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Exploring Middle School Science Teachers' Curriculum Sensemaking

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ABSTRACT

A teacher's working context is an important factor in how they make sense of and enact curriculum. Understanding how external factors (e.g. state and/or district policies, school cultural norms) interplay with teachers' personal resources (e.g. self-understanding, rules of thumb for decision-making) can help identify supports for implementation of increasingly available standard aligned curriculum materials. However, in science education, limited research has explored how curriculum enactments are influenced by this complex interplay. In this qualitative embedded case study, we investigated how four middle school science teachers within the same school district used their internal resources to make sense of external factors when enacting new NGSS-aligned place-based curriculum materials. Data collection occurred over multiple years and included semi-structured individual and focus group interviews, lesson plans, weekly surveys, observations, and memos. Using thematic analysis, we found that a new district-level policy implementing a 6-week science assessment caused differential enactments of the unit, depending on which internal resources teachers drew on to make sense of the curriculum materials. Our findings contribute to further understanding how internal personal resources and external factors support and impede science teachers' use of curriculum materials in ways that align, or do not align, with recent reform-based learning outlined in the NGSS.

KEYWORDS

Curriculum; energy literacy; middle school science teachers; NGSS; sensemaking

Remillard (2005) defines curriculum materials as "the resources and guides used by teachers" (p. 213) which serve as a cornerstone of teaching by aiding teachers in making daily decisions about what to teach and how to teach it (Ball & Cohen, 1996). Historically, teacher curriculum use focused on fidelity of implementation—implementing curriculum materials without change, deviation, or adaptation—for teacher adherence (O'Donnell, 2008). However, this measure is not beneficial since curriculum materials should mediate teacher activity involving a "continuous process of transformation and creativity" (Wertsch & Ruppert, 1993, p. 230) as they actively interpret and adapt these materials (Brown, 2009).

Teachers' interpretation and uses of curriculum materials are influenced by a complex interplay of their internal tools and resources, including self-understanding, rules of thumb about how teaching and learning occur, and external factors that include educational policy and cultural norms within their educational settings (Kelchtermans, 2009; Troyer, 2019).

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This process of interpretation and adaptation is guided by sensemaking, wherein teachers actively construct meaning and understanding of their curriculum materials. Curriculum sensemaking occurs when a teacher "tries to negotiate tension and resolve ambiguity" (Cherbow & McNeill, 2022, p. 414) between their internal resources for using their curriculum materials and external factors, such as their institutional contexts, in which the enactment occurs.

Despite the importance of this interaction, exploration on how this affects the implementation of curriculum materials is nascent (Burkhauser & Lesaux, 2017), particularly within science education (Davis et al., 2016; Ryder, 2015). While much of the existing literature on curriculum sensemaking and reform implementation is rooted in U.S. policy contexts, international perspectives provide valuable insights into how teachers navigate reform efforts. In many countries, curriculum reform is not solely enacted through written materials but also through broader frameworks that emphasize professional collaboration, teacher autonomy, and locally driven adaptation. For example, the curriculum for Wales 2022 embraces a flexible, teacher-driven approach to curriculum design, moving away from prescriptive content toward broader learning goals (Sinnema et al., 2020). However, as in many countries, such flexibility presents both opportunities and risks—while it empowers teachers as curriculum designers, it also requires strong professional learning structures and policy alignment to ensure effective implementation and coherence across schools (Sinnema et al., 2020). Critical perspectives on reform further highlight the tensions between top-down policy initiatives and teachers' agency in shaping their instructional practices (Ball et al., 2012). Acknowledging these diverse approaches helps situate the present study within a broader global discourse on curriculum reform and teacher sensemaking.

As new curricula and teaching methods are introduced in science education to align with reform-based science standards (National Academies of Sciences, Engineering, and Medicine [NASEM], 2022; Reiser et al., 2017), it is essential to understand how teachers interpret these materials drawing upon their personal resources for curriculum sensemaking, especially when they encounter tensions within their instructional contexts (Troyer, 2019). This is where this study is situated. We explore how four science teachers, within the same district, interpreted and made sense of new NGSS-aligned curriculum materials amid a new district-level policy requiring a science assessment every 6 weeks. We also extend the curriculum sensemaking literature by applying the personal interpretative framework (PIF) (Kelchtermans, 2009) to add a nuanced understanding of how the four teachers' internal resources, such as their self-understanding and personal "rules of thumb" educational theories interacted with this external factor to shape their curriculum sensemaking. Our guiding research question is: How do middle school science teachers draw upon their internal resources for curriculum sensemaking when navigating ambiguity introduced by their educational contexts?

Background literature

Research on how science teachers implement and make sense of reform-based curriculum materials remains an evolving field. While prior studies have highlighted the variability in how science teachers engage with these curriculum materials, ranging from full fidelity to relabeling traditional practices as reform (Buxton et al., 2015;

McNeill et al., 2018), much of this research focuses on individual-level factors, such as teachers' preexisting knowledge, beliefs, and experiences. For example, Buxton et al. (2015) examined teachers' engagement with curriculum materials in the context of a PD program designed to support science language practices for English Language learners. They found that individual teachers selected curriculum elements that "felt the most comfortable and familiar" (p. 497) because those elements aligned with their existing knowledge, even when the PD encouraged them to adopt new science instructional strategies. Far less attention has been paid to how these individual factors interact with the broader educational context, including organizational and systemic influences (Allen & Heredia, 2020; Allen & Penuel, 2015; Cherbow & McNeill, 2022). This limited perspective misses an opportunity to understand the dynamic interplay between internal and external resources that shape science teachers' curriculum sensemaking and implementation processes.

Emerging research demonstrates the importance of examining how organizational contexts mediate curriculum implementation. For example, Lowell et al. (2024) used organizational sensemaking to explore how two middle schools approached the implementation of reform-based science curriculum materials. They noted that teachers' experiences and implementation varied depending on their school contexts. One school focused on implementing the materials with fidelity but viewed the curriculum as ineffective for supporting multilingual students and students with disabilities, so deprioritized it, favoring traditional, teaching-centered practices. In contrast, teachers in a different school customized the materials to better align with their instructional model and students' needs, ultimately achieving practices more closely aligned with reform-based instruction. The difference in sensemaking across these schools was due to individual and contextual factors such as teacher agency, collaboration with colleagues, and access to discipline-specific leadership (e.g., a science instructional coach). Similarly, McNeill et al. (2018) found that procedural fidelity alone does not ensure meaningful engagement with reform-based science practices. These studies underscore the nuanced ways teachers' internal resources interact with external contexts to either align with or contradict reform goals.

Supporting teachers' curriculum sensemaking tends to focus on teachers' responses to PD programs (e.g., Buxton et al., 2015) or broad reform initiatives (e.g., McNeill et al., 2018; Lowell et al., 2024). While these studies often frame organizational and systemic factors as barriers, they rarely account for teachers as active, strategic agents navigating these systems (Allen & Heredia, 2020). However, science education research has had little exploration of how teachers respond to a specific reform-based curriculum unit within the context of a district-wide mandated assessment. This gap is especially notable considering that previous studies have identified assessments as a key contextual barrier to curriculum reform and implementation (Brown & Livstrom, 2020; Heredia, 2020; West, 2020).

The tensions between new curriculum materials and district- and/or state-level assessments, especially when those assessments may or may not align with the curriculum, introduce new layers of complexity into the sensemaking process. Science teachers are not merely reacting to PD or curriculum mandates but are also responding to policies beyond their control. State and/or district assessments, with implications for teacher accountability, serve as both a constraint and a cue, prompting teachers to interpret and adapt the curriculum materials in ways that balance reform goals with practical constraints while aligning with their professional identities (Troyer, 2019).

Conceptual frameworks

Personal interpretative framework

To understand the internal resources drawn upon for viewing materials and curriculum sensemaking, we situated this work within Kelchtermans (2009, 2013) personal interpretative framework (PIF). This framework is at the individual level in which teachers ask, and answer, "what is going on here?" and "what do I do next?" (Weick et al., 2005). The PIF has two domains that teachers draw upon to answer these questions and take action. These are the domain of self-understanding and the domain of subjective educational theory. Together, these interconnected domains serve as "a set of cognitions, of mental representations that operates as a lens through which teachers look at their job, give meaning to it and act in it" (Kelchtermans, 2009, p. 260). These mental representations serve as internal resources that mediate how a teacher views, interprets, and enacts their curriculum materials (Ball & Cohen, 1996; März & Kelchtermans, 2013; Weick, 1995).

Self-understanding domain

The self-understanding domain is an individual's conception of themselves as a teacher built on their own perception of their teaching self and feedback from others as to how they are viewed as a teacher; it entails their reasons for remaining in the profession, expectations for the future, and emotive response to their work (Darby, 2008). There are five elements entwined that define an individual's self-understanding. These are self-image (their own self-perception, but more so how others mirror back their perceptions of the individual *as* a teacher), self-esteem (appreciation of their own job performance), job motivation (why they remain a teacher), task perception (what they need to do their job well), and future perspective (what they will do in the future as a teacher) (Kelchtermans, 2009). The domain of self-understanding is a teachers' "self" at a moment in time (a product), but it is also a process of making sense of one's experiences to further define the self (Kelchtermans, 2017). Kelchtermans referred to this domain as the "what" of teaching as it is where a teacher holds knowledge and beliefs about what good teaching is (Kelchtermans, 2009). Evidence of this domain can be seen in Darby's (2008) study of teachers' professional self-understanding. They note that feedback from university faculty and instructional coaches that recognized progress of student and teacher growth, reinforced teachers' self-understanding when enacting reform-based initiatives.

Subjective educational theory domain

The other domain, subjective educational theory, is idiosyncratic as it contains teachers' personal theories about teaching and learning that are built from different career experiences within educational contexts (Kelchtermans, 2017). Kelchtermans identified that it is within this domain that the "how" of teaching is located for individuals (Kelchtermans, 2009). It is a judgment laden with "rules of thumb" that individuals build across time within educational contexts. It is a highly personal system in which teachers interpret the situation and put into practice "what works for me" based on prior knowledge, beliefs, and experiences. This domain is situated within individuals' past and present experiences and their expectations for how teaching occurs. When this domain is fore fronted, curriculum changes are idiosyncratic in which a teacher draws upon their personal experience of how to teach content through their experience of what works. It is within this domain in which

a teacher may choose what to implement, and what not to implement, within their new curriculum materials (Troyer, 2019).

Curriculum sensemaking

Curriculum sensemaking emphasizes the interconnected relationship between internal resources and perceived external contextual factors that science teachers make sense of particularly when enacting new NGSS-aligned curricula (Allen & Heredia, 2020; Allen & Penuel, 2015; Cherbow & McNeill, 2022). Curriculum sensemaking is activated through contextual cues occurring within the classroom, school, and/or district which creates uncertainty (i.e., lack of supportive resources) and ambiguity (i.e., conflicting goals). Uncertainty or ambiguity can arise when a teacher perceives conflict, contradictions, or paradoxes such as limited resources for an issue, event, and/or situation; a lack of clarity for their role and responsibilities; and/or the presence or absence of new measures for judging success. These contextual cues may be actual, imagined, or implied making it so different individuals perceive and interpret contextual cues differently and respond in different ways (Maitlis & Christianson, 2014). To make sense of ambiguity or uncertainty, a teacher searches through their mental representations for patterns that match the current contextual cue to determine how to move forward with their curriculum materials. Therefore, how a teacher frames the contextual cues will create scenarios in which they will put a particular perspective in action and reject other perspectives (März & Kelchtermans, 2013).

The school setting can create moments of ambiguity around curriculum implementation through a variety of mechanisms such as assessments, close monitoring of classrooms by administrators, and lack of colleagues for collaboration (Allen & Penuel, 2015; Brown & Livstrom, 2020; Marco-Bujosa et al., 2017). Specifically, how a teacher perceives their accountability to district and state assessments may serve as a critical mediator for curriculum sensemaking (West, 2020). This is very prominent in the middle school grades, in which state and district assessments create cultures that focus on increasing test scores (West, 2020). These mechanisms create ambiguity and uncertainty about instructional materials that result in curriculum sensemaking in which a teacher draws upon their internal resources to determine how to enact the curriculum to resolve the ambiguity or uncertainty.

Teachers continuously shift between their internal resources and external context when engaging in curriculum sensemaking. This dynamic process involves teachers using their personal beliefs, prior experiences, and professional knowledge to interpret and respond to external demands and constraints (Spillane & Anderson, 2014). For instance, when faced with a new NGSS-aligned curriculum, a science teacher might draw on their understanding of pedagogical strategies to make the material accessible to students while simultaneously considering the expectations of the educational context. In Allen and Penuel's (2015) study, despite science teachers' shared beliefs in the value of science practices and actively engaging students in doing science, their school-specific context afforded or constrained their sensemaking. This back-and-forth negotiation allows teachers to adapt their teaching practices to fit the unique needs of their educational context. This iterative cycle of reflection and adaptation highlights the complex nature of curriculum sensemaking, as teachers work to balance personal and institutional expectations to achieve educational goals (Weick et al., 2005).

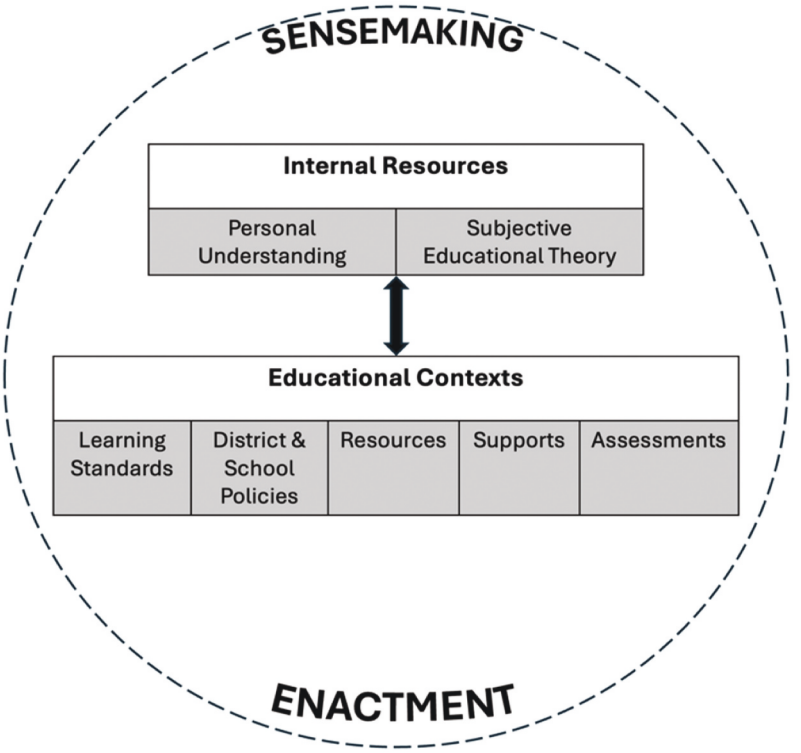

Figure 1. Conceptual framework of teacher sensemaking with internal resources and external factors.

We draw upon the literature about a teachers' personal interpretative framework and curriculum sensemaking to create our conceptual framework, as shown in Figure 1. Curriculum sensemaking occurs through the PIF, where a teacher views and interprets their materials. As a teacher perceives cues from the educational context that creates uncertainty or ambiguity regarding curriculum implementation, they search through their PIF to find mental representations that they can use to answer, "What is going on here?" and "And what do I do next?" It is within answering these questions their design choices for their curriculum come about which we define as their curriculum sensemaking.

Methods

Study design

This was a single case study analysis within a school district called District M [pseudonym] (Yin, 2009). This is a longitudinal embedded case study that occurred from Spring 2020 – Summer 2022. We explored how four 6th-grade teachers from District M viewed curriculum materials and implemented the EYE unit during pilot implementation.

Table 1. EYE lesson sequence.

Module No.	Module Title	Description
1	Introduction to Engineering Design	Introduces the building as an energy system. System components focus energy source origination within natural systems (renewable versus nonrenewable) that supply energy to the school building for human energy consumption (e.g., light switch behaviors) to energy outputs from the building (e.g., carbon emissions).
2	Lighting Our Classroom	Building components are highlighted within the building system to teach the kinetic model of energy (such as light energy or thermal energy). As students learn about sequences of energy transfer and transformations between components, students begin to form ideas for how the individual components link together and trace energy flow through the building elements. They iterate their engineering designs to add lighting, windows, and other devices necessary for classroom function.
3	Staying Warm and Cool in the Classroom	
4	Designing and Constructing Your Classroom	Students use their energy knowledge to engineer an energy efficient one-room building and examine how their choices impact natural systems.

Curriculum

The curriculum that was the focus of this study was funded through a National Science Foundation (NSF) early exploratory project titled Energy and Your Environment (EYE) to design and implement an engineering design focused energy literacy unit awarded in the Spring of 2020. The EYE unit fore fronted place-based education by using the school building to teach energy transfer between buildings and Earth systems, and for students to use their building to design a one-room building that required less energy consumption. This provided students opportunities to engage in real-world problem solving within their local setting (Powers, 2004). The curriculum was expanded from the American Association for the Advancement of Science (AAAS) Project 2061 outline "An Outline for A Green Schools Energy Curriculum" (2015) using established curriculum heuristics (i.e., Krajcik et al., 2008).

While the unit fore fronts the NGSS middle school engineering standards, it is also aligned in the NGSS cross-cutting concepts of energy and matter, and systems and systems models. A learning goal of the unit is to support students in tracing energy transfer from nonrenewable and renewable resources to light and thermal energy transformation within their school building. The first lesson focused on energy flow tracing within a system (following the flow of energy from resources into the classroom), while the kinetic model of energy was introduced across lessons 2 and 3 as students learned about energy transformation. In lesson 4, students used their knowledge of energy transfer and transformation within their one-room building design, such as considering where to place windows to optimize light and heat. A description of the EYE lessons is provided in Table 1. All materials teachers needed to teach the unit were supplied with the unit. A detailed discussion of the unit NGSS-alignment, learning goals, and teacher guides is available in Zangori et al. (2023). The unit was designed to take 6 weeks.

Instructional context

District M Public Schools is in a small Southern Midwestern U.S. city (city population ~ 100,000). The K-12 student population within District M during the time of this study year was approximately 18,000 (Columbia Public Schools, n.d.). Within the

Table 2. Teacher and school demographics.

Teacher	Years Exp	School	School Total Population	Free/ Reduced Lunch
Malia (she/her)	29	South MS	601	29%
Hannah (she/her)	9			
Donna (she/her)	15	North MS	611	59%
Sharon (she/her)	18	Central MS	511	35%

district, middle school is defined as grades six through eighth. The district has seven middle schools, each with at least two 6th grade teachers. During this study, the COVID-19 pandemic was ongoing. Teachers taught through Zoom in the Fall of 2020 and returned to face-to-face in Spring 2021. Students returned to their classrooms with COVID-19 procedures, such as masking and quarantining for 10 days with a positive COVID-19 test during the year of this study. District M is in a state that did not adopt the Next-Generation Science Standards (NGSS, 2013), so the science content scope and sequence for K-12 was defined by the district.

We used purposeful sampling to choose study participants. The district science coordinator recommended five 6th-grade science teachers for this study. All five teachers agreed to participate. All teachers provided feedback on the EYE unit lessons as they were being developed during the 2020–2021 school year prior. In the summer of 2021, the teachers attended a face-to-face weeklong workshop in which they tested, discussed, and collaboratively revised the unit. On the last day of the workshop, one 6th-grade teacher was notified that she would be teaching 7th-grade science in the upcoming school year, so she was not included in this study. The four remaining teachers represent three of District M middle schools, as shown in Table 2. Malia and Hannah were 6th-grade science teachers at South MS while Donna and Sharon were each one of the two 6th-grade teachers at their respective schools. Four of the teachers identified as White (Hannah, Donna, Sharon) and one teacher (Malia) identified as Indian. Across the study years (2020–2022), energy was the first topic taught within the sixth-grade district scope and sequence. During the pilot implementation, the teachers chose to implement EYE as the first science unit of the school year.

Data collection & analysis

This is a longitudinal study that took place from Spring 2020 – Summer 2022. Data collection and data analysis occurred iteratively. Data collection included all interactions with the teachers beginning with the Spring 2020 discussion about the project and continued into the fall of 2020 as they were teaching their "business-as-usual" energy materials during the COVID-19 pandemic through virtual class meetings. Data collection continued into the Summer of 2021 during the EYE unit in person workshop, across the 2021–2022 EYE implementation in person school year, and ending with the summer 2022 workshop focusing on EYE unit revisions. Data collection included virtual and in-person meetings with teacher participants, focus group interviews, individual interviews, lesson planning, weekly Qualtrics surveys during implementation of the EYE unit, classroom observations,

and artifacts that included qualitative memos written by the research team, e-mails, and hand-written lesson plans written and submitted by teachers.

During the first year of data collection (2020–2021), teacher interviews focused on their ideas about the role and use of curriculum materials in their teaching. All teachers implemented the EYE unit beginning at the start of Fall 2021 school year. During the first week of implementation, the new superintendent issued a policy to collect student data every 6 weeks using an assessment issued from the district for each subject area. For sixth-grade science, the first assessment area was announced as potential and kinetic energy. This test, called the 6-week assessment and its focus on potential and kinetic energy, became the external context that created tensions, in some way, for each teacher which led to curriculum sensemaking. Since the EYE unit was designed to be completed in 6 weeks, the first assessment would occur at the end of the unit.

Interviews

Teachers were interviewed multiple times within the study year using open-ended interview protocols. Interviews were intensive in nature (Charmaz, 2006) to elucidate each teacher's interpretation of the role and use of curriculum materials in their classrooms, how the EYE curriculum materials supported their teaching, and how their perceptions of their teaching context impacted their interpretation.

First, teachers were interviewed in focus groups at the start of the study in Spring 2020, again in the Summer 2021 prior to EYE unit implementation, and the workshop in the Summer 2022, and after the workshop. Each focus group interview lasted for approximately 60–90 minutes. This open-ended interview protocol used during the focus groups included questions that focused on the role and use of curriculum materials in their classrooms, their perceptions of their curriculum choice for teaching, their perceptions of what curriculum materials should include (such as teacher guides, prepared power point slides, differentiation strategies, optional activities, etc.), and how they used curriculum materials in their day-to-day teaching. In the second focus interview, in addition to the initial questions, we also asked the perceived affordances and constraints at the national and district level for curriculum choice and implementation, and how national-, state-, and district-level policies and procedures impacted their choice and implementation of curriculum materials.

Second, individual interviews took place in the Fall of 2020 about their "business-as-usual" energy unit taught virtually and Fall 2021 as each teacher finished implementing the EYE unit during face-to-face instruction. These individual interviews lasted for approximately 45–60 minutes. The open-ended interview protocol focused on how each teacher interpreted, perceived, and understood the goals of curriculum materials in general and of the EYE unit specifically; if they felt ownership of curriculum materials in general and of the EYE unit specifically; how curriculum materials in general and the EYE unit specifically fit within their classroom contexts; and how their planning and implementation structures at their school buildings, such as co-planning, available resources, curriculum professional development opportunities offered at the school building and/or district levels, and other affordances or constraints they perceived regarding curriculum choice and implementation.

Teacher weekly survey

During the implementation of the EYE unit, teachers completed a survey every Friday through an online survey program called Qualtrics. The survey asked the teachers what EYE

lessons they had taught that week and if, during planning, they determined they needed to offload, adapt, and/or omit any aspects of the lessons and why they made those decisions.

Observations

An observation protocol was designed and implemented by the project team. Since the unit was place-based, the protocol included the location of the lesson, impression of student engagement within the lessons (such as student and/or teacher confusion or excitement), the lesson focus, how the lesson was implemented (such as written, adapted, omitted, etc.), and what materials were used for the lessons (such as a taught through Smartboard, EYE student investigation materials, etc.). The project team members wrote notes of what was occurring within the lesson and after, wrote a memo of their observations and impressions of the lesson analyzed within the data corpus.

Other artifacts and communication

Throughout implementation, the teachers were encouraged to contact the project team through text, e-mail, and/or phone or video call. In addition, the project team sent a weekly e-mail to check in with the teachers. All phone/video calls were recorded, and all written correspondence was saved within the data corpus. Other artifacts also included analytical memos (Charmaz, 2006) that were written after each teacher interaction (observation, interview, and other contact). The memos were free-flowing and served to capture the thoughts, impressions, and ideas of project team members that occurred during the teacher interaction.

Data analysis

We used thematic analysis to interpret teachers' views of curriculum materials and their use of the EYE curriculum materials within their teaching contexts (Braun & Clark, 2022). Data analysis occurred in multiple rounds and included elucidating theoretically and empirically what was occurring within the data corpus. The project team met weekly to review collected data, memos, and codes that were emerging from the data.

In the initial phase of analysis, we used the conceptual framework as our a priori coding framework: Self-Understanding in relation to Curriculum Materials, Subjective Educational Theory in relation to Curriculum Materials, Contextual Influence, and Implementation Outcome (defined in Table S1). These codes enabled us to characterize teachers' internal resources (self-image, self-esteem, job motivation, task perception, future perspectives), perceptions of external factors (administrative policies, district expectations), and their curriculum sensemaking processes. From these initial codes, the project team wrote detailed and extended analytical memos for each teacher that attempted to capture their views of curriculum materials, the ambiguity and uncertainty each teacher experienced while planning and/or enacting the EYE unit, and how they resolved that ambiguity and uncertainty through sensemaking. We also wrote memos for each teacher according to each dimension of the self-understanding domain in the PIF See Table 3 for an excerpt for this analysis for Sharon. Once these detailed memos were complete, we worked across the memos for patterns within the data. This process highlighted differences in how teachers navigated the same external factors, such as the 6-week assessment, and how their internal resources, specifically their self-image and task perceptions, shaped their curriculum sensemaking

Table 3. Self-understanding coding and memo examples from Sharon.

Self-Image	"Um it's always rewarding to me when the kids finally understand what you're saying when they finally . . . you've been working hard trying to get them to get it, and then it clicks, finally, that is truly the best moment." "I'm a huge toy person! They can connect [difficult concepts] with that!"
Self-Esteem	"[T]he most frustrating moment is when we have gone through the plans and they just. Weren't. Getting it. Um, potential and kinetic energy. They weren't getting it! We went through things and the kids just weren't getting it . . . .So I had to make it [the unit] me. And so I admit . . . that I added it to where it fit more of a personality thing, as well as okay guys, this is what we've been talking about now let's start with something that you probably can connect to. So I connect it [energy] with things like that [toys], and then they can kind of take it then they finally started putting connections together.
Job Motivation/Task Perception	"We ended up playing with toys [to teach kinetic and potential energy] . . . My classroom has the most toys. And so, we got hot wheels. Almost every kid in my class knows what a hot wheel is!" "They really can connect with that when they know the toy. Barbie yes, I can put Barbie in about anything these days! "
Future Perspective Imaginings	I don't think I'll be able to [teach the unit again] in all honesty, because light is primarily a seventh-grade thing. And so that's something that they [7th-grade teachers] get to cover. And so, I kind of feel like I was stealing some of their thunder.
Memo	Task perception appears to take over all aspects of Sharon's self-understanding. It is through her perception of student learning with toys that she defines what she needs to do in order to do her job well. Her perceptions of her self-imagine were within her ability to teach difficult concepts in interesting and engaging ways using everyday objects. She found the unit frustrating because she could not perceive, in the moment of a task, if students understood kinetic and potential energy, since these concepts were spread throughout the unit and taught using the school building. She perceived that toys were critical for student understanding of kinetic and potential energy because they were concrete and connected to lived experiences. Sharon's job motivation was also within how she uses toys. She discussed with enthusiasm that when her students used toys, they were able to make connections to energy, which she perceived they were unable to do within the EYE lesson. She also discussed that she has invented new ways to teach difficult concepts using toys. She finds that using toys provides endless possibilities within her teaching for different content. Sharon does not imagine teaching the unit again because she perceived the unit encroached on content that was designed for 7th-grade (light energy) so she had no plans to implement it again in 6th-grade.

responses. These emergent themes were further refined into sub-categories based on the interplay between internal resources and external factors.

For example, teachers like Sharon and Hannah, who had strong self-images built from prior teaching experience, demonstrated modest flexibility in adapting the curriculum, as evident in their internalized approaches to teaching and modifications based on prior teaching experience. Malia, with extensive experience and perceived strong administrative support, was able to maintain curriculum integrity while adapting to external constraints. In contrast, Donna, whose self-image was more influenced by external validation, experienced more tension when district mandates conflicted with her teaching approaches. These patterns informed the identification of two key themes that were integral to our analysis: Curriculum Viewed Through Subjective Educational Theory and Curriculum Viewed Through Self-Understanding. Teachers' curriculum sensemaking was examined within these themes, revealing the nuanced ways in which internal resources and external factors shape instructional decisions.

Findings

While the COVID-19 pandemic served as a backdrop to this study, teachers did not identify it as an external factor requiring curriculum sensemaking. Instead, tensions emerged in the second year of data collection, particularly due to administrative

changes and new district assessment policies. A key disruption occurred with the appointment of a new district superintendent in Summer 2021, who mandated a 6-week assessment cycle, significantly impacting teachers' curriculum decision-making. Since the EYE unit was designed to take 6 weeks to implement, the assessment would occur at the end of the unit. Aligning with our framework, we structured our findings around teachers' internal resources (self-image, self-esteem, job motivation), perceptions of external factors (administrative policies, district expectations), and curriculum sensemaking processes. This structuring highlights how teachers' prior experiences, beliefs, and feedback from students and administrators influenced their curriculum adaptation. Additionally, we categorized teachers' curriculum sensemaking responses, refining the themes of subjective education theory and self-understanding.

Curriculum viewed through subjective education theory: Sharon and Hannah

Internal resources and curriculum perceptions

Sharon and Hannah viewed curriculum materials as flexible guides that required modification to align with their self-understanding as teachers. Their curriculum adaptations were informed by their internalized beliefs about effective teaching, which they evaluated through student engagement and comprehension. Sharon emphasized that she adjusted lessons to "fit my personality," reinforcing the idea that her effectiveness as a teacher was tied to her ability to personalize instruction. Hannah similarly described modifying the curriculum to foster student exploration and engagement, such as supplementing her light energy lessons with additional materials to make concepts more tangible.

Both teachers relied on prior experiences and student feedback to validate their instructional decisions. They consistently referred to their "tried and true" strategies—pedagogical approaches they had refined through experience. Sharon, for instance, emphasized the importance of using toys in her instruction, believing they facilitated concrete associations with scientific concepts. She stated, "I was a huge toy person," and viewed toys as integral to her "teaching personality." She further explained, "almost every kid in my class knows what a hot wheel is," which allowed students to make meaningful connections between kinetic and potential energy. Hannah also reinforced this perspective, stating, "So I gathered extra materials for the path of light . . . just a small little change . . . so the kids would really get into it." She emphasized that modifications allowed students to "explore . . . and make mistakes" as part of their learning process.

Curriculum sensemaking and response to external factors

Tensions arose when district mandates conflicted with teachers established instructional approaches. Sharon's primary concern was not the 6-week assessment itself but rather the way kinetic and potential energies were framed in the EYE unit and this alignment with her own knowledge of how to teach energy. She struggled with how to integrate the unit into her established teaching practice, ultimately modifying lessons by incorporating her "go to" which were toys, to reinforce energy concepts. She recalled, "Okay, in all honesty, the most frustrating moment is when we have gone through the lesson one plan and they [students] just weren't getting it." She further questioned, "What else do I need to do? How do I add things into making it [the unit] me?"

Hannah, however, directly addressed the district assessment as a challenge, recognizing the need to explicitly prepare students for it. To resolve this tension, she inserted an additional lesson on kinetic and potential energy using a PBS simulation and a roller coaster activity. She stated, "From my experience, roller coasters were the best way for students to learn potential and kinetic energy." She placed this activity between EYE lesson one and lesson two, instructing students to "take a picture of where energy transferred and where it was the highest, where it was the lowest with kinetic, where it was the highest, where it was lowest with potential." Unlike Sharon, who replaced significant portions of the EYE unit, Hannah maintained the unit's core structure but supplemented it with activities that aligned with both district requirements and her instructional style.

Curriculum viewed through self-understanding: Malia and Donna

Internal resources and curriculum perceptions

Malia and Donna's curriculum adaptations were shaped by their self-image as teachers, which was largely informed by feedback from students, parents, and administrators. Malia, the most experienced teacher in the study, frequently adjusted lessons throughout the day based on student reactions, demonstrating a dynamic approach to instruction. She stated, "The great thing about teaching the same thing four times a day is by your last class you've kind of like used your other classes as Guinea pigs and you're thinking 'Oh, this is going so well!'" Her perception of strong administrative support reinforced her belief that she had the autonomy to make instructional modifications as needed.

Donna, in contrast, sought validation from parents and district leaders. She valued curriculums that facilitated connections between students and their families, interpreting parental engagement as an indicator of instructional success. She explained, "This [the unit] is something they could talk about at home with mom and dad . . . it's something they [the parents] would know about." Unlike Malia, Donna expressed uncertainty about administrative expectations and lacked confidence in district support, which influenced her hesitancy to fully adopt new instructional materials.

Curriculum sensemaking and response to external factors

Malia maintained fidelity to the EYE unit despite tensions arising from the district's 6-week assessment mandate. While she recognized the need to reinforce kinetic and potential energies for assessment purposes, she carefully selected an additional lesson that aligned with both district requirements and her teaching philosophy. Her strong sense of job motivation and administrative support enabled her to sustain the unit's integrity while adapting instruction to meet assessment expectations.

Donna, however, experienced significant tension regarding the assessment's purpose and implications. She expressed frustration, stating, "I mean I don't know (why we have the assessment). We weren't even told how they're [assessment scores] going to be used!" Uncertainty about how assessment results would be used contributed to her reluctance to fully implement the EYE unit. She ultimately chose to teach only the first two lessons, removing engineering and place-based components to focus on energy concepts most relevant to the assessment.

Summary

The findings illustrated how science teachers' internal resources, perceptions of external factors, and curriculum sensemaking processes intersected to shape instructional decisions. Teachers with strong self-images and perceived administrative support (e.g., Malia and Hannah) demonstrated greater flexibility in adapting curriculum while maintaining core instructional goals. In contrast, teachers who sought external validation (e.g., Donna) or whose self-image was deeply tied to specific pedagogical approaches (e.g., Sharon) exhibited more tension in their curriculum adaptations. These findings reinforce the importance of recognizing teachers as active agents in curriculum sensemaking, navigating both internalized beliefs and external constraints. By explicitly delineating the role of internal resources and external factors in shaping curriculum decisions, this study contributes to a nuanced understanding of how teachers adapt instructional materials in response to dynamic educational contexts.

Discussion

Curriculum sensemaking as a negotiation between internal and external factors

This study highlights how middle school science teachers navigate curriculum sensemaking within the constraints of district-mandated assessments, demonstrating that teachers' personal interpretative frameworks (PIFs) (Kelchtermans, 2009) play a critical role in shaping how they engage with reform-based curricula. While previous research has emphasized the role of teachers' knowledge, beliefs, and experiences in curriculum adaptation (Buxton et al., 2015; McNeill et al., 2018), less attention has been paid to how these internal resources interact with institutional constraints and accountability structures. Building on the work that situates curriculum implementation within organizational sensemaking (Allen & Penuel, 2015; Cherbow & McNeill, 2022), our study demonstrates that external pressures, such as mandated 6-week assessments, do not lead to uniform responses among teachers. Instead, these pressures interact with teachers' internalized professional identities and pedagogical beliefs, producing diverse instructional decisions. This variation suggests that district policies, while influential, do not dictate curriculum enactment in a linear way; rather, teachers actively reinterpret and negotiate reform-based materials within accountability structures that sometimes reinforce traditional instructional approaches instead of promoting innovation.

Variability in curriculum sensemaking within the same policy context

Prior research has documented variability in curriculum sensemaking across schools, often linked to administrative support and professional collaboration (Lowell et al., 2024). However, our study demonstrates that important variations also exist within the same district, suggesting that individual teachers' internal frameworks, how they see themselves as educators and what they believe constitutes effective teaching, mediate their responses to external pressures. Unlike studies that frame policy implementation as a top-down process in which teachers either comply or resist (West, 2020), our findings reveal a more nuanced picture. Teachers do not simply react to external mandates; instead, they actively negotiate their curriculum decisions through the lens of their own professional beliefs and sense of

self. For some, this negotiation resulted in sustained engagement with reform-based instruction, while for others, it led to strategic modifications or even retreat into traditional teaching approaches.

The role of PIF domains in shaping curriculum decisions

A central finding of this study is that teachers' dominant PIF domains, either subjective educational theory or self-understanding, significantly influenced how they responded to the curriculum and the district's assessment policy. For teachers who prioritized subjective educational theory, their personal theories and beliefs about teaching, developed through years of experience, guided their decision-making. Sharon and Hannah, for example, leaned on longstanding instructional routines when integrating the EYE unit. Sharon approached the curriculum through her established pedagogical strategies, incorporating toys and other familiar materials to reinforce energy concepts rather than engaging with the unit as written. Similarly, Hannah supplemented the unit with a roller coaster simulation, an activity she had previously found effective for teaching potential and kinetic energies. Even though Hannah was more open to the reform-based instructional approach, she still modified her enactment based on prior teaching experiences, ensuring that students were adequately prepared for the district's assessment.

For other teachers, self-understanding, or their perceptions of their own teaching effectiveness and external validation from administrators and colleagues, was the dominant influence. Malia, for example, had a strong sense of professional autonomy and administrative support, which allowed her to maintain fidelity to the curriculum despite the external pressure of the district's assessment schedule. She continuously adjusted lessons based on student feedback, rather than reacting to the assessment as a rigid external constraint. In contrast, Donna experienced persistent uncertainty about administrative expectations, which shaped her hesitant and restrictive approach to curriculum adaptation. Unlike Malia, who felt empowered to experiment and adjust, Donna was concerned about how her teaching would be evaluated, leading her to omit key elements of the unit and focus exclusively on assessment-driven instruction. This contrast underscores the role of perceived administrative support and professional confidence in determining whether teachers engage fully with reform-based curricula or retreat to more familiar, test-focused instructional practices.

Implications

These findings reinforce existing literature on curriculum sensemaking under accountability pressures while offering new insights into why some teachers conform to these pressures while others resist. Research has shown that high-stakes testing and assessment-driven policies often push teachers to modify instruction in ways that emphasize test performance over inquiry-based learning (Sezen-Barrie et al., 2020; West, 2020). Our findings build on this work by demonstrating that the degree to which teachers conform to or resist these pressures is largely determined by their PIF domain. Teachers who viewed curriculum through self-understanding (e.g., Malia) were more likely to sustain reform-based instruction, while those who relied on subjective educational theory (e.g., Sharon and Hannah) selectively modified or

supplemented the curriculum to align with their preexisting instructional approaches. This suggests that sensemaking is not simply a reaction to external mandates but an active negotiation process that is deeply embedded in teachers' professional identities. These findings have several important implications for teacher PD and district policy.

Recognizing the diversity of curriculum sensemaking

PD programs should acknowledge that teachers filter reform through their PIFs and provide structured opportunities for teachers to reflect on their instructional identities and pedagogical beliefs. Encouraging teachers to critically examine their instructional habits and assumptions may help bridge the gap between longstanding instructional practices and reform-based curricula (Narayanan et al., 2024).

Aligning assessments with instructional goals

Prior research suggests that curriculum sensemaking triggered by ambiguous assessments is one of the most important factors in mediating their curriculum enactments (Allen & Penuel, 2015; Brown & Livstrom, 2020; Troyer, 2019; West, 2020). High-stakes testing has impacted all elements of curriculum enactments, including what and how to teach, as well as the time allotted for standardized test preparation (West, 2020). These shifts cause ambiguity and uncertainty for science teachers when implementing new reform-based curricula, often resulting in modifications to their teaching practices and learning goals that are incongruent with reform-based science practices (Sezen-Barrie et al., 2020; Troyer, 2019). For instance, Sezen-Barrie et al. (2020) found that under pressures of standardized testing, science teachers may adopt a more "authoritative position" (p. 1084) in which they focus on providing data and explanations rather than encouraging exploration and inquiry, as outlined in the NGSS. Similarly, Donna removed all engineering and place-based components from the unit and focused on reinforcing kinetic and potential energy content through repetition due to ambiguity from the district assessment. Our work further highlights the complex relationship between internal resources, and their local educational context as evidenced by other teachers in the study modifying the curriculum to meet their specific needs and exhibiting a high amount of autonomy in enacting the curriculum. While a new NGSS curriculum is being released, it is important that PD supports coherent alignment of tests with NGSS science instructional practices but also allows flexibility in implementation to meet different needs to support successful shifts in classroom science teaching practices (Marshall et al., 2021). This is particularly crucial in states that did not adopt the NGSS, as districts (such as the one in this study) may need further support in identifying alignment between science curriculum and assessments.

Districts should ensure that assessments reinforce rather than contradict reform-based curricula. In this study, the 6-week assessment was perceived as a constraint rather than a support, leading some teachers to narrow their instructional focus. Prior research suggests that when assessments are misaligned with reform-based instruction, teachers may shift toward rote instruction rather than inquiry-based learning (Brown & Livstrom, 2020). Reducing this misalignment could mitigate tensions between curriculum reform and assessment-driven accountability.

Strengthening administrative support for teacher agency

Teachers like Donna, who sought external validation, were more likely to experience uncertainty and restrict their curriculum adaptations, whereas teachers like Malia, who felt supported and autonomous, were able to sustain reform-aligned instruction despite external pressures. This suggests that administrators should provide consistent, formative feedback that reinforces teachers' professional agency, rather than emphasizing rigid compliance with assessment policies. Research has shown that teachers are more likely to experiment with and sustain reform-aligned practices when they feel supported rather than monitored (Marshall et al., 2021).

Ultimately, this study underscores the importance of recognizing the complex interplay between teachers' internal frameworks and external assessment pressures. By integrating PIF with curriculum sensemaking research, we provide a more nuanced understanding of how internal and external factors intersect in shaping science instruction. Recognizing these dynamics is essential for developing more effective policies, professional learning initiatives, and assessment practices that support meaningful science curriculum reform. Future research should explore how longitudinal changes in science teachers' PIFs influence their curriculum sensemaking over time, as well as how districts and schools can create more supportive environments for reform-based instruction.

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