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Multiple Perspectives on Elementary Teachers' Science Identities: A case study

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This narrative case study examined the relationship between teacher identity and elementary science teaching. Teacher identity was described using a modification of Gee's framework incorporating three perspectives: the teachers' self-described identity, the researchers' view of teacher identity, and the students' views of teacher identity. Over the course of one school year, we studied one class of second-grade students receiving science instruction from three different teachers. We found that each teacher had unique identity characteristics. Further, the three perspectives of teacher identity were sometimes in conflict with one another within individual teachers, emphasizing the importance of incorporating multiple perspectives in order to give a complete description of teacher identity. This study has meaningful implications for understanding the ways in which students' perspectives can enrich our understanding of teacher identity.

Keywords: *Elementary science; In-service teacher education; Teacher identity*

Introduction

In classrooms across the USA, teachers are preparing to implement the Next Generation Science Standards ([NGSS] NRC, 2013). These new standards include a number of conceptual shifts, including the integration of science and engineering practices (e.g. experimental design, modeling, argumentation, and problem solving) throughout the standards. This integration facilitates students' and teachers' abilities to *do science* in an authentic manner rather than simply learning about science. But can

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a student *do science* without a scientific identity? Can a teacher? In this study, we examine the science identities of elementary school teachers over the course of one school year. We will incorporate teachers' self-described perspectives, the perspectives of their students, and our own perspectives as researchers and outside observers in our descriptions.

When we consider teachers at the elementary level, they are typically generalists, as opposed to experts in a particular content area, and tend to have especially varied backgrounds, interests, and preparation (Wilson, Floden, & Ferrini-Mundy, 2002). Prior studies (Davis, Petish, & Smithy, 2006; Fulp, 2002) have shown that the variability in *science* preparation for elementary teachers is high. This variability suggests that many elementary teachers feel unprepared to teach science even though they are accountable for their students' performance in science. This increase in accountability for students' performance has resulted in increased attention being paid toward science instruction at the elementary level (Duschl, Schweingruber, & Shouse, 2007; Grigg, Lauko, & Brockaway, 2006).

Understanding the complex interaction of teachers' self-perceptions of their knowledge, skills, and confidence along with the perspectives of others, can help us to better structure professional development efforts to improve science teaching. Given the reported variability in elementary teachers' knowledge and confidence in science and science teaching, we believe that learning more about how teachers identify with science and teaching in general can help to structure our investigation of these complex interactions. Our work explored how several perspectives on science identity and practice overlap and help to further clarify the research communities' understanding of elementary science teaching.

Theoretical Underpinnings

Teacher identity is a multifaceted construct that can be used as a theoretical lens to examine and understand teachers' practices. A teacher's identity is informed by personal influences such as likes and dislikes, strengths, self-efficacy, and interests as well as contextual influences such as factors related to a teacher's community or school (Appleton & Kindt, 2002; Beijaard, Meijer, & Verloop, 2004). Identity can be thought of as what 'kind of person' someone is (Gee, 2000–2001). The kind of person one is shapes the way she interacts with others and the world around her.[1] Given that science preparation and content knowledge likely shape instructional strategies and interactions with students, understanding teachers' scientific identities can help us to describe teaching practices, and interpret students' experiences.

The 'kind of person' one is can be either be described by the person herself or by others observing and interacting with her; therefore, definitions of a 'kind of person' can differ depending on who is providing the description. In a useful approach influencing our study, Sfard and Prusak (2005) coined the terms *actual* and *designated* identity to refer to the actual state of one's identity and the presentation of one's identity in a school setting respectively. These designated identities can be self-narrated, self-designated, or designated by others (i.e. her students and the researcher).

Synthesizing data across these perspectives can help us to better understand a teacher's actual identity. When we consider perspectives of both the self and others, the interconnectedness between a teacher's identity and practice becomes obvious—we cannot describe who she is without observing or interacting with her in action.

Many researchers have examined teachers' identities in general, and science identities in particular, each focusing on different perspectives. In most studies, the designated perspective on teacher identity typically comes from other adults the teacher interacts with (e.g. teacher colleagues, researchers, and administrators) (Beijaard, Verloop, & Vermunt, 2000; Luehmann, 2007; Pedretti, Bencze, Hewitt, Romkey, & Jivraj, 2006). Yet, students with whom teachers interact in the classroom are another potential source of designated identity. To date, little is known about what students' views might reveal concerning teacher identity, and only a few studies (Christidou, 2011; Madden & Wiebe, 2013) include students' perspectives. Researchers can provide the perspective of an 'outsider' who occasionally observes lessons or engages the teacher in discussion when designating a teacher's identity. Students, however, are active participants in a teacher's instruction and, as such, collectively and individually influence a teacher's actions. Students have daily interactions with teachers over extended periods of time and can provide information about many experiences and interactions over the course of an instructional unit or school year. Incorporating students' perspectives into identity descriptions can provide a more complete description and deeper insight as to how this identity shapes instruction.

When considering science instruction, it is important to more carefully define what is meant by science identity. Throughout the literature, we see 'science identity' used in a multitude of ways. From our perspective, one's science identity can incorporate many different facets including, but not limited to, one's identification as: a scientist (i.e. a person who does science), a science teacher (i.e. a person who teaches science), or a science leader (i.e. a person who serves in a science leadership role within her school or community). For the purpose of this study, we will consider teachers who hold scientist, science teacher, or science leader identities to be science-oriented teachers, thus holding science identities.

The majority of research regarding science identity focuses on secondary teachers (Beijaard et al., 2000; Moore, 2008; Pedretti et al., 2006). Numerous studies have found that secondary teachers who hold scientific identities often engage in effective science teaching roles (Brickhouse, 1990; Helms, 1998; Luehmann, 2007; Luehmann & Markowitz, 2007). However, elementary teachers generally have a variety of levels of preparedness, knowledge, and confidence in science and science teaching. Thus, there is likely to be a distinct difference in the science identities between these generalists and more specialized secondary teachers (Davis et al., 2006). The few studies addressing elementary teachers' science identities (Appleton & Kindt, 2002; Mensah, 2011; Siry & Lara, 2012; Varelas, House, & Wenzel, 2005) suggest that elementary science teaching is also influenced by teachers' science identities. For example, Appleton and Kindt (2002) found that primary-level teachers' identification as *scientists* related to their use of reform-based instructional practices, thus

influencing their *science teacher* role. Appleton and Kindt (2002) further noted, 'Those teachers with clear self-perceptions of themselves as teachers and teachers of science more quickly established workable teaching practices in science and were able to progress to thinking about their pupils and the learning in which they were engaging' (p. 59). Siry and Lara (2012) found that co-teaching during science teacher preparation helped teachers to assume science identities and become more willing to take pedagogical risks. With the advent of the NGSS, and the new focus on doing authentic science at all grade levels, it is critical to understand how *elementary* teachers' identities influence their instruction.

Paralleling the paucity of science teacher identity research at the elementary level, the literature on experienced teachers' identities is also sparse. Most of the literature on teacher identity focuses on studies of pre-service and early-career teachers (Appleton & Kindt, 2002; Luehmann, 2007; Pedretti et al., 2006; Proweller & Mitchner, 2004; Settlage, Southerland, Smith, & Ceglie, 2009; Siry & Lara, 2012). These studies provide information about individuals who are in the formative stages of developing their identities as teachers (i.e. transitioning from pre-service to practicing teacher), or specifically as science teachers. However, research has shown that various critical incidents *throughout* an experienced teacher's life and career can influence changes in her identity (Eick & Reed, 2001; Fulton, 2012; Moore, 2008). A few studies (Beijaard et al., 2000; Moore, 2008) have examined the identities of more experienced teachers, revealing differences in teachers who would be considered comparable based on other typical measures (e.g. similar experience levels, pre-service preparation, and professional development). From these studies, we can say that experienced teachers' identities in general, and science identities in particular, influence their instructional practices; and that teacher identity is an ever-changing, dynamic characteristic. These findings highlight the worthiness of better understanding the relationship between identity and practice in more experienced teachers. Our study examined the identities of three experienced elementary teachers, and adds to the teacher identity literature by focusing on a type of teacher rarely studied through this lens.

Our study explored the following question about three second-grade teachers:

> How can the integration of student, researcher, and teacher self-reported perspectives on science identity strengthen our understanding of teachers' identities and practices?

As stated earlier, teacher identity is a broad concept, and many research-based models can be used to describe identity. In an attempt to fully investigate the above question, we used a modified version of the identity theory framework developed by Gee (2000–2001).

Gee's (2000–2001) framework has been used to describe science teacher identity in many prior studies (Carlone & Johnson, 2007; Luehmann, 2007; Settlage et al., 2009). Gee's identity frame uses four broad areas to describe identity: nature, institution, discourse, and affinity. Given the broad framing and resulting overlap in each of the four areas Gee described, researchers have interpreted this framework differently, especially with regard to nature-identity. Gee differentiated between

attributes that are a matter of 'nature' (i.e. genetic) and the 'nature of the person' (influenced by social and physical environments), while acknowledging that *both* were part of one's nature-identity. Some researchers limit their interpretation of nature-identity to race, gender, and other genetic factors, but we see this construct as broader (cf Bullough, 2003). Institutional identity describes one's organizational position within the workplace. Teachers' institutional identities are heavily influenced by school-based factors such as curricula and standards. Evidence for a teacher's discourse identity can be attained through understanding the type of communicative interactions she has with her students, colleagues, and others. Affinity identity is linked to nature and includes affective attributes such as interests, self-efficacy, and confidence. In sum, Gee's framework allows us to provide rich descriptions about teachers and interrelated social interactions considering four critical, but overlapping components of one's identity.

However useful, Gee's framework is focused on 'who a teacher is' rather than 'what a teacher does'. This second element is crucial to understanding how identity translates into practice. To address this, we have incorporated a fifth dimension to Gee's framework: expertise, as defined by Beijaard et al. (2000) framework. Beijaard and colleagues proposed that teacher identity should incorporate both a teachers' perception of herself and her allocation of areas of expertise within her teaching practices. We believe that incorporating expertise from several perspectives can strengthen our descriptions of identity by highlighting the connection between identity and practices—integrating who one *is* with what one *does*.

This research is guided by the belief in the social connectedness of individuals and accounts not only how adults influence each other's behaviors, but also how students respond to adults' actions and reciprocally influence them. While prior studies have included both teacher and researcher perspectives on identity, we have seen few examples that include student perspectives on identity. Students are constantly developing their own identities and interests—students respond to cues received from both their peers in the classroom and from their teachers as to what science-oriented modeling will be rewarded (Carlone, Scott, & Lowder, 2014). This evolving identity-driven behavior in the classroom reciprocally sends important cues to their peers and teachers. The student voice, when combined with the other data sources through this model, can more fully reveal how students are shaped by the teacher's actions, and also how they perceive their teacher. We hope to provide a more complete description of teacher identity for three teachers by using this modification of Gee's framework with the following data sources: classroom observations, teacher interviews, teacher questionnaires, student notebook entries, and student interviews.

Methods

Study Context

This study took place within the context of one second-grade class (Class X) over the course of the 2009–2010 school year. Class X was one of three second-grade classes

in the school, located in an urban/suburban school district in the southeastern USA. The school served children grades K-5 and has a population that is ethnically diverse (approximately 35% African-American, 13% Latina/o, 4% multiracial, 45% Caucasian, and less than 1% Asian or Native American; about 7% of the students have limited English proficiency) and consists of children from a variety of socioeconomic backgrounds (~40% of the students received free or reduced-price lunch). The school used kit-based science curricula. Science kits include a series of 10–20 sequential lessons, classroom investigation materials, and a teacher's guide based on several broad learning goals around a major scientific idea. This school's science curricula consisted of four science kits per year. In second grade, the teachers used a unique model for science instruction in which each teacher 'specialized' in just one kit and rotated through each of the three classes. This study model is based on a Latin square design, which ensures that all classes experience all of the teachers and kits over the timeframe of the study (Montgomery, 2008). During the first quarter of the school year, the students were taught science by their homeroom teacher. During the fourth quarter, all three teachers returned to their homeroom classes and taught the same kit, *STC Changes* (NSRC, 2004). Throughout the entire school year, the students used the same science notebook. Thus, their notebooks captured their interaction with and instruction from three different teachers.

Participants

We explored the identities of the school's three second-grade teachers: Melissa, Janice, and Donna (pseudonyms). Melissa[2] was the homeroom teacher for Class X and taught the *STC Lifecycle of Butterflies* kit during the first quarter and *STC Changes* kit during the fourth quarter (NSRC, 2004). Janice taught Class X during the second quarter and taught the *FOSS Air and Weather* kit (FOSS Project, 2008). Donna taught Class X during the third quarter, and used the *Insights Sound* kit (EDC, 2004).

Class X consisted of 22 students. The science notebook entries for all 22 students were collected and photographed. Four students in the class (2 male, 2 female, 2 Caucasian, 2 Latina/o) were also interviewed once per quarter as part of this study. These four students represented a criterion sample as they were enrolled both in Class X and in the school's after-school program and thus were available for interviews outside of the instructional day (Patton, 2001). Given the extremely limited time allocated to science at this school (30 minutes once per week), we chose to interview only students who were available outside the academic school day in an effort to not take away from their science learning experiences in the classroom. The interviewed students were described by their homeroom teacher (Melissa) as average to above average in terms of science performance. The after-school program was funded by parent-paid tuition, thus it is possible that the students who were interviewed did not represent the range of socioeconomic statuses of the those attending this school.

Study Design

The study employed a narrative case study design, following Class X over the course of the 2009–2010 school year (Creswell, 2003; Stake, 1995; Yin, 2009). The case was bound by the experiences of the students during science lessons over the course of the school year. Issues influencing the case were the three different teachers and the content and curricula those teachers covered (Stake, 1995). A narrative thematic description, using the identity characteristics as the guiding framework (Gee, 2000–2001), of each of the teachers is given to define and describe the issues surrounding the case (Reissman, 2008).

Data Sources

Classroom observations. Classroom observations were conducted by one researcher during science instruction for Class X 11 times during the course of the school year. These included three observations during each of the first three quarters and two during the fourth. For a point of contrast, Janice's homeroom class (Class Y) was also observed twice during the fourth quarter in which all teachers taught the same kit, *STC Changes.* Donna did not invite the researcher into her classroom during the fourth quarter for comparison observations. Science lessons took place once weekly for 30 minutes at a time, with observations scheduled based on classroom and teacher availability.

During observations, the researcher took detailed field notes, paying particular attention to use of science notebooks and teacher–student dialogue. Within 48 hours of completing an observation, field notes were coded using the [name withheld for anonymity] classroom observation protocol (GEES Project, 2010). This protocol included: a synopsis of the lesson, documentation of when and how science notebooks are used, excerpts of notable dialogue, and information regarding lesson introduction and closure. The notable dialogue section allowed us to better understand the teachers' discourse identities. The science notebook use helped us to interpret general teaching strategies and framed our interpretation of instruction as experienced by students.

Teacher interviews & questionnaires. All three of the teachers were interviewed one on one by one researcher during their first two weeks of the quarter in which they taught Class X. These interviews followed a semi-structured format and were recorded digitally and transcribed verbatim. Teachers were asked to describe:

- Their interest in science;
- Their preparation in science (including pre- and in-service training);
- Their science teaching style;
- Whether they saw themselves as scientists or science leaders; and
- Their distribution of expertise across content, pedagogy, and classroom management.

During the fourth quarter, each teacher completed a questionnaire consisting of a five-point Likert-type survey and open-ended items. The survey items asked teachers to identify their level of agreement with statements regarding their science teaching and identities. These items were modeled after items included in the Science Teaching Efficacy Belief Instrument (Enochs & Riggs, 1990) and were selected and modified because of their focus on enjoyment of science teaching and knowledge of strategies for teaching science. No quantitative analysis was made to teachers' responses on survey items due to the small sample size. The open-ended items asked teachers to describe:

- Their science teaching;
- Their thoughts on the rotational science teaching model; and
- Changes in their students over the course of the year.

Science notebooks. The district supported the use of science notebooks, with the teachers provided with three half-days of professional development on their use. Campbell and Fulton's (2003) book was the pedagogical guide for this professional development. Every entry in the science notebooks kept by each of the 22 students in Class X was photographed and catalogued. Themes in the ways each of the three teachers used the notebooks were noted and described in order to understand how students interpreted the teachers' science instruction.

Student interviews. During the last two weeks of each quarter, four students were interviewed one-on-one during the school's after-school program to better understand the students' perspectives on each teacher's identity (see 'Participants'). The students brought their notebooks to use as a reference during the interviews. The students were asked to describe:

- Whether their teacher was a scientist (and why);
- What they learned in each science unit; and
- What entries they put in their science notebooks.

The interviewer took detailed notes and transcribed exact quotations when possible. To ensure that paraphrased notes were accurate representations of interviewee comments, the interviewer read notes aloud and allowed interviewees to edit. It should be noted that the students' perspectives on each teacher over the course of the school year might have changed as a result of experiencing instruction from other teachers. To compensate for these changes, during the fourth quarter, the students were asked to describe any differences they noticed regarding the three teachers along with the three questions listed above.

Analyses

Each data source was uploaded into Atlas.ti® and coded thematically using identity markers described by Gee (2000–2001), and expertise (Beijaard et al., 2000) in

the synthesized identity framework. Some of the data were double or triple coded, illustrating the overlapping nature of identity. The teacher interviews and questionnaires were the primary sources for data from the teachers' own perspective, while the student interviews and classroom observations were the primary sources for student and researcher perspectives. Places in which data from various perspectives conflict are also discussed.

Findings

For each of the three teachers, Melissa, Janice, and Donna, we present a general description along with detailed information about her identity—both science identity and general teacher identity—while teaching science. Our guiding framework was made up of Gee's (2000–2001) four identity markers: nature, institution, discourse, and affinity plus expertise, as defined by Beijaard et al. (2000). We believe that teachers' characteristics related to elementary teaching in general, and science specifically help inform our understanding of teachers' identities. The descriptions of each teacher's identity are presented below along with excerpts of classroom dialogue.

Melissa

At the time of the study, Melissa was in her sixth-year of teaching. She held a BA in Elementary Education, but began college as a Biology major, thus taking several undergraduate courses in science. She previously participated in district-sponsored professional development regarding the use of science kits and notebooks, and participated in a project using graphics in science notebooks to help students understand abstract scientific phenomena.

Nature. Melissa described her science teaching style as hands-on, noting that she dislikes 'talking at' her students. During four of her five observed lessons, Melissa's students engaged in hands-on activities. Over the course of the 2009–2010 school year, Melissa was observed using a variety of strategies including traditional elements such as reading aloud from books and reform-based practices such as use of open-ended student exploration. Typical classroom practices during Melissa's science lessons included: reflection on prior activities, making predictions about change (both growth of caterpillars and phase changes in water), and use of student-directed instruction, resulting in the researcher designating Melissa as science-natured. The students agreed and cited her use of experiments and connecting science to other subject areas during their interviews. Melissa herself was a bit more hesitant in her description of herself as a scientist, reporting that she is growing in that area.

Institution. In terms of institution, Melissa reported that she enjoyed talking with colleagues about science and believed her colleagues viewed her as a science leader. The researcher and students also saw Melissa as a science leader. One student

noted that Melissa 'teaches the other teachers about science'. The researcher reported that Melissa served on various school-wide science-related committees, and served as the resident 'butterfly expert', maintaining the school's butterfly habitat.

Discourse. During one class in the fourth quarter, Melissa was observed capitalizing on a 'teachable moment'. The students were given water in plastic cups that were warmed in the microwave, and asked to observe the water's liquid–gas phase change. One student noted that pressing his hand on top of the cup caused the cup to change shape. At this point, the Melissa re-directed the lesson allowing the entire class to observe another example of phase changes, solid–liquid changes in plastic. An excerpt of the class discussion follows:

T:	What happened to this cup here? (*holds up distorted cup*)
S1:	[Name] changed the shape.
T:	But what if I took a regular cup without hot water and pressed down on it? (*presses on a new cup and it breaks*) I can't get this to change shape the way [Name] did. Why is that?
S2:	Because you pushed too hard.
T:	Well, think about this like the clay you worked with in art class. What is the clay like when you first get it from the teacher?
S3:	It's really hard.
T:	Good. Then what happens when you play with it for a while?
S3:	It gets softer and you can make it into different stuff.
T:	Great. The warmth from your hands helps you to be able to shape the clay. It's like a candle. When we heat candles, they change from solid to liquid. When we added heat to these plastic cups, and [Name] pressed down on the top, the plastic moved a little bit and rolled at the bottom.
S4:	*At* [*Name*] You made the plastic melt?
T:	Well he didn't but the hot water did. So is plastic a solid liquid or gas?
S5:	It's a solid and a liquid!

Though the above discussion illustrates the typical observed science-related interactions, she was also observed leading some teacher-directed discussion, especially when relaying instructions to students. Her students concurred, noting that she was a scientist because, 'she asks questions of herself and others'. On her questionnaire, Melissa also agreed with a statement that it was important for the teacher to provide the right answer for students. This seemed to be in conflict with her typical use student-centric discourse, since during observed class discussions, Melissa often pressed students for understanding rather than simply providing the 'right answer'. This transmission-style of discussion seemed to be most closely related to standard instructional practices such as turning in work, and returning materials, capitalizing on Melissa's elementary teacher identity rather than a science identity.

Affinity. In terms of affinity, Melissa reported that she enjoys science and science teaching. During one observed lesson, Melissa empathized with students who were

anxious to begin caterpillar observations, sharing her own excitement for the topic, which helped the researcher to assign a science-interested affinity identity to Melissa.

Expertise. Regarding expertise, Melissa herself reported feeling most comfortable with science content, followed by pedagogy. The researcher observed her engaging in a variety of pedagogical practices grounded in a strong science content background.

Janice

During the 2009–2010 school year, Janice was in her fourth-year of teaching. She held a BS in Psychology and MEd in Elementary Education with a concentration in Technology. Janice had no prior college-level science content courses, though she did take one science methods course during her teacher preparation program. Additionally, she took part in the school district's optional science kit and science notebook training.

Nature. Janice reported during her interview that she was not comfortable with science, and saw herself as a 'math person'. The students' views on Janice's nature were mixed with one student reporting that Janice was a scientist, 'when she wore her glasses'. The researcher observed Janice using technology in several lessons, and therefore assigned a technology-savvy nature to Janice.

Institution. Janice described her science teaching philosophy as 'trial and error', and added that she 'does what the manual says and tweaks it'. This year was the first time she actually had an opportunity to teach science to second graders, as teaching assignments were different at her school during prior years. On her questionnaire, Janice noted that she can 'fake' a scientist identity for her students, and also that she wanted more practice in the area, self-describing an inexperienced science teacher institutional identity. From observing Janice's teaching, both with Melissa's homeroom class and her own as a comparison, it was clear that her teaching followed a more regular pattern than that of the other two teachers. In most lessons, students began by taking out science notebooks, affixing stickers containing focus questions, and labeling sections for predictions, observations, and conclusions (the district's recommended notebook format). Next, Janice asked some questions and provided some direct content instruction. Guided exploration of hands-on materials would follow, with her lessons typically concluding with a short class discussion and teacher-provided conclusion statement for students to transcribe into their science notebooks. The students described this same pattern in their interviews, resulting in both students' and researcher's perspectives' on Janice's institutional identity as classroom leader.

Discourse. The excerpt below is an example of typical classroom discussion in Janice's class. Janice explained to the students that they would be making parachutes, and wanted students to predict how the parachutes worked before creating their own examples. In an effort to move the lesson forward, Janice cut the discussion short by providing an answer for the students:

T:	What's your prediction?
S1:	When air goes inside the parachute, it helps it float down.
T:	So you think it goes in to the parachute?
S1	nods
T:	Anyone else?
S2:	Air helps [the parachute to] push in . . .
T:	(interrupting) Traps the air in?
S2:	Yeah, traps it and helps it float.
T:	OK class, now we're going to make our parachutes.

Janice's strategies included some discourse, but most of this discourse was driven by her transmitting information to her students, and providing the 'correct' answer. The non-pedagogical instructional practices that Janice used were based on the classroom routines. As a result, the amount of classroom dialogue, both whole class and within small groups, was limited in Janice's classroom. This type of discussion led the researcher to categorize Janice's discourse identity as teacher-led discussion. On her questionnaire, Janice reported not being interested in scientific discussions outside of class, and her students did not mention her discourse identity.

Affinity. The researcher was not able to assign an affinity identity for Janice based on the areas we measured, but Janice described herself as a person uninterested in science on her interview and questionnaire.

Expertise. In terms of her expertise, the students and researcher both found Janice to be strongest in didactics or classroom management, while Janice self-described her greatest area of strength as pedagogy.

Donna

Donna had the longest tenure of the school's second-grade teachers, in her 26th year in the position. She held a BA in Elementary Education and an MEd in Language Arts. Her science preparation included one methods course at the undergraduate level more than two decades prior to the 2009–2010 school year, and no science coursework. She also participated in the district-sponsored science kit and notebook training.

Nature. Donna reported that she had science-related hobbies and that she was personally interested in science and science teaching during her interviews,

self-describing a science nature. When asked about her science teaching methods Donna described, 'Ideally, [I start by] presenting [hands-on activities to the class] and students responding to their hands-on activities'. All of the observed lessons that Donna taught were characterized by an abundance of classroom management and student discipline issues. In one of the three observations, the entire lesson was dedicated to quieting the students, and no science instruction took place at all. In the other two lessons, she began with a focus question, which students put in their science notebooks. Next, she led whole class discussion, followed by some exploration of phenomena and data collection, and concluded by responding to questions in science notebooks. Each of these lessons was cut short due to time and classroom management issues.[3] As a result, only one of the four students assigned a science nature-identity to Donna during their interviews; the researcher was unable to report on her nature identity.

Institution. When asked about her institutional identity, Donna explained that she felt she had expertise in the topic of sound, and that among the second-grade teachers, they were 'science-equals'. Because of her observed teaching, the researcher assigned Donna an extrinsic motivator, and pedagogical modeler institutional identity.

Discourse. Classroom management issues were not the only hindrances to meaning making in science discussions in Donna's classroom. On the day the students created balloon drums, Donna attempted to lead the students in a discussion about the differences in volume and pitch among drums. On the whiteboard in front of her classroom, Donna posted the day's focus question: 'How can we change our drums to create different sounds?' Beneath the question she also posted: 'Pitch = high or low, Volume = loud or soft'. She asked students to think about the question, then to come up and sit at the front of the classroom, where she had balloon drums of a variety of sizes and shapes, and one drum with a suede top (rather than balloon). After explaining how the drums were assembled, Donna asked students to compare the sounds. Students focused on differences in volume making comments such as, 'The drum with the [suede] towel is softer because it's thicker', and 'The balloon vibrates more because its thinner and that makes it louder'. The teacher probed the students about pitch, 'What can we tell about high and low sounds?' The students' responses focused solely on volume. Next, she gave each pair of students a drum, asking them to explore the drums and answer several questions in their notebooks. The students were not observed explaining differences in pitch when working in pairs. After this paired activity, Donna asked the students to share out responses, and the teacher simply accepted all responses, missing an opportunity to demonstrate her science content expertise with effective discourse. For example, the excerpt below describes how Donna's students shared answers to one of the three questions they worked on in pairs:

T: What is the difference between hitting the drum when it's in the air and on your desk?
S1: When you hold the can [in the air] it vibrates louder
S2: It sounds different in the air and the desk
S3: When it's on the desk the vibrations go into the desk instead of in the air.
T: Wow, these are all creative answers.

Rather than guiding the class conversation toward meaning making, Donna simply praised students' responses and told them what to do or record in their notebooks, resorting to traditional transmission style dialogue in her classroom. Both the researcher and students assigned Donna a discourse identity as one who uses a transmission style of discourse to engage her class. Donna herself described an identity of a person interested in talking about science, especially with her son, a biologist.

Affinity. Neither the students nor the researcher were able to weigh in on Donna's affinity-identity, but Donna herself reported having a personal interest in science that has grown over the course of her career.

Expertise. In terms of expertise, the researcher assigned Donna an identity of a weak classroom manager, as her management hindered her ability to teach science. Donna reported on her questionnaire that she was strongest in science content (specifically sound) and pedagogy. The students had fairly mixed opinions ranging from one reporting that Donna taught him how sounds were made and another noting, 'she doesn't do any science, just sound. She's helping us listen better'.

Discussion

Clearly, each of these teachers approached science instruction with the same group of students in a unique way, arising in part from their unique identities. Our identity framework allowed us to explain these differences both in terms of approaches to science teaching and elementary-level teaching in general. We return to the question driving our investigation to explore the utility of our data sources and framework:

> How can the integration of student, researcher, and teacher self-reported perspectives on science identity strengthen our understanding of teachers' identities and practices?

We found that using the teacher-narrated, researcher-, and student-designated identities together allowed us to describe these three teachers' identities in a nuanced way, sometimes revealing conflicts among the perspectives. In some cases, entire categories of a teachers' identity would be overlooked if all three perspectives were not included. For example, neither the researcher nor the students could describe any of Donna's or Janice's affinity identity characteristics; the self-narrated perspective was necessary. Students' perspectives provided a key source of identity in other areas, often deepening the researcher's perspective; they were often in line with that of the researcher. Yet, in some instances, they were not. For example,

several students believed Janice was a scientist, while the researcher did not. Similarly, Donna self-reported a scientist identity while the students and researcher did not. Knowing the ways in which students designate their teachers' identities can help us understand students' perspectives on instruction along with their broader understanding of science and scientists. Studies (e.g. Finson, 2002) show that elementary students often have misconceptions or stereotypical views on science and scientists. With the onset of the NGSS, students will be required to do science more—they must be able to see themselves and their teachers as scientists engaging in science. We believe that their voices should have equal weight to that of the teachers and researchers when describing identity. Nonetheless, prior studies examining teachers' identities or practices have largely neglected this very important voice.

The students' perspective provides insights into how a teacher's identity is translated into her classroom practices and interpreted by the students. Simply by the nature of their respective roles, the student is a true participant in the classroom while the researcher is only an observer. As a participant, students' perceptions of identity also have the opportunity to shape both what is observed by the researcher and a teacher's approach to instruction. Within these three cases, there was an opportunity to see a case where the students, teacher, and researcher were all in general alignment, one where there was some degree of misalignment between the three perspectives, and one where the teacher was not in alignment with either the students or researcher on key facets of identity.

All three data sources were crucial for understanding the implications for classroom instruction based on the varying degrees of alignment between students and teacher. For Melissa, the students' perspective provided additional information to strengthen what was observed and reported by the teacher herself, providing examples of Melissa acting as a scientist during social studies lessons and commenting on her inquisitive nature. The result was that the students, researcher, and teacher seemed to all be 'on the same page' as to the importance of scientific practice and discourse in her classroom. For both Donna and Janice, the students offered different information from the other data sources, resulting in mixed impressions on their teachers as scientists as well as whether or not their teachers taught science at all. These multiple perspectives were necessary to develop a more complete understanding of each of these teachers' identities and interactions between identity and practice. The student perspective provides rich insights into the implications of students within the class either coming to agreement or conflicting with the teachers' own self-perceptions, and what are the classroom practices that seem to emerge in response to teacher and students coming together in the crucible of the classroom.

Experienced Elementary Teachers' Identities

Most of the research on teacher identity focuses on teachers prior to or early on in their careers, and focuses on the initial establishment of an identity as a teacher (or science teacher). However, the identities of individuals who are more experienced also influence their practices (Cooper & Olson, 1996). Our study supported the

findings of prior research that suggests that experienced teachers' who might otherwise be seem similar can have significant differences in terms of their teaching and science identities (Beijaard et al., 2000; Moore, 2008). Donna's case was particularly interesting and surprising. As a 26-year veteran teacher, one might assume that she had mastered classroom management and developed a strong repertoire of pedagogical strategies for delivering science content to her students. Additionally, unlike many elementary teachers, Donna believed that she held a science-oriented identity. While Donna's science-oriented identity evolved over the years, she was limited by her ability to manage her classroom. It is difficult to believe that she did not personally recognize her struggles with classroom management, but seemed unable to address them. She was uncomfortable inviting the researcher into her homeroom class during the fourth quarter, and though she did not explicitly say so, this might have been due to her discomfort managing behavior with these students as well as Melissa's (Class X). Her example highlights the importance of focusing on teachers across the entire experience spectrum and illustrates that content knowledge and years of experience alone do not always result in effective teaching.

Though Melissa and Janice were earlier on in their careers, both had moved beyond the initial two-to-three-year induction phase, where most studies of early career teacher identity focus. At this point in their careers, it is reasonable to assume that their current identity was shaped both by who they are (including their initial professional training) and, just as importantly, by what they do along with the day-to-day interactions they have with their students and colleagues. Melissa leveraged her science-oriented identity throughout her teaching, creating a classroom environment characterized by exploration and student-driven science dialogue. Though Janice did not self-narrate a technology-expert identity (and her students did not designate this identity either), to the researcher, it was clear she used technology expertise to guide her science instruction. Her pedagogy was also heavily shaped by her reliance on developing set classroom routines. It is possible that this pedagogical approach was a result of her low interest and confidence in science. More likely, her classroom management skills found a synergy with her lack of science nature and high comfort level with technological tools to shape an instructional approach that served all of these identity elements. Janice also suggested that she was not interested in having additional professional development in science, and preferred to just continue teaching the unit in the same way. Perhaps she feared that doing either of these things would expose her lack of content knowledge, while teaching on her own would allow her to master a small number of science content ideas independently. For both Melissa and Janice, science identity (or lack thereof) strongly influenced their pedagogical practices. As noted earlier, this contrast was seen during each teacher's instruction with the same class and while both teachers were covering the same unit with their homeroom classes during the fourth quarter. Melissa's willingness to engage in open-ended discourse with her students demonstrated a willingness to move outside of a small set of already mastered science facts and concepts.

Most of the knowledge base on science teacher identity focuses on secondary teachers, yet the few studies in existence suggest that science identity also plays a role

in teachers' practices at the elementary level (Appleton & Kindt, 2002; Varelas et al., 2005). Our study closely examined the science teaching and identities of three experienced elementary teachers interacting with the same class of students. Each teacher approached science in a unique way, and their instruction was tied closely to various facets of their identities. Like many elementary teachers, two of the three teachers in our study, Janice and Donna, had very little academic preparation to teach science, though Donna's personal interest led her to learn more about the subject on her own. In contrast, Melissa had extensive preparation in science. These differences in preparation may have contributed to differences in how each teacher taught science, echoing the findings from prior studies (Appleton & Kindt, 2002, Mensah, 2011; Siry & Lara, 2012; Varelas et al., 2005). Melissa's instruction relied heavily on creating more authentic hands-on experiences, while Janice used more focused and teacher-directed instruction. However, we also see that even with strong knowledge and interest in a subject can be limited by their lack of expertise across various areas of teaching. Though Donna reported strong content knowledge, she was limited by her classroom management skills. The data collected in this study were not able to ascribe causality to observed dynamics in Donna's class. It therefore was not possible to untangle whether poor classroom management masked her science knowledge and interest from her students, or whether the students' disbelief in Donna's ability to teach science resulted in the classroom management issues, or a combination of both. However, it is likely that mismatches between the teacher and students in a teachers expertise and ability to teach science is likely to influence the classroom dynamic.

Connecting identity with practice is critical for understanding the implications of identity on student outcomes and similarly requires a rich dataset from the classroom (from three perspectives) to understand these mechanisms in their fullest. These identity differences also emphasize the variety of backgrounds elementary teachers bring to their careers, its influence on classroom practice, and confirm that more content preparation can lead to more confidence in using reform-based science teaching practices.

Conclusions and Implications

This study provides a unique look at the science identities of three second-grade teachers. Including students' perspectives on teacher identity allowed us to develop richer, more nuanced understanding of how teachers view themselves and how they are viewed by others, including the ways students perceive their practices. The student voice also served to validate and expand on the other teacher- and researcher-centric data sources. Through these three teachers, we saw instances of both alignment and conflict between differing voices on a teacher's identity, all linked to unique approaches to instructional practice in science. The loss of any of our data sources through this lens of identity might have led us to a different understanding of the implications of their current, evolving identity as teachers.

This study focused on the identities of teachers from three perspectives, including that of the students. An interesting avenue for future work would be to follow teachers over a longer period of time to better document the impact of interactions with students and teaching peers on their individual identities. Certainly also of interest is what the impact of these different identities have both on the short-term learning opportunities in science these students have had and what might be the longer term implications on their interest and capacity to pursue science learning. Given the critical importance of student–teacher interactions, another avenue for future work will be to also consider differences in the three perspectives on students' identities—narrated, designated by the teacher, and designated by the researcher, to better understand how students' actions are influenced by interactions with teachers.

Notes

1. We acknowledge that teachers can be both male and female. However, the three teachers in this study, like most elementary teachers, are female, thus *she* and *her* will be used throughout the paper.
2. Melissa was involved with a professional development project led by this paper's second author. She agreed to allow us to conduct this study in her classroom and invited the other teachers at her grade level to join.
3. It should be noted that there were no major classroom management concerns in either Melissa or Janice's lessons with the same class of students.

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