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Supporting Teachers in Navigating Change Towards Science Practices Focus in the Classroom: Investigating Current Teacher Support for Science Practices

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Abstract: A growing emphasis on teaching science as practice calls for a significant change from traditional science education. We must provide teachers with the appropriate support to navigate this change. The first step in supporting teachers to help students learn science practices is understanding current approaches for teaching science practices. We investigated the question: How do teachers support science practices in their classrooms? We analyzed how two teachers supported students by engaging and guiding students to participate in science practices; we focused on two key science practices: constructing and defending scientific explanations and analyzing and interpreting data. We found that teachers most frequently engaged students in practices but did not necessarily provide guidance for how to participate, explain why science practices are important, or describe how all the practices are connected. Teachers may need additional guidance to develop concrete teaching strategies to support science practices.

Keywords: science teaching, science practices, teachers as learners

Introduction

Science as practice: Teaching and conceptualizing science as practice has recently emerged as a prominent perspective in science education. This perspective views science as progressing beyond a reasoning process to encompassing how we understand, make sense of, evaluate, and represent the world around us (Lehrer & Schauble, 2015). While previous views of science as a reasoning process have focused on the logical construction of experiments, manipulation of variables, and interpretation of data (Lehrer & Schauble, 2015), the view of science as practice emphasizes a broader focus on the holistic process by which knowledge is constructed in the scientific community. This view of science is central to the new emphasis on science practices in education. Science practices span the entire process of science, from being able to generate and write a hypothesis, collect data, analyze data, understand how the data supports the hypothesis, and draw conclusions from the data and interpret the findings. The importance of these practices has been placed at the forefront of science education, as seen by their inclusion in the Next Generation Science Standards (NGSS). These new standards restructure previous attempts to shift science education towards inquiry-based, hands-on-science by "elaborate[ing] how to engage in the work of inquiry, and how this work is part of building knowledge" (Reiser, 2013, p. 5). More specifically, the NGSS break down the practice of science into eight components: asking questions; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking; constructing explanations; engaging in argument from evidence; and obtaining, evaluating, and communicating information (NGSS Lead States, 2013).

While these practices are often presented as a list, they should not be conceptualized as step-wise, sequential skills. Rather, all the science practices are interdependent components of a single system of making sense about the world, and they must be viewed as such in order to fully understand the practice of science (Reiser, 2013; Lehrer & Schauble, 2015). This goal necessitates an integrated and holistic view of the science practices that build on one another, describing the process and reasoning of science. Teaching these practices in isolation would remove them from the context of the whole process by which the scientific community constructs knowledge; students cannot fully understand science as practice without a holistic approach to integrating science practices in the classroom. Students must learn to: ask scientific questions that drive the development of their investigations; analyze and interpret data from their investigations; and use this data to construct models and explanations about the phenomenon they are investigating. Ultimately, students must be able to develop convincing, well-supported arguments that use their data and explanations to answer their research questions and communicate their findings to the scientific community.

The science practices should not be conceptualized as a sequential list; however, it may be useful to think of them as hierarchically organized. Lehrer and Schauble (2015) advocate for such a hierarchical approach and place modeling as an over-arching, governing practice that is most central to the practice of science and supported by the rest of the practices. Others emphasize that engaging in argument from evidence is a central practice of science by which scientific knowledge is generated and learned (Berland & Reiser, 2009; Reiser, Berland, Kenyon, 2012; Driver, Newton, & Osborne, 2000). We follow this lead and view engaging in argument from evidence as a culminating practice that unifies all of the science practices. Most highly interrelated in the hierarchical structure, engaging in argument from evidence is contingent on students' ability to analyze and interpret data and to construct explanations.

Changing teacher practice to support science practices: The growing emphasis on the importance of teaching science practices in the classroom calls for a change from traditional science education. The science practices we are now asking teachers to incorporate in their classrooms require significant changes in *teacher practice*, for which we must provide teachers with the appropriate guidance and support (Reiser, 2013, Windschitl, Thompson, Braaten, & Stroupe, 2012). The *teacher* in the classroom plays a hugely important role in how the curriculum is enacted (Remillard, 2005). Remillard (2005) emphasizes the importance of the relationship between the teacher and curriculum; she highlights that the curriculum that is actually enacted in a classroom is a complex combination of the formal curricular materials and the intended curricular aims of the teacher. Acknowledging the active roles teachers play in the enacted curriculum focuses attention on ensuring that teachers are well prepared and properly supported to create effective learning environments when they implement new curricula. We cannot expect a new way of conceptualizing science as practice to be successfully enacted in the classroom without actively supporting teachers in implementing science practices. We can design curricula to support students' learning of science practices, but this is not enough—we must understand *how to help teachers* support their students' learning of science practices

Tabak and Radinsky (2015) acknowledge that research on teaching is typically absent in the field of learning sciences and call for exploration in this domain as "a unique target for research on learning" (p. 345). We agree and seek to answer this call. In this paper, we begin to explore this question of how to best help teachers support students' learning of science practices in the classroom by first exploring how teachers currently support their students. In order to effectively help teachers navigate the shift to centering science education on science as a practice, we must first understand their current teaching approaches related to science practices. In the present study, we investigated how teachers supported science practices in the classroom. We focused on the central, overarching, and high-leverage (Reiser, 2013) practice of engaging in argument from evidence and the next most essentially related practices of analyzing and interpreting data and constructing explanations. We further focused on the holistic view of the science practices, which sees all of the science practices as interrelated and interdependent, emphasizing the relationship between practices. We aimed to answer the research question: How do teachers support science practices in their classrooms?

Particularly, we focused on the following mechanisms of support: opportunities to engage in practices (e.g. Driver, Newton, & Osborne, 2000; Cavagentto, 2010); guidance for how to participate in practices (e.g. McNeill, Lizotte, Krajcik, & Marx, 2006; Sandoval & Reiser, 2004); guidance for why science practices are important (Sandoval & Millwood, 2005); and guidance for how the practices are connected to one another (Erduran, 2014). Previous research has found these ways of supporting science practices to be beneficial for students; however, the large majority of these supports and forms of guidance have been material-based tools and interventions. There is much less empirical research on guidance coming from *teachers* to support science practices and even less research on how to help improve teachers' support for these practices in their classrooms. To address this gap in the literature and our research question, we used classroom observations of two teachers to investigate whether teachers simply had students engage in these practices as activities or if they actually provided guidance and supported students so they could learn *how* to approach analyzing and interpreting data, constructing explanations, and engaging in argument from evidence. We further investigated whether teachers discussed with students *why* these are important practices- why it is important as participants of science to analyze data, construct explanations, and use data to support explanations to create strong arguments. We finally examined whether teachers expressed the holistic nature of the practices to their students and made connections between the practices in the classroom to help students see how the practices are interdependent.

Methods

Participants and context

The participants in this study were two sixth grade science teachers, Mrs. Lloyd and Mr. Gordon. Both teachers taught at the same public middle school in a mid-sized, US Midwestern city. Mrs. Lloyd and Mr. Gordon had 13 and 23 years of teaching experience respectively, and they had both been working with the design-based, inquiry CoMPASS physics curriculum (Puntambekar, Stylianou, & Goldstein, 2007) used in this study for seven years. Their previous work with this curriculum is important because their experience entails that the teachers were familiar with ideas of having students justify claims, use data, and write explanations since these practices are embedded and emphasized throughout the curriculum. We chose two teachers in order to conduct a detailed, indepth analysis of the teachers' actions in the classroom over time. We chose to analyze two teachers instead of conducting an individual case study so we could compare differences between teachers. This was a ground-up study through which we wanted to create a good baseline for understanding teachers' support for science practices, as little is know about this question.

The curriculum was a 4-week design-based curriculum in which students learned the physics concepts of force, mechanical advantage, work, and energy by investigating how two different simple machines could help them accomplish challenges with ease. The students investigated how pulleys could help them solve the challenge of lifting a statue of their school mascot up to its pedestal and how incline planes could help them solve the challenge of getting a pool table into the back of a truck. Students worked together in small groups of three or four to conduct experiments using virtual computer simulations and to research the physics of simple machines using the CoMPASS eTextbook. The student-centered and inquiry-based nature of this curriculum positioned the teacher as a facilitator for student learning instead of as an authoritative source of information. The intended role of the teacher was to help facilitate discussion among students, monitor and assess students' conceptual understanding, and (most importantly for the context of this study) guide students to think like scientists and engage in the practice of science.

Data sources

We used classroom observations of the teachers implementing the physics curriculum to investigate how teachers supported science practices through pedagogy in their classrooms. All classes were video- and audio-recorded to analyze how teachers supported and discussed science practices involved in arguing from evidence in their classrooms. We followed Mrs. Lloyd and Mr. Gordon through the entirety of the 4-week unit in one of their science classes to capture how each teacher supported students' learning of science practices throughout the process of generating scientific questions, writing hypotheses, conducting experiments, analyzing and interpreting data, and constructing and defending explanations for final decisions to solve students' challenge. This resulted in seven videos (363 minutes) for Mrs. Lloyd and eight videos (358 minutes) for Mr. Gordon.

Analysis

We used a two-dimensional coding scheme to capture how the teachers supported students to learn science practices in the classroom. We focused on the central, overarching, and high-leverage practice of engaging in argument from evidence and two other essentially related practices: analyzing and interpreting data, and constructing explanations. Given the practical difficulty of distinguishing the practice of constructing scientific explanations and engaging in argument from evidence (Berland & Reiser, 2009), we discuss these two practices together as constructing and defending scientific explanations. This resulted in two science practice codes: 1) analyzing and interpreting data and 2) constructing and defending scientific explanations. We first coded the classroom videos for instances of these two science practices.

We then coded each of these instances for the type of support the teacher provided in order to better understand the quality of *how* teachers supported their students. We used four types of teacher support: a) engaging students in practice, b) guiding students in practice, c) discussing epistemic importance of practice, and d) connecting practices to present science as a holistic process. These support types distinguish whether the teachers were simply having students engage in the practice or if they were actively providing support to help teach students *how* to participate in these practices. These types of support also illustrate whether the teachers were talking with students about why these practices are important in science and whether the teachers were presenting science as a holistic process by making explicit connections between science practices. These support types are not to be considered in a rank order. While simply having students engage in a practice (a) does not provide the guided participation that students may need for learning how to participate in science as a practice, the remaining three types of support (b, c, d) are not necessarily increasing in quality or value. Table 1 illustrates what each of the four types of support codes would look like for the two science practices codes.

We segmented the videos into two-minute intervals for consistency of coding and provision of enough time for development of distinct instructional moves. We coded for the presence or absence of the types of support the teachers provided for the two science practices of focus within each segment. A second researcher helped us code 10% of the videos for each teacher and achieved 88% agreement overall and "substantial" or "almost perfect" kappa values (Stemler, 2001) for all but two of the individual codes. All disagreements were resolved through discussion and the first author coded the remaining videos.

We first quantitatively analyzed the overall patterns of support each teacher provided throughout the unit, considering both science practices under investigation together. To do this, we divided the total frequency of each type of support code by the total number of two-minute segments for each teacher to standardize frequencies across unequal video lengths. It is important to note that each two-minute segment could contain multiple codes if multiple types of support or science practices occurred. We then compared the frequencies of support provided by the two teachers for the practices independent of each other. For this analysis, we conducted a Chi-squared test of homogeneity of proportions to compare the total proportion of each type of support for each science practice. We looked at the practice of analyzing and interpreting data and the practice of constructing and defending scientific explanations as independent practices in order to investigate differences in the support of science practices.

Table 1. Description of types of teacher support codes for both scientific practices investigated

		Type of teacher support codes			
		Engaging students in practice	**Guiding students in practice**	**Discussing epistemic importance of practice**	**Connecting practices to present science as holistic process**
Scientific practice codes	**Analyze and interpret data**	- Giving students opportunities or telling to look for patterns or relationships - Asking what patterns or relationships students see in their data or how one variable affects another	- Pointing to parts of data table or directing attention to specific parts of data table to highlight patterns and/or relationships between variables - Directing students on how to look at data tables to find patterns	- Discussing how scientists look for patterns and relationships in data to understand and make claims about how concepts are related - Discussing purpose of using data to support claims and answer research questions	Making explicit connections between analyzing and interpreting data and: - Previous hypothesis; deciding if hypothesis is supported or not - Research question or hypothesis; deciding where to look in data chart based on question or hypothesis - Understanding data allows you to construct arguments based on that data
	Construct and defend scientific explanations	- Giving students opportunities or telling to provide (write or say) an explanation or argument - Promoting students to explain "why" - Asking open-ended questions that require students to give explanation	- Showing students how to use appropriate data to support claims - Helping/prompting students to look at data to construct explanation/argument - Giving hints about what students should include in an explanation or argument	- Discussing that scientists must justify or prove their statements (explanations) with data/evidence - Discussing the need to convince or persuade others (who may not be familiar with the data) of explanations by using evidence to back up claims	Making explicit connections between an explanation or argument and: - Research question or design challenge you are trying to answer/solve - Previous hypothesis - Understanding data allows you to construct arguments based on that data

Results

Overall patterns of teacher support

To examine the types of support teachers most frequently provided for both science practices, we analyzed the total proportion of each type of support, looking at both of the practices together. Both teachers showed the same pattern in the type of support they provided students to learn science practices in the classroom.

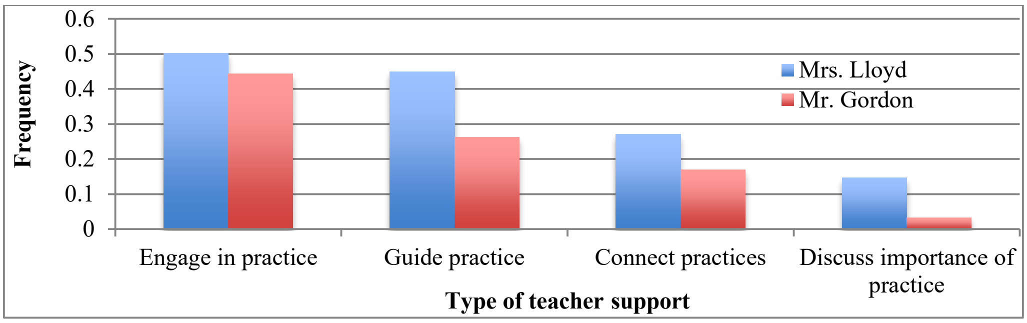

Figure 1. Frequency of different types of support teachers provided overall for both science practices.

Both Mrs. Lloyd and Mr. Gordon's most frequent type of support was *engaging* students in the practice (0.50 and 0.44 respectively). Their second most frequent type of support was *guiding* how to engage in the practice (Mrs. Lloyd = 0.45, Mr. Gordon = 0.26), followed by *connecting practices to present science as a holistic process* (Mrs. Lloyd = 0.27, Mr. Gordon = 0.17). Both teachers least frequently *discussed the epistemic importance* of the practice (Mrs. Lloyd = 0.15, Mr. Gordon = 0.03). This common pattern of the type of support provided for students to learn science practices in the classroom can easily be seen in Figure 1. This figure clearly shows how both teachers (from most frequently to least frequently) engaged, guided, connected, and discussed importance of practices.

Comparisons between teachers

To better understand how the two teachers supported the science practices in their classrooms, we compared how often the teachers provided each type of support to see if there were any differences in their teaching practices. We analyzed the practices independently to further tease apart differences in support for the individual practices (see Table 2). We have organized the following comparisons by the type of teacher support code for clarity and included excerpts of teachers' discourse to help illustrate the support teachers provided.

Table 2. Proportions (and frequencies) of teacher support across the unit and between teacher comparisons

Science Practice	Type of teacher support	Mrs. Lloyd	Mr. Gordon	Z score
Analyzing and interpreting data	Engaging students in practice	0.20 (37)	0.16 (30)	0.90
	Guiding students in practice	0.18 (34)	0.09 (17)	2.55 *
	Discussing epistemic importance of practice	0.06 (12)	0.03 (5)	1.73
	Connecting practices	0.14 (26)	0.08 (14)	1.99 *
Constructing and defending scientific explanations	Engaging students in practice	0.30 (56)	0.28 (51)	0.51
	Guiding students in practice	0.26 (49)	0.17 (31)	2.24 *
	Discussing epistemic importance of practice	0.08 (15)	0.01 (1)	3.64 *
	Connecting practices	0.13 (24)	0.09 (17)	1.13

* $p < .05$

Engaging students in practice

Mrs. Lloyd and Mr. Gordon spent the same proportion of time *engaging* students in the practices of analyzing and interpreting data ($z = 0.90$, $p = .37$) and constructing and defending scientific explanations ($z = 0.51$, $p = .61$). Engaging students in these practices involved giving the opportunity to and prompting students to analyze and interpret their data or construct and defend a scientific explanation based on their experiments in class. Mrs. Lloyd often engaged students in analyzing and interpreting data by asking students to talk to a neighbor about any patterns or relationships they saw in their data and then having students share their ideas with the class. Mr. Gordon similarly engaged students in analyzing and interpreting data by frequently asking students what patterns they saw in their data or telling them to look for these patterns. For example, he said: "What are you guys seeing so far? What kinds of patterns?" and "You should be looking at your data and discussing the patterns that you see." In one example of engaging students in the practice of constructing and defending scientific explanations, Mrs. Lloyd gave students time to write their explanations on a designated page in their notebooks and said: "Ok, so I'm going to let you try this. It says, 'We found that,' well, what did we find…and then back it up here in the second part. So let's work, see what you can do on your own." All of these excerpts show examples of how both teachers gave students opportunities to engage in science practices without necessarily providing any additional instruction or guidance. These instances simply involved students "doing" each practice.

Guiding students in practice

Mrs. Lloyd spent significantly more time than Mr. Gordon *guiding* the practice of analyzing and interpreting data ($z = 2.55$, $p < .05$) and *guiding* the practice of constructing and defending scientific explanations ($z = 2.24$, $p < .05$). The following excerpts exemplify how Mrs. Lloyd guided students on how to participate in both of these practices. The first excerpt illustrates how Mrs. Lloyd guided students to analyze and interpret data. She had asked students to discuss patterns in their data, and in this excerpt, she provided explicit guidance on how they could look at their data charts:

> See if you notice, because you guys tested out, 1, 2, 5 different kinds of pulleys. And as we went down this row [of the data chart], we added more, like, wheels to the pulleys – they became more complex. So do you notice anything as you sort of work your way down the chart? [*Mrs. Lloyd points to a data chart projected on the classroom white board and moves her hand down each column*] Do you see any patterns of things as we added more pulleys to our system?

Instead of only telling students to find patterns in their data, she directed students to consider looking down specific columns in their data chart in order to help them find a meaningful relationship. The second excerpt illustrates how Mrs. Lloyd guided students on constructing and defending scientific explanations. In this example, students practiced constructing an explanation in their notebooks about the relationship between height and potential energy and defending their explanation with data from their experiment:

> We are looking at number two that compares height to potential energy. So for the first part where it says 'We found that,' you should explain what we found, that more height, what happened to potential energy? *[Students: 'Increased']*. It increased. So you talk about that. Then you give data, at least two pieces of data. 'Cause we lifted our mascot to two different heights. So show an example at .1 meters and an example at .2 meters so you have data to back up what you are saying.

Mrs. Lloyd helped students see that they needed to state the relationship they found between height and potential energy, and she explicitly guided them on how to include multiple pieces of data to defend their ideas.

Connecting practices to present science as holistic process

Mrs. Lloyd spent significantly more time than Mr. Gordon *connecting* the practice of analyzing and interpreting data to other science practices (z = 1.99, p < .05), but both teachers provided similar amounts of support for *connecting* the practice of constructing and defending scientific explanations, (z = 1.13, p = 0.26). The following excerpt is representative of how Mrs. Lloyd made connections between analyzing and interpreting data in students' data charts to the overarching challenge and research question students were trying to solve: "Or also think about our challenge. Remember we wanted to increase our mechanical advantage and decrease our force. So what do you notice about mechanical advantage and maybe force. Take a look at those columns as well." Mrs. Lloyd helped students understand how their research question influenced where they should look in their data chart in order to analyze the data with a purpose; Mr. Gordon rarely made such connections. The next excerpt exemplifies the support both teachers provided for making connections to constructing and defending scientific explanations. As students constructed explanations about an experiment, Mr. Gordon had them return to the hypotheses they wrote before the experiment and said: "Look at what you wrote [for the hypothesis], and then go back and look at your data, and then go to your report out and circle whether you were confirmed or not. Then, we found out what? What did we find out about height and PE?" Mr. Gordon explicitly made the connection between the initial hypothesis about a research question, data analysis, and constructing and defending an explanation to help students see that these components were all related and in service to the scientific explanation.

Discussing epistemic importance of practice

Mrs. Lloyd and Mr. Gordon spent similar amounts of time *discussing the epistemic importance* of analyzing and interpreting data (z = 1.73, p = .08), but Mrs. Lloyd spent significantly more time than Mr. Gordon *discussing the epistemic importance* of constructing and defending scientific explanations (z = 3.64, p < .05). Mrs. Lloyd helped students understand the purpose of interpreting data to understand relationships and emphasized the importance of using data to support claims they present to other people; Mr. Gordon offered similar support by discussing the purpose and importance of interpreting data to support students' explanations: "Just having numbers [data] isn't enough. Explaining it means how does one thing affect the other…Did you put enough data to explain why?...Is the data you wrote enough to demonstrate fully your understanding?" Mr. Gordon tried to help students understand the purpose of interpreting data to show how science concepts were related and that including data in their explanation was important to demonstrate their understanding. For constructing and defending scientific explanations, Mrs. Lloyd most often discussed with her students how scientists must convince others of their ideas by constructing strong arguments using data:

> "Now the next question says, 'We know this because.' How do we know this? Notice it says, 'Refer back to your data chart.' So this is one thing as a scientist you have to do. If you tell somebody something, they are gonna say, "So what? Prove it! Prove it to me!" Now do we have data that can prove this? *[Students: 'Yes.']* Yeah, we have a lot of data that can prove this. So when you are reporting out, you have to make sure that you include some data to show that what you are saying really, really is indeed true. It really is indeed true."

In this example, Mrs. Lloyd talked with students about the purpose for why they needed to use data to justify and defend their claims and emphasizes how important this practice was in science in order to prove their statements to other people. Mr. Gordon, on the other hand, rarely discussed this purpose with his students.

Discussion and implications

Given the increasing focus on science as practice in education, it is essential to understand how to help teachers navigate this shift and implement this focus in their classrooms. A first step in this process is assessing the current state of teachers' approaches regarding science practices. The goal of this paper was to investigate how teachers currently support students to learn the high-leverage and most central science practices in the classroom on a daily basis. We first review and discuss the findings from this study with respect to this goal. We then offer implications for supporting teachers as they continue to shift their classes to center on science practices and offer avenues of future research to address yet answered questions.

Overall, both teachers showed the same pattern of supporting students to learn how to analyze and interpret data and how to construct and defend scientific explanations. In order of greatest to least frequency, the teachers engaged students in practices, guided their participation in practices, connected practices, and discussed the importance of practices. While both teachers spent a similar amount of time engaging students in the practices of analyzing and interpreting data and constructing and defending scientific explanations, one teacher spent more time providing students with guidance on how to participate in these science practices, making connections between science practices that conveyed the holistic process of science, and discussing why these practices are important in science. The fact that both teachers in this study most often engaged students in the practices is consistent with previous ideas that teachers are not well prepared to support students to learn science practices in the classroom (Reiser, 2013). While one teacher appeared to use additional support strategies while engaging students, the other teacher most often engaged students with no additional support. These findings suggest that teachers do not necessarily use strategies beyond giving students opportunities to engage in science practices in order to help them learn. Giving students opportunities to participate in practices is an important part of helping students became active participants in the practice of science (Lave & Wenger, 1991), but other researchers suggest that having opportunities and being exposed to these practices is not sufficient for learning how to actually participate in science (Simon, Erduran, Osborne, 2006). Students likely need additional, explicit guidance on how to participate in these practices. While the teachers in the study did provide some guidance for how to analyze data and to construct and defend explanations using that data, the fact that Mrs. Lloyd provided guidance significantly more often than Mr. Gordon suggests that there are important differences, and likely some deficits, in how teachers approach helping their students to learn science practices. These differences suggest that while teachers are capable of providing the types of more explicit support students may need, some teachers, similar to Mr. Gordon, may not know how additional guidance can help students learn how to analyze and interpret data and then to use that data to construct a well-supported explanation.

Some teachers might currently guide students on how to participate in the critical data analysis and explanatory practices of science, but they may not be supporting students to truly understand science as a practice of building and refining knowledge about the world. The teachers in this study did not frequently make connections between science practices that explicitly showed students how the practices work together in service of constructing well-supported arguments to answer a question or solve a problem. Teachers' minimal time spent making connections between science practices in the classroom does not entail that they do not understand these connections themselves; not making connections could reflect a lack of intention to discuss these connections. Additionally, the teachers did not spend much time discussing why the practices are important in the field of science. Sandoval and Millwood (2005) suggest that students may need to understand the purpose behind these science practices in order to truly learn the practice. If students do not understand that the purpose of using data in an argument is to help convince an audience of their claims, they may struggle to construct well-supported arguments and fail to see how this practice is part of the practice of science as a whole. Thus, teachers' support may be inadequate for students to truly learn and understand the practice of science.

The lack of additional support in the classroom provides some insights into where teachers may struggle as they navigate implementing a focus on science practices in their classrooms. It appears that some teachers may not have readily available support strategies for helping students learn science practices. It may also be the case that teachers believe that doing inquiry-based science in the classroom will inherently teach students the practice of science, and they are not aware of the need for additional support strategies. Further, if teachers do have knowledge about strategies to teach science practices, they may be struggling to actually enact these in the classroom. Remillard (2005) emphasizes the complex relationship between what teachers want to implement in the classroom and what they actually implement in practice. From this lens, teachers implementing a new focus on science practices are in the middle of a complex relationship between their own understanding of science practices and strategies to teach these practices, as well as a wealth of additional curricular and environmental factors. Even if teachers' knowledge of science practices and teaching strategies were well-formed, there may be important factors associated with departing from traditional, teacher-centered classroom environments that might hinder the enactment of necessary support for students to learn the practice of science.

In offering implications for this study, it is important to reiterate the teaching experience and context of the two teachers. As mentioned previously, the teachers in this study were experienced science teachers who were familiar with having students justify claims, use data, and write explanations. They were not new to the idea of engaging students in the practice of science and thinking about what the practice of science looks like in the real world. Therefore, even teachers who have had several years of experience implementing innovative, design-based curricula that thoughtfully aimed to teach science practices showed need for further support in their own understanding and teaching of science practices. We should not assume that the process of teaching a curriculum designed to help students learn science practices will necessarily help *teachers learn* how to better support science practices. The idea that "learning by doing" may not be sufficient applies to teaching when we conceptualize teachers as learners. If students may need explicit guidance to learn science practices, why should not teachers also need explicit guidance to learn how to support their students' learning of science practices?

The goal of this paper was to assess the current state of teacher support for science practices in the classroom. The findings from this study suggest that teachers may need additional support and guidance to explore and develop concrete teaching strategies that support their students' learning of science practices. In future work, we aim to investigate what this support for teachers should be and interventions to support teachers as they help students learn the practice of science. In this future research, we will use interviews to investigate how teachers conceptualize science practices since their own understanding may influence how they help their students learn these practices. There is still much work to be done to achieve the goal of centering science education on helping students learn science as a practice, but this study provides important understanding of target areas where we can begin helping teachers to better support science practices education in the classroom.

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