7-2020

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Received: 20 November 2018 | Revised: 11 November 2019 | Accepted: 24 January 2020

DOI: 10.1002/sce.21568

Science Education WILEY

SCIENCE TEACHER EDUCATION

Truth, success, and faith: Novice teachers' perceptions of what's at risk in responsive teaching in science

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Abstract

Responsive teaching—or teaching that builds from the "seeds of science" in student thinking—is depicted in STEM education literature as both important and challenging. U.S. science education reform has been calling for teachers to enact instruction that attends to and takes up the substance of students' STEM ideas; however, responsive teaching represents a substantial shift from the current state of affairs in most U.S. classrooms, where content is often presented authoritatively as facts, definitions, and algorithms, with little consideration of student thinking. Drawing on language from literature about sense-making, this paper identifies some of the "vexation points" that novice science teachers face as they consider implementing responsive teaching practices in science—that is, what doesn't make sense, to teachers, about this instructional approach. In particular, we show that novice teachers express moral concerns about responsive teaching; themes in their written reflections suggest that they perceive responsive teaching to put truth, success, and faith at risk. We argue that though these concerns originally seem distinct from the institutional constraints to responsive teaching posed by the literature, teachers' concerns about truth, success,

and faith are in fact mutually reinforced by and reinforcing of external constraints. We use this connection to pose implications for research and teacher education.

KEYWORDS
novice teachers, power, responsive teaching, science teaching

1 | INTRODUCTION

A growing consensus calls on teachers to attend and respond to the substance of students' ideas in STEM classrooms, orienting toward these ideas as productive starting places from which to build, instructionally (Ball, 1993; Hammer, Goldberg, & Fargason, 2012; Robertson, Scherr, & Hammer, 2016; Sherin, Jacobs, & Philipp, 2011). As part of a university pedagogy course focusing on being responsive to students' ideas, Jane,[1] a student in the course, reflected on a class discussion about what constitutes the "beginnings" of scientific understandings, or "seeds," that teachers might draw on in class. She wrote:

> *I think of three types of seeds: seeds of scientific practice, …seeds of canonical thinking, and seeds of reasoning. The "magic" video[2] is an example of a seed of scientific practice. It is apparent that [the students'] interactions emulate a great scientific discussion where they work as a community to answer a question. It also shows the scientific practice of making links between experiences: balloons and play structures. I see Ofala's and Sean's ideas[3] about odd and even numbers as examples of seeds of reasoning. They both show great reasoning and are able to answer questions about their ideas. Ofala's idea is also an example of a seed of canonical thinking because it not only shows great reasoning but it is a seed towards the canonical answer.*

Jane went on to describe her concerns about teaching that centers on noticing and taking up these "seeds," writing:

> *I am concerned that without ample time to explore everything and have a wrap up at the end of every class there will be confusion. I can easily imagine students from the Sean number[s] video being confused about odd and even numbers if there was not a wrap-up. I can also imagine frustration on a physics idea if no one brings up the canonical idea and there is a rich discussion but at the end they do not have the right answer for the test.*

Looking at these two quotes together, we can see that Jane—a novice teacher—understands what it would mean to frame student thinking as sensible and to identify ways to build on the "seeds of science" (Hammer & van Zee, 2006) therein, both hallmarks of responsive teaching (RT). In the *same* reflection, she articulates her concerns about this way of teaching—that students will be confused and frustrated, and that not reaching a consensus that is aligned with canonical understandings will have negative consequences.

Jane's concerns are examples of what Odden and Russ (2018a) call "vexation points" in sense-making: "critical moment[s]…when students attend to and articulate an inconsistency or gap in their understanding, the thing that doesn't "make sense" to them" (p. 281). Literature on instructional reform tells us that sense-making about instructional approaches is necessary for successful reform (Spillane, Reiser, & Reimer, 2002), and literature in science education (e.g., Odden & Russ, 2018b) treats sense-making as central to knowledge construction. This paper is about novice science teachers' sense-making about RT, focusing on the vexation points or inconsistencies that they perceive between RT and their own commitments as teachers. Jane and her peers are Physics Learning Assistants (LAs), undergraduate students who support student learning in introductory physics courses at the

college level. LAs are simultaneously enrolled in a pedagogy course (described in Section 3) where they are considering various instructional strategies and approaches, including RT; many (usually between 10% and 40%) plan to become secondary science or mathematics instructors.

In this paper, we will show that Jane and her peers perceive that RT:

- puts the learning-of-right-ideas at risk, which they often say puts learning what is true or what is right at risk;
- puts students' academic and professional success at risk; and
- puts students' faith in teachers, the academic system, and their own existing ideas (which have been reinforced by that system) at risk.

These concerns were often expressed in affectively charged language, using words like "absurd," "moral," "feeling wrong," "great disadvantage," "ineptitude," "backlash," and "lose faith." Drawing on LAs' own language, we say that LAs perceive RT to put truth, success, and faith at risk. These perceptions may limit teachers' enactment of RT practices.

On the surface, these concerns appear distinct from the institutional constraints (e.g., curricula, the scientific method, and/or lack of administrator support) that have been identified as limiting teachers' enactment of RT (Chazan & Schnepp, 2002; Levin, 2008; Levin, Hammer, & Coffey, 2009; Rop, 2002; Settlage & Meadows, 2002; Tang, Coffey, Elby, & Levin, 2010; Thompson, Windschitl, & Braaten, 2013; Valli, Croninger, Chambliss, Graeber, & Buese, 2008). The institutional constraints described in the literature are often framed as externally imposed, whereas the "risks" our teachers articulate seem to be internally held, moral commitments about right and wrong, good, and bad, when it comes to teaching. However, we will argue in this paper that the relationship between institutional constraints and the "risks" in RT articulated by LAs can be seen as *co-constitutive and mutually reinforcing*. That is, the "risks" are communicated to LAs by a *system of schooling* that exerts its power and influence (in part) through meta-messaging about what is at risk if such a system is disrupted. The external constraints depicted in the literature are *institutionalizations of* this power. In this way, the constraints communicate a set of risks, which then become internalized by teachers and students, who go on to shape what happens in schools. This cycle contributes to the reproduction of the system (and its incumbent constraints and risks).

We construct this argument in the remainder of the paper, first by giving some context, then by describing and illustrating the "risks to RT" articulated by our LAs, and then by connecting these risks to education research literature. We end by considering what this study might tell us about teacher education centered around RT. In particular, we make visible that asking teachers to engage in RT is asking them to become agents who disrupt dominant narratives of schooling and school science (Giroux, 1983), and we consider the kinds of support teachers might need to do so.

2 | RT IN THE LITERATURE

In this section, we situate our work in existing literature about RT, first describing RT, then naming some of the reasons scholars and teachers are advocating for it, and then describing what others have said about constraints that teachers face as they seek to enact responsive instruction.

2.1 | What is "responsive teaching"?

RT, as construed here and elsewhere, is grounded in several foundational assumptions: that students come to classrooms with a wealth of productive knowledge and experience; that this wealth is too rich and diverse for teachers and curricula to know it fully in advance; and that the ideas students are bringing to bear are sensible in some way (Duckworth, 2001; Hammer, 2000). From these assumptions emerges the claim that instruction should attend to and build on students' own ideas and experiences.

In this spirit, responsive instruction *foregrounds the substance of students' ideas* (Ball, 1993; Brodie, 2011; Coffey, Hammer, Levin, & Grant, 2011; Duckworth, 2001; Hammer, 1997; Hammer et al., 2012; Jacobs, Lamb, & Philipp, 2010; Levin et al., 2009; Rosebery, Warren, & Tucker-Raymond, 2015; Sherin et al., 2011; Windschitl, Thompson, Braaten, & Stroupe, 2012). Teachers attend to the meaning that students are making of their disciplinary experiences and seek to understand these ideas rather than reflexively evaluate them. Responsive instruction also *seeks out disciplinary connections within students' ideas* (Ball, 1993; Hammer, 1997; Hammer et al., 2012; Jacobs et al., 2010; Russ, Coffey, Hammer, & Hutchison, 2009; Sherin & van Es, 2005), assuming that these ideas are inherently sensible and can serve as "disciplinary progenitors" (Harrer, Flood, & Wittmann, 2013, p. 4). These disciplinary progenitors—or "seeds" of science (Hammer, 1997, p. 511)—may be, for example, the beginnings of canonical understanding, participation in specific scientific practices, or affective experiences that are central to scientific activity (Jaber & Hammer, 2016). As teachers enact RT, they "consider the [discipline] in relation to the [students] and the [students] in relation to the [discipline]" (Ball, 1993, p. 394). RT also *adapts or builds instruction on students' ideas* (Ball, 1993; Campbell, Schwarz, & Windschitl, 2016; Empson & Jacobs, 2008; Fennema et al., 1996; Hammer, 1997; Hammer et al., 2012; Jacobs et al., 2010; Maskiewicz & Winters, 2012; Russ et al., 2009; Sherin & van Es, 2005), in ways that both respect student thinking and make progress along disciplinary dimensions. In this sense, responsive instruction is partially emergent, on short- and longer-term scales (Atkins & Frank, 2016, Maskiewicz & Winters, 2012). Hammer et al. (2012) write:

> *A responsive approach… is to adapt and discover instructional objectives responsively to student thinking. The first part of a lesson elicits students' generative engagement around some provocative task or situation (or, perhaps, by discovering its spontaneous emergence). From there, the teacher's role is to support that engagement and attend to it—watch and listen to the students' thinking, form a sense of what they are doing, and in this way identify productive beginnings of scientific thinking. In this way, the teacher may select and pursue a more specific target, in a way that recognizes and builds on what students have begun (p. 55).*

2.2 | Why is RT important?

Researchers and teachers have offered a number of compelling reasons that teachers might choose to teach responsively. One is that students in responsive classrooms often improve their conceptual understandings (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Empson & Jacobs, 2008; Fennema et al., 1996; Fennema, Franke, Carpenter, & Carey, 1993; Hammer et al., 2012; Hiebert & Wearne, 1993; Kersting, Givvin, Sotelo, & Stigler, 2010; Pierson, 2008; Radoff, Robertson, Fargason, & Goldberg, 2018; Robertson et al. 2016; Saxe, Gearhart, & Seltzer, 1999). Fennema et al. (1996) found that gains in students' mathematics achievement co-occurred with shifts in teachers' responsiveness to their students' mathematical thinking, and Radoff et al. (2018) report that students in a responsive elementary school classroom "scored far above the district average" (p. 78) on a science benchmark test. Classrooms that center on the pursuit of students' own ideas also provide opportunities for authentic engagement in disciplinary practices and sense-making (Ball, 1993; Colley & Windschitl, 2016; Engle & Conant, 2002; Hammer, 1997; Schwarz, Passmore, & Reiser, 2017). Some authors highlight that this kind of pursuit recognizes students' agency in the construction of ideas (Duckworth, 2001; Ko & Krist, 2019; Sikorski, 2016). Finally, responsive instruction—and particularly its framing of students' ideas as generative beginnings for their learning—shifts away from a "dichotomous view" (Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001, p. 531) of student thinking, which focuses on the compatibility (or incompatibility) of students' everyday ways of knowing and those of scientists. Warren et al. (2001) argue that this dichotomous view especially disadvantages minoritized students, and they call for pedagogies that take up other stances. We (the authors) value RT for all of these reasons, and for what it produces in us as teachers: an orientation toward students as "having wonderful ideas" (Duckworth, 2001) that are worth paying attention to and an orientation toward teaching as an opportunity to learn from and with students.

2.3 | What constrains teachers as they seek to teach responsively?

Though many teachers, researchers, and other stakeholders (National Research Council, 2012; NGSS Lead States, 2013) are enthusiastic about the vision of teaching that RT represents, this kind of instruction is challenging to enact. RT represents a substantial shift from the current state of affairs in most U.S. classrooms: large-scale observational studies demonstrate that content is often presented authoritatively as facts, definitions, and algorithms, with little consideration of student thinking (Banilower, Smith, Weiss, & Pasley, 2006; Horizon Research International, 2003; Roth & Garnier, 2007).

Indeed, the literature poses a number of constraints that teachers face as they seek to engage in responsive classroom instruction (e.g., Chazan & Schnepp, 2002; Levin, 2008; Levin et al. 2009; Rop, 2002; Settlage & Meadows, 2002; Tang, et al., 2010; Thompson, et al., 2013; Valli, et al., 2008). For example, Levin (2008) points to the "multiple accountabilities" (p. 105) that teachers face and to the role of high-stakes, district-mandated testing in directing teachers' attention toward the correctness of students' thinking, over and above substance. Levin et al. (2009) tell the stories of two novice teachers—one (Emma) whose classroom practice more consistently reflected attention to the substance of students' thinking, and another (Kay) whose practice more consistently reflected attention to classroom management. The authors recount how the administrators in the school in which Emma and Kay taught were pleased with Kay's performance and concerned with Emma's, directing the latter to "meet with a staff development person daily to work on organizing her lessons, improving her presentation, and managing student behavior" (p. 155). Rop (2002) and Chazan and Schnepp (2002) likewise note the influence of institutional constraints such as district-mandated tests and curricular coverage on enactments of responsive instruction.

In this paper, we identify themes in novice teachers' concerns about RT—reasons they think it's "risky" or even "wrong" to engage in RT. These concerns were often cited as reasons *not* to implement responsive instructional practices and so could be conceived of as another, distinct set of constraints, like the ones summarized in this section. However, as we will argue in Section 6, making sense of *why* these risks feel so risky to novice teachers caused us to conceptualize them as co-constitutive and mutually reinforcing of the institutional constraints cited in the RT literature. Before we get to this argument, though, we describe our research context and methods.

3 | RESEARCH CONTEXT: TEACHER EDUCATION COURSES FOCUSED ON RT

Our description of the "risks" that teachers associate with RT (laid out in detail in Section 5) emerged from our analysis of written assignments from teacher education courses that focused in some capacity on RT. All of the courses were a part of the Physics Learning Assistant Program at Seattle Pacific University, a small private university in the Pacific Northwest United States. Though the pedagogy instructor (and first author of this paper, Robertson) did not introduce the term "responsive teaching" to participants in the courses, the readings on which participants are reflecting center on the themes we introduce above: attending to, seeking disciplinary connections within, and building on the substance of student thinking. We describe these courses in more detail in this section.

3.1 | LA Programs

LA Programs originated at the University of Colorado, Boulder, as a way to support introductory physics course reform (Otero, Pollock, & Finkelstein, 2010). Undergraduate LAs are selected competitively from a pool of students who have successfully completed the introductory course, and they partner with physics faculty who are seeking to shift their instruction toward active learning approaches (Goertzen, Brewe, Kramer, Wells, & Jones, 2011; Pollock & Finkelstein, 2008). LAs' primary role in these courses is to facilitate small-group conversations among students.

As of Fall 2019, 88 colleges and universities in the United States have LA Programs (Learning Assistant Alliance, 2019). Many of these programs serve multiple disciplines, including physics.

In addition to being instructors, LAs in LA Programs are also learners, participating in a three-pronged approach to *learning to become physics instructors*. This approach includes (a) a weekly pedagogy course, (b) preparation meetings with the instructors of the courses LAs support, and (c) teaching practice (Learning Assistant Alliance, 2019). We describe local instantiations of each of these prongs in the next subsection.

LA programs are meant to serve as both (i) a teacher recruitment mechanism for students with strong disciplinary grounding, providing these students with early teaching experiences, and (ii) a specialized teacher preparation opportunity for already-committed preservice teachers. As such, many LAs intend—or eventually decide—to become K-12 science teachers.

3.2 | The Physics Learning Assistant Program at Seattle Pacific University

The content and structure of the LA Program at Seattle Pacific University (SPU) instantiates the general, three-pronged approach described above and provides LAs with experiences comparable to those of preservice teachers in science methods courses with field placements. LAs take a pedagogy course that focuses on educational theory and best practices, and they meet weekly to plan and prepare for that week's course content, in conjunction with ongoing instructional placements in algebra- and calculus-based introductory physics courses. In their placements, LAs facilitate collaborative dialogue among groups of physics students in a combined lecture and lab course. This course extensively uses physics-education-research-based instructional materials, including both materials developed onsite and *Tutorials in Introductory Physics* (McDermott & Shaffer, 2011). The *Tutorials* are a set of instructional materials designed to build conceptual understandings and address common misunderstandings in introductory physics. As an example of the kind of instruction SPU LAs support, the "Light and Shadow" *Tutorial* begins by showing students an arrangement in which a mask with a very small circular hole is placed in between a "very small bulb" (p. 185) and a screen in a dark room. The first page of the *Tutorial* invites students to make predictions for a number of different situations, including what happens to the lit area on the screen if the bulb is moved upward, if the mask is replaced by a different mask with a triangular hole, or if a second bulb is added above the first. In making predictions, conducting the experiments, and then explaining their observations, the *Tutorial* means to support students in developing a geometric model for light, where light travels in straight lines outward from a source (Wosilait, Heron, Shaffer, & McDermott, 1998). LAs facilitate conversations among students as they complete the *Tutorials* and other activities in the course.

The artifacts we analyze in Section 5 were submitted as part of LA coursework over four academic years, or 12 academic quarters, between 2012 and 2016. During these 4 years, the LA course met three times a week: once in a preparatory meeting with the instructors of the courses that LAs staffed, to review course content; once in a preparatory meeting with the first author (Robertson), to develop pedagogical content knowledge and curricular knowledge (Shulman 1986) associated with the week's course content; and once in a pedagogy course meeting with the first author, to discuss educational theory and best practices.

Between 2012 and 2016, the physics LA pedagogy course was a year-long sequence. Unlike at CU-Boulder, LAs at SPU were required to enroll in the course any time they served as an LA (i.e., not just in their first quarter or semester as an LA). As seen in the appendix, some LAs participated in the LA Program and associated pedagogy course for a single quarter, some for multiple quarters, and a few for more than 1 year. The course often included both experienced and first-year LAs.

LAs were required to submit weekly teaching and reading reflections, situating their developing ideas in their teaching practice (Borko & Putnam, 1996; Putnam & Borko, 2000) and in relation to educational theory and research. In pedagogy course meetings, the first author took an overtly responsive stance toward LAs' ideas, treating these ideas as worthy of collective reflection. LAs' questions, concerns, and ideas drove the substance of

class discussions, and subsequent assignments were often based on LAs' developing interests and reflections. For example, assignments often included questions like:

> *This week in class, Charlie posed the question, "Is it right for the teacher to pursue these [mathematical "seeds"], or is it just going to confuse students?" (We started to answer this question, but I think there's more discussion to be had!) What do you think would be Ball's answer to this question?*

LAs were regularly asked to say where they were in relationship to particular ideas (e.g., those discussed in a paper) or why their peers' ideas made sense to them, even if they disagreed. Typically, class would begin with a set of questions, submitted in advance by LAs and then written on the whiteboard before class started. The first author (pedagogy course instructor) would then take notes on the board as LAs discussed their ideas in relation to particular questions.

As one example of how this unfolded, during Winter 2013, LAs spent three class periods discussing the question, "Is it ever okay to leave students with the wrong answer?" This question emerged during LAs' discussion of Ball (1993); as usual, LAs had submitted questions that they wanted to discuss in advance, and the first author wrote them on the whiteboard before class. After discussing an agree/disagree question about a quote from Ball's paper, LAs nominated Amanda's question—"Do we think Ball is willing to let students walk away with wrong answers?"—for collective discussion. LAs quickly decided that they thought Ball *is* willing to do so, and the first author elevated that maybe the question was not whether *Ball* is willing to do so but whether *they* (LAs) were. This initiated the 3-week-long conversation in which LAs began (in Week 1) brainstorming a list of reasons that this would be okay with them and reasons that it wouldn't; continued that discussion in Week 2, articulating some of the affordances of leaving or not leaving students with incorrect answers; and then "finished" the discussion in

Week 1: Black text represents questions submitted by LAs in advance, written on board by course instructor. Red text in left picture are LAs' responses to the first question. Green text in left picture are LA responses to emergent question: Are we willing to let students walk away with wrong answers? Red text in right picture are additional responses to this question after brainstorming in small groups.

Week 2: Red text in left two photos includes brainstormed reasons from prior week's conversation. Black text in all photos represents additions and modifications proposed during Week 2's conversation. Green text represents the values and foci of assessment that each list reflects.

Week 3: Black text represents lists from previous week, written on the whiteboard before class by course instructor. Blue text in right picture is a list of open questions posed by LAs at the start of class. Most time in class was spent elaborating on ideas already posed in black. Red and green text are additions made during class conversation.

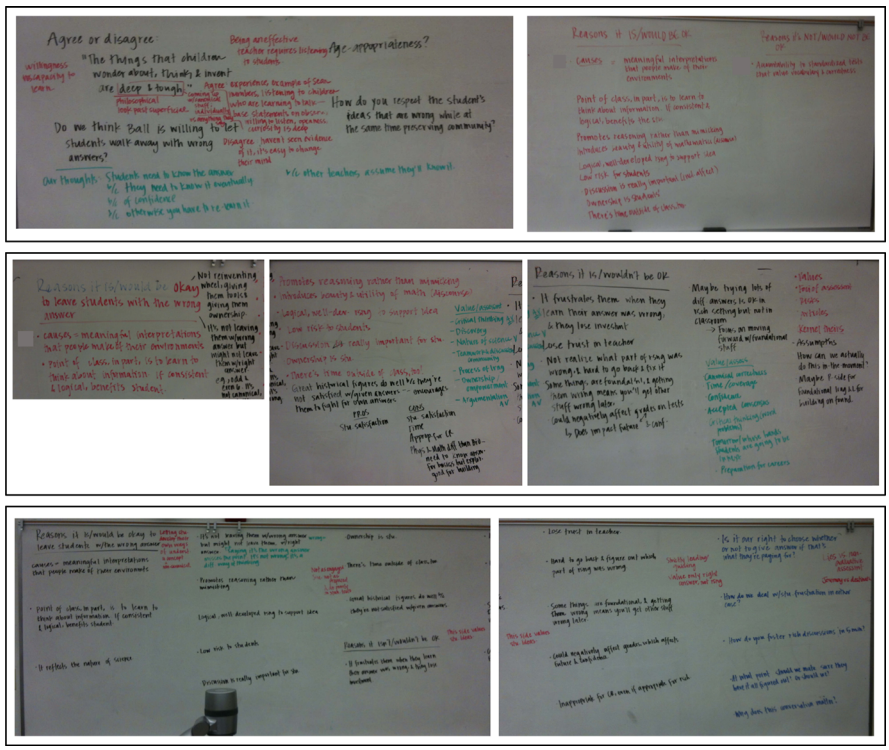

FIGURE 1 Whiteboard photos from 3-week discussion of question, "Is it okay to leave students with the wrong answer?," during the 2012–2013 academic year [Color figure can be viewed at wileyonlinelibrary.com]

Week 3, with each "side" working to understand the arguments of the other. Whiteboard photos from this sequence of discussions appear in Figure 1.

Sometimes, instead of discussing a reading (like Ball, 1993), the class would focus on collective viewing and analysis of classroom video, or on creating or negotiating a product (e.g., a classification scheme) that LAs had elevated as important to them. The course structure and framing—including LAs' teaching reflections—provided LAs with multiple opportunities to sense-make about being responsive to students' ideas.

RT as an instructional approach was a focus of the course during seven of the 12 quarters, though not named "responsive teaching" explicitly. (The remaining five quarters differed in focus but often included discussion of theories of learning, conversation facilitation strategies, nature of science, etc.) RT was introduced differently each year, always in response to emerging questions from LAs. For example, in the 2013–2014 academic year, Hammer (1997) was offered as an example of (a) how instruction might embody theories of learning that had been previously discussed in the course (e.g., Driver & Bell, 1986; Smith, diSessa, & Roschelle, 1993) and (b) how instructors might choose "among multiple, competing foci of attention" (course assignment, 1/21/14). The language that became foregrounded that year was responding to the "seeds" (of scientific practice, canonical understandings, etc.) in student thinking. Though introduced differently across years, course assignments included similar readings (Ball, 1993; Hammer, 1997; Jaber & Hammer, 2016; Russ et al., 2009); in this sense, the concerns articulated in Section V emerged in response to similar content. In Section 5, we draw mostly from LAs' reading reflections, where LAs say what they think about these articles and our course discussions about them. We draw on a few teaching reflections, where LAs describe and reflect on interactions in which they sought to be responsive in practice (and/or said why they chose not to do so). In the next section, we say more about how we selected and analyzed LA reflections for this paper.

4 | METHODS

The original idea for this paper emerged from the first author's sense-making about her experience teaching the LA pedagogy course at SPU for 5 years. In Robertson and Richards (2017), the first author and another colleague document an especially successful case of one LA cohort's sense-making about RT—sense-making that we argued was entangled with their consistent (and emergent) enactment of RT practices in their LA placements. In the 2 years following the cohort featured in that paper, the first author observed that, with similar opportunities, LAs were sense-making about but often *not* choosing to engage in RT, instead expressing significant concerns about RT. Part of what was puzzling (and interesting!) was that the concerns articulated by LAs who chose not to enact RT resonated with sticking points that the first author had heard LAs express in *every* year that she introduced RT in her pedagogy course, and with concerns that she hears in-service teachers elevate in professional development. That became the original focus of analysis for this paper: drawing on language from literature on sense-making (Odden & Russ, 2018a, 2018b), what are some of the *vexation points* that novice teachers—in this case, LAs—face as they consider implementing RT practices in science?

4.1 | Sense-making about RT

We started by narrowing our data set to instances in which LAs were both (a) sense-making about RT and (b) expressing concerns about RT. We drew on themes from literature on instructional reform, which frames sense-making as *triggered by ambiguity and uncertainty*, and as *a process that aims toward resolution* (Allen & Penuel, 2015; Coburn, 2005; Ketelaar, Beijaard, Boshuizen, & den Brok, 2012; Weick, 1995; Weick, Sutcliffe, & Obstfeld, 2005). In this case, resolution need not be a definitive or final stance on an issue; it may be more a feeling of clarity or a step in the "continued redrafting of an emerging story" (Weick et al., 2005, p. 415). Sense-making is further framed in this literature as *an active process of meaning construction* that involves selecting relevant features of a situation to attend to, and interpreting and creating meaning from these features in interaction with existing ideas, prior

experiences, and so forth. Similarly, in science education, sense-making is represented as a (cognitive) process of trying to "'fit' new knowledge into our existing knowledge frameworks, which are built out of ideas that we have learned or gathered from our experiences" (Odden & Russ, 2018b, p.8). Odden and Russ (2018a) argue that "[w]ithin this sensemaking process, a critical moment occurs when students attend to and articulate an inconsistency or gap in their understanding, the thing that doesn't 'make sense' to them" (p. 281). Odden and Russ define such moments as "vexation point[s]" (p. 281).

Many LA concerns were expressed in these terms. That is, in expressing specific concerns about RT, LAs identified ways in which RT does not or cannot "fit" within their existing conceptualizations of science teaching. In some cases, such as with many of the LAs in the cohort described in Robertson and Richards (2017), these vexation points triggered more sense-making, through which the concerns become "resolved," not in the sense of becoming irrelevant, but more in the sense of becoming less salient, or of evolving toward a more nuanced view that made room for the concerns to coexist with salient reasons to engage in RT. In other cases, the vexation points were of such deep concern to LAs that they were not resolved in the course of 1 quarter or 1 year in the LA Program. These are the vexation points that we highlight in this paper, in part because they were salient to us as analysts and in part because we think they have important implications that to our knowledge have not been elevated in the literature on RT in science.

4.2 | Data and analysis

Data for this paper includes written assignments from the first author's LA pedagogy course. In particular, we began with reading reflections, teaching reflections, and course projects that included questions or prompts around RT, for the seven quarters during the four academic years that RT was a focus of the course. We started with 243 reading reflections, 250 teaching reflections, and 16 class projects submitted by 36 distinct LAs during those 4 years. (Individual LAs' participation is tracked in the appendix.) As noted above, we narrowed this data set to responses that expressed *concerns about responsive teaching*, and in particular those concerns that seemed to be irresolvable or major sticking points; this was often indicated by the use of affectively charged language, such as "absurd," "moral," "great disadvantage," or "backlash." We then looked for themes (Krippendorff, 2013) in these concerns within and across cohorts. Three such themes—those that were most salient to us, expressed in the most affectively charged language, and in our view most relevant to teacher education—are the substance of Section 5. Though our effort was not to construct a comprehensive characterization of LA concerns, the three themes are not uncommon; we identified each theme in more than half of the 36 LAs' written reflections, and all three themes were topics of pedagogy class conversations every year from 2012 to 2016.

In Section 5, we name each theme using language from LA reflections. Our primary effort in our analysis and narration of LAs' thinking is to illustrate and make sensible the substance of their concerns—what makes these concerns reasonable, what wisdom might researchers and teacher educators derive from LAs' thinking, and what might teacher education that takes these concerns seriously look like? Resonances between LAs' thinking and themes from science education literature led us to reimagine the relationship between the concerns LAs articulate and the external constraints depicted in the literature on RT, framing the latter as institutionalizations of power and the former as internalizations of meta-messaging from powerful systems. This reconceptualization is the topic of Section VI.

Our analysis capitalized on the expertise of researchers who were both "near to" and "far from" the data: the first author (Robertson) was a participant in the courses and thus brought her understanding of the context to the analysis, and the second author (Atkins Elliott) was not and so could separate her interpretation from experiences in the course. Further, our interpretations are both constrained and motivated by our relationship to conversations about power. Both of us are white, wealthy, cis-gendered PhD-holding scientists (with more axes of privilege than we name here). As such, we have been socialized not to see power; its remaining invisible to us is part of the mechanism by which systems of harm persist (Bonilla-Silva, 2003; Doane, 2003). This social reality limits our

capacity to see power clearly and to speak about it with authority (Collins, 2000). We are deeply grateful for the colleagues, friends, authors, and activists who have educated us by offering their wisdom and lived experiences. We are motivated to participate in the struggle for collective liberation, through the dismantling of oppressive systems of power, in part because of the convictions that this education has given birth to, and in part because of our own marginalized identities: we both identify as women (and the first author as disabled) who deeply believe that our liberation is bound up in the liberation of all people (Freire, 2000; Lorde, 2007). This paper is part of our effort within that struggle.

In suggesting that our work has relevance beyond the first author's local context, we are implicitly claiming that the LAs in the first author's course are *cases of* (Erickson, 1986; Yin, 2003) novice science teachers, and that their concerns are *cases of* broader concerns and themes about RT. Though there are limitations to this claim, it seems reasonable to us on a number of fronts. First, as we say in Section 3, the structure of the first author's pedagogy course resembles the structure of many university science methods courses taken by novice teachers: students in the course learn about educational theory and best practices, try these out in their field placements (in this case, in introductory physics courses), and reflect on their implementation. Second, though the students that LAs are teaching are university physics students, many of LAs' reflections and discussions extended beyond their teaching assignments and into K-12 education writ large—that is, LAs were not only concerned about what RT risked for *their* students but also what RT would risk for *any* student. Part of what we are claiming is that LAs' concerns represent an internalization of meta-messaging that comes from the U.S. system of schooling; we see this reflected in the scope of LAs' concerns (*i.e.*, beyond their own teaching context). Because many pre- and in-service teachers have been exposed to the same educational system, we expect similar concerns to materialize in more traditional teacher education contexts, such as methods courses. In fact, the "risks" we report in this paper have emerged in conversations in methods courses taught by the second author and in professional development courses for in-service teachers documented by the first author.

In sharing these themes and our interpretation of them, our aim is to be *illustrative*, not *representative;* we are striving for *plausibility*—does our analysis "ring true" (Connelly & Clandinin, 1990, p. 8) to our readers and their experience—more than reproducibility (Eisenhart, 2009; Erickson, 1986). Our hope is that our work will broaden readers' awareness (Donmoyer, 1990; Eisenhart, 2009; Maxwell, 1992; Wehlage, 1981)—and then interpretation and response, as deemed appropriate—in their local contexts, not to inform preemptive action or predictions. It is the set of themes, not their specific instantiations in LA reflections, that we expect to be useful. To us, this means that though the strength and tenor of LA reflections may be specific to their context, the essence reflects something more universal (Erickson, 1986).

5 | TRUTH, SUCCESS, AND FAITH: UNDERGRADUATE LEARNING ASSISTANTS' PERCEPTIONS OF WHAT IS AT RISK IN RT

In this section, we introduce themes from undergraduate Learning Assistants' pedagogy course reflections that highlight what these LAs consider to be "at risk" in RT. We will show that LAs' concerns reflect moral and ethical commitments—what is right and wrong, when it comes to their role as teachers—including commitments to *truth*, to students' *success*, and to students' *faith* in institutions and in teachers. These concerns are often tied to one another: for example, RT puts *truth* at risk, which puts (both undergraduate and K-12) students' *success*, in and out of school, at risk; and, when students do not learn right ideas and when their coursework doesn't position them for broader success, students lose *faith* in teachers and schools.

Our goal in identifying these concerns is not to evaluate the merits of LAs' claims but to consider why RT might feel so risky to them. Doing so has helped us to see the wisdom in their concerns, to make visible to ourselves places where teacher education around RT could better support novice teachers in sense-making about RT, and to honor the tensions that emerge as they do so.

5.1 | RT puts truth at risk

In LAs' coursework, they frequently note that RT puts learning-right-ideas, which they often tie to learning *what is right* or *what is true,* at risk. For example, in Section 1, Jane, an LA, considers the merits of third-graders debating whether or not six is both even and odd (since it can be divided into three groups of two). As she does so, she expresses her worry that students will be "confused about odd and even numbers" and will "not have the right answer for the test" (quote from Week 7, Winter 2014). Both of these concerns underscore a commitment to right ideas, both for the integrity of the idea itself (i.e., it is worth knowing the "truth" about odd and even numbers) and for students' performance on tests. For Jane, an extended conversation that takes seriously the idea that six might be odd, while having some affordances, puts her commitments to the correctness of the ideas that students learn and to students' test performance at risk. The first of Jane's concerns we describe as *truth* being at risk; the second (related) concern we will describe as students' *success* being at risk. In this section, we offer additional quotes from LAs that are aligned with the first.

The first quote below is from Tobias, whose writing articulates an even stronger commitment to truth than Jane's. He argues that students' reasoning and engagement in scientific practices are valuable only insofar as they lead them to *truth*, or to a correct understanding of the physical world. He writes:

> *While I firmly believe that scientific thinking and reasoning strategies are intrinsically important to the wellbeing of student learning as a whole, they are rendered useless if they fail to deliver the student to the correct answer. The pursuit of knowledge, a working understanding of the natural world, is noble only in our ability to accurately understand. We must experience the world as it truly exists in its most absolute essence. Science is the most clinical pursuit of truth and if we do not place truth on the highest echelon of goals, then we fail to perform science correctly. That is not to say that the pursuit itself is not noble and valuable. I only maintain that an emphasis on the mechanism of thinking without holding the conclusion's truth value to an nonnegotiable standard is absurd. It is absurd that value can be placed on the technique if the product is rubbish (Week 5, Spring 2016).*

In this quote, Tobias uses strong, affectively laden language: "absurd," "rubbish," "highest echelon," "noble," "truly," and "absolute." This language is infused throughout Tobias' reflections across the two quarters he was enrolled in the first author's LA course. For example, earlier in the year, Tobias (and his peers) wrote personal teaching philosophies that drew on the theories of learning they had discussed in the pedagogy course. Tellingly, Tobias included in his philosophy:

> *Furthermore, I should…always ensure that their [(students')] learning revolves around the rules set forth by our predecessors. The natural, objective, absolute, essential, intrinsic, verifiable, accepted, impartial truths are the language that scientists use to communicate. While these ideas may or may not actually be truth (here we fail to define truth), they must be accepted as such to create a usable discussion and allow for the propagation of knowledge and learning (Week 4, Winter 2016).*

Here, again, is language that points to Tobias' sense of science—and, in particular, of the science that he wants his students to learn—as "objective," "absolute," "impartial," and consisting of "truths," or at least of being "accepted as [true]" for the noble purpose of "propagat[ing] knowledge and learning." It seems that for Tobias, then, RT risks truth as a pole star of scientific inquiry.

In fact, it was the affective tenor of Tobias' and others' statements that inspired this paper: these LAs are not skeptical of RT solely because they want to "teach how they were taught" (McDermott, 1991) or because of institutional pressures and constraints (Chazan & Schnepp, 2002; Levin, 2008; Levin, et al., 2009; Rop, 2002; Settlage & Meadows, 2002; Tang et al., 2010; Thompson, et al., 2013; Valli, et al., 2008). Their concerns are tied to a deeper sense of right and wrong.

Further evidence that LAs perceive RT to put truth at risk comes from the use of words like "honesty," "morals," and "feel[ing] wrong [about] doing it," all suggesting that to teach responsively—with the possible consequence of students "having" wrong ideas or answers—is akin to lying, being dishonest, or violating moral code. For example, one LA, Grayson, reflected that his "attending to the right answer" stems from his "honesty toward others" and from his "upbringing as a person with morals" (Week 8, Winter 2015). Another LA, Jane, reflected on how she tried but "could not" leave a particular teaching interaction in which a student had "the "wrong" answer with good reasoning." She writes:

> *This week I wanted to experiment and have a situation where I left a student with the "wrong" answer with good reasoning. I had decided I wanted it to be on a smaller idea that would not impact their grade, but that also would have the potential of being readdressed later. [The course instructor] said the engine tutorial would not be on the test so I tried it Friday. I could not do it. With one student we got to the end of her reasoning and her conclusion, and it just felt wrong to me to leave. This was the first teaching experiment I set up that I failed to do, and I believe it was a learning experience for me. Whether or not letting a student leave with the wrong answer is more or less productive does not matter if I feel wrong doing it (Week 5, Winter 2013).*

Here, Jane's concern is not that students' success is at risk; she chose to experiment with a topic that is not on a test and where there would be later opportunities to get the right answer. But she nonetheless "felt wrong doing it." Moreover, perhaps in response to course readings [like Russ et al. (2009)] that suggest that attention to reasoning over and above correctness is productive, Jane notes that *even if* prioritizing reasoning was productive, it does not matter if she "feel[s] wrong doing it."

To summarize, we see in these LA comments a concern that RT, which focuses on the substance of or reasoning behind students' ideas (and not their correctness), puts *truth* in science teaching at risk. This concern seems tied to two separate but related commitments: (a) a commitment to truth for truth's sake, and (b) a commitment to students' acquisition of this truth. As we will show next, LAs perceive that if RT puts *truth* at risk then it also puts students' *success* at risk.

5.2 | RT puts students' success at risk

Returning again to the case of "Sean Numbers": in Ball's (1993) account, students define a category of numbers that "have an odd number of groups of two" (p. 386), called Sean Numbers, which the class then explores together. This emergent classroom activity is deeply mathematical, with students proposing definitions, looking for patterns, and describing characteristics of Sean Numbers. Sean Numbers as a mathematical set do not put truth at risk; as Ball notes, there *is* a set of "even numbers [that] have an *odd* number of groups of two" (p. 386), and students can do the same kind of productive pattern-seeking for this set that they can with numbers that are even or odd. However, the category of Sean Numbers that they spend so long defining may not be recognized by their school (e.g., on standardized tests or in later coursework, Atkins & Frank, 2016) or broader communities (e.g., in work environments), and Jane is worried that spending time exploring these numbers may confuse students. Success as measured by traditional schooling practices often confers a form of power (Bourdieu, 2003; Bourdieu & Passeron, 2000), and LAs perceive that responsive instruction puts this conferral at risk.

To distinguish LAs' concerns with "truth" from their concerns with "success," in this section we identify quotes that reflect the notion that correct answers in science are valuable not only in their own right (the "truth" argument of 5.1 above), but also because they contribute to academic and/or professional success. These quotes are grouped by the type of success that is perceived as being at risk: success on exams, success more broadly in the educational system, success in later courses, and success outside of the classroom.

LAs note that performance on exams and similar metrics is at risk when teachers value something other than correct answers:

- Molly: "Years in the schooling system in a setting that values the right answer, the quizzes that our students will soon be taking, and direct pressure from the students, all lead to valuing the right answer, for better or worse" (Week 5, Winter 2015).
- Ellie: "You also have to set your students up for success for the state wide exams" (Week 4, Winter 2013).
- Kafil: "We need to give more priority to students learning correct concepts in class because they are graded on it… This [attention to right answers] ensures in exams they don't get zeros" (Week 7, Spring 2016).
- Charlie: "I make sure the students got to the correct answer. This is still an important piece of it all for me, and I always do (and probably always will…) hold this in the highest regard, as I maintain that it is not fair for me to ignore that piece, focusing instead on understanding, and leaving them to fight for themselves on quizzes and exams" (Week 2, Winter 2014).

Other LAs suggest that that success in education more broadly means having the right answer. For example, Grayson writes:

> *I care about the right answer because I want to give the student the best chance to succeed in education. My language is chosen very carefully in this answer because it needs to be… In the American system, answers are what matter (Week 8, Winter 2015).*

Similarly, LAs note that students' ability to succeed in later courses is compromised when RT foregrounds students' own (perhaps incorrect) ideas. For some LAs, this argument is closely tied to the notion that physics builds on itself and is used in other sciences. For example:

- Charlie: "… it could be very useful for them to make conclusions on their own, but limits must be put on that, and their conclusions must be checked. If not, they will struggle later in the class, future teachers will have to spend more time reviewing material rather than working on new material…" (Week 5, Winter 2013).
- Sonya: "It is important to me that the students do not feel 'left behind' in the class, and that they really understand the subject matter when the class moves on… Physics is something that builds on itself greatly, and without an understanding of the basics the student will be at a great disadvantage later down the line of their physics career" (Week 8, Winter 2015).

Finally, LAs saw RT as risking students' success beyond the context of school:

- Grayson: "I value students' ideas, but I value the correct answer more… the answer comes first because that will get them a good grade, getting them a diploma, grad school, and job" (Week 5, Winter 2015).
- Tobias: "They will tell their professor or potential employer or mentor their 'wrong' idea and then be judged as incompetent. Their reputation as a scholar will be tarnished and in any highly competitive field (medicine, technology, business) they will be shunned for their ineptitude" (Week 8, Spring 2016).

LAs' writing uses strong, emotional language to express concerns for students' success: "the highest regard," scores of "zeros," "best chance to succeed," "a great disadvantage," "tarnished," and "shunned for their ineptitude." While some LAs seem ambivalent ("for better or worse"), much of the language suggests convictions of a moral nature.

5.3 | RT puts students' faith—in teachers, in the educational system, in their prior learning, and in their future capacity to succeed—at risk

The first risk we discussed, "truth," centers on philosophical commitments: students' understanding of the natural world is risked by RT. The second, "success," centers on power and success that students need to navigate their futures. The third is more relational than these; it is the faith that students have in their teachers and in educational systems that is perceived as being put at risk by RT. We name it "faith" based on LAs' own language. For example, Will writes:

> *When the student figures out that they had the wrong answer the entire time[,] I fe[e]l that the student would lose some faith in the teach[er] and thus confidence in their understanding of the material. They might think that if this one thing is wrong, what else that I have learned is also wrong. Causing doubt in their own understanding thus affecting their learning for the entire class potentially (Week 5, Winter 2013).*

This quote and others reflect an implicit contract (Brousseau, 2006): "what each partner, the teacher and the student, will have the responsibility for managing and, in some way or other, be responsible to the other person for" (p. 31). That is, as Brousseau argues, students and teachers have a set of "reciprocal obligations" to one another; students expect that doing the assignments teachers give them and interacting with their instructors will lead them to success and/or truth. When LAs engage in RT, which includes attending to students' own ideas and reasoning over and above canonical correctness, LAs see themselves as breaking this contract and thus putting students' faith—in them as teachers, in the educational system as a whole, in the integrity of students' own prior learning, and in their future capacity to succeed—at risk. Thus concerns about RT risking *faith* are often entangled with risks to *truth* or *success*, but also stand out in their foregrounding a risk to the student-teacher relationship as teachers breach the implicit contract.

We see evidence of risks to "faith" in LA reflections that anticipate that students would be upset not to have their answers corrected:

- Katie: "…students expect me to correct them when their answer is 'wrong' and there would probably be a lot of backlash" (Week 2, Winter 2014).
- Sonya: "[Students] will be upset when they realize they have been wrong for x amount of time and no one helped them when they had the chance" (Week 5, Spring 2016).

Though not as clearly expressed as a loss of faith as in Will's response above, we interpret these reflections as indicating that students had a set of expectations for their instructors that the instructor failed to meet.

LAs also suggest that students who move on with incorrect answers and then struggle later will lose confidence in the teacher, in the class, or in themselves. Echoing the quote from Will above, Charlie writes, "[When they struggle later] the student's confidence in the class and in the teacher could be compromised" (Week 5, Winter 2013).

Finally, LAs draw on their interpretations of interactions with their students to infer that students are losing faith in them or in the system as LAs try implementing responsive instructional practices. For example:

- Aubrey: "The students probably thought that I would be the 'bumpers' for their bowling ball of thought; not knowing that I planned to only let them figure out the problem themselves. After the interaction, I felt pretty much useless…" (Week 6, Winter 2015).
- Amanda: "I could've just let her believe what she wanted and not really challenge it, but she expressed her frustration with how it seemed like LAs never seem to confirm her answers or really answer her questions. She felt like she had the right to learn and get help since she pays for her education" (Week 6, Winter 2013).

Again, we highlight specific terms that underscore these concerns as moral and personal: "backlash," "upset," "compromised" confidence, I felt "useless," she "had the right," "lose faith," "lose confidence," "causing doubt." These all reveal LAs' concerns for how their students would feel about instruction and the instructional relationship in RT.

5.4 | Discussion: RT puts right-and-wrong at risk

In the previous three subsections, we showed that LAs perceive RT to put truth, success, and faith at risk. We could phrase the above risks as "students will not get the right answers," "students will do poorly on assessments," and "students will be frustrated with the teacher." We chose, instead, to describe them in the more value-laden terms of truth, success and faith because the LAs themselves used such terms. In fact, it was the affectively laden tenor of LAs' reflections that inspired us to do this study; we saw that for these LAs, what was at risk was not strictly externally imposed, but also internally felt—it was about what is right and wrong to *them*, as agents in the unfolding story of their experience as novice teachers.

Originally, these moral and ethical risks seemed distinct to us from existing accounts of what constrains teachers' engagement in RT (e.g., Chazan & Schnepp, 2002; Levin, 2008; Levin, et al., 2009; Rop, 2002; Settlage & Meadows, 2002; Thompson, et al., 2013; Valli, et al., 2008). These accounts from the literature pose curricular coverage, administrative oversight, and standardized exams as reasons that teachers do not engage (or engage only partially) in RT. Though we saw overlaps—for example, both our LAs and the teachers depicted in the literature are concerned about students' performance on exams—we also felt that LAs' concerns represented a new and important set of vexation points, with different implications than the constraints articulated by the literature. In particular, LAs are expressing *moral and ethical dilemmas* that are tied to what they feel right or wrong about doing in classroom spaces. If LAs feel that it is *morally wrong* or *unethical* to foreground and pursue students' own thinking, then relaxing external constraints such as standardized testing may not sufficiently lower barriers to the enactment of RT.

Much of this still seems true to us; that is, we continue to think that LAs' concerns about truth, success, and faith are new insights worth sharing with the teacher education and research communities, and that they showcase unique implications for the way researchers and teacher educators think about creating supportive conditions for RT. However, as we began to make connections between LAs' concerns about RT and the education and science education research literatures, we came to see these risks as related to external institutional constraints, rather than distinct from them. We describe this relationship in the following section.

6 | SYSTEM OF SCHOOLING, EXTERNAL CONSTRAINTS, AND LA CONCERNS: CO-CONSTITUTIVE OF, NOT DISTINCT FROM, ONE ANOTHER

In this section, we will draw on literature to suggest that the U.S. system of schooling, as described by Bourdieu (1986, 2003) and Bourdieu and Passeron (2000), is part of the mechanism by which power is constructed and maintained in society, such that disruptions to the knowledge (truth), qualifications (success), and relationships (faith) endorsed by that system of schooling are disruptions to power. We will argue that this is (at least part of) why RT feels so risky to LAs. Further, we will reflect on the external constraints depicted in the literature in these terms, suggesting that these constraints are *institutionalizations of the power* that the system of schooling creates and maintains. In doing so, we will build the argument represented in Figure 2.

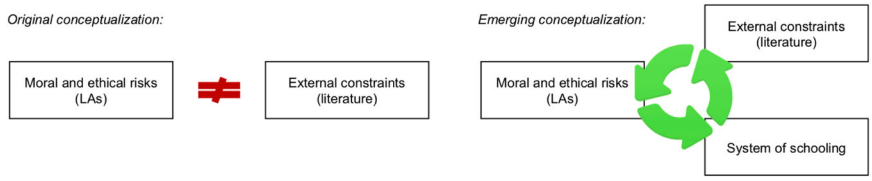

FIGURE 2 Evolving conceptualization of relationship between moral and ethical risks articulated by learning assistants (LAs) and external constraints articulated by literature [Color figure can be viewed at wileyonlinelibrary.com]

6.1 | The system of schooling creates and maintains power relations: Bourdieu

A central argument in Bourdieu's work (1986, 2003; Bourdieu & Passeron, 2000) is that *schools serve to produce and reproduce the institutional conditions necessary for maintaining power relations.*

First, Bourdieu argues that *power in societies is maintained by the dominant group, in part, by producing a "misrecognition…of the arbitrariness on which [power-maintaining structures] are based"* (Bourdieu, 2003, p. 164). In particular, he argues that hierarchical structures within society reflect neither what is merited nor what is optimal, but are designed to reinforce and entrench existing power relations. They do so by "producing misrecognition of the limits of the cognition that they make possible" (Bourdieu, 2003, p. 164), thus constructing specific ways of thinking and being as universal or just "the way things are." These ways of thinking then seem to reflect *truth*, and so they "foun[d] immediate adherence" (p. 164) to themselves. Bourdieu emphasizes again and again that what has often gone unquestioned—framed as the "natural" order of things—is in fact a cultural "arbitrary" that "correspon[ds] to the objective interests (material, symbolic, and… pedagogic) of the dominant group" (Bourdieu & Passeron, 2000, p. 7).

Second, and relatedly, Bourdieu suggests that *the system of schooling contributes to the production and maintenance of power in society more broadly.* One of the central tenets of his "theory of symbolic violence" (Bourdieu & Passeron, 2000) is that

> *Every institutionalized educational system…owes the specific characteristics of its structure and functioning to the fact that, by the means proper to the institution, it has to produce and reproduce the institutional conditions whose existence and persistence (self-reproduction of the system) are necessary both to the exercise of its essential function of inculcation and to the fulfilment of its function of reproducing a cultural arbitrary…, the reproduction of which contributes to the reproduction of the relations between the groups or classes (social reproduction) (p. 54).*

In other words, according to Bourdieu and Passeron, educational systems produce and maintain power relations by instilling values and knowledge (inculcation) that align with the (dominant) cultural arbitrary and by perpetuating the conditions under which the arbitrariness is misrecognized. Further, they create *institutional structures* that support this study, such that the arbitrariness is further hidden in policies and practices that become "the way things are" in school. And "the way things are" in school affects "the way things are" in society more broadly.

In particular, Bourdieu plays this argument out with "academic qualifications." Academic qualifications make it possible "to relate all qualification-holders (and also, negatively, all unqualified individuals) to a single standard, thereby setting up a single market for all cultural capacities and guaranteeing the convertibility of cultural capital into money, at a determinate cost in labour and time" (Bourdieu, 2003, p. 187). Lareau and Weininger (2003) take up Bourdieu's emphasis on forms of capital, arguing that "in nearly all economically advanced countries, schools play a crucial and growing role in the transmission of advantage across generations" (p. 568). They quote Bourdieu and Passeron's definition of cultural capital as "the educational norms of those social classes capable of imposing the…criteria of evaluation which are the most favorable to their children" (p. 588).

Bourdieu (2003) elaborates that academic qualifications, having been "guaranteed by law," are "freed from local limitations" and thus

> *the cultural capital which they in a sense guarantee once and for all does not constantly need to be proved… Once this state of affairs is established, relations of power and domination no longer exist directly between individuals; they are set up in pure objectivity between institutions…[which become] social mechanisms which produce and guarantee both the social value of the qualifications and the positions and also the distribution of these social attributes, among biological individuals (pp. 187–188).*

Bourdieu's perspective on schooling challenged our original notion that LAs' concerns are distinct from external constraints. As participants in the system of schooling—first as students, and now as "the corps of agents recruited and trained to carry out inculcation" (Bourdieu & Passeron, 2000, p. 57)—LAs internalize a set of epistemologies, ethics, and responsibilities that endorse and are endorsed by that system. That is, the truth, success and faith they perceive as at risk are values promoted and endorsed by schooling. Renegotiating these commitments is risky, at least in part, because doing so constitutes a disruption to power. We turn to this next.

6.2 | Disruptions to the knowledge, qualifications, and relationships endorsed by the system of schooling are disruptions to power

6.2.1 | Truth at risk: RT disrupts the knowledge—and, in particular, the epistemology of science—endorsed by school

Traditional schooling has endorsed a narrative of science as identifying, in Tobias' (LA quoted earlier) words, "natural, objective, absolute, essential, intrinsic, verifiable, accepted, impartial truths." Using Bourdieu's lens, this narrative treats science—and scientific findings—as "just the way things are," rather than presenting science as socially constructed, subject to revision, and the product of a particular culture and time. In fact, education researchers have pointed to the ways in which science education reinforces an epistemic stance of "final form" science (Duschl, 1990) or a "rhetoric of conclusions" (Schwab, 1958) that conveys Western scientific narratives (Bang, Warren, Rosebery, & Medin, 2012), develops mythologies of scientific discovery that depict new insights as "feats of ancient genius" and not discoveries by everyday people (Martinez, 2011, p. 255), and tends to press students toward notions of science that are contrary to the ways in which science is practiced (Marx, Mian, & Pagonis, 2005). Even as teacher education and policy move towards the more practice-based standards outlined in the Next Generation Science Standards (NGSS), which appear to expand the notion of what will count as science, students continue to lack academic agency in the knowledge production and practices of their classroom community (Miller, Manz, Russ, Stroupe, & Berland, 2018). There continues to be no ambiguity around what practices are sanctioned or the knowledge that these practices should produce.

Importantly, then, LAs' epistemic stance toward science as defining or identifying "truth" is not solely drawn from idiosyncratic personal epistemologies the LAs hold, but from epistemologies that are supported by (and, in turn, support) the system of schooling that Bourdieu outlines, one that produces and reproduces power relations by perpetuating conditions under which a dominant cultural arbitrary—in this case, Western science[4] —is misrecognized as such.

6.2.2 | Success at risk: RT disrupts the academic qualifications endorsed by school

Bourdieu's work also helps us to interpret LAs' concerns that RT puts student success at risk. In particular, traditional academic success and its attendant qualifications *do* confer power and signal status, and that success is traditionally indicated by performance on exams and having "right" answers. That this conferral is anything other

than meritorious—for example, that it could signify the "transmission of advantage across generations" (Lareau & Weininger, 2003, p. 568) via the imposition of the "educational norms" (p. 588) of the dominant class—is "misrecognized," according to Bourdieu; the conferral of capital to "successful" students seems like the "natural" order of things (Louie, 2018). Furthermore, the *standards* that educational systems uphold and reinforce will also seem like the natural and objective order of things, and disrupting this order by renegotiating educational standards, even on a small scale, feels risky.

Some LAs acknowledge the possibility of another "order," or they acknowledge that the system of schooling embeds values that may in fact be arbitrary or inadequate. For example, we quoted Molly above as writing:

> *"Years in the schooling system in a setting that values the right answer, the quizzes that our students will soon be taking, and direct pressure from the students, all lead to valuing the right answer, for better or worse."*

Here, Molly articulates some of the structures and values that found an adherence to "rightness," "for better or worse." LAs like Molly do seem to recognize—or at least are beginning to recognize—the arbitrariness of educational structures and standards, but they nonetheless feel compelled to adhere to them because not doing so would restrict students' access to the academic qualifications that confer power and signal success.

6.2.3 | Faith at risk: RT disrupts the relationships—and responsibilities—endorsed by school

The system of schooling and its attendant epistemology of science supports and is supported by an implicit contract (Brousseau, 2006) between students and teachers; namely, teachers have a responsibility to "make sure the students [get] to the correct answer" (LA quote). Allowing students' ideas and practices to drive curricular decisions would disrupt what has been constructed as the "natural order" in schools. Such disruption clearly feels risky—and possibly even dystopic—to our LAs, and this is also not surprising, from Bourdieu's perspective. He writes that teachers are "the corps of agents recruited and trained to carry out inculcation" and that they must "operate within institutional conditions" which "exclude, without explicitly forbidding, any practice incompatible with the function of reproducing" the system (Bourdieu & Passeron, 2000, p. 57).

Importantly, teachers are not just accountable to the institution of schooling, abstractly speaking; students, too, are (often) willing participants in this system, anticipating this inculcation, the truth it reveals, and the success it bestows. The system of schooling suggests a certain set of obligations that a teacher has; to teach responsively is to break those. Renegotiating those responsibilities is not just an epistemological risk—a risk to students' access to "truth" or to what will "count" as science—nor just a risk to students' success; it also risks the immediate relationship between student and teacher and students' faith in the system of schooling.

6.2.4 | Revisiting Figure 2

In this subsection, we have primarily oriented toward one direction in the relationship between the moral risks articulated by LAs and the system of schooling that is depicted in Figure 2: that is, how the system of schooling imposes particular moral commitments on its participants, including our LAs, such that LAs' concerns reflect internalizations of meta-messages communicated by powerful systems. However, in taking these commitments up, LAs, who are novice teachers, are maintaining and reinforcing—in fact, recreating—the system of schooling and the power relations it creates and perpetuates. In this way, the two are mutually reinforcing.

6.3 | External constraints depicted in literature on RT are institutionalizations of the power relations that the system of schooling creates and maintains

The third input in Figure 2 is the set of external constraints to RT articulated in the literature, particularly expectations of curricular coverage, standardized tests, and administrator oversight. Bourdieu's perspective would suggest that such external constraints are in fact *institutionalizations* of the power relations that the system of schooling creates and maintains. For example, standards (and standardized testing) endorse particular forms of knowledge, and administrator oversight enforces particular relationships between teachers and students. In this sense, external constraints reinforce—and create material consequences for—the risks that LAs perceive, and their perceptions of risk support their adherence to and reproduction of these constraints, completing the cycle represented in Figure 2.

7 | CONCLUSION AND IMPLICATIONS FOR TEACHER EDUCATION AND RESEARCH

In Section 5, we described three core commitments that RT puts at risk for LAs: *truth*, for its own sake and for students' knowing of it; students' *success* in school and in their long-term futures; and students' *faith* in teachers and in the educational system. We argued that these commitments reflect issues of morality—what is "right" or "wrong" to LAs. In Section 6, we drew on literature from education research and science education to suggest that part of why these risks feel so risky is because the system of schooling, in seeking to create and maintain power relations, imposes particular moral commitments on students and teachers.

Critics have argued that reproduction theories like Bourdieu's elevate "mechanistic notions of power" and an "overly determined view of agency" (Giroux, 1983, p. 271), treating schools as factories that produce adherence to dominant ideologies and history as "made "behind the backs" of the members of society" (p. 259). Theories of *resistance*, on the other hand, acknowledge that "people do make history" (p. 259) and "assig[n] an active role to human agency and experience" (p. 285) in shaping schooling. Giroux argues that while both have limitations, theories of reproduction make visible the role of schools in contributing to the reproduction of dominance, and theories of resistance make visible the agentive role that humans—including those subordinated by the system—can play in rewriting history. Our paper takes up Bourdieu's theory not so much in the service of seeking to *establish* that schools play a reproductive role, but more in the service of explaining why RT may feel especially risky to LAs. Bourdieu layers *power* on to our analysis of LAs' perceptions, giving us the tools to articulate how perceived disruptions to the knowledge, qualifications, and relationships endorsed by school are perceived disruptions to power. Here, in our Conclusion, we also draw on theories of resistance, suggesting that novice teachers, like our LAs, are agents that can reshape dominant narratives of school science. Writing this paper helped us to see that this is what we are asking LAs to do—and what they *experience* us asking them to do—when we ask them to engage in RT. Though we think there is room for RT to grow in its emancipatory capacity so as to include and celebrate a broader range of ways of talking and being (Robertson & Elliott, 2017), RT does challenge dominant narratives of schooling in its assumptions and practices. RT positions *students*—not (just) disciplinary experts—as central knowers and practitioners of classroom science, and it positions scientific knowledge as flexible and evolving, ready to be rethought in light of what students observe and conclude.

So what does it mean to support teachers—like our LAs—in becoming agents that reshape dominant narratives of school science, in this case through RT? Centrally, we think it means making visible and taking seriously the concerns that our LAs have articulated. These concerns represent authentic vexation points (Odden & Russ, 2018a) in novice teachers' own sense-making about RT; they show us what needs to be reconciled in order for sustained instructional change to take place (Spillane, et al., 2002). If what we posit in Figure 2 is true—that external constraints, moral risks, and the system of schooling are tied to one another—then *relaxing the constraints* will not

necessarily translate into instructional change. Instead, we must also (a) make fundamental changes to the system and (b) acknowledge and sit with the concerns that LAs are raising—concerns that we think have been imposed by the system and then internalized by these novice teachers. Further, drawing on theories of resistance (Giroux, 1983), the grappling that these LAs are doing is itself a disruptive and agency-building activity; this agency may eventually manifest as overt resistance—participating in dismantling the system—or it may be more subtle, in choosing, for example, to pursue student thinking in spite of pressures to do otherwise.

Which leads us to ask: what would it look like to "take these concerns seriously" in teacher education contexts? We think our analysis offers guidance on a number of fronts. First, taking these concerns seriously means foregrounding them instructionally, in our teacher education programs, in ways that honor them as real risks. Much of the rhetoric in the literature seeks to persuade teachers and teacher educators of the *value* and *viability* of RT on intellectual and empirical grounds (e.g., Coffey et al., 2009; Hammer & van Zee, 2006; Russ et al., 2009). However, these intellectual and empirical arguments often reflect a moral imperative that is in conflict with the one imposed by the system of schooling. For example, Russ et al.'s (2009) call for classroom science to be "more accountable" to the practice of professional scientists reflects a vision of science as flexible and evolving, emphasizing mechanistic reasoning over and above canonical correctness. These accounts are likely to "miss" our teachers, in the ways that traditional instruction sometimes misses opportunities to hear and then build on students' own ideas and experiences.

What we are suggesting is that teacher education programs treat the moral content of teachers' concerns as *disciplinary substance* (Coffey et al., 2009), providing opportunities for novice teachers to notice and then articulate their concerns, and then elevating these concerns to the level of curriculum. The first author (Robertson) has sought to do that in her own teacher education context (see Section 3 for details about this context) with varying levels of success. By "varying levels of success," we mean both (a) she has felt more and less able to hear, understand, and elevate LAs' concerns across cohorts, and (b) cohorts responded by pressing more or less deeply into RT as an idea to pursue intellectually and instructionally. In cases in which LAs *did* choose to enact RT, they often connected a shift in their instructional practice to opportunities to grapple with their concerns alongside their peers in the LA Program. For example, Victoria wrote the following in an end-of-year homework assignment in which LAs were asked to articulate their philosophies of teaching:

> *Throughout the year, my philosophy of teaching has changed dramatically. In the beginning, I was very concerned with directing students to the canonical answer. I held on tightly to the tutorial, and was afraid of deviating from it. I listened for specific buzzwords from students, and when I heard those words, I pursued them to the canonical answer. Personally, I think that this stemmed from my lack of confidence in my ability to answer students' specific questions. As we wrestled through the question, "Is it okay to leave students with the wrong answer?" in pedagogy, I wrestled with my philosophy of teaching. I began to realize that students are capable of figuring things out for themselves and that I wasn't required to know everything or leave them with the right answer. When I started to realize this, it felt like a huge weight was lifted off of my shoulders. I felt freer in my teaching, and I began to take on the role as "expert learner" instead of "expert answer giver." Instead of guiding students to a certain answer, I began to value their ideas and really care about what those ideas were. It made me excited to see all that students could do and it reinforced my teaching as "expert learner" (Week 10, Spring 2014).*

In this quote, Victoria notes a shift in her instructional foci – from "buzzwords" and "the canonical answer" to students' "ideas" and "all that students could do"—and she attributes this shift to her coming to see that "students are capable of figuring things out for themselves" and that she "wasn't required to know everything or leave them with the right answer." She associates this realization with her "wrestling" with the question of whether it is okay to leave students with the wrong answer, alongside her peers in pedagogy class. More details about cases in which SPU LAs have chosen to enact RT can be found in Lovegren and Robertson (2013), Robertson and Richards (2017), and Robertson, Gray, Lovegren, Rininger, & Wenzinger (n.d.).

Further, and relatedly, we highlight that teacher concerns about RT are morally charged and therefore affectively laden for novice teachers. We see this in the language that LAs use, including terms like "absurd," "great disadvantage," "ineptitude," "backlash," and "lose faith." Again, we see this as evidence that the values that these concerns reflect were instilled and reinforced by *real* systems that maintain their power by suggesting that acting in ways that challenge the system will restrict or cut off students' access to commodities like truth, success, and faith. Centering this affectively laden disciplinary substance in ways that take it seriously asks something different of teacher educators than when teacher thinking is conceptualized strictly as (disembodied) intellectual content. For example, conversations about success which make visible the power and privileging of certain forms of cultural capital within existing educational systems often act to re-narrate the meaning of "intelligence," of "truth," or of "success in school" (Louie, 2018; Michaels, 2005). Our experience is that these conversations are especially challenging for teachers who have historically been narrated as smart and successful in school. Further, our experience is that the only way through these conversations is *through* them—that is, for teachers to experience the challenge of them, to grieve the loss of the narratives associated with them, and to reconstruct images of themselves as social agents of change within systems that narrate certain people as smart and certain stories as true (and others as not smart or untrue). Relatedly, taking teachers' concerns about RT seriously means acknowledging that choosing to enact—or even consider enacting—RT in the context of our existing system of schooling and its attendant moral commitments constitutes an act of bravery.

ACKNOWLEDGMENTS

The authors are thankful to the four cohorts of LAs whose reflections are represented in this paper; we learned so much from you. The authors gratefully acknowledge feedback on earlier drafts of the manuscript from Rachel E. Scherr. This study was supported in part by NSF DRL 1418211.

ENDNOTES

[1] All teacher names are pseudonyms.

[2] The "magic" video is a video from Sharon Fargason's third-grade classroom. Sharon's students have been discussing how to make a toy car move, and among their ideas has been to use static electricity and magnets. In the video, Sharon opens with a revoicing of one student's statement about how this works: that "it's like magic." She asks, "How is it like magic?" Students discuss what makes electricity and magnets like magic—citing, for example, that balloons that have been rubbed pull your hair up, when your hair usually falls down because of gravity—and what makes electricity and magnets not like magic—there are lots of things, including balloons and play structures, that behave this way. Sharon has made the video from her classroom publicly available at goo.gl/MFhKGQ.

[3] When Jane refers to Ofala's and Sean's ideas, she is referring to what happens in the "Sean Numbers" episode, discussed extensively in Ball (1993) and publicly available at https://deepblue.lib.umich.edu/handle/2027.42/65013.

[4] In making our argument here and earlier in the paper, we take the position that dominant narrations of Western science—the science endorsed by the U.S. system of schooling—as objective and "final form" (Duschl, 1990) mask the "arbitrariness on which [Western science is] based" (Bourdieu, 2003, p. 164) and so maintain and reproduce systems of power that center some and marginalize others. Western science embeds (among other things) white, masculine values and is largely credited to individual, great White men (Bang et al., 2012; Harding, 1991; Sheth, 2018). Western science is also powerful, both as a system and as a story. It is one form of cultural capital that has translated into wealth, decision-making power, and positionality. It is "arbitrary," borrowing from Bourdieu; it is one way to make sense of the natural world—not the *only* or even the *best* one—and it is dominant at least in part *because of* its power; its power has produced a "misrecognition of the limits of the cognition which [it] make[s] possible" (Bourdieu, 2003, p. 164).

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How to cite this article: Robertson AD, Atkins Elliott LJ. Truth, success, and faith: Novice teachers' perceptions of what's at risk in responsive teaching in science. *Science Education*. 2020;104:736–761. https://doi.org/10.1002/sce.21568

APPENDIX

	Pre-2012	Fall 2012	Winter 2013	Spring 2013	Fall 2013	Winter 2014	Spring 2014	Fall 2014	Winter 2015	Spring 2015	Fall 2015	Winter 2016	Spring 2016
Amanda	•	•	•	•									
Maya	•		•			•							
Erika	•	•	•	•									
Charlie		•	•	•	•	•							
Ellie	•	•	•	•	•	•	•						
Jane	•	•	•	•	•	•							
Rose	•	•	•	•	•	•	•	•	•				
John			•	•									
Sophie		•	•	•									
Grace			•										
Will		•	•	•			•						
Forrest		•		•									
Kai				•									
Lizzie					•	•							
Rusty					•	•							
Eddie					•	•	•	•					
Victoria					•	•	•						
Katie					•	•	•						
Martin							•	•	•				
Aubrey								•	•	•			
Grayson								•	•				
Sara									•	•	•		
Molly								•	•	•			
Jake								•	•			•	
Sonya									•		•	•	•
Anthony								•	•	•			
Madison											•	•	
Doug											•	•	•
Elena											•	•	•
Alex											•	•	
Tobias											•	•	•
Susie												•	
Logan											•	•	
Harry											•	•	•
Esther										•			•
Kafil											•		•

Note: Individual LAs' participation in the Physics LA Program, by quarter, for the 4 years documented in this study is tracked. Columns highlighted in green represent quarters for which we analyzed data for this paper. All LA names are pseudonyms.

Abbreviation: LA, learning assistant.