OPPORTUNITIES FOR SENSEMAKING IN SCIENCE FOR STUDENTS WITH DISABILIITIES AND STUDENTS EXPERIENCING DIFFICULTY: A MIXED METHODS STUDY

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The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

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For Maggie J

Who could write a best-selling book about how to be the most supportive partner.

I love you. Alltaf.

And AJ, Sis, and Andy P

Who kept asking if my book was done.

Mommy’s book is finally done. I love you so much.

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ABSTRACT

Each and every student, including students with disabilities, needs to be engaged in high-quality science instruction that moves beyond just memorization and recall of facts and toward critical thinking that supports informed decision making about current issues. There are notable achievement gaps between the science proficiency of students with and without disabilities, and these gaps widen as students progress to higher grade levels. The gaps in achievement may be symptomatic of gaps in opportunities for sensemaking within the general education science classroom. Using an explanatory sequential mixed methods design, the current study explored the relationship between teacher beliefs and opportunities to participate in sensemaking discussions in middle school science classrooms. Integrated findings from the study suggest that teachers' beliefs influenced the opportunities students with disabilities had to participate in sensemaking discussions and, at times, there was a mismatch between teacher beliefs and practice. This study addresses an important gap in the research literature on opportunities students with disabilities have for sensemaking in science classrooms, a grossly under researched area of inquiry.

CHAPTER 1

Introduction

Each and every student, including students with disabilities, needs to be engaged in high-quality science instruction that moves beyond just memorization and recall of facts and toward critical thinking that supports informed decision making about current issues. Decisions about these issues need to be informed by research (Quinn & Cooc, 2015). As a nation, we have seen the impact of decision making during the pandemic (i.e., getting the COVID-19 vaccine vs. not getting the COVID-19 vaccine, wearing a mask vs. not wearing a mask) and how these decisions have either negatively or positively impacted ourselves, our families, and the public. Simply knowing how to define 'pandemic' or 'virus' will not support the decision-making process and, tasks that require only basic knowledge and isolated facts are insufficient to be successful with the Next Generation Science Standards (NGSS) performance expectations (National Research Council, 2014). On the contrary, having a deep understanding of current events and making informed decisions to address issues is critical (National Research Council, 2012). Yet, many Americans do not have the scientific literacy necessary to understand critical issues and make important decisions that have important community, cultural, and societal implications (Hazen & Trefil, 2009). The lack of scientific literacy may be traced back to a lack of opportunities to participate in a high-quality, standards-aligned science education in K-12.

Achievement Gap

Despite the push for improvement in science achievement for all students by researchers and policy makers (e.g., National Research Council, 2013; U.S. Department of Education, 2019), there are still notable achievement gaps between the science proficiency of students with and without disabilities (NGSS Lead States, 2013; U.S. Department of Education, 2019). Furthermore, these gaps widen as students progress to higher grade levels (Hand et al., 2016; Morgan et al., 2016). Many students, not just students with disabilities, experience difficulty learning science (Morgan et al., 2016).

As a nation, students with disabilities are not meeting proficiency in science as compared to their general education peers. The National Assessment of Educational Progress (NAEP) assessment is given to a representative sample of students, including students with disabilities, in both public and private schools in 46 states across the nation (National Center for Education Statistics, 2019). In 2019 only 15% of fourth grade students with disabilities scored proficient on the NAEP science assessment as compared to 39 % of fourth grade students without disabilities who scored proficient or advanced. For eighth grade students with disabilities, 12% scored proficient and 38% of eighth grade students without disabilities scored proficient or advanced (National Center for Education Statistics, 2019).

In addition to the achievement gap occurring nationally, state-wide science assessments are trending similarly. For example, on the 2019 Missouri Assessment Program (MAP) science assessment, only 13.8% of 5th grade students and 10.5% of 8th grade students with disabilities scored proficient or advanced on the state-wide assessment as compared to 42.5% of 5th grade students and 43.7 % of 8th grade students without disabilities (Missouri Department of Elementary and Secondary Education, 2019). Both national and state achievement data highlight the achievement gap between these two groups of students. However, Elliott and Bartlett (2016) state, “perhaps the achievement gaps start with or are exacerbated by gaps in opportunities to learn” (p. 10).

Opportunity Gap

Shifting from thinking about measures of achievement to examining what is occurring within instruction in the general education classroom illustrates a different description of the discrepancy between students with and without disabilities (Flores, 2007). Findings from research suggest the gaps in achievement are largely a result of the inequitable learning opportunities students receive within science (Moss et al., 2008; National Research Council, 2012; Oakes et al., 1990). Oakes and colleagues (1990) go on further to say, “unequal learning opportunities provide some specific clues to how educational practices may help create and perpetuate differences in achievement and participation” (p. 6).

Learning opportunities should include participation in a high-quality education. High quality education has been described by the NGSS as instruction that allows students to develop key skills and an in-depth understanding of key content that will support them in their educational journey and in life (NGSS Lead States, 2013). However, it is important to consider that opportunities for students with disabilities should not be just exposure to content, but rather, providing students with opportunities to actively participate so they can “think, feel, act, and interact powerfully with content knowledge and meaningfully apply that knowledge” (NGSS Lead States, 2013, p. 127). Participation in high-quality science learning can lead to citizens who have the confidence, desire, and ability to continue to learn about critical issues that affect their lives, others, and the communities in which they work and live (National Research Council, 2012).

The National Joint Council on Learning Disabilities (NJCLD) has also put forth recommendations for what they call High Quality Education Standards (HQES). HQES are articulated as rigorous standards in which students utilize higher-order skills that allow them to think deeply about a complex and challenging curriculum (Gartland & Strosnider, 2017), such as the skills required in the NGSS. Having access to a more rigorous curriculum is necessary for students with disabilities to fully participate in school, learning, and their futures (Morocco, 2001). The NJCLD advocate that students with disabilities receive instruction that aligns with HQES and that they possess the capability to be successful with this type of instruction. However, research suggests that students with disabilities are often given less access to demanding science instruction (Weiss et al., 2003), teachers hold low expectations for their learning and performance (Moss et al., 2008), and students with disabilities are underserved in our current educational system (Pak & Parsons, 2020). Elliott and Bartlett (2016) suggest that the inconsistency in providing high-quality instruction and opportunities have a significant impact on performance for students with disabilities.

Equity Gap

Kolonich et al. (2018) defines equitable science classrooms as “spaces where teachers position students as knowledge holders, use students’ cultural knowledge to enrich instruction, and provide students with skills and opportunities to learn science” (p. 693-694). When students with disabilities are given equitable learning opportunities, they can engage in scientific thinking, sensemaking, rigorous science instruction, and can achieve success in science (Lee et al., 2014; Lee & Buxton, 2008). One of the goals of educational equity requires all students be held to rigorous standards (NRC, 2012).

National organizations such as the National Science Teaching Association (NSTA) and the National Science Foundation (NSF) promote equitable instructional opportunities for all students, including students with disabilities (Anderson et al., 1998). National science standards like NGSS were developed for *all* students, including students with disabilities, to have equitable access to more rigorous science instruction (NGSS Lead States, 2013). Additionally, the Every Student Succeeds Act (ESSA; Every Student Succeeds Act, 2015) requires that all students be taught to high academic standards and states a commitment to equal opportunity for all students. Moreover, the NJCLD advocates for the implementation of a high-quality education for all students, including students with disabilities (Gartland & Strosnider, 2017). National organizations, national standards, and current law are all promoting, and in some cases requiring, equitable opportunities to learn for all students, including students with disabilities, but there is currently little research suggesting to what extent these opportunities are or are not occurring within the science classroom for this specific population of students.

Clear statements are made throughout the literature that science learning needs to move beyond rote memorization and recall and that students with disabilities can participate in a more rigorous instruction, but, at the same time, students with disabilities may be experiencing gaps in opportunities within the science classroom. Therefore, it is critical to look beyond simply *if* opportunities to learn are provided to students with disabilities and to look more deeply at what types of opportunities are made available and who is or is not receiving these opportunities (Miller et al., 2018). Classrooms need to be a place where we move beyond simply saying “all students will learn science” and focus on action and implementation supporting participation in a high-quality education from each and every student (Miller et al., 2018). Pak and Parsons (2020) argue that to study instructional practices specific to students with disabilities, gaps in equity must be explicitly examined. Additionally, they argue that systemic and individual biases toward students with disabilities need to be addressed to move toward transformational inclusion practices within more rigorous curricula. To articulate opportunities for equitable science instruction, researchers must make it a priority to delve into classroom discourse, an area where inequities can arise, to identify opportunities and challenges (Pak & Parsons, 2020). The priority then, and the purpose of this study, is to examine equity issues, namely sensemaking opportunities within whole-class discussions, during science instruction for students with disabilities and students experiencing difficulty in science (SWD&D).

CHAPTER 2

Review of the Literature

In Chapter 1, I showed that students with disabilities are not achieving in science as compared to their peers without disabilities and researchers suggest this may be due to the opportunities they are or are not afforded in general education science classrooms. Moreover, national organizations, national standards, and current law are all promoting, and in some cases requiring, equitable opportunities to learn for all students, including SWD&D, justifying the need for examining what is occurring in general education science classrooms for SWD&D.

In this chapter, I will situate and discuss why the current study is rooted in the social constructivism theoretical framework and report on the current literature regarding the teachers' role in providing opportunities for SWD&D to participate in sensemaking through discourse. Knowing how social constructivism connects to science instruction is crucial to understanding the kind of instruction required by the current science standards and the role the teacher plays in affording students opportunities to learn within this kind of instruction. I will begin by discussing social constructivist theory and situate the current study within social constructivism. I then explore the literature related to the teacher's role in social constructivist learning and how their beliefs and interactions have implications for the opportunities SWD&D have within general education classrooms.

Theoretical Framework

Social Constructivism

Lev S. Vygotsky was an early proponent of social constructivism. His research focused on the education of students with disabilities long before disability was defined or codified in federal law. Vygotsky believed in opportunities to learn for all students and worked toward programs of treatment and mediation to support struggling students to maximize their potential. According to Vygotsky,

> Every function in the child's cultural development appears twice: first, on the social level and, later on, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals. (Vygotsky, 1978, p. 57)

The social aspect of social constructivism is highly dependent on the role language plays in cognitive development and how we make sense of the world. Vygotsky (1978) suggests that communication is a pre-requisite to learning and understanding concepts. Furthermore, he suggests that people learn through sensemaking, not simply through facts. At the heart of social constructivism is the idea that knowledge is not just constructed, but rather, co-constructed through social acts and communication. One instructional activity that draws from social constructivism is the use of discussion in the classroom. Moreover, social constructivism has a long history in the field of science education and the idea that knowledge is socially constructed underpins modern perspectives of science education.

Language is a Tool That Mediates Learning. Language is used as a tool to help students make sense of science (Bjørkvold & Blikstad-Balas, 2018). Science education reform has placed increased importance on science discourse (Kelly, 2014). When students participate in science discourse they learn and use new ways of speaking, listening, and interpreting science. In doing so, students become viewed as competent and capable with the others in their classroom community. Additionally, when participating in science discourse, students begin to understand scientific concepts. Said another way, scientific understanding is socially constructed through talk (Lemke, 1990). Moreover, language is critical to sensemaking as it provides opportunities for learners to interact with each other, learn from others' thinking, and negotiate meaning making (Fitzgerald & Palincsar, 2019).

A large body of research exists that suggests a deeper understanding of science is supported by providing students with multiple opportunities to talk in science (e.g. Colley & Windschitl, 2016; Krajcik & McNeill, 2015; Murphy et al., 2017, 2018; Snow, 2015). Furthermore, science talk is at the center of student engagement, construction of knowledge, and scientific literacy (Kelly, 2007; Lemke, 1990, 2004).

Social Environment Effects Learning. In social constructivism, the role of the social environment effects learning (Tudge & Scrimsher, 2003). Developmental processes are stimulated and cognitive growth occurs when humans within the environment interact (Schunk, 2012). In a classroom, these interactions typically take the form of student-student or teacher-student(s) interactions where in the latter, an apprenticeship occurs. It is during these interactions that students transform their prior knowledge and experiences into new understandings.

Individuals learn through their interactions with others (Greeno & Engeström, 2006). Lave and Wegner (1999) called the social environment a "community of practice." Participation in socially mediated learning experiences is important to learning because it can offer a structure that transfers the agency from teachers to students which can, in turn, increase students' contributions and participation during collective sensemaking. Additionally, participating in learning experiences that include social mediation can provide motivation for students to continue to want to participate in intellectually challenging activities and create supports so students can experience, co-construct, and appropriate the knowledge and ideas of members in the group (Englert & Mariage, 2014).

Vygotsky stressed the importance of providing opportunities for students to participate in social forms of cognitive behaviors through activities and by interacting with teachers and peers in the general education classroom. Driver et al. (1994) described this as 'social negotiation', meaning those involved in the social situation continually negotiate, discuss, and revise their thinking about scientific ideas. These social interactions are critical to the co-construction of knowledge.

Social Mediation Decreases Cognitive and Social Barriers. There are a number of studies that suggest that classroom discourse can lead to deeper engagement and reasoning by "students who might not normally be considered able students" (Chapin & O'Connor, 2004; Cobb et al., 1997; Lampert, 2001; Michaels, 2005). Some researchers have suggested that it is important for students with limited experience and exposure to academic language to participate in discussions (Adger et al., 2018; Cocking & Mestre, 1988; Lee, 2001; Moll et al., 1992; Walqui, 2006).

Vygotsky suggests that when learning occurs in a community of practice where social mediation is present, cognitive and social barriers can be decreased or even removed (Englert & Mariage, 2014). Said another way, when students talk with one another and learn from one another, challenges with thinking and interacting can decrease. Furthermore, when science learning includes mediation through instruction that includes discussion, students with disabilities not only benefit but can approach the level of learning of their general education peers (Mastropieri et al., 1998; Scruggs et al., 1993). This is true because classroom discussion has the potential to draw from students with disabilities' strengths while at the same time de-emphasizing their areas of struggle (i.e., reading informational text, expressing their thinking through writing). However, simply providing opportunities for classroom discussion does not guarantee benefits to learning as students with disabilities need support from their teachers to actively construct knowledge (Scruggs & Mastropieri, 1994).

Teachers' Role in Social Constructivism. The use of social mediation shifts the role of the teacher from the knower and giver of all the information to a mediator of student learning. When teachers draw from social constructivism in their instruction, they engage in shared problem solving, create opportunities for discourse, and are responsive to student ideas (Kugelmass, 2007).

In the science classroom, social constructivism allows learners to develop an understanding of science, sensemaking, through interactive learning experiences designed to support exploration of phenomena and ideas (Kugelmass, 2007). These interactive learning experiences are mediated by the teacher during whole-class discussions where students are interacting and participating in discourse with their teacher and peers. One example of this is Guided Inquiry Science Teaching (Palincsar et al., 2000) where students are provided with guided questions to use in a guided inquiry process with additional questions provided by the teacher throughout the process. This approach to co-constructing meaning through observing and interacting with phenomenon and sharing ideas around that phenomenon was investigated with students with disabilities and was found to be effective when students were provided with additional supports throughout the process. Interestingly, the main barrier to this instructional approach was not the theory it draws from but rather the lack of differentiation in expectations for students with disabilities (Collins, 2003; Palincsar, et al., 2000).

Students with disabilities must be provided with appropriate support and practice so they can understand the science content and make sense of the information (Mastropieri & Scruggs, 2001; Mastropieri et al., 1997; Scruggs & Mastropieri, 1994; Therrien et al., 2017). Spies and Xu (2018) provide an instructional sequence that increases access and participation in meaningful academic talk which includes scaffolds to help students with disabilities recall academic vocabulary, recall content knowledge, and present their ideas. When students with disabilities are provided with opportunities to participate in science talk, they are provided with opportunities to be exposed to academic vocabulary, repetition of ideas, an opportunity to verbally rehearse ideas, opportunities to think with others, and opportunities to make connections (Zwiers & Crawford, 2011). Moreover, a meta-analysis of discovery-based instruction suggests that when teachers use feedback and scaffolding, students are supported in attempting to explain their ideas (Alfieri et al., 2011). In terms of discussions, when teachers provide feedback throughout the discussions and use scaffolding to guide students, students can construct their knowledge around scientific concepts. However, there is no research to date examining if and how teachers are providing SWD&D these opportunities within instruction that is based on current science standards.

Next Generation Science Standards

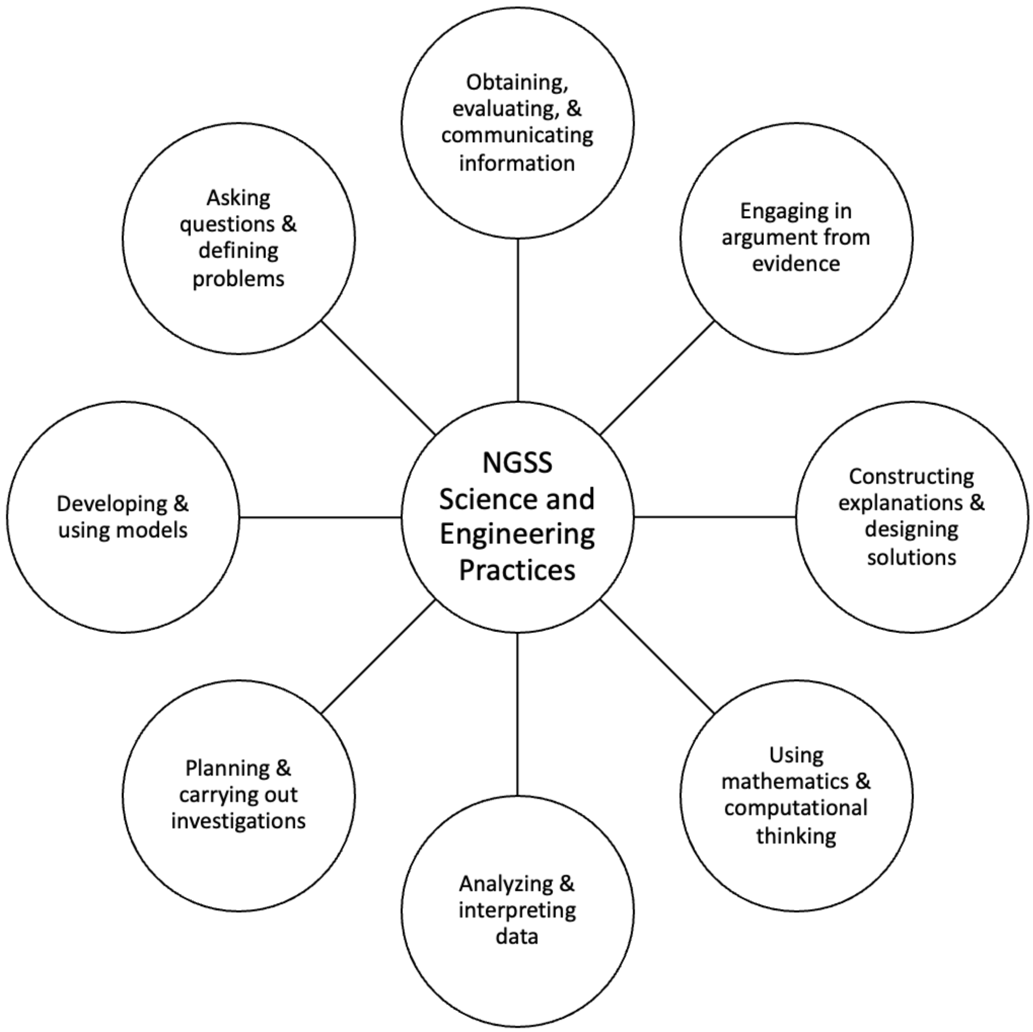
Building on the previous work of *Science for All Americans*, *Benchmarks for Science Literacy* (Americans for the Advancement of Science, 1993), and the National Research Council's (NRC) *National Science Education Standards*, is *A Framework for K-12 Science Education*. From this framework the NGSS were developed and adopted or adapted by states (NGSS Lead States, 2013). The main goal of the framework is

> To ensure that by the end of 12th grade, *all* students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology (NRC, 2012).

The framework puts heavy emphasis on science and engineering practices (SEPs) and a focus on a limited set of cross cutting concepts (CCCs) and disciplinary core ideas (DCIs). Other principles of the framework include the idea that children are born investigators, understanding develops over time, science and engineering require knowledge and practice, a connection to student interest and experiences, and promotion of equity. The NGSS include eight essential SEPs that help students understand how science knowledge is developed. See Figure 1 for an overview of the eight essential NGSS SEPs (NGSS Lead States, 2013).

Figure 1

Next Generation Science Standards Science and Engineering Practices (NGSS Lead States, 2013)



Engaging in any of the eight SEPs involves both sensemaking and language use (NGSS Appendix D, 2013). The NGSS states that all students, including students with disabilities, can learn science even with the increased rigor brought with the new standards and should be engaged in the SEPs. Furthermore, the NGSS state that for students to engage in any of the SEPs they must participate in classroom science discourse (NGSS Lead States, 2013). More research is needed to examine if SWD&D are receiving opportunities in the general education classroom with the type of instruction that includes opportunities for sensemaking, what role the teacher plays in affording these opportunities, and what may be hindering or facilitating these opportunities.

Sensemaking

Odden and Russ (2019) suggest a lack of theoretical clarity around the idea of sensemaking and put forth a theoretical definition drawn from a synthesis of science education research literature. They define sensemaking as “a dynamic process of building or revising an explanation in order to “figure something out”—to ascertain the mechanism underlying a phenomenon in order to resolve a gap or inconsistency in one's understanding” (p. 192). In addition to this definition, Odden and Russ (2019) describe three strands of sensemaking: sensemaking as a stance toward science learning, sensemaking as a cognitive process, and sensemaking as a discourse practice. The third strand, sensemaking as a discourse practice, involves collaborative communication supporting sensemaking. Having regular and meaningful opportunities to engage in sensemaking practices is critical to fostering equitable participation in science. Three principles guide the expansion of meaningful opportunities to learn in science. They include teachers noticing sensemaking repertoires, supporting sensemaking, and engaging diverse sensemaking (Bang et al., 2017). Using these principles can support teachers in creating more equitable opportunities for learning in science, which illuminates the role of the teacher in creating opportunities for students to engage in this kind of learning.

There is a dearth of research focused on how students make sense make in science (Berland et al., 2016; diSessa, 1993; Ford, 2012; Kapon, 2017; Odden & Russ, 2019; Russ et al., 2008). Sensemaking practices are central to student learning and support advancement in students' scientific thinking (National Research Council, 2012; NGSS Lead States, 2013) and with the shift in emphasis from memorizing and reciting facts to utilizing higher-level thinking, sensemaking is a critical practice in science education. Furthermore, participation in sensemaking discussions promote a deeper understanding of complex concepts and promote more thorough reasoning (Resnick et al., 2010). Shifting away from memorization and recall toward supporting student sensemaking is important because it shows that teachers value the diversity of experiences and ideas students bring to the science classroom which can ultimately lead to a more equitable learning environment (Davis et al., 2020; Rosebery et al., 2010).

Sensemaking Supports Student Learning

Sensemaking has implications for students' science achievement and public sensemaking involving dialogue is valuable to learning (Resnick et al., 2010). Cannady et al. (2019) conducted a review of the literature including a dataset involving over 2,500 6th and 8th grade students. The researchers found that scientific sensemaking can predict science content learning gains. This finding was constant even across student characteristics. The review supports the idea that students of varying characteristics can learn and be successful with sensemaking. Furthermore, sensemaking plays a significant role in science content learning across different student groups, including groups who are traditionally systemically excluded in science education (Cannady et al., 2019). Although this study made a clear connection between opportunities for sensemaking and science achievement, it did not specifically focus on the opportunities and achievement of SWD&D.

Engagement in discourse could pose challenges for SWD&D, however, providing opportunities to participate in discourse could help support science learning which also serves as a rich language-learning opportunity for students who might struggle in this area (NRC, 2012). Lee et al. (2014) outline criteria for improving opportunities in science for underrepresented groups, such as students with disabilities. One of these criteria is the opportunity for discourse. The researchers suggest that sensemaking occurs through science discourse and soliciting student ideas and utilizing scaffolds can support equitable participation in discourse. Participating in discourse is especially important for students with disabilities who may have language processing issues (Lee et al., 2014) and science talk can support students in synthesizing scientific evidence (Palincsar, 1998).

Talk and Sensemaking

For students to engage in science practices they must use both sensemaking and language. Language plays a central role in science learning and scientific literacy (Gee, 2015). Participating in scientific discourse is a requirement for engaging in the scientific practices (Lee et al., 2014). Integrating science content with scientific practices through science discussions helps move beyond just memorizing facts and supports students in understanding scientific phenomena in sensemaking (Berland & Reiser, 2009). In science classrooms this can be characterized by groups working to co-construct meaning that generates scientific knowledge (Weick, 1995).

Scientific understanding is socially constructed through talk (Lemke, 1990). According to Lemke (1990), “learning science means learning to talk science” (p.1). Furthermore, the NGSS state that for students to engage in the science practices, they must participate in classroom science discourse (NGSS Lead States, 2013) and 92% of middle school classes engage their students in whole-class discussion at least once per week (Banilower et al., 2013). Participating in science talk is critical to students' sensemaking and learning. If we expect students to develop scientific literacy so they can make decisions about their lives, teachers must engage them in the practices and in science talk, so they have opportunities for sensemaking.

Equitable Opportunities for Sensemaking

The construct of *equity* encompasses both providing all students adequate opportunities to learn science and expecting all students to meet high academic standards (National Research Council, 2012). Providing opportunities within general education science classrooms for students to participate in sensemaking discussions is critical to increased science achievement, equal opportunities, and scientific literacy. Participating in sensemaking has potential to open up science to those who are traditionally excluded (Lowell et al., 2022) thus increasing representation not just in the classroom, but potentially in future science careers as well. However, literature on discourse opportunities suggest that not all students have equal access to the discourse opportunities that support sensemaking (Reinholz & Shah, 2018).

When sensemaking is equitable, student sensemaking is noticed and responded to. Haverly et al. (2020) describe equitable sensemaking in terms of epistemic authority. Epistemic authority can be described as the positioning of experts within the science classroom based on their knowledge and ways of thinking. Often in science classrooms, teachers hold the epistemic authority (Carlone et al., 2011). In whole-class discussions this looks like teachers soliciting participation from students where there is a right answer. Dominance of this type of solicitation does not lead to equitable sensemaking.

Additionally, when teachers share epistemic authority with students, knowledge is co-constructed and sensemaking can occur.

Teachers' Role in Sensemaking Opportunities

Teachers play a critical role in who gets opportunities and what those opportunities look like (Kloser et al., 2019). When teachers are at the center of facilitating student talk, they are therefore at the center of facilitating sensemaking. In their review of student sensemaking across disciplines, Fitzgerald and Palincsar (2019), found several teaching practices that promote sensemaking. Overarching all the practices was engagement in discourse. Within discourse, they highlighted several teaching practices associated with sensemaking including, questioning, making connections, increasing challenge, enculturating students to engage in sensemaking, and differentiating instruction, all of which fall within the role of the teacher. Additionally, in science classrooms, teachers hold power to engage students in the discourse taking place (Kelly, 2007). A teachers' interactions with students have the power to influence student engagement in sensemaking (Mercer et al., 2009; Resnick et al., 2010). Taking this power and using it to create sensemaking opportunities can lead to more equitable participation from students (Aguirre et al., 2013; McLaughlin & Barton, 2013).

If learning occurs in social contexts, then teachers must be cognizant of the social interactions that promote learning. Additionally, teachers must consider the variability present within students in their classrooms, especially when students with disabilities are being included in instruction in the general education science classroom. Because of this, it is imperative to examine classroom discourse, particularly the ways teachers use instructional moves to decide who gets to participate and at what level. Palincsar (1998) suggests that examining discourse in this context allows researchers to see the ways teachers support student participation. Related to supporting student participation, Baxter et al. (2002) reported that a teacher in an inclusive fourth-grade math classroom was often conflicted between involving students with less language and mathematical skills and maintaining a focused discussion. Furthermore, Palincsar et al. (2001) reported that academically struggling students were reluctant to participate in class discussions, and when they do, their participation tends to be meager. Similarly, Wiebe and Kim (2008) analyzed patterns of teacher talk across four inclusive classrooms. The researchers found that students with disabilities were less involved and participated less in whole-group instruction. They concluded that with more attention to the use of involvement strategies, teachers would be able to develop their students' mathematical thinking and communication skills. These studies highlight the vital role that teachers have in ensuring students have opportunities to participate.

Inviting Participation in Sensemaking. One reason talk is so important to science learning is because it helps teachers understand who is not participating (Windschitl et al., 2018). O'Connor et al. (2017) examined the learning outcomes of silent vs. vocal participation from students. They found that in the short-term (over one or two lessons), it is less important to solicit participation from all students but over the course of an entire unit all students should be solicited to participate. This finding becomes critical when designing studies that examine student participation because participation needs to be examined over multiple lessons. In terms of students who are not participating, Windschitl et al. (2018) found that students who are just listening and not contributing to the discussion may not be participating because they feel marginalized or intimidated. In these cases, it is within the teachers' role to figure out why they are not participating and use appropriate strategies to enable participation. Furthermore, when teachers do engage students in more authentic forms of discussion that align with the expectations of the NGSS and promote sensemaking, they tend to solicit participation from "privileged or high-track students" (Applebee et al., 2003). However, Wright and Gotwals (2017) found that giving students opportunities to participate in discussions and share ideas supports sensemaking, especially for students who may not read or write independently.

Research has highlighted many different strategies for supporting more student participation in discussions (Hufferd-Ackles et al., 2004; Michaels et al., 2010). Even so, some students receive more opportunities to participate in the discussions than others (McAfee, 2014; Sadker et al., 2009). Because students who are systemically excluded are often not perceived as capable of doing science, their participation is ignored and not solicited. This has been examined with Indigenous students (Bang & Medin, 2010), students from non-dominant communities (Bang et al., 2012), and culturally and linguistically diverse students (Parsons & Carlone, 2013) but little research has been conducted to examine how and if teachers are soliciting participation from SWD&D specifically. Overall, research suggests that some students are hesitant to participate in discussions and that when teachers do solicit participation, it tends to be from students who are "higher-track" or are not from historically marginalized groups.

Levels of Sensemaking. The level of solicitation a teacher uses with a student can impact the level of sensemaking that occurs. Two teaching practices that support sensemaking are teacher questioning and increasing the challenge within instruction

(Mercer et al., 2009; Resnick et al., 2010). The questions a teacher asks can create an environment that promotes learning and sensemaking (Erdogan & Campbell, 2008) and asking students high-level questions can help them engage in higher-order thinking (Van Booven, 2015). Additionally, using higher cognitive demand questions or solicitations help focus on sensemaking (Windschitl et al., 2018).

Even with increased importance placed on using discourse to make sense of phenomena in the NGSS (NGSS Lead States, 2013), science talk still relies heavily on the teacher directing the discussion often looking for correct or short answers from students (Osborne & Dillon, 2008; Pimentel & McNeill, 2013). In the context of whole-class discussions, this typically entails teachers using a pattern of teacher initiation, student response, and teacher evaluation (IRE; Lemke, 1990). While the IRE pattern has a place in science discussions, it has its limitations as well. Relying heavily on IRE has implications for what is made accessible to learn. Even in a classroom where all students are participating, but are only solicited to provide low-level responses, such as IRE sequences (Cazden, 2001; Mehan, 1979), the students are not provided with opportunities for sensemaking and therefore the instruction is less equitable (Reinholz & Shah, 2018).

The solicitation levels a teacher uses have the power to either provide or hinder opportunities to participate and access the content to be learned (Ernst-Slavit & Pratt, 2017). Chin (2006, 2007) suggests the types of questions teachers ask can influence students' engagement in cognitive processes as they engage in sensemaking, and the role teachers play in questioning significantly affects student learning. Furthermore, the use of questioning allows teachers to modify the cognitive demand within the task (Henningsen & Stein, 1997) with low-level questions removing most of the challenge. Low-level questions do not allow students to use certain cognitive processes (Banilower et al., 2013) such as the cognitive processes necessary for the sensemaking that takes place during science discussions.

Research suggests that high-level reasoning from open-ended questions affords students opportunities to engage beyond just facts and recall and gives students the opportunity to show how and why they know something (Scott et al., 2006; van Zee & Minstrell, 1997). Teachers can raise the cognitive demand by asking high-level questions that allow for deeper thinking (Boyd & Rubin, 2002). Furthermore, using high-level questions with students increases students' use of both expressive and receptive language (Wasik et al., 2006). There is a large body of research that supports the use of open-ended questions to elicit more student thinking versus shorter student responses (Nystrand et al., 2003). When science talk includes opportunities to engage with high-level solicitations, complex understandings are supported and can develop (Lowell et al., 2022).

Windschitl et al. (2012) describe the teachers' role in leading sensemaking discussions as a form of ambitious science teaching. This is because teachers are required to use questioning practices that allow students to make sense of phenomena and teachers work together with students to co-construct knowledge which often removes traditional roles of authority (Benedict-Chambers et al., 2017). When teachers use instructional moves such as open-ended questions and follow-up prompts, more rigorous sensemaking takes place (Colley & Windschitl, 2016). Additionally, empirical evidence suggests that when teachers rely on open-ended prompts sensemaking is enhanced (Black & Wiliam, 1998; Nystrand et al., 2003).

Benedict-Chambers et al. (2017) analyzed the questioning practices of an experienced teacher. The researchers found that the teacher generally asked four types of questions: 1) explication questions, 2) explanation questions, 3) science concept questions, and 4) scientific practice questions. Overall, the questions the teachers asked, while largely teacher-centered, moved students toward instruction that is aligned with current science reform. In another study, Kawalkar and Vijapurkar (2013) examined the types of questions asked by teachers during inquiry or traditional instruction. The researchers found that when teachers supported inquiry-based instruction, such as that required by the NGSS, they used a variety of high-level question types that pushed students thinking as they generated and refined ideas over time. Overall, research suggests that using high-level questions with students can support students through the process of sensemaking in science.

Responding to and Noticing Sensemaking. In addition to how students are solicited to participate and given opportunities to engage in high-level solicitations, it is also important to consider the ways that teachers notice and respond to student ideas. When teachers focus on evaluating student responses, the teacher's authority is reinforced (Lemke, 1990; Mehan, 1979). Alternatively, when teaching is responsive to student ideas, sensemaking can occur (Colley & Windschitl, 2016). The teachers in a study by Tytler and Aranda (2015) rarely responded to students' ideas in a judgmental way, but responded by acknowledging, clarifying, or extending student ideas. Haverly et al. (2020) developed a conceptual model of sensemaking analyzing sensemaking moments. Each moment begins with an initial question or idea, or how the moment is set up by the teacher or students. Following the initial question or idea are responses, or what the teachers or students say or do. To complete the moment, further interactions about the moment occur. This includes ideas that are shared that are elevated, privately discussed, or not taken into consideration for the discussion. These sensemaking moments contribute to both equitable individual and collective sensemaking for students.

The teachers' role is critical in student sensemaking. Teachers hold the power to validate (or not) students' ideas and sensemaking (Bang et al., 2017). The ways in which teachers interact with students are critical to the ways in which students engage in scientific sensemaking (Mercer et al., 2009; Resnick et al., 2010). Furthermore, teachers are responsible for providing opportunities for sensemaking and knowing when and how to respond to this process (Schwarz et al., 2021). The ways in which teachers respond to specific students within the sensemaking opportunities they provide have consequences for systemically excluded groups, such as students with disabilities. Whole-class science discussions provide an opportunity for students to be seen as competent and capable by their peers (Cohen & Lotan, 1997). Schwarz et al. (2021) suggest that equitable and meaningful participation is fostered when teachers notice and respond to student sensemaking in ways that leverage diverse ways of knowing by opening up opportunities.

Hagenah et al. (2018) studied classroom talk patterns that supported student sensemaking. The researchers found that teachers both funneled and focused ideas. When teachers funneled ideas, they privileged science knowledge over student ideas. Science talk that funneled ideas reinforced students recalling facts and getting the "right" answer. When teachers focused ideas, they emphasized student ideas and used them for joint meaning making. The researchers noted that both talk patterns were occurring in classroom studied, however focusing ideas more closely aligns with current science reform and moves away from memorization and disconnected concepts.

Similarly, Lowell et al. (2022) examined discussion types that support student sensemaking. Researchers in this study found that the teacher consistently worked to surface and clarify student ideas during the discussion. Additionally, they uncovered a new talk pattern they call Propose-Probe-Clarify-Restate (PPCR) which supported the teacher in honoring student ideas throughout the discussion. The PPCR talk pattern requires the teacher to stay with one student over multiple turns during a discussion which helps communicate that the students' ideas are valued, and the teacher is looking for more than just a “right answer.” Bang et al. (2012) and Hand and Schoerning (2012) suggest that when teachers work to surface and clarify student ideas, students have space to equitably participate in sensemaking. However, only surfacing and clarifying ideas and the PPCR talk pattern are insufficient in supporting student sensemaking. Other talk moves are necessary to fully support student sensemaking.

Research suggests that the type of instruction where students are solicited to participate, high-level solicitations are used, and student ideas are responded to in a non-evaluative way that further pushes thinking is taking place in science classrooms with students (see Carpenter et al., 2020). However, what is unknown is whether SWD&D are receiving opportunities to participate equitably in this type of instruction in the general education science classroom. One factor that may impact whether teachers engage SWD&D in this type of instruction is their beliefs about learning and about SWD&D.

Teachers’ Beliefs

A consistent definition for teachers' beliefs is difficult to find, however, operating under some assumptions about the construct can aid in understanding the meaning (Fives & Buehl, 2012). Beliefs can be both implicit and explicit. Implicit beliefs are indirect or implied while explicit beliefs are more direct or stated. This distinction becomes important when considering methodologies for understanding teacher beliefs. Implicit beliefs can be measured through observations or planned actions with the support of some inference on the part of the researcher. Explicit beliefs can be measured through asking teachers about their beliefs in a questionnaire or a survey (Fives & Buehl, 2012).

A second assumption about beliefs is they exist along a continuum of stability (Fives & Buehl, 2012). Said another way, one must consider whether beliefs are stable or change over time. Furthermore, beliefs are activated by context demands. This assumption becomes important when considering SWD&D. Do teachers' beliefs change across context or subgroups of students, such as SWD&D? Another assumption is that teacher knowledge and beliefs are interwoven, and beliefs are understood as integrated systems (Churchland & Churchland, 2013). Thus, there are many contextual influences acting upon a teacher's beliefs, such as political or social factors. The final assumptions to consider are the ideas that beliefs filter information and experience, beliefs frame situations and problems, and beliefs guide intention and action. (Fives & Buehl, 2012).

Teachers' beliefs are just a small part of a more complex system (Churchland & Churchland, 2013; Fives & Buehl, 2012). This is important because it helps us frame beliefs as not a single belief but rather a belief system that is influenced by many different factors. Within the belief system, teachers may hold various different beliefs that could make it challenging to examine the ways beliefs influence instruction

(Lombaerts et al., 2009). Research suggests that overall, teachers' beliefs influence their practice including what they do in the classroom and how they interact with students (Cain & Cain, 2012; Khader, 2012; Phipps & Borg, 2009).

Pajares (1992) simplified the construct of beliefs by stating that teachers' beliefs are simply teachers' attitudes about education. Education, according to Pajares, can be broken down into schooling, teaching, learning, and students. Teachers' beliefs about students can cause them to make assumptions about students' abilities (Otero & Nathan, 2008). Students with disabilities and students experiencing difficulty in science and the beliefs that teachers hold about them is important to consider because of the implications the beliefs can have on the opportunities SWD&D are afforded within the general education science classrooms.

Beliefs About Teaching Science to Students with Disabilities

Empirical evidence suggests that teachers' beliefs about disability impact the way they work with students with disabilities including the instructional interactions that take place and the level of dialogue teachers use with these students (Jordan et al., 1993; Jordan & Stanovich, 2003; Stanovich & Jordan, 1998). Assessing teachers' beliefs can show whether teachers are more likely to engage students with disabilities in more cognitively demanding instruction (Kiely et al., 2015) such as the instruction required by the NGSS. Research suggests that students with disabilities are often given less access to demanding science instruction (Weiss et al., 2003) and teachers hold low expectations for their learning and performance (Cook et al. 2000; Moss et al., 2008; Pettit, 2011) which can affect their outcomes (Jussim & Harber, 2005). Whether or not a student with a disability gets the support they need in the classroom connects to the teacher's beliefs (Kiely et al., 2015).

Beliefs about groups of students, including students with disabilities, are reflected in science teaching (Kiely et al., 2015). Cameron and Cook (2013) found that general education teachers' expectations of students depended upon the obviousness of the student's disability. Teachers held expectations for students with mild disabilities related to classroom behavior, academic performance, and self-confidence and teacher expectations for students with more severe disabilities were mainly focused on social development with little concern for academic performance. Kiely et al. (2015) noted this as a challenge for studying teacher beliefs regarding students with disabilities. Because disability is not homogeneous and teachers have different expectations and actions dependent upon the disability of the student, it is difficult to describe teacher beliefs. Like holding low expectations, teachers tend to underestimate the performance of students with disabilities (Hurwitz et al., 2007). Additionally, when curriculum becomes more challenging, teachers tend to struggle in preparing students with disabilities to engage in this more challenging curriculum (Deshler et al., 2008). This is important because a more challenging curriculum includes more opportunities for sensemaking. Teachers' beliefs about disability and whether it is fixed or malleable is also a contributing factor and may impact the opportunities made available to students with disabilities in general education science classrooms. Regarding students with disabilities, de Boer et al. (2011) found that teachers hold either neutral or negative views about including students with disabilities in the general education classroom. Cook et al. (2000) found that when general education teachers were asked to identify students of concern, they disproportionately identified students with disabilities. Considering beliefs in terms of the ways teachers interact with students during discussions is important because beliefs play a critical role in the way teachers frame instructional activities (Nespor, 1987; Pajares, 1992; Torff & Warburton, 2005). Furthermore, because of the contextual influences acting upon teachers' beliefs (Fives & Buehl, 2012), the way a science teacher expresses how they approach instruction may be different than what occurs in practice (Buehl & Beck, 2015; Louca et al., 2004; Tobin & McRobbie, 1997).

Rationale

The NGSS calls for all students to participate in the SEPs which all require discourse that promotes sensemaking. Furthermore, the NGSS state that all students, including students with disabilities, are capable of sensemaking in science and stress the criticality of providing students with equitable opportunities to engage with the practices and sensemaking in science classrooms (Lee et al., 2014). Research suggests the teacher plays a critical role in who gets opportunities for sensemaking and what those opportunities look like in general education science classrooms. The literature is clear that this kind of instruction is present in science classrooms across the nation. However, there is little research to suggest if and to what level this kind of instruction is happening for SWD&D who receive their science instruction in the general education classroom. We cannot say *science for all* if we do not know if *all* includes SWD&D.

Students with disabilities are not performing well in the content area of science (Missouri Department of Elementary and Secondary Education, 2019; National Center for Education Statistics, 2019; NGSS Lead States, 2013; U.S. Department of Education, 2019) especially when compared to their peers without disabilities. It is possible their poor performance may be due in part to lack of equitable opportunities for sensemaking (Moss et al., 2008; National Research Council, 2012; Oakes et al., 1990). Perhaps, this population of students is not achieving in science because of inequitable opportunities within the science classroom. This is important because the ways in which SWD&D are solicited to participate and the opportunities they have may impact their opportunities to learn science. When opportunities to learn science are impacted, opportunities to develop necessary skills to increase scientific literacy are also impacted. Beginning the path to exploring SWD&D' opportunities in science and what relationship teachers' beliefs have to the opportunities afforded to SWD&D requires examining what is happening in the general education classroom since this is the context in which this instruction is taking place (Banilower et al., 2013; Cawley et al., 2002).

Therefore, the purpose of this study is to explore equity issues, namely sensemaking opportunities during whole-class discussions, for SWD&D. The following research questions will be addressed:

Quant RQ1: Is there a significant relationship between disability status and opportunities to participate in sensemaking discussions?

Qual RQ2: What are teachers' beliefs about SWD&D and opportunities for sensemaking in science?

MIXED RQ3: What is the relationship between teacher beliefs about SWD&D and opportunities to participate in sensemaking discussions?

CHAPTER 3

Methods

In Chapter 2, I situated the current study in social constructivist theory and reported on current sensemaking literature. This chapter will describe the research methodology and methods used in the current study including a detailed description of the study design, recruitment and participants, quantitative and qualitative measures, quantitative and qualitative data collection procedures, data analysis, and integration. The purpose of the current study was to explore equity issues in opportunities students had for sensemaking in general education middle school science classrooms. This was explored by conducting classroom observations of whole-class science discussions and semi-structured interviews with the teachers of these classrooms.

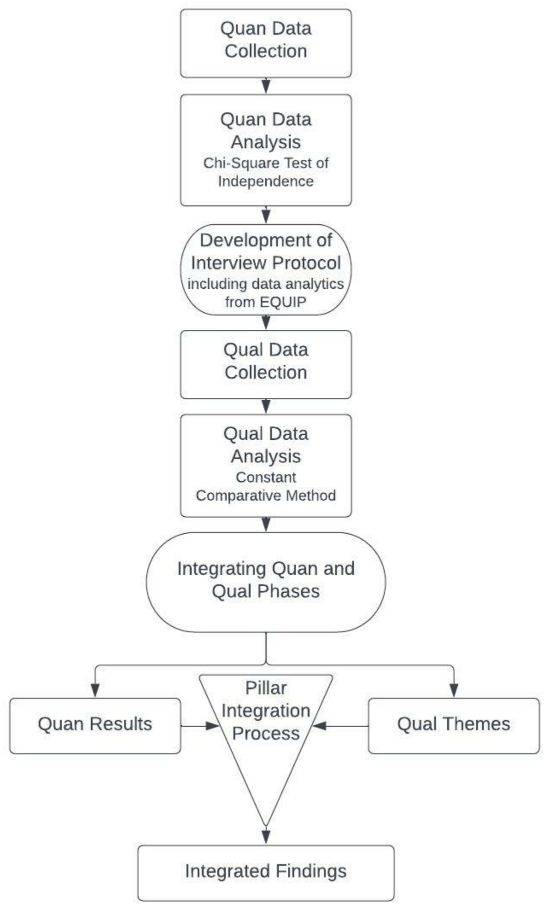
Research Design

While strictly quantitative methodologies rooted in positivism have been considered the gold standard in special education research (Cook & Cook, 2013; What Works Clearinghouse, 2020), qualitative methodologies are growing in use and provide meaningful contributions to evidence-based research in special education (Kozleski, 2017). Mixed methods, which includes elements of both quantitative and qualitative methodologies, is a growing research methodology being utilized in the field of education (Ivankova et al., 2006). A recent review of the 15 top-ranked journals in Special Education from 2007 to 2019 found only 43 articles reporting the use of mixed methods (Corr et al., 2020). However, Corr and colleagues (2020) argue that "By equally weighting methods or privileging qualitatively derived knowledge in mixed methods research, special education researchers can answer more complex, diverse research questions grounded in real-world contexts" (p. 8). Furthermore, Reinholz and Shah (2018) argue that quantitative methods alone are not enough to examine equity issues and that mixed methods are necessary to examine this construct within classroom instruction. The current study aimed to extend the previous work conducted in special education by innovatively using mixed methods to examine opportunity gaps in middle school science classrooms.

The current study used an explanatory sequential mixed methods design (Figure 2; Creswell & Plano Clark, 2018). This research design was well suited for the current study because it allowed for the use of qualitative data to further explain the quantitative results. Reinholz and Shah (2018) suggest that quantitative or qualitative analyses alone are not enough to capture all the nuances of equity issues and the use of an integrated, mixed methods approach better allows for different types of data to be collected for examining multiple perspectives. The quantitative data provided a baseline of participation patterns that lead to further explanations of the participation patterns via the qualitative data. Said another way, the design allowed for a further explanation of the quantitative results.

Figure 2

Explanatory Sequential Study Design



Recruitment and Teacher Participants

Approval from the University's Institutional Review Board (IRB) was obtained prior to beginning the study (IRB: 2038723). See Appendix A for the IRB approval letter. For recruitment, a recruitment script (see Appendix B) was read by the principal investigator to all teachers participating in a larger professional development project focused on using scaffolding to support diverse learners in general education science, English language arts, and special education classrooms. A Google Form which included the recruitment script (description of the study, what teachers would be asked to do, compensation for time and completing study requirements, how participation would benefit the field, and contact information for questions regarding the study) was sent to the teachers via email after the recruitment script was read. If teachers were interested in participating, they were asked to give consent, via the Google Form, which included space for their name and the date. Five teachers responded with interest, however, two of them could not participate due to district constraints. The inclusion criteria were: (a) teachers held a current teaching license and certificate, (b) teachers taught middle school general education science, and (c) there was at least one student with a disability in the teachers' class. Teachers who consented to participate and met the inclusion criteria received an email thanking them for their consent to participate and a separate consent form to send to all parents of students in the class. Given the exploratory nature of the study and the use of a mixed methods design, a small number of teacher participants were selected. The small number allowed for an in-depth exploration of the teachers' instruction and beliefs.

Teacher participants ($n = 3$) represented two districts in the Midwest. District 1 educates approximately 1,790 students, 9.55% of which were identified as students with disabilities. District 2 educates approximately 776 students, 10.05% of which were identified as students with disabilities. All three teacher participants teach at the middle school level. Teacher A and Teacher C described their school as a small rural school with small class sizes. Teacher B described her school as rural but rapidly growing into more of a suburban school. Teacher B and Teacher C were both part of the larger professional development project mentioned previously, and Teacher A learned about the study from

Teacher C, expressed an interest in participating, and met all the inclusion criteria. See Table 1 for detailed teacher participant demographics.

Table 1

Demographic Information of Teacher Participants

Teacher	District	Experience	Grade	Highest Degree Earned	Race	Gender
A	2	3	8	MEd Admin	white	female
B	1	24	6	MEd English (TESOL)	white	female
C	2	14	7	MEd (C&I)	white	female

Classroom Instruction

The teachers' general education classrooms included students with and without disabilities/difficulties who all accessed the general education science curriculum through an inclusive classroom model. Across all three units, the teachers used whole-class discussions as a way for students to engage in sensemaking. Students in all three classrooms were engaged in instruction, asked and responded to questions, and seemed genuinely interested in the unit topics.

Teacher A. Teacher A's unit focused on human body systems. She began by focusing on each system independently and spent time helping students make sense of the organs and the functions of the organs. Then, she began to ask students to think about the ways the body systems worked together. She did this by using modeling and helping the students make connections to their own bodies. She stated that this content was critical because so many of her students had future plans to be nurses or work in the medical field.

Teacher B. Teacher B's unit focused on climate change. She focused heavily on getting her students to make claims backed by evidence and reasoning. Teacher B wanted her students to be able to decide if evidence was valid and think about ways they could cope with future climate change. In addition to the goal of making claims backed by evidence and reasoning, she wanted her students to be able to write about their claims in a way that they could be shared with and critiqued by other students.

Teacher C. Teacher C's unit focused on Earth science and the human body. Specifically, she focused on climate and how the climate effects human body systems. Her goals for students were to have a deeper understanding of climate including the why and how of climate, how geographic features affect climate, how people affect climate, and how the climate affects people.

Student Demographics

Each teacher participant sent home a recruitment letter with their students several weeks before the start of their units. Two of the three teachers used an opt-out option (See Appendix C) where parents and students were able to opt their child out of the study if they preferred. If a parent/student chose not to opt-out, their student participated in the study. One teacher used an opt-in option (See Appendix D), at the request of her administrator, where each parent signed a consent form giving consent for the student to participate. Student participants (n = 52) across all three classrooms included students with and without disabilities. Twenty five percent (n = 13) of the student participants were students with identified disabilities including: specific learning disability (n = 2), speech or language impairment (n = 1), intellectual disability (n = 2), students experiencing difficulty in science (n = 8). Teacher participants were asked to give a rationale for why they identified a student as experiencing difficulty in science and gave the following reasons: trouble focusing, executive functioning issues, low work ethic, low self-esteem, poor reading and writing skills, low attendance, task completion issues, and suspected undiagnosed dyslexia. See Table 2 for percentage of consenting SWD&D in each class.

Table 2

Demographic Information of Students Within Teachers' Classes

Teacher	Consenting Students	Consenting SWD&D (% in class)
A	17	5(29%)
B	12	4 (33%)
C	23	4 (17%)
TOTAL	52	13 (25%)

Teacher and Student Demographic Data Collection

Google Forms were sent to each teacher after completion of their unit that asked for student first name, student last name, grade level, and disability status, including type of disability or description of difficulty, if applicable. Teachers were asked to sort their students into only one of three status categories: 1) students with a disability, 2) students experiencing difficulty in science, and 3) students without a disability or difficulty. Students with a disability were students who received special education services because they have an identified disability documented in an Individualized Education Program. Students experiencing difficulty in science were identified by teachers as students who did not receive special education services and were not identified as having a disability but were considered a student who struggles in science. Given that a focus of the study was on teacher's beliefs (i.e., who struggles and how that influences her interactions in the classroom) and would be elaborated on as a part of the data collection, the teachers were not provided with a definition of who a student is that struggles in science. Students could only be identified in one disability status category. This decision was made based on formative assessments, summative assessments, or observations made during science instruction.

So as to not assume that just because a student has a disability they would experience difficulty in science, the principal investigator asked teachers a short follow-up question. Regarding students with disabilities, teachers were asked the following question, "Of the students you identified as having an IEP/student WITH a disability, would you say any of them DID NOT struggle in science? So, if they didn't have an IEP, would you have put them in the "student experiencing difficulty in science category?" One teacher said, "They all struggled in science. I would have put them into the "student experiencing difficulties" category. None of them can accomplish the tasks independently." Another teacher said, [student name] didn't necessarily struggle in science. He did really well in my class. There were some concepts that were tough for him but otherwise he did very well. And he did have an IEP." The last teacher did not have any consenting students with identified disabilities so the follow-up question did not apply.

It was important that teachers were the ones identifying students experiencing difficulty in science as they were the ones who spent the most time interacting with this group of students. According to Reinholz and Shah (2018) it is logical to have teachers identify the students experiencing difficulty in science because the ways teachers identify students are what drives the interactions they have with students and ultimately the opportunities they receive. Students who did not receive special education services and were not identified as having a disability or were not identified by their teacher as experiencing difficulty in science, were identified as students without a disability/difficulty. Student names were only used for identification purposes in the video observation and were de-identified after observational data was coded. It is important to note that information about students' identification in one of these three categories were collected after the observations. The purpose of collecting this information after the observation was to remove any performance bias (Cook, 2014) that could have occurred during the observation.

Quantitative Phase

Quantitative Measure

The Equity QUantified in Participation (EQUIP) tool (Reinholz & Shah, 2018) was used to create data analytics of the quantitative data. EQUIP allows for easy tracking of student participation patterns through a customizable observation tool. EQUIP is designed to be used during real-time observations but can also be used with video data of classroom instruction (D. Reinholz, personal communication, September 25, 2020). EQUIP uses equity analytics to use quantitative data related to equity as a complement to more comprehensive qualitative equity data. Reinholz and Shah (2018) state that equity analytics are a method for analyzing classroom discourse for patterns of equity and inequity. See Figure 3 for an example of the contributions equity analytic and Figure 4 and example of equity ratio equity analytic, which are developed from inputting the quantitative data into the EQUIP tool. In Figure 3, contributions are the number of contributions for each code across disability status. In looking at the equity analytics for contributions, you can see which groups contributed more to which type of solicitation. In Figure 4, equity ratios are the ratio of actual participation to expected participation. For example, if 20% of the classroom is composed of SWD&D, then it would be expected that 20% of the high-level questions are asked to this group of students. Reinholz and Shah (2018) describe equality as a waypoint toward equity. To increase the equity in classrooms, aiming for an equity ratio of 1 for marginalized groups, such as SWD&D, is suggested.

Figure 3

Example of the Contributions Equity Analytic from EQUIP

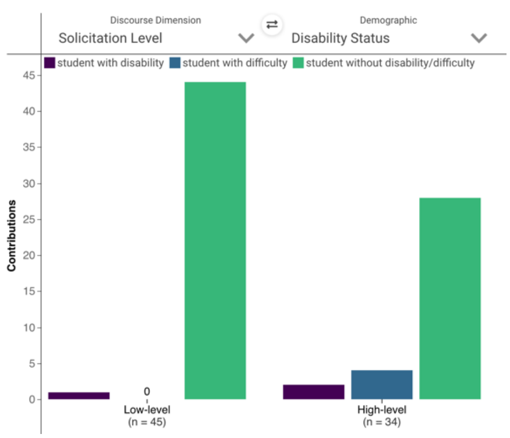
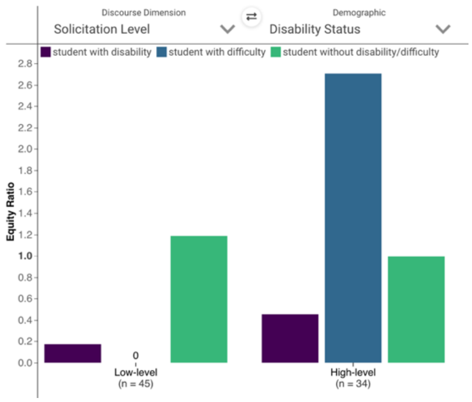


Figure 4

Example of the Equity Ratio Equity Analytic from EQUIP



Quantitative Data Collection Procedures

The goal of the quantitative phase was to examine equity issues by comparing the opportunities SWD&D received during whole-group science discussions to their peers without disabilities. Classroom observations of each lesson within one whole unit were conducted with all three teachers. A total of 23 lessons were observed across all three teacher participants. Due to COVID-19 restrictions at the time of data collection, district administration were not allowing outside visitors. Because physical access to the classrooms was not possible to conduct the observations, the observations were conducted using Swivl technology. The Swivl is a device with a connected iPad and microphones. The device sits on a stand in the classroom and records video through the iPad and audio through the microphone the teacher wears. Additionally, the Swivl tracks the teacher as she moves around the room to capture audio and video in motion. Each teacher received individual training on how to use the Swivl technology prior to the start of their observations. Prior to the start of the unit, each teacher did a practice session with the Swivl. The principal investigator accessed the recordings and provided each teacher with feedback on placement of the Swivl stand and general technical troubleshooting.

Each day the teacher taught a lesson from their unit, they set up the Swivl to record both audio and video of their lessons. The video recordings were stored on a secure, password-protected app that was accessed remotely by the principal investigator. Teacher A recorded 7 lessons, Teacher B recorded 9 lessons, and Teacher C recorded 8 lessons. The lessons ranged in length from 19 minutes to 44 minutes with the average lesson lasting 31 minutes and 31 seconds.

Quantitative Data Organization

Audio from each observation was transcribed using Otter.ai and then checked for accuracy by the principal investigator. After all transcriptions were accurate, a total of 26 whole-class discussions were identified. Whole-class discussions were identified as instructional time where the whole-class was involved in a discussion. Students and the teacher needed to be actively discussing science content, phenomena, or a lab. Whole-class discussions did not include independent work or small group work. The start and end times of each whole-class discussion were noted on a spreadsheet and the transcriptions for the whole-class discussions were bolded within the transcripts. There were 7 whole-class discussions identified for Teacher A, 10 whole-class discussions identified for Teacher B, and 9 whole-class discussions identified for Teacher C.

Within each whole-class discussion, a total of 428 participation sequences were identified. For this study, participation sequences served as the unit of analysis. A participation sequence is any string of utterances from a single student. Meaning, if a new student contributes, a new string of utterances or participation sequence begins. If a student speaks back and forth with the teacher and no other student contributes, then this is all considered part of one string of utterances or participation sequence. Several instances were not counted as a participation sequence including non-consenting or unidentifiable students speaking, multiple students answering or choral responses, and side conversations or turn and talks. Only whole-class discussion with *visible participation* was included as a participation sequence. The purpose for these decisions was it allowed for the data to be disaggregated by disability status, it showed multiple back-and-forth moves which reflect discussion moves teachers use in classroom instruction, and segmenting when a new student speaks made it easier to identify new participation sequences. Separating the data in this way allowed for each participation sequence to be more easily coded.

Quantitative Data Coding

The participation sequences were coded among three dimensions related to teacher behavior: solicitation method (Engle, 2012; Sadker et al., 2009; Tanner, 2013), solicitation level (Boyd & Rubin, 2002; Braaten & Windschitl, 2011; Henningsen & Stein, 1997), and teacher evaluation (Engle, 2012; Schoenfeld, 1988). The term solicitation was used instead of questioning in the case that a teacher used a statement, rather than a question, to elicit more information from a student ("explain why you think that" or "tell me more about that").

Solicitation method refers to who—whether the teacher or student—initiates a new participation sequence. Solicitation method was coded as either *teacher-initiated* or *student-initiated*. Teacher-initiated meant the teacher was responsible for picking who gets to talk either by calling the student's name or by pointing to them or using a gesture to let them know it was their turn to participate. An example from the data of a solicitation method coded as teacher-initiated is:

Teacher: And what is it predicting is going to be the cause of those rise in temperatures? [student name].

Student: Greenhouse gases.

Teacher: Greenhouse gases are produced by things like factories and cars, and burning fossil fuels.

Student-initiated meant the student initiates the contribution and starts speaking unsolicited without their name being called or receiving a gesture from the teacher to signal it was their turn to participate. An example from the data of a solicitation method coded as student-initiated is:

Teacher: It's conditions over a day. Yep. So yeah, if you want to say that it's just snowing that day. However, if this cat was stranded in the North Pole, then it might be climate, but the odds of a cat like that being stranded in the North Pole are pretty slim.

Student: Let's hope it's in Minnesota.

Teacher: Yeah, let's hope it's in Minnesota. Alright. Alright, last one.

Solicitation level refers to the level of cognitive demand (low or high) of the solicitation the student was given to engage. Solicitation level was coded as either *low* or *high*. A low-level solicitation is a lower cognitive demand solicitation that typically focuses on memorization to recall facts, listing things or describing vocabulary, or procedural tasks that follow specific steps or a formula. These low-level solicitations generally have a "right answer" that can be given in just a few words and do not reveal much about a students' thinking. Sometimes these solicitations follow the Initiate-

Response-Evaluate (IRE) pattern and do not typically push students to do anything with their thinking or ideas. An example from the data of a solicitation level coded as low is:

> **Teacher:** So what is the function of the digestive system? To…
>
> **Student:** To digest the food?
>
> **Teacher:** Okay, so what does digest mean?
>
> **Student:** So we use the food for our body…

A high-level solicitation asks students to share what is happening and explain their thinking. Teachers' follow-up on students' thinking and ask students to elaborate or comment on others' thoughts and the teacher's questions are responsive to student ideas. With a high-level solicitation students are pushed to do something with their thinking or ideas. There is typically no "right answer". An example from the data of a solicitation level coded as high is:

> **Teacher:** Okay. Let's think about this last one. I'm gonna read the question again. Okay. Why do you think it's important to make climate models? Why is it important that we have these models to make these predictions? Why is this important? Anybody willing to read your answer to me?
>
> **Student:** I will!
>
> **Teacher:** You sure? [student name], what do you think?
>
> **Student:** (starts to read)...
>
> **Student:** It is important to make climate models so we can predict the future in our climate.
>
> **Teacher:** I like it.

Teacher evaluation refers to if/how the teacher evaluated the student's ideas. Teacher evaluation was coded as *yes* or *no*. A code of yes meant the teacher simply stated yes/no or right/wrong without any further inquiry into the idea or the teacher praises the response. An example from the data of a teacher evaluation coded as yes is:

> **Teacher:** All right, go ahead, [student name], why could this possibly be weather?
>
> **Student:** This could be weather because I don't think it would be like sunny every single day.
>
> **Teacher:** Okay. Yeah. Or if it's just showing you that day's conditions, it could be weather, like, maybe it's sunny that day, but tomorrow, they'll be clouds or something. Good. Alright. Uh. Whoops. Hold on. What do you think?
>
> **Student:** Climate.
>
> **Teacher:** Good.

A code of no meant the teacher left the correctness of the student's idea open allowing for other students to evaluate the idea or restates or reformulates the student's idea so other students have an opportunity to hear or understand the idea. Or the teacher made the student's idea public without explicitly evaluating the idea. An example from the data of a teacher evaluation coded as no is:

> **Teacher:** What do you guys think?
>
> **Student:** It's basically a solar cooker.
>
> **Teacher:** It's basically a solar cooker. Can you explain that?
>
> **Student:** The heat from the sunrise transforms through the glass and then all of the interior just soaks up the heat and all the heat….

In this example, the teacher did not respond or evaluate the student's response and left it open for another student to participate in the discussion.

Intercoder Agreement

A doctoral student familiar with the current study was recruited to double code participation sequences from each teacher. All coding was done on a spreadsheet prior to entering codes into the EQUIP tool. Prior to coding, the doctoral student received training that covered a description of how participation sequences were identified as well as descriptions, definitions, examples, and keywords for each dimension and code. All this information was developed and contained in a codebook. See Appendix E for the quantitative codebook.

A random sample of participation sequences were used for practice during the training where the doctoral student and principal investigator would code the sample of segments independently then discuss their individual coding and any discrepancies. This helped the two coders come to a mutual understanding of the codes before independently coding 20% of the participation sequences. Additionally, the discussion helped refine the codebook.

Following practice, 20% of the participation sequences (not used in practice) from each teacher were randomly selected. The doctoral student had access to the transcribed participation sequences on an excel spreadsheet with drop down menus for each dimension and code. Additionally, she had access to the classroom observation videos to use during coding.

Intercoder agreement was calculated using Cohen's Kappa. Cohen's Kappa was calculated rather than percent agreement to consider the possibility of the agreement occurring by chance. Interpretation of Cohen's Kappa was as follows: 0.21-0.40 indicated fair agreement, 0.41-0.60 indicated moderate agreement, 0.61-0.80 indicated substantial agreement, 0.81-0.99 indicated near-perfect agreement, and 1 indicated a perfect agreement (Cohen, 1960). See Table 3 for Cohen's Kappa results. Solicitation level for Teacher B yielded only a fair agreement because the two coders had a misunderstanding of the original solicitation used by the teacher. However, after meeting to discuss, the two coders came to consensus on the solicitation level for Teacher B. Discrepancies were discussed and final codes for the participation sequences in question were agreed upon resulting in a final Kappa result of $\kappa = 1$ for each teacher and each dimension. The codebook was clarified, and the principal investigator coded the remainder of the participation sequences. Once all the participation sequences were coded on a spreadsheet, they were entered into the EQUIP tool to create the data analytics used later in the qualitative phase. Additionally, frequency counts for each dimension and code were totaled and included in a contingency table.

Table 3

Cohen's Kappa for Intercoder Agreement

	Solicitation Method	Solicitation Level	Teacher Evaluation
Teacher A	$\kappa =$ .879	$\kappa =$ .602	$\kappa =$ .726
Teacher B	$\kappa =$ 1	$\kappa =$ .234	$\kappa =$ .595
Teacher C	$\kappa =$ .862	$\kappa =$ .846	$\kappa =$ .625

Quantitative Data Analysis

A Chi-square Test of Independence was conducted to examine whether Disability Status and Solicitation Method, Disability Status and Solicitation Level, and Disability Status and Teacher Evaluation were independent. There were 2 levels in Disability Status: SWD&D and students without disabilities/difficulties. There were two levels in Solicitation Method: teacher-initiated and student-initiated, two levels in Solicitation Level: low and high, and two levels in Teacher Evaluation: yes and no.

The assumption of adequate cell size was assessed, which requires all cells to have expected values greater than zero and 80% of cells to have expected values of at least five (McHugh, 2013). All cells had expected values greater than zero, indicating the first assumption was met. A total of 100.00% of the cells had expected frequencies of at least five, indicating the second assumption was met.

Qualitative Phase

Qualitative Measure

Interview Protocol Development. The interview protocol used in this study was adapted from two established interview protocols. The first protocol focused on eliciting teachers' beliefs about conducting talk in science classrooms (Pimentel & McNeill, 2013). The second protocol focused on using data analytics to support reflection on student participation in whole-group discussions (Reinholz et al., 2019). The adapted protocol used in this study was vetted by experts in both the field of special education and science education and refined based on their expert feedback. See Appendix F for the final semi-structured interview protocol.

The interview protocol started by asking teachers to describe their school, the unit they taught, and anything that was different due to the pandemic. Additionally, the teachers were asked to explain how they identified students who were experiencing difficulty in science. The next part of the interview focused on using discourse in science with SWD&D and asked questions focused on discussion in general, equity in participation, discussion and SWD&D, and challenges with discussion that may be attributed to COVID-19.

The last part of the interview asked teachers to look at data analytics from the EQUIP tool. Questions in this part of the interview asked teachers to examine the data analytics and probed teachers to reflect on their instruction and think about whether they attributed the data to something about the learning context, something about their instruction, something about the student, or something else. Teachers were asked to predict and interpret the data analytics focused on student participation patterns between the disability statuses (student with a disability and student without disability). Teachers were provided with data analytics that included contributions for each dimension and equity ratios for each dimension. Each interview lasted approximately 75 minutes.

Qualitative Data Collection Procedures

In the qualitative phase, data was collected through semi-structured interviews (Merriam & Tisdell, 2016). All interviews were conducted by the principal investigator in August 2021, individually, with each of the teacher participants.

Interview Transcripts

The semi-structured interviews were conducted via Zoom (Zoom Video Communications, Inc., 2020) and were automatically audio recorded and transcribed verbatim. The principal investigator checked the accuracy of each transcription in each of the transcripts. Once the transcripts were checked for accuracy, they were uploaded to MAXQDA 2020 (VERBI Software, 2019) for further analysis.

Qualitative Data Analysis

Qualitative data analysis was conducted using the constant comparative method (Glaser, 1965). The principal investigator read through each of the interview transcripts. Open coding (Merriam & Tisdell, 2016) was used to code segments within each transcript. Lincoln and Guba (1985) describe a segment of data as any segment that reveals information relevant to the study and any segment that is small enough to stand on its own and be interpretable out of context. The principal investigator read through the interview transcripts several more times applying the codes and adding new codes to segments of data. The principal investigator then used the MAXQDA software to retrieve segments under each code to read through and ensure they still fit under the assigned code. If a segment did not fit any longer, it was recoded. In addition to codes, the principal investigator jotted memos that included reflective notes about what was being learned from the data, insights, and preliminary interpretations.

Next, the principal investigator conducted axial coding (Charmaz, 2014) The goal for this phase of analysis was to capture recurring patterns that cut across all the data. During this step, codes were combined, grouped, removed, and themes were identified. A codebook with descriptions of all codes was developed. See Appendix G for the qualitative codebook.

To establish credibility of the coding scheme, the principal investigator and a graduate student engaged in the process of intercoder agreement (Campbell et al., 2013). The principal investigator conducted a meeting to train the same graduate student who coded the quantitative data on coding the qualitative data. The training session lasted approximately one hour. The training reviewed the purpose of the study, described the spreadsheet to be used for double coding, described the codebook with all codes and code descriptions, and provided practice with a random selection of segments. Twenty percent of the segments (n = 86) were randomly selected to be double coded by the graduate student.

After the principal investigator and the graduate student independently coded 20% of the segments, they met to discuss the process. During the first meeting, questions about the codes and code descriptions were discussed and the codes were clarified. The principal investigator and the graduate student then went back to the qualitative data to re-code the segments. The principal investigator consulted with a qualitative researcher to confirm the analysis plan. During the second meeting, codes were compared. The two coders had 84% intercoder agreement. Agreement was defined as assigning the same code to a segment. Next, any segment that had disagreements were discussed to ensure the way the segments were coded made sense considering the data and a final code was agreed upon for all segments with disagreements. Finally, emergent themes were identified from the codes. Quotes chosen to represent the themes were selected because they supported and represented the themes across all three teachers.

Internal Validity and Trustworthiness

Brantlinger (2005) describes different methods for triangulating qualitative research to increase internal validity, three of which are relevant to the current study, including the use of multiple methods, multiple sources of data, and multiple investigators. Using three different forms of triangulation increased the credibility and internal validity of the qualitative phase of the current study (Patton, 2015).

In the current study, multiple methods were used. For the qualitative phase, interview data was collected and checked against observations that occurred in the quantitative phase. Specifically, the qualitative data collected from the interviews confirmed and expanded upon the quantitative data from the observations. Additionally, multiple sources of data were used. Conducting follow-up interviews with the same participants that were observed allowed for data to be collected through different times and different places. Finally, multiple investigators were used for coding the data. Two researchers independently analyzed the same qualitative data and came together to compare their analysis.

Guba (1981) described four criteria for trustworthiness including credibility, transferability, dependability, and confirmability. To increase the trustworthiness of the current study, provisions from each of the criteria were implemented. First, for credibility, the principal investigator adopted appropriate and well recognized research methods. In the context of the current study which examines equity issues, mixed methods were an appropriate approach. According to Klingner and Boardman (2011) issues such as inequitable learning opportunities, which is explored in the current study, can be partially explained, by the failure to conduct different types of research, such as mixed methods. Additionally, because two of the teacher participants were part of a larger research project the principal investigator was involved in for two and half years prior to the current study, a familiarity and rapport with the participants was established. Describing the principal investigator's positionality helps add to the credibility of the current study. Due to the current study being a dissertation study, peer scrutiny was built-in to the research process through the proposal process as well as regular meetings through the process with members of the dissertation committee. Finally, the principal investigator led member checks with the teacher participants of the data interpretations.

Regarding transferability, the principal investigator provided an in-depth context of the study as well as a description of what the current study sought to examine. This allowed comparisons to be made. Dependability was increased by using overlapping methods, or a mixed methods approach, where integration occurred at different points throughout the study. Additionally, providing a detailed description of the methods and procedures used in the current study contributed to the dependability. Finally, regarding confirmability, the principal investigator used strategies for triangulation to reduce investigator bias. Stating the principal investigator's positionality also lent itself to the conformability of the current study. Finally, in Chapter 5, the principal investigator will describe limitations of the current study, which will also contribute to the confirmability.

Positionality

Stating the principal investigator's positionality in terms of this study is a way to engage in critical self-reflection and provide transparency about assumptions and biases that may affect the study (Holmes, 2020). First, the principal investigator's experiences with the topic explored will be acknowledged. Then, a description of how these experiences influence the principal investigator's interpretation will be articulated.

The principal investigator's experience as a former general education teacher who taught science to SWD&D and current special education doctoral student inspired her to explore this topic. The principal investigator views disability through a radical model where intersectionality is identified, difference is embraced, and the right to a high-quality and equitable learning opportunity is viewed as a social justice issue. It is a combination of the principal investigator's past experiences and views of disability through a radical model that influenced the interpretation of the data. For example, the principal investigator noticed when teachers attributed data from the observations to the ability of the SWD&D in their class or when students with disabilities were not given the same opportunities as students without disabilities/difficulties.

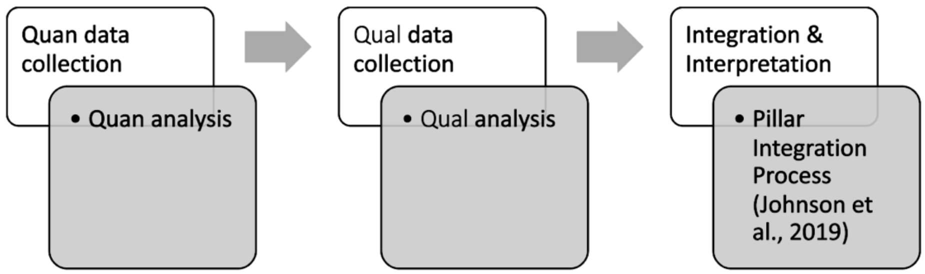
The principal investigator worked with two of the three teacher participants as part of a larger research project focused on professional development around scaffolding for diverse learners during the time of the observations. However, at the time of the interviews, the principal investigator was not involved with the teacher participants as part of the larger research project. The experience with the two teacher participants during the larger research project gave the principal investigator additional context about the teachers and their students which influenced the interpretation of the data in the current study.

Integration of Quantitative and Qualitative Data

Creswell et al. (2011) describes options for systematically integrating quantitative and qualitative data including merging and connecting. In the current study the data was merged by creating a joint display where both quantitative and qualitative data were combined and displayed together. The data in the current study was connected by first analyzing the quantitative data collected during observations and using those results in the qualitative data collection during the interviews when teachers reflected and interpreted the quantitative data. See Figure 5 for a visual of the flow of the current study leading to integration. The goal is to synthesize the quantitative and qualitative data together.

Figure 5

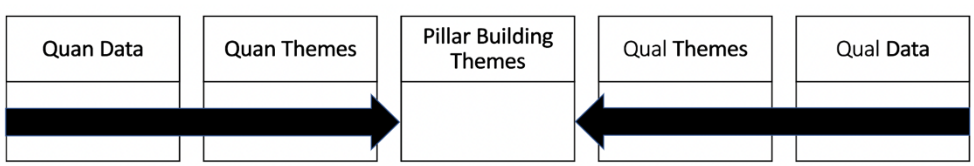
Flow Leading to Integration



The principal investigator used the four steps of the Pillar Integration Process (PIP; Johnson et al., 2019) to systematically integrate the quantitative and qualitative data: 1) listing, 2) matching, 3) checking, and 4) pillar-building. See Figure 6 for a generic representation of the PIP template used. The PIP was chosen for integration because it allowed for a rigorous and systematic way to integrate the quantitative and qualitative data, which is key to a true mixed methods study.

Figure 6

Generic Representation of the Pillar Integration Process



For the first step (listing), quantitative data from the quantitative phase was listed under the quant data column. Observed and expected values from each of the dimensions and codes were listed as well as the number of participation sequences. Then, themes from thinking about what these results meant were listed in the next column called quant themes. For the second step (matching), the principal investigator matched qualitative codes and quotes from the qualitative analysis with data in the quant columns. For example, solicitation method and corresponding chi-square statistics were listed in the quant columns and that was matched with the qualitative code “teacher initiating participation” along with quotes that were coded with that code in the qualitative code column. Then, the principal investigator read through all the codes and quotes in that row and documented emerging themes in the qual theme column. For the third step (checking), the principal investigator checked to ensure accuracy of the matches across all rows. Checking for accuracy included checking across all four columns to ensure they were complete and the data in each column matched. Finally, for the last step (pillar theme building), the principal investigator participated in pillar building. In this step, quantitative data and qualitative data in the same row were compared, contrasted, and synthesized and themes were identified and documented in this column. The principal investigator used the themes that emerged to build possible explanations for the findings. The synthesis and subsequent themes were documented in the pillar column of the PIP.

CHAPTER 4

Findings

The purpose of this study was to examine equity issues in sensemaking opportunities made available to SWD&D in general education science classrooms. Classroom observations of science units occurred with each of the teachers in the current study, from which whole-class discussions and participation sequences were identified. A chi-square test of independence was conducted to compare the sensemaking opportunities made available to SWD&D to students without disabilities/difficulties for sensemaking during whole-class discussions. A semi-structured interview protocol was developed based on the results of the chi-square test. In this chapter, I present the results, beginning with quantitative results from the observations and chi-square test, followed by a discussion of the qualitative findings that emerged from the semi-structured interviews. Additionally, I present findings from the integration of the quantitative and qualitative results.

Quantitative Results

During the Spring semester of 2021, classroom observations of science units were conducted with each of the teachers (n = 3) in the current study. A total of 26 whole-class discussions were identified from the units. A total of 428 participation sequences were identified from the whole-class discussions. Participation sequences were the unit of analysis in the current study and were coded among three dimensions of teacher behavior: 1) solicitation method, 2) solicitation level, and 3) teacher evaluation.

Research Question 1: Is there a significant relationship between disability status and opportunities to participate in sensemaking discussions?

To address research question one, three separate chi-square tests of independence were conducted to examine whether disability status and each dimension of teacher behavior (solicitation method, solicitation level, and teacher evaluation) were independent. There were two levels in disability status: SWD&D and students without disabilities/difficulties. There were two levels in each dimension of teacher behavior: solicitation method/teacher-initiated and student-initiated, solicitation level/low and high, and teacher evaluation/yes and no.

Assumptions

The assumption of adequate cell size was assessed, which requires all cells to have expected values greater than zero and 80% of cells to have expected values of at least five (McHugh, 2013). All cells had expected values greater than zero, indicating the first assumption was met. A total of 100.00% of the cells had expected frequencies of at least five, indicating the second assumption was met.

Solicitation Method Results

A chi-square test of independence was performed to examine the relationship between disability status and solicitation method. The relationship between these variables was significant, $\chi^2(1, N = 52) = 14.89$, $p < .001$, suggesting that disability status and solicitation method are related to one another. Table 4 presents the results of the chi-square test for solicitation method.

Table 4

Solicitation Method Observed and Expected Frequencies

Disability Status	Solicitation Method: Teacher-initiated	Solicitation Method: Student-initiated	χ^2	*df*	*p*
SWD&D	29[16.81]	23[35.19]	14.89	1	< .001
Students without disabilities/difficulties	109[121.19]	266[253.81]			

Note. Values formatted as Observed[Expected].

The results suggest that SWD&D initiated their own participation *less* than expected. In contrast, SWD&D were solicited to participate by their teacher *more* than expected.

Solicitation Level Results

A chi-square test of independence was performed to examine the relationship between disability status and solicitation level. The relationship between these variables was significant based on an alpha value of .05, $\chi^2(1, N = 52) = 10.36$, $p = .001$, suggesting that disability status and solicitation level are related to one another. Table 5 presents the results of the chi-square test for solicitation level.

Table 5

Solicitation Level Observed and Expected Frequencies

	Solicitation Level				
Disability Status	Low	High	χ^2	*df*	*p*
SWD&D	30[39.33]	22[12.67]	10.36	1	.001
Students without disabilities/difficulties	293[283.67]	82[91.33]			

Note. Values formatted as Observed[Expected].

The results suggest that SWD&D received low-level solicitations *less* than expected. In contrast, SWD&D received high-level solicitations *more* than expected.

Teacher Evaluation Results

A chi-square test of independence was performed to examine the relationship between disability status and teacher evaluation. The relationship between these variables was not significant .05, $\chi^2(1, N = 52) = 0.01$, $p = .903$, suggesting that disability status and teacher evaluation could be independent of one another. This implies the observed frequencies were not significantly different than the expected frequencies. Table 6 presents the results of the chi-square test for teacher evaluation.

Table 6

Teacher Evaluation Observed and Expected Frequencies

	Teacher Evaluation				
Disability Status	Yes	No	χ^2	*df*	*p*
SWD&D	38[38.36]	14[13.64]	0.01	1	.903
Students without disabilities/difficulties	277[276.64]	98[98.36]			

Note. Values formatted as Observed[Expected].

The results suggest that SWD&D received *about the same* opportunities as would be expected.

Qualitative Findings

During the Summer of 2021, teacher participants ($n = 3$) participated in semi-structured interviews. The interview protocol was adapted from two existing interview protocols (Pimentel & McNeill, 2013; Reinholz et al., 2019), which elicited information about teachers' beliefs about conducting talk in science classrooms and asked teachers to view data analytics from the quantitative phase to interpret and reflect on the data. The use of the qualitative phase allowed for insights derived from teachers' perceptions, observations, and reflections that the quantitative data alone may have failed to capture. Several themes emerged illustrating teachers' beliefs about SWD&D and the opportunities teachers provided for sensemaking in science.

Research Question 2: What are teachers' beliefs about SWD&D and opportunities for sensemaking in science?

Teachers believe SWD&D need to participate in sensemaking discussions. Teachers believe in using talk in the science classroom to encourage the sensemaking process for SWD&D. They noted several benefits. First, teachers noted that giving students opportunities to share their thinking by talking about science supports students who may struggle with sharing their thinking by writing about science. Specifically, teachers described that their SWD&D struggle to write about what they are making sense of in science, but they are easily able to talk about it and that writing often becomes a barrier for sharing their ideas and thoughts. One teacher said,

> It's so important to encourage them [SWD&D] to talk because special ed kids, more than anybody, and kids that are struggling, more than anybody, they are more afraid to be a part of the discussion and put themselves out there and things like that…

Teachers noted that SWD&D may struggle to share their ideas through writing and benefit from talking about science content to share their ideas. One teacher said,

> I have a lot of kids who can process the information up here, but it can't get out of their hand...I like to describe that they can answer my questions verbally and have discussions, but they can't get it on paper and so we're not seeing what they really know if it's all about writing...and so it gives them an opportunity to express themselves in a way that people can understand.

Teachers also noted that talk supports SWD&D as they process scientific ideas. Moreover, talk allows students the opportunity to process their ideas aloud which aids in sensemaking. One teacher said, “And I think that with discussions and with talking it just helps them kind of like process the information, a little bit better.”

Teachers are also seeing the benefits of the collaborative process of discussion. They noted the ways that talk supported collective sensemaking by allowing students to learn with and from each other's sensemaking. One teacher said,

> So, it helps them to communicate their thoughts and better understand the concepts, because you know they're talking through it together and two heads are usually better than one. But those discussions help bring new ideas and thoughts to the table.

From what the teachers said, the use of discussion helps support students in collaboratively sharing their sensemaking when sharing ideas through writing may be a challenge and it helps provide a way for them to process their ideas.

Teachers believe SWD&D need confidence to participate in sensemaking discussions. Teachers expressed beliefs that SWD&D were hesitant to participate in sensemaking discussions because they lacked confidence and were afraid to participate for fear of being "wrong." One teacher said, "I think sometimes it's just that they lack confidence. I mean a lot of times; it seems like they actually know the answer but they're not going to volunteer because they're afraid that they're going to be wrong."

Teachers discussed feeling like SWD&D needed immediate feedback on their responses to feel confident to continue participating. They felt that when SWD&D had the "right answer" it increased the likelihood they would continue to participate in whole-class discussions. One teacher said,

> And then, sometimes when I would do that frequently, and I would say, like yes, good job, yes, you have it right, yes, those are the answers. And they would feel more comfortable the next day, when I would go over those things again. Then

> they would feel more comfortable because they knew that their answers are right.

When teachers evaluated student responses during sensemaking discussions, by either telling them their response was right or wrong, they noted it increased students' confidence to continue participating in the discussion. Meaning, when teachers confirmed a students' answer, and the student knew they were "right", they were more confident to continue sharing their thinking during the discussion. The teachers also compared the overall confidence levels SWD&D to students without disabilities/difficulties and said,

> I mean the students without disability or difficulty, they're more comfortable with, their more confident, they've had more success in school, you know, over the years and so they're more likely to say something, and not be afraid to talk.

Teachers reported their SWD&D were more confident to participate in sensemaking discussions when given low-level solicitations. One teacher said,

> The more that I asked those lower-level questions, sometimes the more those students that were having difficulties are a little bit more willing to answer...if they're lower level, and if they're an easier type of question to answer. So I definitely tried to ask lower level questions to those students.

Another teacher said, "Sometimes, if I want to hear from this student that maybe isn't as strong on a topic I'll make it more of a yes or no question." Both of these quotes illustrate that teachers used low-level solicitations as a way to build confidence in SWD&D so they would be more willing to participate in whole-class discussions.

Teachers do believe that high-level solicitations promote sensemaking, but only certain students can "handle" high-level solicitations. One teacher said, "If it's somebody that I think can handle a little more rigor I'll make him explain why or how is that different from blah blah blah, so I try to make it more open-ended." and,

> …and the students that I had that were struggling or the students that I had that had disabilities, I would generally give them the easier [solicitations], like the [answers] that they knew quickly. And I would have my other students do a little bit more of the harder [solicitations] or whatever. Just so it would give those students that were struggling a chance to actually participate and get an answer correct.

Teachers used low-level solicitations as a way to build the confidence they believe SWD&D need; however, this did not give SWD&D opportunities to engage with more high-level solicitations needed for sensemaking.

Teachers believe the structures they put in place allow students to have equitable opportunities to participate in sensemaking. Throughout the interviews, teachers discussed structures both in and around sensemaking discussions that led to more equitable opportunities throughout the discussions. These structures included things that happened both before and during the discussions. One structure put in place before discussions was providing multiple opportunities for practicing participating in discussions. One teacher discussed providing multiple opportunities for discussions starting from the first week of school, so by Spring her students were very comfortable participating in whole-class discussions. She said, "By the time that spring break came, everybody was comfortable. They were comfortable with each other," regarding offering multiple opportunities to practice engaging in discussions. In this example, the structure put in place was using whole-class discussions regularly throughout the school year during instruction.

Another structure put in place before discussions was focusing on relationship building. Teachers noted spending time throughout the school year getting to know students and helping them feel comfortable in the classroom and with the teacher/student relationship. About relationship building, one teacher said,

> I just try to build relationships with the students before I try to do big group discussions, just because, like if they don't have a good relationship with me and they don't feel comfortable talking to me then they're not going to feel comfortable talking in front of the class, you know? Like they're not going to feel comfortable giving the answers if they don't feel comfortable with me in general. And so, I tried, I really tried to build those relationships.

Using structures, such as relationship building activities, before discussions supported students' participation during discussions throughout the rest of the school year.

Structures during discussions included things such as games and letting students take the lead of the discussions. In one classroom, a game that allowed for equitable participation was called the pumpkin game, which was described as,

> ... whoever catches it, they have to answer the question, or they say something. And I know, most of them, there's a few that are too shy they don't really want to play, but when they catch it, usually no matter who it is, will try to answer and that way I can hear from them and know if they're on track, or what they're thinking.

Structures such as the pumpkin game ensured that all students had an equal chance to participate in the discussion, however, it was up to the teacher to decide what level of solicitation to use with the student and how to notice and respond to their sensemaking.

When it came to allowing students to direct the discussion content, the teachers reported that it often led to more high-level discussions, more connections, and more sensemaking. One teacher said,

> Sometimes the kid goes in a direction I wasn't expecting, and I'll just go with that too and we'll keep going with a discussion...sometimes even their discussion helps me move to new questions and just keep going with it because I feel like sometimes they make really good connections I hadn't thought of.

Having structures in place in and around sensemaking discussions supported both the quality and equity of the sensemaking occurring throughout the discussions.

Teachers noted SWD&D need more time to process scientific concepts than other students and at times, not putting structures in place to allow processing time caused other students to overpower their chances to participate in discussions. One teacher said, “you know the rest of the kids will be shouting out answers so quickly that those who take a little longer to process don't have time to respond.” Another teacher said,

> And so I think sometimes those kids take a little bit longer to process the question before they will answer, and so they never had time to be a part of a discussion because all the kids just very quickly answer the questions...our students with disabilities and difficulty, I mean they had problems participating sometimes or they wouldn't be able to get a word out because our other students would take over.

These data suggest that teachers notice that SWD&D need more time to process to be able to participate in sensemaking discussions, but if structures are not in place to allow them to have this time, such as routines and expectations for how to participate in discussions, other students are overpowering their chances to be able to participate in the discussion thus making is less equitable.

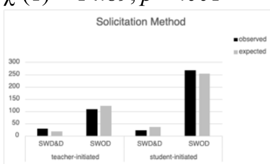
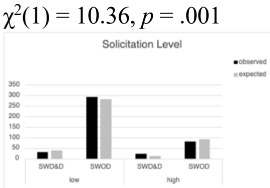
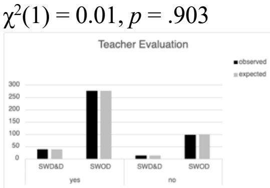
Integrated Findings

The hallmark of mixed methods research design is the integration that occurs at different points throughout the process (Fetters, 2019). To address research question three, the Pillar Integration Process (Johnson et al., 2019) was used as an analytic process to juxtapose and analyze the quantitative and qualitative results and the findings from this process are shared in the following section.

A joint display (Johnson et al., 2019) of quantitative and qualitative results was developed to visualize the findings from both phases of the current study leading to integration. See Table 7 for the joint display of integrated findings.

Table 7

Joint Display of Integrated Findings

Quan Results of Chi-square Test of Independence for Each Dimension of Teacher Behavior	Findings Based on Qual Semi-structured Interviews	Integrated Findings
Solicitation Method $\chi^2(1) = 14.89, p < .001$  	Teachers believe the structures they put in place allow students to have equitable opportunities to participate in sensemaking. Teachers believe SWD&D need to participate in sensemaking discussions. • Science talk is useful for SWD&D	Belief in value of talk explains more solicitations from teacher for SWD&D Mismatch between using more high-level solicitations with SWD&D and belief in the value of using more low-level solicitations with SWD&D
Solicitation Level $\chi^2(1) = 10.36, p = .001$  	Teachers believe SWD&D need confidence to participate in discussions. • Evaluating student responses increases confidence to participate • Low-level solicitations increase confidence in SWD&D • High-level solicitations promote sensemaking but only certain students can "handle" high-level solicitations	Belief that providing evaluation to student responses increases confidence to participate explains the number of times teachers evaluated student responses
Teacher Evaluation $\chi^2(1) = 0.01, p = .903$  		

Research question 3: What is the relationship between teacher beliefs and opportunities to participate in sensemaking discussions?

The first dimension of teacher behavior, solicitation method, was statistically significant suggesting a relationship between disability status and the method for soliciting participation.

For solicitation method, SWD&D initiated their own participation *less* than expected and were solicited to participate by their teacher *more* than expected. This is supported by the qualitative data because teachers believe that SWD&D lack confidence to participate in sensemaking discussions. If a student lacks confidence to participate in a discussion, then it makes sense they would initiate participation less than expected. Additionally, because teachers believe that talk is useful for SWD&D then teachers would be more likely to call on them to participate in the discussion. Because teachers believe in the value of talk for SWD&D, and they believe these students have ideas to share but sometimes struggle to share them in writing, it makes sense that they would call on them more than expected to share their ideas during a discussion.

The second dimension of teacher behavior, *solicitation level*, was also statistically significant suggesting a relationship between disability status and the level teachers solicit participation from students.

For solicitation level, SWD&D received low-level solicitations *less* than expected and high-level solicitations *more* than expected. The qualitative data contradicts the quantitative data because teachers expressed beliefs about the value of using low-level solicitations to build confidence and increase participation for SWD&D. This is not to say the teachers in the current study did not use any low-level solicitations in practice, they just used less than what would be expected if the opportunities were equitably distributed among the two groups. Teachers expressed beliefs that only certain students can "handle" the high-level solicitations and about using low-level solicitations specifically with SWD&D.

The third dimension of teacher behavior, *teacher evaluation,* was not statistically significant suggesting there was not a relationship between disability status and the ways teachers evaluated responses from students.

For teacher evaluation, SWD&D received *about the same* opportunities as would be expected. This is explained by the qualitative data because teachers believe that SWD&D need confidence to participate and providing students with this evaluation that their response is correct increases their confidence and their subsequent participation in discussions. In addition to evaluating student responses, one teacher did discuss letting her students "sit" with an idea and giving them time to figure it out rather than evaluating the responses, however, this was not common across all three teachers.

Summary

The purpose of the current study was to examine equity issues in opportunities SWD&D have for sensemaking in general education science classrooms and the relationship between teachers' beliefs and the nuances of the opportunities given. In summary, the results indicate there is a relationship between disability status and the opportunities to participate in whole-class sensemaking discussions. Probing further into the quantitative results revealed that teachers hold certain beliefs about SWD&D including beliefs that may explain why teachers may be more likely to call on SWD&D rather than expecting them to initiate participation themselves, beliefs about the benefits of low-level solicitations for SWD&D' participation and who can "handle" certain levels of cognitive demand, and beliefs about the benefit of evaluating SWD&D' ideas during whole-class discussions.

CHAPTER 5

Discussion

Using data collected from classroom observations of whole-class science discussions and interviews with teacher participants, the current study explored equity issues in sensemaking opportunities between students with and without disabilities/difficulties and the relationship between teacher beliefs and sensemaking opportunities of SWD&D. This is a little explored area in the special education literature so there is much to learn about how middle school general education science teachers provide opportunities for SWD&D in whole-class discussions, which are a large part of giving students opportunities for sensemaking in science. This is a particularly critical area for exploration in classrooms where SWD&D receive instruction in the general education science classroom and the general education teacher must rely on her own belief system to guide her interactions during the whole-group discussions. Thus, the current study used an explanatory sequential mixed methods design to integrate the quantitative and qualitative results to examine the relationship between teacher beliefs about SWD&D and opportunities to participate in sensemaking discussions. The following sections will further summarize and interpret the findings related to research question 3: What is the relationship between teacher beliefs about SWD&D and opportunities to participate in sensemaking discussions?

Two main conclusions can be drawn from the integrated findings in this study. First, teachers' belief in the value of talk for SWD&D influenced their interactions with SWD&D during sensemaking discussions and second, teachers' beliefs do not always match what is occurring during instruction.

Value of Using Talk for Students with Disabilities and Students Experiencing Difficulty in Science

Because teachers in the study believed that talk was beneficial for SWD&D, and they also believed that SWD&D lack confidence to initiate participation on their own, they tended to solicit participation from them more than expected. This finding is surprising because current literature suggests that students from marginalized groups such as Indigenous students (Bang & Medin, 2010), students from non-dominant communities (Bang et al., 2012), and culturally and linguistically diverse students (Parsons & Carlone, 2013), are not perceived as capable of doing science and their participation is ignored or not solicited at all. This idea is also echoed by other scholars who found that when teachers engage students in more authentic forms of discussion that align with the expectations of the NGSS and promote sensemaking, they tend to solicit participation from "privileged or high-track students" (Applebee et al., 2003). What the current study does, however, is demonstrate that contrary to current literature on other marginalized groups, that because of teacher beliefs, SWD&D *are* being solicited to participate in sensemaking discussions.

Having opportunities to participate in sensemaking discussions has important implications for SWD&D. First, current literature suggests that sensemaking supports student learning (Cannady et al., 2019; Resnick et al., 2010) and even if SWD&D may struggle engaging in discourse, providing them the opportunity can support equitable participation (Lee et al., 2014). Furthermore, this finding is consistent with current literature that suggests that giving students opportunities to participate in discussions where they can share ideas supports their sensemaking (Wright & Gotwals, 2017).

Mismatch Between Beliefs and Practice

The second main conclusion that can be drawn from this study connects to the ways in which teachers engage with SWD&D during sensemaking discussions. Namely, their beliefs do not always necessarily match what is occurring during instruction. This finding is not surprising. Numerous studies have found discrepancies between teacher belief and practices (Bryan, 2012; Buehl & Beck, 2015). What is interesting in this study, however, is what these discrepancies looked like in relation to sensemaking discussions and how it impacted SWD&D.

First, in terms of the level of solicitation given to engage, SWD&D were given less low-level solicitations, and more high-level solicitations than would be expected, but teachers expressed beliefs that SWD&D needed more low-level solicitations to feel confident to participate in sensemaking discussions. However, in the current study, the disconnect or mismatch worked for the benefit of the SWD&D because, in practice, they received less low-level and more high-level solicitations across the units. Reinholz and Shah (2018) suggest that for marginalized groups, such as SWD&D, "ensuring fairness in opportunities to learn for students from marginalized groups might actually require allocating them more resources and different resources than students from dominant groups" (p. 146). They go on to state that in some cases inequities, such as what the solicitation level results in the current study suggest, can actually be equitable. The impact being able to engage in more high-level solicitations than expected is engagement in deeper sensemaking.

Even though the teachers used less low-level solicitations in practice, the beliefs teachers hold regarding the use of low-level solicitations with SWD&D is troubling because the literature suggests that using high-level solicitations can help students focus on sensemaking (Windschitl et al., 2018) and support the development of complex understandings (Lowell et al., 2022). Teachers holding beliefs about the importance of engaging SWD&D in low-level solicitations is consistent with current literature that suggests teachers hold low expectations for SWD&D' learning and performance (Moss et al., 2008; Cook et al., 2000; Pettit, 2011).

While using low-level solicitations can be a good starting point for sensemaking, teachers need to work to push SWD&D' thinking further during discussions by continuing to push students to *do* something with their ideas. This idea was echoed by Lowell et al. (2022) who suggest that overly relying on a single type of talk pattern is not sufficient to support student sensemaking. Furthermore, when teachers provide scaffolding that pushes students to extend their contribution during a discussion, rather than just the simple IRE sequence (Mehan, 1979) commonly seen in science classrooms (Nassaji & Wells, 2000; Pimentel & McNeill, 2013; Rees & Roth, 2019; Scott et al., 2006; Wells & Mejia Arauz, 2006), ideas can be transformed into deeper moments of sensemaking (Alexander, 2015; Resnick et al., 2010). Overly relying on low-level solicitations does not allow for sensemaking to take place (Carlone et al., 2011; Reinholz & Shah, 2018). For SWD&D, holding low expectations about the level of sensemaking in which they can engage can have a significant impact on their learning outcomes as engaging in sensemaking has been found to play a significant role in science content learning (Cannady et al., 2019).

Second, the results for the teacher evaluation dimension suggest there was not a significant difference between the ways teachers evaluated responses from students with and without disabilities/difficulties. However, overall, teachers did tend to evaluate student responses more than not. In terms of SWD&D, teachers in the current study expressed beliefs that they needed confidence and providing students with evaluation that their response was "right" increased their confidence and their subsequent participation in discussions. However, evaluating student responses has implications for the sensemaking that can take place, by way of epistemic authority.

By focusing on providing SWD&D with an evaluation that their response is "right", teachers are not giving them epistemic authority. Giving students epistemic authority allows for equitable sensemaking (Haverly et al., 2020). Haverly et al. (2020) describe one way teachers can support students' epistemic authority is by inviting students to participate in classroom discourse. So, if students are not being given this opportunity, they are not being given equitable opportunities for sensemaking. In the current study the teacher held epistemic authority by overwhelmingly evaluating student responses. This is consistent with the literature that suggest that in science classrooms, it is often the teacher who holds the epistemic authority (Carlone et al., 2011). Science instruction that aligns with the current vision of science reform and current literature suggest that teacher evaluation of student ideas during discussions should be *non-evaluative* (Tytler & Aranda, 2015). Bang et al. (2012) and Hand and Schoerning (2012) suggest that when teachers work to surface and clarify student ideas, which would have been considered non-evaluative in the current study, students have space to equitably participate in sensemaking. However, in the current study, opportunities for epistemic authority were not the norm for students with or without disabilities/difficulties.

Limitations

Although there are several interesting outcomes from the current study, there are three main limitations to discuss: generalizability, opportunities for sensemaking that took place outside of whole-class discussion, and impacts of the pandemic.

In terms of generalizability, due to the exploratory nature of the study, the sample in the current study was small (n = 3). Furthermore, the sample was homogeneous. All three teachers in the current study identify as white females. While most of the teaching population is white (79.3%) and female (76%), the sample of teachers in the current study is not representative of the current teacher demographics in the United States (U.S. Department of Education, 2017). Additionally, all three teachers in the current study taught in rural schools from one state in the Midwest. Due to the limitations, if this study were conducted with different teachers in different contexts, the results, findings, and outcomes may be different. Future iterations of this study could benefit from a larger sample size of a more diverse sample of teachers. A larger sample size with a more diverse sample of teachers would provide opportunities for broader generalizations and a richer understanding of the opportunities SWD&D have for sensemaking in general education science classrooms.

Second, in the current study, the focus was on whole-class discussions to look at the opportunities teachers afforded SWD&D for sensemaking. While the literature does suggest using whole-class discussions to promote collective sensemaking (Lemke, 1990; Michaels & O'Connor, 2017; Zangori & Pinnow, 2020), there are other instructional opportunities teachers use to promote sensemaking such as small group discussions or one-on-one discussions (Wright and Domke 2019; NRC 2012). Focusing solely on opportunities for sensemaking in whole-class discussions rather than examining sensemaking opportunities happening in small groups or one-on-one could have impacted the data in terms of the frequency of opportunities offered to SWD&D. Future studies could examine other contexts for sensemaking to further examine sensemaking opportunities for this population of students.

The final limitation that needs to be discussed is the impact the pandemic may have had on the current study. Due to social distancing requirements put in place at the district level, teachers in the current study reported not being able to use discussion structures and formats they used during whole-class discussions before the pandemic. Not being able to use these structures and formats may have impacted the opportunities the students had for sensemaking within the whole-class discussions and consequently impacted the observational data collected and analyzed. Additionally, there were many other challenges in schools during the pandemic that may have impacted the kind of instruction teachers were able to deliver (i.e., increased sickness, increased absences, increased responsibility) which may have also impacted what was observed throughout the classroom observations and conclusions that were drawn from the quantitative data.

Implications for Practice

The current study was limited to three teachers, thus providing only some insight into teachers' beliefs about SWD&D and the relationship between these beliefs and the opportunities SWD&D have for sensemaking. However, a number of key ideas emerged from the study that are worthy of consideration. First, findings from this study suggest that teachers believe using talk for SWD&D' sensemaking is useful, but they struggle to believe they can handle high-level solicitations and that they need responses evaluated during whole-class discussions. High-level solicitations and non-evaluative responses are critical in pushing the sensemaking of students during whole-class discussions (Schwarz et al., 2021). Therefore, teachers would benefit from professional learning opportunities focused on challenging their beliefs and supporting their practice during whole-class discussions. Research suggests that for teachers to address their belief systems they need to be made aware of their belief structures (Churchland & Churchland, 2013).

Additionally, science teachers report feeling underprepared to teach science to SWD&D (Kahn & Lewis, 2014). Knowing this, and adding what was learned in the current study, teachers need more support on ways to help SWD&D feel more comfortable and confident to participate in discussions that will promote their sensemaking. Professional learning opportunities that focus on identifying barriers to participation (i.e., lack of confidence) and matching instructional strategies to remove barriers to SWD&D have equitable opportunities to participate in sensemaking is critical.

Second, because of the focus on teacher behavior and the role of the teacher in affording SWD&D opportunities for sensemaking with the science classroom, future research needs to focus on the teacher, starting with preservice training. Asking pre-service teacher preparation programs to examine the ways general education pre-service teachers are prepared to acknowledge and provide equitable instruction to SWD&D is critical. Historically, most general education pre-service teacher preparation programs spend extraordinarily little time on information related to SWD&D (Norman et al., 1998). This must be addressed for general education teachers to enter the classroom ready to notice and address the variability of learners that will be present in their science classrooms. Challenging deficit thinking is difficult but critical work.

Future Research

The current study has expanded upon research on the opportunities made available to marginalized groups for sensemaking during whole-class discussions in general education science classrooms by specifically looking at SWD&D, a severely understudied group in science education. Continuing this line of research, which bridges two fields (special education and science education), is critical to supporting the success of this group of students, not just in the general education science classroom, but as they go out and use science to make sense of the world and make decisions that have impacts on themselves and those around them. To continue examining equity issues in science for SWD&D there are several avenues of research that could be explored.

Findings from this study suggest that there is a difference between the opportunities students with and without disabilities/difficulties have for sensemaking. What is still unknown is what practices allow for more equitable participation from SWD&D during whole-class discussions. The current study is just a start to examining what is occurring in science classrooms for SWD&D and, therefore, there is need for further research that extends the current study. For example, researchers could begin by identifying teachers who have EQUIP equity ratios close to 1, suggesting they have close to equitable instruction occurring in their classrooms. Then, digging deeper into the practices they use and structures they put in place that support equitable participation in sensemaking in their classrooms could help the field understand what practices and structures are needed to promote equitable sensemaking.

In addition, identifying the teachers who have equitable instruction occurring in their classrooms and probing into their belief systems in terms of SWD&D could help gain an understanding of the kinds of beliefs teachers hold that may be predictive of equitable teaching practices. The current study adds to existing literature on teacher beliefs about SWD&D. Research has been conducted regarding teacher beliefs about SWD&D learning science (i.e., Kahn & Lewis, 2014) but no current studies exist that explore the relationship between teacher behavior and equitable science learning opportunities. Exploring this relationship adds to simply collecting data on teacher beliefs by examining exactly what is happening in classrooms for SWD&D and making connections between what is happening and what teachers believe. Bryan (2012) suggested this avenue of inquiry regarding teacher belief research with a focus on sociocultural dimensions of beliefs. The current study examined the equity in sensemaking opportunities between students with and without disabilities/difficulties thus beginning to explore this line of inquiry. The work of examining teacher beliefs in the context of what is happening in classrooms is important because ultimately the progress of SWD&D is impacted by teacher beliefs (Kiely et al., 2015) and the instructional opportunities they are afforded.

The current study used equity analytics from the classroom observations during the teacher interviews to get teachers to interpret and reflect on their teaching practices related to sensemaking discussions and SWD&D. The teachers in the current study expressed how seeing the data was a helpful reflection tool and gave them ways to think about improving their practice. In the current study, the data analytics and reflections were only used at one timepoint. In future research, data analytics could be used at different timepoints throughout the school year to interpret, reflect, and analyze improvement in practice in terms of equitable opportunities for sensemaking. Similar work has been conducted with mathematics teachers (Reinholz & Shah, 2018) and at the undergraduate teaching level (Ernest et al., 2019; Reinholz et al., 2019). However, providing this level of data and time for reflection could be powerful for K-12 teachers as they reflect upon their own instructional practices regarding the opportunities they afford SWD&D and could provide data on the ways equity analytics can change teachers' implementation of equitable instructional practices over time.

Conclusion

Exploring the current reality for SWD&D within science in the general education classroom is a critical first step in addressing equity issues for this population of students. Using an explanatory sequential mixed methods research design helped capture a robust picture of what opportunities are currently being afforded to SWD&D by examining what was currently occurring in middle school science classrooms and gaining further insight into the relationship between teacher beliefs, the instruction they provide, and their beliefs about the students they teach. Examining who participates and the ways in which teachers are soliciting students to participate in science discourse can help the field of special education understand the current reality for SWD&D and plan future research to support general education teachers in delivering equitable instructional opportunities for this population of students. All students—including SWD&D—deserve equitable opportunities to learn and the support necessary to be successful.

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APPENDICES

APPENDIX A

Institutional Review Board Approval

Institutional Review Board
University of Missouri-Columbia
FWA Number: 00002876
IRB Registration Numbers: 00000731, 00009014

482 McReynolds Hall
Columbia, MO 65211
573-882-3181
irb@missouri.edu

December 02, 2020

Principal Investigator: Rachel Juergensen
Department: Special Education-PHD

Your IRB Application to project entitled Opportunities for Sensemaking in Science for Students with Learning Disabilities and Students with Learning Difficulties: A Mixed Methods Study was reviewed and approved by the MU Institutional Review Board according to the terms and conditions described below:

IRB Project Number	2038723
IRB Review Number	286527
Funding Source	Council for Exceptional Children - Division of Learning Disabilities Department of Special Education Office of Graduate Studies
Initial Application Approval Date	December 02, 2020
IRB Expiration Date	December 02, 2021
Level of Review	Exempt
Project Status	Active - Exempt
Exempt Categories (Revised Common Rule)	45 CFR 46.104d(1)
Risk Level	Minimal Risk
Approved Documents	Student demographic sheet teachers will fill out about their students. Semi-structured interview outline. This interview will be largely guided by the data collected during the observation. The outline includes broad ideas I will design questions about depending on the data collected. Consent letter that will be sent to teachers in the study via a Qualtrics form. Information in the letter will be at the top of the Qualtrics form with an option to consent or not at the bottom. This email will be sent to parents of students in the classrooms where teachers will be observed.

The principal investigator (PI) is responsible for all aspects and conduct of this study. The PI must comply with the following conditions of the approval:

1. **COVID-19 Specific Information**
   Enrollment and study related procedures must remain in compliance with the University of Missouri regulations related to interaction with human participants following guidance at

research.missouri.edu/about/covid-19-info.php
In addition, any restarting of in-person research activities must comply with the policies and guiding principles provided at research.missouri.edu/about/research-restart.php, including appropriate approvals for return to work authorization for individuals as well as human subject research projects.

2. No subjects may be involved in any study procedure prior to the IRB approval date or after the expiration date.
3. All changes must be IRB approved prior to implementation utilizing the Exempt Amendment Form.
4. The Annual Exempt Form must be submitted to the IRB for review and approval at least 30 days prior to the project expiration date to keep the study active or to close it.
5. Maintain all research records for a period of seven years from the project completion date.

If you are offering subject payments and would like more information about research participant payments, please click here to view the MU Business Policy and Procedure: http://bppm.missouri.edu/chapter2/2_250.html

If you have any questions or concerns, please contact the MU IRB Office at 573-882-3181 or email to muresearchirb@missouri.edu.

Thank you,
MU Institutional Review Board

APPENDIX B

Recruitment Script

As part of the Linking Science & Literacy for All Learners Professional Development Program, you are being asked to take part in a dissertation study. This study is titled *Opportunities for Sensemaking in Science for Students with Learning Disabilities and Students with Learning Difficulties: A Mixed Methods Study.* The study will not ask you to do anything beyond your regular instruction. You will be asked to allow me to observe two lessons that include a whole-class discussion. This observation can occur in one of three ways:

1. In person if your district will allow me in the building to observe and record
2. Via Zoom if your district does not allow visitors but you are teaching in person
3. On Zoom if you are teaching virtually

What you will be asked to do:

- Complete a student demographic sheet including student name, race, sex, and disability status
- Send an email describing the study to parents
- Schedule times for me to observe the lessons
- Complete a follow-up interview about the lessons

You will be compensated for your time and willingness to complete all the requirements. This compensation will be in addition to the stipend you receive for the Linking Science & Literacy for All Learners project. You will receive $50/observation and an additional $50 for the follow-up interview.

Your participation in this study is voluntary; you may choose not to participate and there will be no penalty or consequence. If you decide to participate, you may withdraw from the study at any time without penalty.

Your participation in this research study will improve understanding of opportunities for students with learning disabilities or learning difficulties receive to participate in sensemaking. The information gained in this study may be published and be useful to professional developers and science educators. Information produced by this study will be stored in the principal investigator's file and identified by a code number only. The code key connecting your name to specific information about you will be kept in a separate, secure location. Information contained in your records may not be given to anyone unaffiliated with the study in a form that could identify you without your written consent, except as required by law. When using your interviews as data and reporting the findings of this study, your name will be replaced with a pseudonym.

If you want to talk privately about your rights or any issues related to your participation in this study, you can contact University of Missouri Research Participant Advocacy by calling 888-280-5002 (a free call), or emailing MUResearchRPA@missouri.edu. If you have questions, you may also contact me, Rachel Juergensen (juergensenr@mail.missouri.edu).

Please let me know if you have any questions about the study or your participation in the study. I am looking forward to working with you to learn more about sensemaking in science.

Thank You,

Rachel Juergensen

APPENDIX C

Opt-out Option Consent Form

Opportunities for Sensemaking in Science for Students with Learning Disabilities and Students with Learning Difficulties: A Mixed Methods Study
University of Missouri Columbia

Dear Parents,

The purpose of this letter is to inform you that your child's teacher is participating in a research study called "Opportunities for Sensemaking in Science for Students with Learning Disabilities and Students with Learning Difficulties" I am studying how teachers ensure that all students have fair opportunities to participate in class discussions.

I will be videotaping the teacher's classroom. I will also be collecting background demographic information about the students in the class. Demographic information collected will include student name, race, sex, and disability status.

Student identity will be kept confidential to the extent provided by law. All of the data collected as part of this research project will be anonymized—student names will not appear in any presentation or publication that comes out of the study. Video clips from the teacher's classroom may be used in research presentations or for professional development to help teachers learn to teach in more equitable ways.

No more than usual classroom time is required. There are no risks associated with participating in this project.

If you **do not** wish for your child to appear in video-recordings, please email me at juergensenr@mail.missouri.edu and let me know. Please note that participation is voluntary; you may choose not to participate at all, or you may refuse to participate in certain parts of the study or discontinue your participation at any time without consequence.

I'm happy to answer any questions, please do not hesitate to email me.

Thank you,
Rachel Juergensen
Doctoral Candidate

University of Missouri Columbia
juergensenr@mail.missouri.edu

Whom to contact about your rights as a research participant in the study:
If you want to talk privately about your rights or any issues related to your participation in this study, you can contact:
University of Missouri Research Participant Advocacy by calling: 888-280-5002 (a free call) or emailing: MUResearchRPA@missouri.edu.

APPENDIX D

Opt-In Option Consent Form

Opportunities for Sensemaking in Science for Students with Learning Disabilities and Students with Learning Difficulties: A Mixed Methods Study
University of Missouri Columbia

Dear Parents,

The purpose of this letter is to inform you that your child's teacher is participating in a research study called "Opportunities for Sensemaking in Science for Students with Learning Disabilities and Students with Learning Difficulties". I am studying how teachers ensure that all students have fair opportunities to participate in class discussions.

I will be videotaping the teacher's classroom instruction. I will also be collecting background demographic information about the students in the class. Demographic information collected will include student name, race, sex, and disability status.

Student identity will be kept confidential to the extent provided by law. All of the data collected as part of this research project will be anonymized—student names will not appear in any presentation or publication that comes out of the study. Video clips from the teacher's classroom may be used in research presentations or for professional development to help teachers learn to teach in more equitable ways.

No more than usual classroom time is required. There are no risks associated with participating in this project.

Please note that participation is voluntary; you may choose not to participate at all, or you may refuse to participate in certain parts of the study or discontinue your participation at any time without consequence.

I'm happy to answer any questions, please do not hesitate to email me.

Thank you,
Rachel Juergensen
Doctoral Candidate
University of Missouri Columbia
juergensenr@mail.missouri.edu

Whom to contact about your rights as a research participant in the study:
If you want to talk privately about your rights or any issues related to your participation in this study, you can contact:
University of Missouri Research Participant Advocacy by calling: 888-280-5002 (a free call) or emailing: MUResearchRPA@missouri.edu.

My student and I have talked about this study and our choice is
Consent to participate in the study
We do not give consent to participate in the study

Please type the first and last name of the PARENT/GUARDIAN in the box below.

Please type the first and last name of the STUDENT in the box below.

APPENDIX E

Quantitative Codebook

Identifying New Contributions

(from Reinholz & Shah)

The basic unit of analysis in EQUIP is called a *contribution*. A contribution consists of any string of utterances from a single student. As soon as a new student contributes, it forms a new participation sequence. If a single student speaks back-and-forth with the teacher but no other students participate, then this whole interaction is counted as a part of the same contribution.

There are a number of reasons that the unit of analysis is defined in this way. First, because EQUIP generates disaggregated analytics, it means that any coding that happens must be able to be tied to a specific student. With student talk, it is clear that it belongs to that particular student. As far as teacher actions are concerned, they must be attributed to a particular student that they are interacting with, so that they can be coded. Thus, coding is segmented in a way so that all segmenting takes place with respect to students, constituting new contributions, and then coding is tied to that particular contribution. This allows the coded events to be disaggregated and aggregated in a number of different ways.

Second, we allow for multiple back-and-forth turns between a teacher and a single student because this reflects our understanding of the discussion moves that teachers use in real classrooms. Very often, teachers may start with a simple question like asking for an answer, and then follow up by asking a student to explain their process, and finally justify why the answer is correct. Our goal is to capture this whole interaction as a single contribution, and to code a high-level of teacher questioning and student response. Otherwise, if we were to code all of the smaller, intermediate questions in the middle, we might instead paint a picture of teacher's teaching that didn't fully capture the richness of the discourse moves. Ultimately this was a design decision in the development of EQUIP. As a result, classrooms in which students have a large number of discussions back-and-forth with each other will have relatively more contributions coded than classrooms in which discourse is more teacher centric.

Third, we segment new contributions when a new student is involved because it gives us a concrete, relatively unambiguous way to mark new contributions. Still, we recognize, for instance, if a single student were dominating a classroom discussion, they might contribute a few ideas that would all be considered part of the same interaction. For this reason, we suggest that users choose a certain amount of time (e.g., one minute, two minutes) as a cutoff between contributions. Following this logic, if a teacher interacted with a student Dan, then lectured for one minute, and then interacted with Dan again, this would be counted as two contributions, both for the student Dan. The appropriate interval of time would depend on the circumstances and the particular goals of a project.

EQUIP coding relies upon identifying a student who participates, so if a participant can't be identified, no contribution is coded. Suppose again that a student "Dan" is in a conversation back and forth with the teacher. If an unnamed or unidentifiable student speaks, and then Dan continues to speak afterwards, it would all be counted as one sequence because the unnamed student is ignored. Similarly, choral responses are ignored because there is no particular student who is making the contribution.

When coding videos, we also recognize that side talk between students might be captured. Suppose a video camera is sitting in the back of a classroom. This may capture talk at a nearby table. However, for the purposes of coding whole-class discussion, we would ignore this talk because it is not public. If a team has different goals, such as a coding small group, then such talk may be included. Similarly, if a teacher has a side conversation with just one student, we would not capture that because it is not public. Or, if two students talk to one another during a think-pair-share or turn-and-talk move, it wouldn't be coded, as it's not public. In general, when coding a whole class discussion, we are looking for participation that is visible to most of the class, because if participation is not seen by other students, it will not contribute to positioning students in the public space.

When coding, it is important to identify each student with a unique name. Typically, we would recommend using only first names or just student initials, in order to protect the privacy of the students involved. However, if multiple students have the same name, then appropriate pseudonyms or last names must be included.

Lastly, we recognize that some coding situations do not focus on whole-class discussions, but could capture small groups, side talk, etc. In such cases, the rules above about public participation would not apply. In general, small group coding will result in far more contributions than a whole-class discussion, because of the density of talk. Also, in such situations it may be easiest to not use any teacher-focused dimensions, if the majority of interactions are students without a teacher.

Solicitation Method

Solicitation method refers to what the teacher does to initiate a new participation sequence. Solicitation method will be coded as either called on or not called on. Coding for solicitation method allows us to see whether the student or teacher is responsible for initiating the interaction.

Solicitation Method	**Definition**	**Example**	**Keywords**

Teacher-initiated	The teacher is responsible for picking who gets to talk.	"[Student Name], would you like to share what you wrote?" "Go ahead, [Student Name]." Student raises hand and teacher calls on or points to them to speak.	Student name Go ahead
Student-initiated	Student initiates the contribution and starts speaking unsolicited.	Teacher asks for hands to be raised but the student talks out without being called on. Teacher doesn't specify how to speak and student talks out.	(after student shares) "Raise your hand." "Stop shouting out."

Solicitation Level

Solicitation level refers to the level of cognitive demand (low or high) of the solicitation the student was given to engage. A *low-level solicitation* is a lower cognitive demand solicitation that typically focuses on memorization to recall facts, listing things or describing vocabulary, or procedural tasks that follow specific steps or a formula. These low-level solicitations generally have a "right answer" that can be given in just a few words and do not reveal much about a students' thinking. These solicitations sometimes follow the Initiate-Response-Evaluate (IRE) pattern and do not typically push students to do anything with their thinking or ideas. A *high-level solicitation* asks students to share what is happening and explain their thinking. Teachers follow-up on students' thinking and ask students to elaborate or comment on others' thoughts. The teacher's questions are responsive to student ideas. With a high-level solicitation students are pushed to do something with their thinking or ideas. There is typically no "right answer".

Solicitation Level	**Definition**	**Example**	**Keywords**

Low-level	Focuses on memorization to recall facts, listing things or describing vocabulary, or procedural tasks that follow specific steps or a formula.	IRE pattern Asking a student to name the states of matter, define a term, or describe what the text says is a difference between weather and climate.	What… Which… True or false...
High-level	Teacher asks students to share what is happening, explain their thinking, ask students to elaborate or comment on others' thoughts, do something with thinking or ideas.	Asking a student to compare or contrast ideas, justify an explanation, or support a claim with evidence and reasoning.	What do you mean… Tell me more… Explain… Why… How...

***When a student participates multiple times within a single participation sequence, solicitation level is coded for the highest level of student contribution. By doing this, we can see whether or not the teacher pushes the student to explain their thinking or provide reasoning.

Teacher Evaluation

Teacher evaluation refers to if/how the teacher evaluates the student's ideas. Teacher evaluation will be coded as yes or no. Yes means the teacher simply states yes/no or right/wrong without any further inquiry into the idea or the teacher praises the response. No means the teacher leaves the correctness of the student's idea open allowing for other students to evaluate the idea or restates or reformulates the student's idea so other students have an opportunity to hear or understand the idea. Said another way, the teacher makes the student's idea public without explicitly evaluating the idea.

Teacher Evaluation	**Definition**	**Example**	**Keywords**
Yes	Teacher simply states yes/no or	Students says something and the	Yes No

	right/wrong without any further inquiry into the idea or the teacher praises the response.	teacher says, “great job!”	That is correct That is incorrect Right Wrong Good Great job Way to go Nice
No	Teacher leaves the correctness of the student's idea open allowing for other students to evaluate the idea.	Teacher may not respond at all or they may revoice what the student said without evaluating the response.	

APPENDIX F

Semi-structured Interview Protocol

Juergensen Dissertation Interview Protocol

You are being asked to participate in an interview exploring the use of whole-class discussion for students with disabilities and students experiencing difficulty in science. During our time together you will be asked to respond to several open-ended questions. You may choose to participate in any or all of the questions. The procedure will involve audio recording the discussion, and the audio recording will be transcribed. The thoughts you share will be confidential and you will not be identified individually. Is it okay if I record our conversation today? **(PRESS RECORD *TO THE CLOUD*)**

Warm-up Questions
How would you describe your school? Describe anything different about your school during the pandemic. Talk about the unit I observed. What were your goals for students throughout the unit? What did you want your students to learn during this unit? What kinds of things did you think about when you identified a student as having difficulty in science? How do you recognize that a student is having difficulty in science?
Discussion (adapted from Reinholz et al., 2019 and Pimentel & McNeill, 2013)
General Discussion Questions How would you describe a lesson that consisted of successful discussion? What are your specific goals for classroom discussion in your classroom? Talk about any teacher moves or instructional strategies you use to promote discussion. How would you describe the overall discussion that occurs between you and your students during a science lesson? Do you believe the discussion changes depending on the lesson? If so, please give some examples. Do you ask different questions depending on the type of discussion you would like to occur in the classroom? If so, how are they different? If you were to think about the types of questions you ask during science lessons, how would you classify them? **Equity in Participation**

<table>
<tr><td>Sometimes particular students in your class might be participating less. How do you think about that as the teacher?
Why do you think some students may participate less than others?
How do you know when a student is participating in discussions?
What do you do when you notice a student is not participating?

Discussion and SWDs
How does talk help students in science? Specifically SWDs or students experiencing difficulty in science?
Describe any challenges your SWDs or students experiencing difficulties faced during whole-class discussions?
Describe any successes your SWDs or students experiencing difficulties faced during whole-class discussions?
What teaching strategies are successful in getting SWDs to participate in whole-class discussions?
Tell me about any lessons/activities I didn’t see that included whole-class discussions.

Challenges Related to COVID-19
What are some challenges you experienced with using whole-class discussion during this unit?
Were there any challenges you would attribute specifically to COVID?
What restrictions were put in place for COVID that prevented your usual discussion activities?
What things would you have done differently, or what things do you typically do, regarding whole-group discussions without the restrictions?</td></tr>
<tr><td align="center">Data Reflections (adapted from Reinholz et al., 2019)</td></tr>
<tr><td>Explain EQUIP analytics. Next we will take a look at some of the data analytics from each whole-group conversation that occurred across your unit. I used a tool called EQUIP to code three different dimensions of teacher behavior. I identified contributions within each discussion and coded each contribution three different ways. (contribution slide - explain)

Ask:
Predicting
What patterns might you expect in the analytics? Why did you expect that? Overall? With respect to individual students? With respect to students with disabilities and students experiencing difficulty in science?

Interpretation
Show overall analytic slides</td></tr>
</table>

What do you notice in the overall analytics? How do you explain those patterns? (Probe on whether they view these as related to the learning context, something about their instruction, something about individual students, etc.) *Show contribution and equity ratio slides* What do you notice in the analytics disaggregated by disability status? How do you explain those patterns? (Probe on whether they view these as related to the learning context, something about their instruction, something about individual students, etc.) *Show individual student contribution slide* What do you notice in looking at individual student analytics? (Probe on whether they view these as related to the learning context, something about their instruction, something about individual students, etc.) What other analytics or breakdowns would you have liked to see? What do you feel that analytics can't capture? Do these kinds of analytics influence how you think about your teaching? How specifically? Do you think you would do anything different (or not) in the future?
Closing
What else should I know that I haven't asked?

APPENDIX G

Qualitative Codebook

Code	Code Definition
participating less	leads to students participating less
talk is useful for SWDs	teacher acknowledges that talk is useful for SWDs
deeper discussion	leads to deeper discussion
overpowering	students are first to answer not allowing enough time for others to answer
lack of prior knowledge	students do not have the prior knowledge needed to participate more
COVID challenges	teacher notes challenges with discussion that were because of COVID
successful discussion	how teachers describe successful discussion
making connections	discussion is leading to students making connections
students with dis/diff	students on an IEP or identified by their teacher as having difficulty in science
students without dis/diff	students not identified by their teacher as having difficulty in science and not receiving SpEd services
chunking	teacher uses chunking as a strategy
multiple modes of action & expression	letting students show what they know in different ways
repetition	teacher uses repetition as as a strategy for participation
activity before discussion	teacher plans for and implements some sort of activity to prepare students for discussion
game	using a game (tech or not) as a strategy for participation
private discussion	teacher walks over to a student to have them participate privately
prepare them	give students a heads up that they will be called on to participate
peer support	asking other students to jump in and help with an answer
push for elaboration	teacher asks follow up questions to push for elaboration from students
check for understanding	teacher uses a strategy to check for students' understanding
norms	setting up norms for discussion
participate more	leads to students participating more
relate	topic must be relatable for students
related to learning context	teacher attributes participation or lack of participation to the learning context
related to instruction	teacher attributes participation or lack of participation to their own instruction
related to student	teacher attributes participation or lack of participation to something within an individual student
prepare for future	helps prepare students for a future in science (life or career)
application	being able to apply the content now or in the future

multiple students participating	hearing from a lot of students during discussion
deeper understanding	a deeper understanding of the topic is a goal of discussion
improved argumentative writing	teacher wants to improve students argumentation skills
use science vocabulary	teacher wants students to use more science vocabulary when they talk
confident in answers	confident in their knowledge and having the right answer
comfortable	students participate more when they feel comfortable to do so even if wrong
willing to talk	things that lead to students being willing to talk/participate more
enjoy talking	when students enjoy talking they participate more
learning from hearing others	students still learn just from hearing others talk
inauthentic inclusion	looks like students are being included but it is not meaningful
not forcing	teachers do not want to force students to participate
student abilities	teacher mentions students abilities
low level solicitations	focuses on memorization to recall facts, listing things or describing vocabulary, or procedural tasks that follow specific steps or a formula
open-ended	teacher asks students to share what is happening, explain their thinking, ask students to elaborate or comment on others' thoughts, do something with thinking or ideas
closed-ended	focuses on memorization to recall facts, listing things or describing vocabulary, or procedural tasks that follow specific steps or a formula
student initiating participation	student is the one initiating participation
student-led	students are initiating direction of discussion
teacher solicit participation	the teacher is responsible for picking who gets to talk
teacher-led	teacher initiates the direction of discussion; IRE
not evaluating	teacher leaves the correctness of the student's idea open allowing for other students to evaluate the idea
evaluating	teacher simply states yes/no or right/wrong without any further inquiry into the idea or the teacher praises the response

VITA

Rachel Juergensen received her bachelor's degree in Early Childhood and Elementary Education from the University of Missouri–Columbia (MO) in 2004 and her master's degree in Educational Administration from Southwest Baptist University–Bolivar (MO) in 2008. Rachel was an elementary general education classroom teacher in a district with a large population of students needing targeted or intensive support, an elementary assistant principal between two large buildings with enrollments of 500+ each, and a statewide coach for Missouri Schoolwide Positive Behavior Support. In all her roles she strived to creative inclusive spaces, hold each and every student to high expectations, and worked to provide equitable opportunities to learn. These experiences as a teacher, administrator, and statewide coach influenced her current research interests—students with learning disabilities, students experiencing learning difficulties, and the role teachers play in who gets what types of opportunities to learn in general education science classrooms.

Rachel is married, has three children, and one snuggly pitbull. Originally from St. Louis, MO, she loves art, organization, coffee, the Mizzou tigers, and traveling to new places.