



“Driving the Ship” or Laying Buoys: Teachers’ Use of Metaphor for Meaning-Making with Storylines

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Abstract: Science curricula require new conceptualizations of how teachers relate to their materials. In this study of teacher learning, we analyze an experienced group of practicing Storylines teachers’ use of metaphor to describe the roles and responsibilities of students and teachers in curriculum enactment. We found that every metaphor that teachers used to describe the uses of Storylines curriculum entailed a sort of *wayfinding*: a destination, a timeframe, a place, a journey, or the students’ or teachers’ respective position in that pursuit. These findings continue to indicate the usefulness of metaphor in foregrounding the central role that students play in NGSS-aligned instruction/materials, as well as the institutional forces that shape how curriculum materials get enacted inside the classroom. This study builds and contributes to current scholarship that aims to support teachers in reconceptualizing their role, relationship to students, and the institution of schooling, in the context of constructivist curricula.

Issue

Science education research has called for a shift in classrooms from “learning about” a topic to “figuring out” a phenomenon or design solution (NRC, 2013). This shift requires teachers to instantiate a complex repositioning of classroom life about whose *knower* status is elevated (Cazden, 2001; Erickson, 1982). Within this shift, teachers should be regarded as sensemakers, adapters, and enactors of their curricular materials (e.g., Remillard, 2015) who work alongside students to support their co-construction of scientific knowledge. For most teachers, shifting from “telling” to supporting students in “figuring out” is a practice that takes abundant practice and professional development support (Krist & Shim, 2023; NASEM, 2016). Furthermore, the relationships of teachers to materials and students are *power-laden*, with authority historically conferred to teachers and published materials like textbooks, versus placing authority for sensemaking on students. We argue that the pedagogical decision-making required by this shift in power and positions is complex and requires a rethinking of the dynamic relationship between teachers, curriculum materials, students, and their local contexts. Although models (e.g. Remillard, 2005) of curriculum enactment highlight the *participatory* relationship between teachers and curricula, NGSS-aligned curriculum materials require us to foreground students in the process of curriculum enactment. These curriculum materials position students as doers, knowers, and knowledge builders; thus, they require that we foreground the role that students play in transforming the written curriculum to the enacted curriculum. While the NGSS-aligned curricula contain some educative features (e.g. Davis & Krajcik, 2005) that provide guidance to teachers on how to shift toward more epistemically agentic models of science instruction (Damşa et al., 2010), the field needs a deeper understanding of *how teachers learn* to reposition themselves, their students, the discipline, and curriculum materials in their instructional practice. In this study, we worked with an experienced group of practicing teachers to examine Storyline curriculum materials (Reiser et al., 2021), which are open-source, NGSS-aligned curriculum materials that are being used across the United States. During a weeklong professional learning (PL) institute, we worked with teachers to support students in becoming more agentic in their own learning. In this study, we highlight how metaphors were used by teachers to describe the roles and responsibilities of students and teachers in curriculum enactment, and we point to their utility for supporting teachers in repositioning themselves, their students, the curriculum, and science in an era of constructivist reform that centers the ideas of students. To support the community of learning scientists invested in shifting teacher positions from “telling about” toward “figuring out,” we ask, *“How do experienced Storylines teachers use metaphor to conceptualize the shift to more epistemically-agentic models of instruction?”*

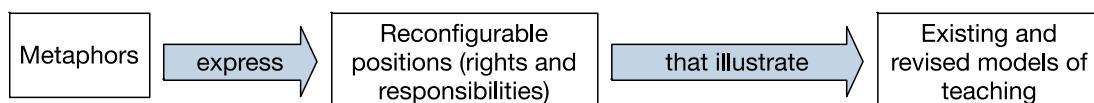
Theoretical approach: Conceptual metaphor

In understanding how teachers reimagine the relationships in their classrooms, the fields of discourse analysis and linguistics hold wide potential (e.g., Hoban, 2000). Cognitive linguists reason that language use is not simply a matter of word-by-word meaning-making; larger cultural, social, and figured worlds are in play as human learners use *metaphor* to “borrow” words among our shared domains of reference (Holland et al., 2001). Learning scientists have a long history of looking to human language and metaphor as a place for culturally-rooted meaning-making, both in classrooms (e.g., Lee, 2005) and across social worlds (Ortony, 1975; Heath, 2012). Teachers are learners who benefit from metaphor: studies in teacher learning research have shown that teachers fruitfully use

metaphor as a way to make meaning across boundaries. For example, a meta-review of teacher education found that, across 17 education studies, metaphor served a depth of purposes and has great potential for teachers to reflect on and deepen their practice (Saban, 2006). These uses of metaphor are *conceptual*; they comprise the use of a term from one sociocultural lexicon within the domain of a different lexicon to convey similar features (Lakoff & Johnson, 1980), using a word from one “world” in another world to widen its meaning. Conceptual metaphors are particularly useful for conveying meaning about abstract concepts. Within everyday conversations, one might say “love is a battlefield” or “money is the root of all evil.” In the context of sociocultural practice, metaphors can concretize new ideas (Fauconnier & Turner, 2008) and they have a history of supporting teacher learning in the learning sciences (e.g., Sfard, 1998), especially building new positions related to curriculum (Saban, 2006). Kliebard (1982) showed metaphors as foundational for curricular issues such as those addressed in the present study: “A curriculum theory, therefore, begins in the transference of meaning metaphorically from the familiar and the comprehensible to the abstract and persistently perplexing problems that arise when we address the question of what we should teach” (Kliebard, 1982, p. 13, cited in Saban, 2006). Metaphors can express the *positions, rights, and responsibilities* that actors understand and convey to each other through their language (Davies & Harré, 1990). The rights and responsibilities of students are at the heart of NGSS-aligned curricula, which were designed with the intention of fostering students’ epistemic agency in curricular materials (Gonzalez-Howard & McNeill, 2020); the heart of epistemic agency is the student’s *right* to make sense of their learning and determine its significance (See Figure 1).

Figure 1

Function of Metaphors in Supporting Teachers in Interrogating Science Teaching and Learning



Storylines and metaphors

Metaphors are already at work within the Storylines model of curriculum design in science education. For example, Storylines science instruction (Reiser et al., 2021) promotes a model in which students “figure out” a phenomenon as they work through a series of lessons. The Storylines approach already employs metaphor to illustrate the repositioning of teachers and students in science instruction. One Storylines routine is that of “navigation” (a word borrowed from seafaring), in which teachers and students collectively determine the next steps to take to make progress on the unit’s or lessons’ question or problem. Metaphors like “navigation” are conceptual metaphors that are used to illustrate intellectual trajectories through a curricular unit (rather than routes on a map). Implicit within these metaphors are also a set of assumptions about students’ *responsibilities* of collaboratively determining where the class “goes” next (Reiser, 2021; Cherbow & McNeill, 2022). Whereas traditional curricular materials transition into and out of lessons with an “anticipatory set” or a “summary,” using the metaphor of navigation as a routine invites more coherence from lesson to lesson, helping students deepen their motivation and epistemic agency (Reiser et al., 2021). Although Storyline curricula currently employ metaphors to support both teacher and student learning, agency, authority, and power are not predetermined by the written curriculum. Teachers’ pedagogical moves to “navigate” along or within the bends of a Storyline can elevate or suppress students’ epistemic agency. Knowing when or how to elevate student ideas is not straightforward; teachers report experiencing tensions as they navigate Storylines because they are unsure of what they say/foreground without “giving away” big ideas. Additionally, Storylines instruction requires a great deal of trust and control placed on the students in the knowledge-building process. Finally, Storylines require flexibility; enactment of Storylines is dynamic and emergent depending on what students do (Cherbow & McNeill, 2022). Examining metaphors is one way to know what teachers aspire to.

Potential significance

Given that these open educational resources (OER) are coherent with national standards and widely proliferated (e.g., publicly available via [Openscied.org](https://www.openscied.org)), it is increasingly important to understand how teachers learn to redistribute epistemic agency while using these materials to support instruction. We focus on experienced high school teachers because our study sought to understand what is possible, so that findings could be tested in the more challenging contexts of elementary and teacher education. This is important because storyline curricula position students’ agency and sensemaking as a central component of science learning (Reiser, Fumagalli, & Novak, 2015). Under this model, students take up the primary role of moving the classroom learning forward: they co-construct the questions that drive their learning in the unit, monitor and problematize aspects of their

emerging explanations and models, and determine the necessary steps to advance their knowledge building processes. Thus, students *are an integral part of* the participatory relationship of curriculum enactment (Reiser et al., 2021). This repositioning of students as a central piece of the transformation of the written to enacted curriculum is not reflected in the dominant frameworks that are used to conceptualize the teacher-student-curriculum relationship (Remillard, 2005). We propose here that teachers 1) are currently using metaphors to make meaning of this dynamic relationship, and that 2) metaphors can expand student epistemic agency in this relationship.

Data

The data from this study come from the first EMPOWER workshop that occurred in summer 2023 with a set of high school teachers from a single district with a diverse population of students. Six high school teachers (three biology and three chemistry) participated in the PD; three of these teachers were Storylines unit designers who also field tested the curricula. All teachers were part of a longstanding development of HS Storylines units and have spent at least one year ($M = 4.25$) teaching Storylines units with their students (see Table 1). The researchers (first and second authors) served as facilitators of the PL workshop. Both are former secondary science teachers familiar with key principles and the materials' arcs and flows, but also with the challenges associated with their enactments. The first author was a former designer of Storylines, and the second author has co-designed a variety of NGSS curricula with teachers.

The workshop spanned 4 consecutive days (32 hours) in the summer of 2023 during which we co-developed our ideas about ownership, engagement, relevance, and epistemic agency, examined Storylines curricula and identified opportunities for adaptations that would increase those dimensions of students' participation, and identified ways to continuously get feedback from students about their sense of belonging and agency in the classroom. On Day 1, we initiated the conversation about what counts as agency through brainstorming discussions and reading existing definitions of epistemic agency (Damşa et al, 2010). *The teachers, unprompted, used metaphors during whole group discussions on Day 1.* After seeing how productive these metaphors were for discussion, the workshop facilitators invited teachers to generate their own sets of metaphors for making sense of how Storyline materials are repositioning students, teachers, and curriculum materials. The metaphors introduced on Day 1 continued to surface and get iterated upon in Days 2-4, as teachers adapted curriculum materials, watched videos of enactment, and planned curriculum adaptations for the subsequent school year. To conclude, we asked each teacher to write about the metaphors they felt best suited their conceptualization of Storyline teaching that positioned students as agents in their learning.

Table 1
Teachers' Experience with Storylines Instruction and Writing

	Kittredge	Wessel	Festa	Anne	Stella	Colfax
<i>Teaching with Storylines (Yrs)</i>	2	4	5	6	5	5
<i>Storyline writing experience (Yrs)</i>	0	2	0	6	0	4

Methodological approach

We logged our data corpus of video, images, photos, artifacts, and journal prompts (60 hours, 300 GB, 150 files), and reduced to the four episodes during which teachers most heavily used metaphor and, to connect their adaptations of OpenSciEd materials to student ideas. The final data corpus was 3 hours of video and one set of artifacts: the Day 4 (final) journal entries in which teachers reflected on their learning through the lens of metaphor. Here, we focused on two particular moments during the week where metaphors were a central part of the conversation: on Day 1 as we built a shared understanding of epistemic agency, metaphors emerged as teachers talked about the roles they take up alongside their students, and on Day 4, when we asked teachers to reflect back on their learning through the week about the role they wanted students to play in the year moving forward. We transcribed each of the videos and input them into MAXQDA software before emergent coding (Saldaña, 2013) for Curricular Elements, Positions, and Metaphors and member checking to understand the ways that teachers use metaphor to relate meaning. We presented a thematic memo to our larger project team for a round of assertion testing before compiling findings.

Major findings

Teachers used metaphors to make sense of the relationship of Storylines curricula and their teaching practice, both *current* and *as they hoped to do in the future*. Almost every metaphor entailed a sort of *wayfinding*: a destination, a timeframe, a place, a journey, or the students' or teachers' respective "position" in that pursuit (Table 2).

Table 2
Metaphors Used by Teacher in PL Workshop

Metaphor	Exemplary Quote	Teachers	Inferred Rights & Responsibilities	
			Teacher	Student
Metaphors used to describe their current teaching				
Teacher driving the boat	"Before covid, I felt that I was driving the ship with few buoys." "I'm steering the boat; students feel like they are driving"	Anne, Colfax, Festa, Stella	Support moment-to-moment idea development	Steering within "buoys" set by teacher
Video game in "learning" mode	"When it comes to intellectual work, I think I tend to end up taking on a little too much of the work out of care for my students and efficiency. I'd like Ss to do more of the work. I want to get us out of tutorial phase."	Wessel	Is currently over-managing the storyline	Is currently safely progressing on a set trajectory
Metaphors that illustrated what they hoped to do in the future				
Laying buoys	"I'd like to strive to be the buoys / leaving the breadcrumbs for students to follow."	Kittredge, Anne, Festa, Stella	Set the course ahead of time (lots of work)	Students drive boat using buoys
Students are driving the boat	"They're driving and I'm floating behind"	Anne	Be present to student idea development	Steering within "buoys" set by teacher
"God" in allegorical story	"Students who feel like class is too easy don't realize their leader has been like God in the 'footsteps in the sand' story."	Wessel	Carry the class without their full awareness	Trust the teacher
Video game designer	"I want to get us out of the Tutorial phase of 9th grade bio game. It's more fun and builds more skills to play a real level of the game"	Wessel	Design a compelling game with meaningful aim	Continue playing, even when it's difficult

Across their use of metaphors, teachers overwhelmingly showed they felt responsible for the overall course-setting of the unit; however, these metaphors varied in their implicit/explicit descriptions of the teachers' and students' roles and responsibilities in the knowledge building process. Interestingly, teachers did not indicate, in their use of metaphor, that units or materials themselves "drive" or give direction. Instead, almost every metaphor held that teachers are the ones responsible for "laying buoys" or "carrying" or "planning" toward an ultimate aim. In the context of our week-long professional learning sequence, these metaphors supported us in illustrating the new possibilities for relating to curriculum materials with students' ideas made more central, and to support teachers in establishing goals for redistributing agency as part of their own professional growth around curriculum use. We describe two emergent themes in these metaphors below.

The "destination" of teaching Storylines

A theme among the metaphors that teachers used during the PL workshop was relating the work of curriculum enactment as a journey or a means of transportation, toward a proscribed *destination*. For example, Ms. Kittredge described roles and responsibilities in relationship to the students' ultimate destination of becoming scientists (use of metaphors are *italicized* in the excerpts):

I like the stance of *dropping buoys* because it allows students to do the majority of the work which facilitates problem solving skills and critical thinking. I think this naturally happens with inquiry-based learning and it allows for problematizing and *students driving the ship*. I aspire to have *students completely drive the ship*. Designing experiments, asking authentic questions, and figuring out how to get the answers on their own. Essentially, becoming scientists. (Journal entry 230727):



In this statement, Ms. Kittredge is linking the metaphors of buoy-setting to teaching and assigns learners the responsibility of “driving” and the right to learn the epistemic practices of science, especially investigation and “figuring out.” She also describes the final destination of “becoming scientists” as the goal of this wayfaring metaphor, but that teachers are the ones using the buoys to chart the course.

Other teachers were more measured in their application of the wayfaring “destination” metaphor, linking larger policy to social constraints of schooling. A second, more experienced teacher, Ms. Colfax, was clear about the ways that her students were navigating toward a goal of graduation. This is especially interesting since she taught in an alternative high school where many students were seeking late graduation at age 19 or 20:

It's always, yeah, it's like, at the end of the day, you got something that you're supposed to teach, because it's standard and whatever graduation requirement, and like, this isn't open inquiry, figure-out-whatever-you-want-to-figure-out. There is something that we're getting to at the end, and *I am going to steer us* towards that. And I'm going to keep going down that path, regardless of what students say, frankly. Because that's, that's the curriculum and material that I have. But how do I uplift their ideas to make them feel like *they're driving the ship when they're not at all?* (Conversation 1.3, 230723).

In this statement, Ms. Colfax connotes that she has a responsibility to help students “steer toward” the larger goals of graduation requirements, despite wanting to make students “feel like they’re driving the ship.” She presents this as a conundrum in contrast to graduation requirements and larger systemic design. In both excerpts, Ms. Kittredge and Ms. Colfax used metaphors to highlight the larger values and goals that were not otherwise made salient. These teachers’ uses of metaphor of wayfaring, especially by boat or buoy, was helpful in helping teachers elaborate, describe, and reflect on the larger purpose of Storyline-driven education and its dynamics (Sengupta-Irving et al., 2021). Ms. Colfax highlighted the difference between perceived and authentic epistemic agency and also of educational systems in shaping student learning, a distinction she encountered daily in her alternative school. The notion of “driving the ship” on an open sea with a destination in mind supported teachers to explain their view of the destination, or purpose, of science education. Another teacher explained this destination in terms of the personal sociocultural outcome, that of “becoming scientists.” Here, metaphors gave the facilitators deeper insight into how teachers conceptualized these larger purposes, or destinations, of science education, and consider how professional learning design could welcome and account for these situated perspectives.

“Carrying” students and epistemic agency

Metaphors also helped teachers clarify their own senses of control: over student ideas, pacing, and implications for epistemic agency. Several related a duality: they did not *in reality* give full control of the Storyline navigation to their students, but they *acted* as if they did. For example, Ms. Colfax described herself as having the responsibility to “know where we’re going” … “so students feel like they’re driving the ship when they’re not at all.” (Conversation 1.3, 230723). When asked how he would describe the intellectual work of students and teachers in Storylines on the last day of the PL, Mr. Wessel journaled two new metaphors: a *videogame designer* and *carrying* students (Journal 4.1, 230727):

When it comes to intellectual work, I think I tend to end up taking on a little too much of the work out of care for my students and efficiency. I’d like students to do more of the work. I want to get us out of the *tutorial phase of 9th grade bio game*. It’s more fun and builds more skills to *play a real level of the game* where your outcome is not predetermined. You can experience setbacks, and you can change your brain. It is hard to *design levels of games* – they require pre-planning and also *lots of playtesting*. (Journal 4.1, 230727).

Taking the metaphor of game design, Mr. Wessel is invoking several roles and responsibilities: teachers have the responsibilities of “designing levels” of games and while students have the right to “have fun” and “do more of the [intellectual] work.” He also compares his current practice as “tutorial phase” (where gameplay is heavily supported) to his goal of having students determine the direction of the game. In this reflection, control is planning and preparing a carefully structured game, but with less moment-to-moment control of student ideas than Ms. Colfax had described. In a final quote, Wessel offers another metaphor explaining this relationship, “Sometimes [they] easy don’t realize their leader has been *like God in the ‘footsteps in the sand’ story*. We carry them through the hard times” (Journal 4.1, 230727). This simile/metaphor combination provided by the teacher invokes a Christian allegory in which a man has a dream where he dies and is looking back at his life represented by a long series of footprints on the beach, and notices that during the difficult parts of his life there is only one pair of footprints shown. Feeling abandoned, he questions God, who responds “during the hard times, I carried you.”



This teacher's use of metaphor links the forethought required by an all-knowing deity to teachers' role of understanding the larger direction of the curriculum. These two metaphors elaborate the teacher's conception of how to engage their students' epistemic agency, whether students are "not driving at all" or "in tutorial phase" or being "carried." Metaphors supported teachers in describing and proposing new degrees of control and thus new rights and responsibilities for students, and new positions of students in curricular progress, or "driving the boat."

Teachers in this study had valuable interpretations of how much information about the curricular direction of a Storyline that students should know at any given time. Some teachers asserted that they would not deviate from the Storyline because of larger goals of schooling (Colfax) but others asserted that they wanted students to be working inside a game that was so well-designed that the teacher could give them fuller decision-making power and provide less moment-to-moment control (Wessel). In other words, metaphors highlighted the influence of larger school structural constraints as influences on lesson-to-lesson navigation.

Discussion and implications

Duit wrote that "Metaphors may open up new perspectives to us and may even help us to see the familiar in totally new ways" (1991, p. 653). In this study, we argue that these experienced Storylines teachers' uses of metaphors helped illustrate *gaps* in dominant conceptions of curriculum use. Teachers borrowed vocabulary from seafaring, game design, and allegory to explain and imagine 1) the ultimate destination of the learning community and 2) differing degrees of control that the teacher can assert in managing the progress of a Storyline unit. Current models of curriculum enactment (e.g. Remillard, 2005) highlight the dynamic relationship between teachers and students, but do not foreground the contested nature of negotiating agency and authority between teachers and students, both in terms of *how* they engage in science learning, and *to what end*. In analysis, we highlight how metaphors were used by teachers (experienced Storyline users) to "see the familiar in new ways," allowing teachers to talk about themselves, their students, the curriculum, and the institutional inertia that influence how curriculum gets enacted inside their classrooms.

Likewise, previous work in curriculum theory points to the utility of metaphors in elaborating difficult-to-describe relationships the teacher-learning relationship; Guerrero & Villamil (2002) found teachers leveraged metaphors of challengers, nurturers, artists, or coaches as they talked about practice-based instruction. Our findings extend this work and draw attention to the multiple actors and systems that are at play during curriculum enactment. We argue that this study highlights the utility of metaphors in supporting teachers' sensemaking and enactment of NGSS-aligned curriculum materials, highlighting the tensions that emerge when they try to redistribute agency and authority in the classroom while co-constructing scientific ideas. These metaphors may also have utility beyond the science education contexts, as constructivist learning materials across disciplines aim to expand how teachers relate to themselves and their students. We also want to note that *no teacher* in this study described that the materials themselves were the sole source of direction. Rather, we propose, alongside theorists of curriculum that argue for sociocultural views of enactment, that teachers must continue to be supported as the primary enactors of curricular materials. In other words, these metaphors' usage extends and supports the notion that curricula do not speak *to* the teacher, but rather *through* the teacher (Remillard & Reinke, 2012), and teachers all indicated their responsibility to support students in their progress. This study lends evidence that teachers' work is artful and expansive (Philip, 2019), and that open-source science materials can hold opportunity for expansive views of student ideas.

The findings we report here have implications for curriculum and professional learning designers. First, the metaphors that teachers used point to the importance of interrogating institutional routines and policies at the district and school levels and how they impact curriculum enactment. This means examining how reform goals for science instruction (and centering students as agentive) can contradict grading requirements, scope, and sequences, etc., as in Ms. Colfax's assertion that "*they think they're driving, but they're really not.*" It also suggests that teachers need sustained professional learning around the use of Storyline curricula to support awareness of the "paths" through instruction, and examine the ways that various adaptations influence student participation and engagement. Fostering collaborative spaces for professional learning should be a parallel goal to curriculum enactments that honor the craft of teaching as a disciplined, improvisational practice, acknowledging the long arc of learning that is required to engage with these materials in ways that go beyond a "fidelity of implementation" approach.

Relatedly, research in curriculum theory and teacher learning should investigate the outcomes for students as epistemic agents. For some teachers, this may mean adding lessons based on student interest or agency- and interest-driven assessments (e.g., Wingert & Penuel, 2019). These types of student-driven adaptations should be considered in contrast to more fidelity-driven approaches to Storylines curricular learning where lessons proceed with the assumption of what "must" happen next according to the materials. This study lends evidence

that teachers can be empowered as capable “navigators” of a unit: they must know the terrain (ideas, practices, standards) and deeply trust their copilots (students) to proceed in the learning together.

Limitations

The data for this study arise from a small sample taken during one week of PL. The conclusions here should be considered empirical, but initial. Second, metaphors are deeply cultural and related to the experiences of particular groups. We discourage anyone from insisting on the use of any metaphor by a group, including video game or Christian allegory metaphors. Rather, we invite the extension of this study by asking teachers in other contexts, “What metaphors do you think fit you, your curricula, and your goals for how learning might go?”

Conclusion

This paper offers a case of how metaphors can deepen the conceptions teachers have of philosophical purposes of teaching, including their rights, responsibilities, aims, and ownership of curricular trajectories. This study found that teachers engaged readily with metaphor as a way of illustrating epistemic agency. Opportunities for teachers to use metaphors to illustrate their relationships to their curricula have the potential to deepen teacher reflections. Future work should investigate how these metaphors support teachers *as they shift* their practice. We aim to explore the classroom practices of teachers alongside their use of metaphors: What specific instructional moves, philosophies, and enactments allow students to truly “drive the boat?”

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