science instruction. In addition to developing a concourse of statements that can be used in future research, we found that administrators could be grouped according to their particular style or areas of focus. Perceptions of effective leadership converged around the establishment and maintenance of positive relationships between teachers and students, an emphasis on setting high expectations for students, and an emphasis on procedural supervision and accountability. Although each of these areas of emphasis is included in prior research on effective instructional leadership, our analyses suggest that individuals tend to endorse one or other perspective rather than embrace or reconcile multiple perspectives. In other words, although all administrators felt strongly about their role as instructional leaders, their strategies for conducting this work differed. Moreover, administrators' feedback on a particular science lesson tended to emphasize general pedagogy and was only partially influenced by the possession of science expertise, suggesting an opportunity for future research on strategies for administrators to demonstrate their expertise in teacher leadership without losing focus on effective instruction that improves student achievement in science.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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ENDNOTES

[1] Since the research was conducted during the COVID-19 pandemic, we investigated administrators' perceptions of teaching strategies that were delivered in an online environment.

[2] This group of individuals was recruited from various districts across the state and not the P sample administrators' district.

[3] One participant was removed due to an anomalous response pattern that produced a negative correlation with their affiliate Factor C group (Damio, 2018).

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