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Examining Science Teacher Reflections on Argument-Based Inquiry Through a Critical Discourse Lens

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Abstract

Developing the future scientists of tomorrow requires that the science teachers of today be well versed in the languages and practices of science. This may require in-service teachers to shift the way they think about learning and the role they play in their classrooms. One approach to helping teachers gain a sense of comfort with current science practices, including the process of argumentation, known as Argument-based Strategies for STEM Infused Science Teaching (ASSIST), has recently been designed as a means of providing professional development opportunities for K-12 science teachers. As part of the ASSIST program, participating teachers provided written feedback in the form of self-reflections that focus on the challenges they have faced when attempting to implement the ASSIST approach with their students. These self-reflections were examined using the tools of critical discourse analysis (CDA) to uncover themes in the language used by participants as they express difficulties in implementing a new approach to science teaching. Our analysis reveals struggles for power at the instructional, institutional, and interpersonal levels that can stand in the way of progressive approaches to teaching and learning. Fundamental to the power struggles reported on in this research are competing educational ideologies that can be discovered and explored using CDA. Implications for the planning and design of science teacher professional development programs will be discussed.

Keywords Argument-based inquiry · Argumentation · Professional development · Science writing heuristic · Critical discourse analysis

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Introduction

Today, we face issues on a global scale that include combating the effects of a changing climate, feeding a rapidly growing population, and access to an ever-shrinking supply of natural resources. Solving these problems will require international cooperation, advancements in engineering and technology, and decision-makers who possess a working knowledge of the scientific process. There is a real need for a scientifically literate populace capable of critical thought (Wieman 2007). To help develop scientific literacy, one needs to gain fluency in the languages of science including both the formal methods of organizing and communicating scientific information, as well as the different behaviors or habits that a scientist might practice (Norris and Phillips 2003). A major component of shaping the scientifically literate thinkers of tomorrow is making sure the science teachers of today are empowered with the tools they need to both participate in, and facilitate the discourses of science in their classrooms. In the USA, newly adopted national science standards (NGSS Lead States 2013) are focused less on science content and more on the practices of science, with an emphasis on student-generated claims and evidence through the process of argumentation. This shift toward a more student-centered approach to learning may require some educators to reconsider many long-held beliefs about their identity as a science teacher.

At the state and local levels, efforts are currently underway to provide professional development opportunities for in-service K-12 science teachers looking to create engaging learning environments in their classrooms through implementation of the Next Generation Science Standards (NGSS Lead States 2013). In a partnership between the faculty of the Colleges of Education at two state universities, along with a local Area Education Agency (AEA), an approach known as Argument-based Strategies for STEM Infused Science Teaching (ASSIST) (Kuhn and McDermott 2017, 2016) was designed to help meet the call of K-12 teachers who seek to develop familiarity with the NGSS while integrating technology, engineering, and mathematics into their science lesson planning and science learning environments (National Research Council 2011). Built upon a foundation of argument-based practices informed by the science writing heuristic (SWH) (Hand and Keys 1999; Keys et al. 1999), the ASSIST approach draws additional inspiration from research areas that include argument-based inquiry (Hand et al. 2004), immersive learning environments (Cavagnetto 2010; Hand et al. 2016a), and the use of multimodal communication (Lesh 1998), along with practicing science in effective STEM classrooms (Asghar et al. 2012) and professional development designed to encourage district-wide implementation (McDermott and Kuhn 2015). Structured around the overarching goal of helping students develop understanding of central science conceptual big ideas, the ASSIST approach also allows instructors to provide opportunities to purposefully infuse a science lesson with technology, engineering, or math applications.

In 2015, developers of the ASSIST approach began offering professional development (PD) for interested in-service teachers. This PD included both immersive weeklong training sessions in the summer months, as well as check-ins occurring regularly throughout the school year via teleconference. Today, there are nearly 50 educators at various stages in their teaching careers involved in the ASSIST program, coming from six different school districts scattered throughout the central and east-central regions of a state located in the Midwestern USA. During the weeklong summer sessions, participating teachers are given a chance to take on the role of the learner, as PD providers lead them through a science learning sequence based on the ASSIST approach. Lesson planning and discussions facilitated by ASSIST project leaders, content experts, and other members of the local science education community were also integrated into PD activities.

With an epistemological foundation that views learning and knowing as the result of an active process where meaning is constructed as one seeks out their own answers (Kang 2008), the ASSIST approach encourages teachers to start units of study with an initial engagement activity designed to elicit questions and science big ideas from their students. These big ideas and questions then become the basis for activity throughout the unit as students come up with and carry out experiments to answer their own big questions, design and engineer solutions to real-world problems related to their big idea, and consult with local experts to see how their ideas align with the scientifically accepted view of the world. The student-focused ASSIST approach looks different from the traditional practices of science teaching, where concepts and instructions regarding how to conduct an experiment are handed down from the teacher, with few opportunities for student contributions to the lesson planning (Lee and Kim 2017; Oakes 2005).

Theoretical Background

Learning Science Through the Language of Argument

From the outset, the ASSIST approach has been built on and grounded in a set of principles and practices borrowed from the SWH (Hand and Keys 1999; Keys et al. 1999). The SWH takes an argument-based view of inquiry that starts with students' questions, which lead into tests and observations that students can then use to generate claims. During an SWH sequence, students' claims are supported by student-collected data that, when combined with their own reasoning, can be used to develop evidence that students negotiate privately and publicly. The questions–claims–evidence orientation advocated for by the SWH (Norton-Meier et al. 2008) is informed by research in the field of argumentation (Driver et al. 2000; Kuhn 1993) and emphasizes the critical role that language plays in science learning (Hand et al. 2016b; Prain 2004). Recognizing the epistemic nature of language in the science classroom, the SWH is aligned with a view of science as something that cannot be done without language (Norris and Phillips 2003), as it pushes teachers to construct immersive learning environments (Cavagnetto 2010; Hand et al. 2016a) where students learn as they *live the language of science* (Hand 2017; Hand et al. 2017; Linebarger and Norton-Meier 2016). Students immersed in a classroom based in argument, like those created by teachers implementing the SWH or ASSIST, are participating in authentic discourse where ideas are shared and debated, just like those enacted by practicing scientists (Cavagnetto et al. 2010).

Prior research provides numerous examples demonstrating the impact that the SWH approach has on student learning, across grade levels, through the creation of immersive environments where students participate in discourse patterns that mirror those seen in the scientific community. Erkol et al. (2010) explored a group of first year science education majors enrolled in a physics laboratory and the impact that the SWH approach had on their content knowledge, ideas about learning, and attitudes about lab. Compared to the control group, students in the SWH section had higher scores on measures of mechanics conceptual understanding and attitudes toward physics lab. Cronje et al. (2013) investigated the influence that the SWH approach had on undergraduates' writing in an entry-level biology course, specifically their ability to effectively communicate scientific claims supported by evidence. Students in the SWH treatment group tended to receive higher scores than students in the control sections and were significantly more likely to receive a higher score on a formal science writing assignment. They argue the scientific reasoning promoted by the SWH

approach may help students draw stronger connections between their claims and evidence when constructing written arguments.

Kingir et al. (2013) examined the impact that the SWH approach had on 9th grade students enrolled in a chemistry course. Students from the SWH treatment group scored significantly higher than their counterparts on a conceptual test of chemical change and mixture. In the treatment group, students constructed their own knowledge through argumentation by testing their own questions to generate claims and justification of those claims via evidence. After instruction, there were fewer misconceptions held by students in the treatment group, suggesting that the SWH does a better job of closing the misconception gap when compared with traditional instruction. Presumably this is due to the number of opportunities that students in the SWH group had to negotiate ideas through written and verbal argumentation. In another study that looked at the impact the SWH approach has at the high school level, Putti (2011) observed AP chemistry students who reported that the SWH improved their conceptual understanding of the experiments, and had a positive impact on their chemistry learning. Specifically, a majority of the students reported that being given the opportunity to read, reflect, and report on how their ideas had changed was a crucial step in working toward tying the ideas explored during the laboratory component of the course to concepts discussed in lecture.

Cavagnetto et al. (2010), in looking at the generative components of student talk associated with argument, found that 5th graders in an SWH classroom engaged in talk to generate an argument that included making claims and counterclaims, discussions about data, and rebuttals marked by alternative explanations of that data. They also report evidence of students working in small groups to negotiate meaning collectively and students engaged in critique as they were challenged to back up their claims and provide clarification, critical components to understanding the practice of argument in science. These studies indicate that language, specifically talking and writing, two central practices of the SWH, is essential to implementing an embedded approach to argument-based inquiry.

Critical Discourse Analysis

Following a similar theme, though not specific to the science classroom, language can be seen through a wider lens. Language not only allows us to do a variety of things, but to also be different things as we use language to build our sense of reality and engage in discourse with others (Gee 2014). At the most fundamental level, discourse could be viewed as any communication that takes on spoken or written form. As we communicate, we string words together into sentences, which ultimately become thoughts or utterances. Gee (2014), taking the linguist's view, claims that "discourse is the sequence of sentences" (p. 18). Alternatively, argues Gee, linguists may see discourse as *language-in-use*, as they attempt to draw connections between language and the context in which that language is used. Gee (2014) also differentiates between the talk, text, and basic components of language that make up discourse and what he calls Discourse (with a capital D), which can be any "characteristic way of saying, doing or being" (p. 47). Language and the practices, behaviors, beliefs, and ways of thinking or acting that are common within a certain community all collaborate to construct a particular Discourse. Teachers have their own Discourse, just like there is a Discourse for bikers, and a Discourse used by lawyers, and a Discourse for basketball players, and politicians, and you name it; the list goes on, and on.

Other thinkers focused on the topic of discourse also see more than just talk or text, framing language as a social practice, built upon social structures (Fairclough 2015). In this regard, discourse is seen as socially constitutive, capable of not only constructing and maintaining the

social status quo but also working to constantly reshape it (Fairclough et al. 2011). Discourse is interpreted as more than just the act of speaking but, rather, language in its relation with other elements of the social process (Fairclough 2015). Still others view discourse as a means by which reality gets built, constantly moving back and forth between reflecting and constructing the social world (Rogers et al. 2005).

Discourse analysis, then, is simply the study of language in action. From a theoretical standpoint, discourse analysis allows the researcher to look beyond the words in a conversation or the sentences on a page, to see relationships across and between utterances within the context that they are being generated (Gee 2014). What sets *critical* discourse analysis (CDA) apart from discourse analysis is the stance CDA takes on issues related to power and social justice (Fairclough et al. 2004). Luke (1999) claims that CDA is focused on social relations, identity, knowledge, and power, and how they are constructed through written and spoken texts in communities, schools, and classrooms. These thoughts are echoed by Lewis (2006) and Martínez-Roldán and Malavé (2004) who argue that CDA provides for the study of language as it relates to society and ideology. Gee (2014) sees all language as being political, tied to what he calls the distribution of social goods. Therefore, it is his view that that *all* discourse analysis needs to be critical.

On a more practical level, CDA provides for a collection of procedures that can be used to dig into the social relations, struggles for power, and ideological messages contained within our use of language. Taking things a step further, critical discourse analysts attempt to seek out explanations of language by offering a critique of what is said, how it is being uttered, and where it is occurring, often with an eye toward power relations (Rogers 2011). Fairclough (2015) provides a model for exploring how language shapes concepts like power and ideology, outlining what he refers to as the 'three stages of CDA' that provides a *description* of the language being used, an *interpretation* of the relationship between that language and the discursive interaction where it occurred, and an *explanation* of the relationship between that interaction and the context in which it took place.

To help cultivate insight into how we use language to define our sense of reality, Gee offers a series of *building tasks* that he sees as being used to construct *significance*, *practices*, *identities*, *relationships*, *politics*, *connections*, and *ways of knowing*. Gee (2014) argues these building tasks are a means by which we create what he calls our *figured worlds*, "simplified, often unconscious, and taken-for-granted theories or stories about how the world works that we use to get on efficiently with our daily lives" (p. 95). This collection of ideas, Gee's building tasks framed within Fairclough's emphasis on power and ideology, and his three stages of CDA serve a complementary set of tools. Throughout this study, these building tasks will be relied on to discover relationships between utterances, while shedding light on the struggles for power between competing ideologies occurring within the larger conversations related to learning and teaching that contribute to the development of our figured worlds.

Historically, CDA has proven capable of discovering power and ideology at play in the language practices of adults and children (Martínez-Roldán and Malavé 2004; Rogers et al. 2005). Fairclough (2015), in his thoughts on the relationship between language and power, argues that power can exist both *in* discourse, as well as *behind* discourse. In the instance of a teacher providing direct instruction to a pupil, we see an example of power residing *in* discourse as the teacher exerts control over the student's contributions. Alternatively, when we hear about educators being asked to teach standardized content though the language of the NGSS, the power here would seem to exist *behind* the discourse. In the case of the teacher communicating with the student through direct instruction, this discourse occurs face-to-face

in real time, whereas a divide in space and time exists between the authors behind the NGSS and the teachers who are being asked to carry them out in their classrooms. According to Fairclough (2015), any place where discourse operates in such a way that it sustains an unequal distribution of power, it does so as a result of ideological differences between the two parties. All of these things can contribute to the construction of Gee's figured worlds, what others have referred to as *cultural models*, or *schema* about how things ought to work and what we infer as *normal*. The study described here reveals interesting parallels between Gee's figured worlds and Fairclough's conceptions of ideology. As we will demonstrate, focusing on Gee's building tasks related to practices, identities, relationships, politics, and ways of knowing provides a means of drawing out similarities and connections between the two.

Returning the focus to science education, CDA has proven to be a useful research method when examining a variety of topics related to the critical role that language plays in science learning, including the relationship between teacher talk and issues related to the accessibility of school science (Hanrahan 2006), the values that get privileged over others in the language of the NGSS (Hoeg and Bencze 2017), and the structures and patterns in teacher–student dynamics that correlate with strong student engagement and high levels of student power (Cochran et al. 2017). The work of Lee and Kim (2017) demonstrates how CDA was used to explore the language used by Korean elementary science teachers and their students as a means of enacting power in teacher-centered, authoritative classrooms. The study described here aims to add to this growing list of literature focused on CDA as a research tool in the context of science education. We will make the case for CDA as a useful means of analyzing the language that teachers use to reflect on their experience implementing an argument-based approach to inquiry in their science classrooms, and what that language says about a teacher's epistemological orientation and educational ideology.

Educational Ideologies

Segueing from the theoretical and analytical tools of language and CDA, we would like to focus more closely on the concept of ideology, with particular attention to the ideologies swirling around the educational arena, the impact these could potentially have on the (re)organization of a teacher's figured world, and the struggles for power that teachers engage in. Van Dijk (2006) views ideologies as being key to shaping the identities of social groups, and are largely accessed, expressed, and reproduced through discourse. Fairclough (2015) sees ideologies as central to sustaining existing social relations and relations of power within institutions like education. Gee (2012) argues that the theories we carry around with us relating to how we think certain groups of people are supposed to act help shape Discourses, influence our figured worlds, underlie all language, and should therefore be viewed as ideological. Language, Gee (2012) claims, is "inextricably bound up with ideology and cannot be analyzed or understood apart from it" (p. 4). Simply stated, ideology is the guiding set of ideas of an individual or group that includes the often-presupposed notions about the way we think things ought to be. Our analysis using both Gee and Fairclough reveals parallels between Gee's concepts of Discourse and figured worlds and what Fairclough has to say about ideology. We speculate that these frameworks offer two different ways of analyzing and talking about the same thing.

Within the context of education, the notion of ideology is something that researchers have been wrestling with for many years. Going back to the early 1970s, Kohlberg and Mayer (1972) identified educational ideologies that they referred to as being of the *cultural transmission*,

romantic, or *progressive* schools of thought, with students assuming a more central role in the development of their own learning at each respective stage. Woolfolk and Hoy (1990), in their work on pupil control ideology, viewed the stance taken by educators related to the control they think they have over their students' learning as being either *custodial*, or *humanistic*, with similar ideas coming out of the work done by O'Neill (1990) who saw teachers' ideologies as being either *conservative* or *liberal*. More recently, Shumba (1999) and Gado (2005) have described instructional ideologies as falling into the categories of *traditional* or *inquiry-based*, with Harpaz (2015) outlining what he sees as three ideologies of education known as *individuation*, *acculturation*, and *socialization*. Wherever you happen to fall chronologically in this review of the literature pertaining to educational ideology, a common theme emerges with teachers' ideologies falling somewhere along a continuum with more teacher-centric ideologies and beliefs about learning living on one end and ideologies privileging the role of the student residing on the opposite end. Fairclough (2015) points out that "in education, children, parents, and teachers, and groupings within each of these (based upon age, class, political allegiance, etc.) may in principle develop different educational ideologies" (p. 110). He goes on to add that the instances where these educational ideologies evolve tend to coalesce around struggles over institutional power, which we will see played out in the study described here. These ideas helped shape the central question that this study attempts to address: What does the language that science teachers use to reflect on their experience implementing an argument-based approach to inquiry tell us about their educational ideologies?

Methods

Setting and Participants

Now in its third year, the ASSIST PD program has consisted of weeklong summer workshops combined with periodic meetings occurring every 3–4 weeks during the school year through a video conferencing platform. Summer workshops provide an opportunity for participants to engage in the dual role of both student and teacher as they are immersed in ASSIST-based science activities just like their students might be, before being given a chance to discuss and reflect from a teacher perspective about what just took place with their fellow participants. In addition to observing firsthand a model of how they might implement the ASSIST approach in their own classrooms, there is also time available during the workshop sessions for planning using templates and other resources developed by the ASSIST research team. The meetings through videoconference during the school year provide a space for teachers from different schools and districts to collaborate and communicate with each other about their experiences implementing argument-based strategies in their classrooms.

There are currently 44 teachers participating in the ASSIST program, bringing with them a diverse array of backgrounds and experiences. Based on responses to entrance surveys, teachers reported feeling confident in their abilities as science teachers and were motivated to participate in the PD based on a desire for additional resources for creating student-centered learning environments and curricular materials aligned with the NGSS. Like many K-12 educators, a large portion of these participants do not specialize in science teaching, with science accounting for a small percentage of their daily teaching duties in many cases. While the majority of these teachers are from elementary schools (prekindergarten through grade 5), there are a small number of middle school and high school teachers participating in the

ongoing professional development. Taken together, these teachers have, on average, just over 17 years of teaching experience, ranging from a single year in the classroom to 45 years spent working with students. There is less diversity when we look at how the ASSIST participants are categorized by gender and race with seven of the 44 teachers identifying as male and the remaining 37 being female. All of the participants identify as Caucasian, with the exception of one female teacher who identifies as African American.

Taking a closer look at the schools and districts these teachers represent gives us some indication of the students that they serve. Overall, teachers participating in the ASSIST program are spread out over six school districts, reaching students from 13 different schools. These school districts range in size from very small, serving less than 200 students in a rural setting, with the largest school district located in an urban, racially diverse community with over 10,000 students. Among the 13 schools in which the teachers are employed, seven are part of a public school system with the remaining six schools being in parochial schools affiliated with either the Lutheran or Catholic Church. Of the 44 teachers participating in the ASSIST program, 23 work in a parochial school.

Data Collection

During the professional development workshops that occurred in the summer of 2016, participants were asked to complete a series of Likert-scale surveys that assessed their comfort levels when it came to their understanding of and ability to implement the ASSIST approach in their classrooms. This was followed by a collection of responses to open-ended prompts that provided participants an opportunity to reflect on a lesson they planned using the ASSIST approach, their overall reaction to that experience, and any challenges they faced during the implementation process. This data was collected through an online platform and saved as an Excel spreadsheet to aid with analysis.

For the purpose of this study, responses to the prompts "Describe your overall reaction to the planning and implementation of this unit" and "Describe the major challenges you had as an instructor in implementing this unit" were selected as the unit of analysis. At the time it was distributed, 23 of the 44 teachers participating in the ASSIST program were present to take the survey. From those 23 participants, responses from six teachers were chosen based on the focus they placed on students and their ability to deeply reflect on the difficulties they faced when attempting to implement a unit that had been planned using the ASSIST approach. While responses from other teachers tended to center around the time and resource constraints associated with a more student-centered approach to learning, the teachers whose reflections are the focus of this study went beyond the typical hurdles that all teachers must overcome to focus on how their ideas about learning, and the role that a teacher plays, have been challenged on a fundamental level. These six teachers, all of whom identify as white females, include Ms. Adams, a 6th grade teacher with 26 years of experience in the classroom; Ms. Baker who has been teaching 1st grade for 7 years; and Ms. Cooper with 19 years of experience teaching 5th graders. These three teachers all work in an elementary school that is tied to the Lutheran Church located in a small, rural community that serves just over 100 total students. Ms. Davis has been teaching kindergarten for 6 years in a public school, also situated in a small, rural community that enrolls over 200 students. Ms. Evans and Ms. Foster are both 2nd grade teachers with 2 and 32 years of experience in the classroom, respectively. Both of these teachers work in public schools located in a large, urban school district with over 10,000 students from diverse racial, ethnic, and socioeconomic backgrounds.

Data Analysis

The self-reflections from these six teachers were filtered through a critical discourse lens in hopes of uncovering any themes related to ideology and an unequal distribution of power. Table 1 contains responses to the prompts identified above from the six teachers at the center of this study. At the time the survey was distributed to the PD participants in January of 2017, Ms. Cooper had been involved with the ASSIST PD program for one and one-half school years, while Ms. Adams, Ms. Baker, Ms. Davis, Ms. Evans, and Ms. Foster each had only one semester of experience using the ASSIST approach with their students.

Upon first cycle coding of the responses, open coding (Saldaña 2016) was used to get a general sense of the language these teachers were using to communicate the challenges they faced when attempting to implement the ASSIST approach with their science classes. This was followed by another cycle that relied on emotion coding (Saldaña 2016) to identify and classify the feelings that were being expressed through these teachers' self-reflections. To help draw connections between the emotions these teachers are reporting here and issues related to power, critical discourse methods that included *building tasks* and *tools of inquiry* (Gee 2014) were employed as a way of further investigating how these teachers illuminate struggles for power through their use of language.

Gee argues that, with language, people are able to construct reality by using the building tasks of communication to emphasize what we feel is *significant*, to help enact the *practices* we engage in throughout the day, and shape the *identities* we want to project onto the rest of the world. We can also use the building tasks of language, claims Gee, to establish *relationships* with others, influence the distribution of socially traded goods and services (what Gee calls *politics*), and make *connections* with other discourses. Finally, it is Gee's view that we also use language to privilege certain *ways of knowing*, what educators might call epistemology (Driscoll 2005; Driver et al. 1994).

Gee (2014) suggests that questions about those tasks should be formed using six tools of inquiry to investigate the work each building task is able to do in a given context, forming what he refers to as a "full" or "ideal" discourse analysis (p. 141). These tools of inquiry include situated meanings, social languages, figured worlds, intertextuality, Discourses, and Conversations. For this study, we decided to focus on five building tasks (practices, identities, relationships, politics, and ways of knowing) and two tools of inquiry (figured worlds and Conversations) because we felt they would be most helpful in uncovering clues about the ideological frameworks that these teachers relied on during self-reflection. As part of their figured worlds, teachers carry around with them some sense of what they think a classroom is *supposed to* look like. Debates, arguments, or themes that exist in certain social groups, or society as a whole, make up the tool of inquiry Gee refers to as "Big 'C' Conversations." The conversations we have with our friends or colleagues are only part of a collection of much larger Conversations that are central to major debates or issues, and influence how we interpret language. Gee (2014) claims that "to know about these Conversations is to know about the various sides one can take in debates about these issues and what sorts of people are usually on each side" (p. 47). As with Conversations about issues like global climate change, evolution, or politics, in the field of education, we are constantly overhearing and participating in Conversations about teaching, learning, and management of the classroom.

Questions were generated for each building task/tool of inquiry pair for a total of 15 questions that included "How does a teacher's figured world contribute to the shaping of their identity through these self-reflections?" and "Are different ways of knowing granted greater privilege than others in teacher self-reflections and do we see this playing out in larger

Table 1 Teacher responses to prompts 1 and 2

Teacher	Prompt 1—*Describe your overall reaction to the planning and implementation of this unit:*	Prompt 2—*Describe the major challenges you had as an instructor in implementing this unit:*
Adams	*The planning was difficult, but it was my first unit, so I understand. It seemed like the first 2 class sessions, I wasn't comfortable, and things weren't clicking. However, during the third class session, the students began asking great questions, and bringing their own ideas into the discussion. At this point, I backed off, and tried to only facilitate the conversation. It was awesome!!*	*I have trouble leading the students to ask good questions and to design experiments to answer those questions.*
Baker	*I was a bit overwhelmed at first. Once I got going, it gained confidence. Sound and light isn't my favorite topic.*	*My most challenging areas included never having students "be in charge" before. Giving them more control with finding the big idea then having negotiations was scary to think about. However, they went great. Not having a ton of background knowledge was also difficult (because this isn't my favorite topic).*
Cooper	*Once I get started, I do ok. I often get stuck at the beginning with the activity. I also struggle with the timing of things and still feel like I will not get through everything that I'm supposed to, according the NGSS and Common Core. I do enjoy the discussions that I have with my students and, after I got used to it, the unpredictability of the lessons. By that I mean that although I have it planned out, the directions the students take it may be different. It is both a bit nerve wracking and fun all at the same time. I just had to get out of my comfort zone.*	*As I mentioned in the above question, each lesson takes a substantial amount of time. While I feel that this also allows the learning to be more meaningful for the students, I will have to keep working on keeping it "moving along," so to speak, so that I also fulfill my responsibilities as far as curriculum. As always, it is a work in progress.*
Davis	*The overall planning took awhile to integrate since it was from scratch. It was really fun to see grow. My original plans from this summer when I began changed a lot according to how the kids took it so I do need to change my overall unit plans. I did have troubles getting my kids to argue about weather. It happened a few times, but not enough! :)*	*I had a challenge accepting to change my whole unit plans to fit the needs of the kids that ran with things a different way! :) They either went a different direction or it was too hard and they weren't interested, etc. Doing it for the first time made me see things I want to change for next year.*
Evans	*At first I was struggling to find a vision for my unit, how to design questions that would lead to student led investigations that would meet the standards. While trying the unit I felt I gained a better understanding of how to lead students questions towards investigations that would both answer their questions and meet the NGSS standards. My students were very excited to see their questions leading our unit and had high ownership with the related projects.*	*The biggest challenge for me was finding a way to make our 1st question student centered. I had a tough time finding an initial engagement activity that would lead students to "obtain information to identify where water is found on earth." I was stuck in thinking of maps, but have since seen ideas that show students looking in their neighborhood for signs of water. This will be an important part of the unit to revisit and modify in the future.*
Foster	*Once we got started the unit seemed to flow—then when I went to implement the unit into my classroom it felt really choppy. Like the activities didn't scaffold.*	*Putting the responsibility onto the students was hard for me. Planning and gathering materials was also a challenge because I was never sure where the students would go.*

Conversations about teaching?" among others (Table 2). Examples of how these data were coded for emotions (underlined text), and building tasks (bolded text) are displayed in Table 3.

Table 2 Questions framed within Gee's building tasks and figured worlds, used to help shape data analysis

Building tasks (Gee 2014, p. 30)	Tools of inquiry (Gee 2014, p. 94)	
	Figured worlds	Conversations
Practices	*What effects do figured worlds have on the practices being communicated through teacher self-reflections?*	*Are the practices enacted and summarized through teacher self-reflection part of a larger Conversation?*
Identities	*How does a teacher's figured world contribute to the shaping of their identity through these self-reflections?*	*Within which larger Conversation(s) are these teacher self-reflections taking place and what impact does this appear to have on their sense of identity?*
Relationships	*What can teacher self-reflections tell us about the relationships that exist within their figured world?*	*Based on teacher self-reflection, what relationships appear to be valued, and are they part of a larger Conversation?*
Politics	*How do teacher self-reflections communicate the exchange of social goods in the figured world in which they operate?*	*How is the exchange of social goods communicated through teacher self-reflections and how is this message shaped by the larger Conversations re lated to learning and teaching?*
Sign systems/knowledge	*Do teacher self-reflections provide evidence that certain ways of knowing are valued more highly than others and, if so, what role might figured worlds play here?*	*Are different belief systems granted greater privilege than others in teacher self-reflections and do we see this playing out in larger Conversations?*

Simultaneous coding (Saldaña 2016) was also used here as the same piece of text could be used for multiple building tasks. Included in this table are our answers to questions like those laid out in Table 2, intended to add validity to claims made about the interactions between these building tasks and tools of inquiry. The ideas coming out of this analysis were organized using Fairclough's three-step model of CDA that emphasizes description, interpretation, and explanation of language, and was done with an eye toward the concepts of teacher epistemology and educational ideology, a process that helped shape the research question central to the study described here.

Findings

Description

Fairclough's model of CDA begins with a description of the text. At first glance, the teacher self-reflections at the center of this study communicate a message of struggle as they work to overcome challenges they faced while implementing an argument-based approach to teaching. We see this demonstrated through the experiential, relational, and expressive values of the language teachers used to describe their reaction to lesson planning with the ASSIST method. Taking a look at Ms. Foster's response to prompt 2 (see Table 1):

> *Putting the responsibility onto the students was **hard** for me. Planning and gathering materials was also a **challenge** because I was never sure where the students would go.*

Ms. Foster is struggling with how much responsibility to give to the students and the constraints that places on the process of lesson planning, as indicated by her decision to use

Table 3 Example of data coded for emotions (underlined) and building tasks (bold), along with our answers to the questions shown in Table 2, intended to draw connections between those building tasks and tools of inquiry (italics)

Building tasks (Gee)	Prompt 1—Describe your overall reaction to the planning and implementation of this unit:	Tools of inquiry (Gee)	
		Figured worlds	Conversations
Identities	*Once I get started, I do ok. I often get stuck at the beginning with the activity. I also struggle with the timing of things and* **still feel like I will not get through everything that I'm supposed to, according the NGSS and Common Core.** *I do enjoy the* **discussions that I have with my students** *and, after I got used to it, the* **unpredictability of the lessons.** *By that I mean that although* **I have it planned out**, *the directions the students take it may be different. It is* **both a bit nerve wracking and fun all at the same time.** *I just had to get out of* **my comfort zone.**	This teacher used to identify herself as the planner of well-timed, predictable lessons. As she implements a new approach to lesson planning, her figured world is evolving as she experiences an identity change that, at first, she wasn't totally comfortable with.	Recently, Conversations surrounding science teaching and learning have shifted to focus largely on the Next Generation Science Standards (NGSS). Teachers are feeling pressure to meet those standards while also fighting to hang on to their traditional identities.
Relationships	*Once I get started, I do ok. I often get stuck at the beginning with the activity. I also struggle with the timing of things and still feel like I will not get through everything that I'm supposed to,* **according the NGSS and Common Core.** *I do enjoy the discussions that* **I have with my students** *and, after I got used to it, the unpredictability of the lessons. By that I mean that although I have it planned out,* **the directions the students take it may be different.** *It is both a bit* nerve wracking *and fun all at the same time. I just had to get out of my comfort zone.*	The relationships that commonly exist in a teacher's figured worlds, namely the relationship between teachers and students, are on display here. We also see evidence of a new relationship between the teacher and the NGSS.	In education, Conversations about the relationship between teachers and students have traditionally framed the teacher as the one who controls learning. For this teacher, newly adopted standards, and participation in the ASSIST PD program, have shifted this Conversation as greater emphasis is placed on the role students play in constructing their own understanding.
Ways of knowing	*Once I get started, I do ok. I often get stuck at the beginning with the activity. I also struggle with the timing of things and still feel like I will not get through everything that I'm supposed to, according the NGSS and Common Core. I do enjoy the discussions that I have*	This teacher appears to value ways of knowing that place her in charge of what students will learn, and the direction they will go through that process. As she gains experience with the ASSIST, her figured world in undergoing a shift away from the	Here we see a case where belief systems that locate the teacher at the center of the learning process are being challenged. This can be attributed to the changing nature of larger Conversations about learning and teaching that reassigns the student to a position of power when

Table 3 (continued)

Building tasks (Gee)	Prompt 1—Describe your overall reaction to the planning and implementation of this unit:	Tools of inquiry (Gee)	
		Figured worlds	Conversations
	with my students and, after I got used to it, the unpredictability of the lessons. **By that I mean that although I have it planned out, the directions the students take it may be different.** *It is both a bit* <u>*nerve wracking*</u> *and fun all at the same time. I just had to get out of my comfort zone.*	traditional teacher-centered view of the world, to one where students have a much greater sense of control.	it comes to what they learn.

expressive language like *hard* and *challenge*. We see a very similar theme when we focus our attention on these reflections from Ms. Baker and Ms. Adams:

> My most **challenging** areas included never having students "be in charge" before. Giving them more control with finding the big idea then having negotiations was **scary** to think about.
> I was a bit **overwhelmed** at first. Once I got going, I gained confidence. Sound and light isn't my favorite topic.
> I have **trouble** leading the students to ask good questions and to design experiments to answer those questions.

Like Ms. Foster, these teachers are *challenged*, or *troubled*, by this idea of having the students take control of the lesson planning, electing to use the words like *scary* or *overwhelmed* to express their level of discomfort.

Examining the other reflections provides more evidence of the difficulties these teachers faced as they became familiar with the ASSIST approach, while also trying to meet the demands of the science standards they are expected to help their students understand. Taking a closer look at the second line in Ms. Cooper's reflection:

> I also **struggle** with the timing of things and still feel like I will not get through everything that I'm supposed to, according to the NGSS and Common Core.

Similarly, with the opening line of Ms. Evan's response to prompt 1:

> At first I was **struggling** to find a vision for my unit, how to design questions that would lead to student led investigations that would meet the standards.

Each of these teachers expresses a level of concern over the constraints being placed on them in the form of standards and the impact these have on their ability to function in the role of teacher that they have become so accustomed to.

Interpretation

Moving ahead to the second dimension of Fairclough's model of CDA, I will interpret each of these teacher's self-reflections to better understand the emerging power struggles evident in

our analysis at the description level, borne out through the choice of language these teachers use to look back on their experience with ASSIST. Initial examination of these teacher self-reflections reveals evidence of major struggles for power that seem to exist along three planes. These planes include contesting for power at the institutional level, at the instructional level, as well as on an intrapersonal level.

Institutional Power

Returning to the reflections from Ms. Cooper and Ms. Evans, we see evidence of a struggle over power that centers on the standards they are being asked to cover in their classrooms. As we mentioned before, there is power behind these standards and the teachers demonstrate that in the way they speak about the expectations that have been placed on them:

> I also struggle with the timing of things and still feel like **I will not get through everything**
> **that I'm supposed to**, according to the NGSS and Common Core.
> At first I was struggling to find a vision for my unit, how to design questions that would lead to student led investigations that **would meet the standards**.

Our analysis suggests that these teachers appear to view these standards with a sense of authority that commands a certain level of respect. The first example makes reference to not getting through everything she's *supposed to*, according to the NGSS standards, with the second excerpt referring specifically to *meeting* the standards. The use of words like *meet* (the standards) and *according to* (the NGSS and Common Core) demonstrates the sense of authority the standards command and the level of respect these teachers have for that authority. This language suggests that Ms. Cooper and Ms. Evans see these standards almost like a contract that they are expected to live up to, put in place by the faceless authors of the standards, wielding power over teachers who assume a subordinate role as implementers of the standards.

Instructional Power

At the same time these teachers are struggling to compete for power against the authors of the NGSS standards they have been charged with enforcing, they are also beginning to (re)develop an awareness of who ultimately controls the learning in their classrooms. Teachers have traditionally been promoted to a position of power over their pupils, as they get to decide what content to cover and how to cover it. As these teachers gain experience with the ASSIST approach, their traditional views of teacher in control have been challenged, as they are pushed to accept a more student-centered model of learning. The opening line of Ms. Foster's reflection to the second prompt provides a wonderful example of this struggle for power at the instructional level:

> **Putting the responsibility onto the students** was hard for me.

Ms. Foster is struggling with this newfound level of responsibility that the students now have access to, and is uneasy with this idea as she comments on how hard it was for her to give up control. Her colleague Ms. Baker shares similar views about handing over responsibility to her students, as shown in the first line of her response to prompt 2:

> My most challenging areas included **never having students "be in charge" before**.

Prior to Ms. Baker's experience with the ASSIST approach, she felt as though she had always been the one in control, having <u>never</u> given the students the opportunity to *be in charge* until now. We see another example of struggle over instructional power in Ms. Davis' reflection on the challenges she faced when implementing the argument-based ASSIST approach in her classroom:

> I had a challenge **accepting to change** my whole unit plans to fit the needs of **the kids that ran with things a different way**! :)

Ms. Davis, like her fellow teachers, also struggled to *accept* the challenges of implementing a new approach to instruction that provides students with the opportunity to *run away* with the lesson in a direction she may not have initially anticipated.

Intrapersonal Power

The third struggle for power that emerges from an analysis of these teacher self-reflections appears to come from within these teachers as their previously existing beliefs about their role in the classroom is met with an alternative way of looking at the world. If we focus our attention on the last two lines of Ms. Cooper's response to the first prompt, here we see an outstanding example of this internal game of tug-of-war taking place inside these teachers:

> It is both a bit **nerve wracking and fun** all at the same time. I just had to get out of my **comfort zone**.

Ms. Cooper harbors a sense that not knowing the direction her students will take a lesson can be simultaneously *nerve-wracking and fun*, as her new perspective on science teaching struggles in a contest for power against the views she held prior to implementing the argument-based ASSIST approach. Ms. Cooper's reflection would indicate that she's trying her best to negotiate the new terrain outside the comfortable environment she's become so used to operating in. On the other hand, we do see instances where teachers may be a bit more hesitant to jump outside their *comfort zone*, as appears to be the case with Ms. Baker's response to prompt 1:

> I was a bit **overwhelmed** at first. Once I got going, **I gained confidence**
> Sound and light **isn't my favorite** topic.

While Ms. Baker may be starting to *gain confidence* after initially feeling *overwhelmed* the fact that she comments on the nature of the content as not being her *favorite* indicates that she may hold on to a more teacher-centric educational ideology, as she expresses frustration about being tasked with teaching a subject that she's not comfortable with. We will try to further unpack the reasoning behind this frustration in the following sections.

Explanation

The third dimension of Fairclough's approach to CDA involves explaining the text within the social context that it occurs. We have argued that the power struggles outlined above have resulted in a structural reorganization of the figured worlds these teachers have long relied on to define what they view as 'normal' when it comes to their role in

the classroom. As a result of participating in the ASSIST program, this figured world has been challenged. We saw earlier that Gee (2014) provides a theoretical framework that allows for an explanation of discourse through the building tools of language that we use to construct our reality. In the section that follows, we will rely on five of Gee's seven building tasks to explain the language these teachers use to enact *practices*, shape *identities*, build *relationships*, express *political* views, and privilege certain *ways of knowing*. We aim to draw out the connections between the power struggles identified earlier and the teachers' figured worlds discussed here, with an eye on the role that educational ideology plays in those struggles.

Practices

Primary to a teacher's figured world are the practices they engage in during their normal routine as an instructor. Gee encourages us to think about the practices that language can be used to enact, and we see glimpses of that in these teacher's self-reflections. Perhaps what is most striking is the apparent sense of role reversal these teachers are communicating through their language as a result of trying to implement the ASSIST approach in their classroom. Looking closely at Ms. Evans' reflection to the first prompt, we see in the second and third lines reference to the practices of questioning and planning investigations:

> While trying the unit I felt I gained a better understanding of how to **lead students' questions towards investigations** that would both answer their questions and meet the NGSS standards. My **students were very excited to see their questions leading our unit** and had high ownership with the related projects.

Here we see Ms. Evans is beginning to become more comfortable with the changing nature of the practice of questioning and the role the students play in that process. Traditionally, the teachers are the ones asking questions to the students, and it was usually the case that the teacher's questions or questions from textbooks or a lab manual were what drove the line of inquiry. Using the ASSIST approach, students are now expected to come up with their own questions and investigations to help answer those questions through argumentation, something students in similar studies have embraced (Hand et al. 1997). Newly adopted practices associated with an argument-based orientation to inquiry also seem to be challenging these teachers, as indicated by Ms. Davis' reflection to prompt 1:

> I did have **troubles getting my kids to argue** about weather. It happened a few times, but not enough!

It may be that Ms. Davis and her students are still warming up to the practice of publicly debating science ideas with their peers, something that does not happen often in the traditional, teacher-centered classrooms that many educators are so used to working in.

Identities

Gee also asks us to think about the identities that language can be used to construct and the clues they might provide about teachers' figured worlds. These teachers indicate that they had traditionally identified themselves as planners of lessons, gatherers of materials, finders of big ideas, and more recently, implementers of standards. And while each of

these components may still play a part in constructing these teachers' identities, their self-reflections reveal a situation that is currently in a state of flux. Both NGSS and ASSIST position students as the askers of questions, designers of experiments, and negotiators of ideas, all things the teacher previously identified with. This evolving identity is a key contributor to the struggles for power facing these teachers as demonstrated by a re-examination of Ms. Adams' responses to both prompts:

> The **planning was difficult, but it was my first unit**, so I understand.
> It seemed like the first 2 class sessions, **I wasn't comfortable**, and **things weren't clicking**. However, during the third class session, **the students began asking great questions**, and **bringing their own ideas into the discussion**. At this point, I backed off, and **tried to only facilitate** the conversation. It was awesome!!
> I have trouble **leading the students to ask good questions** and to **design experiments to answer those questions**.

Self-reflections such as these would seem to indicate that, prior to becoming an implementer of the ASSIST approach, Ms. Adams' identity included playing the roles of questioner, provider of ideas, and designer of experiments. While she may, after time, be more comfortable *backing off*, allowing herself to be relegated to the role of *facilitator of the conversation*, at the same time, she continues to be troubled by her newfound sense of needing to cede control to her students, giving them the power to come up with experiments to answer their own questions, a hallmark of ASSIST.

Relationships

As is the case with the changing identities these teachers reflect on here, the evolving nature of the relationships between these teachers and their students is a key feature of the language these teachers are using and a central component to a teacher's figured world and Conversations about teaching and learning. We see numerous examples of the teachers' use of language to enact their relationship with their students:

> Putting the responsibility onto the **students** was hard for me.
> …I was never sure where the **students** would go.
> …how to design questions that would lead to **student** led investigations…
> …the directions the **students** take it may be different.
> …never having **students** "be in charge" before.
> I have trouble leading the **students** to ask good questions.
> …this also allows the learning to be more meaningful for the **students**
> …fit the needs of the **kids** that ran with things a different way!

It is the case in many of the examples found here that these teachers are struggling with the changing nature of the relationship they are having with their students, converging with what we saw earlier in the discussion about struggles over power at the instructional level. Who is in charge? Who is in control? Who has the power? These are questions these teachers should continue to wrestle with as they implement the ASSIST approach.

In addition to teachers enacting relationships with their students, these reflections also reveal insights into the relationships teachers have with curriculum and the standards they have

been tasked with understanding and implementing. We see evidence of this relationship in the following excerpts:

> …*I will not get through everything that I'm supposed to, according to the **NGSS** and **Common Core.***
> …*I will have to keep working on keeping it "moving along," so to speak, so that I also fulfill my responsibilities as far as **curriculum.***
> …*lead students questions towards investigations that would both answer their questions and meet the **NGSS standards***
> …*how to design questions that would lead to student led investigations that would meet the **standards**.*

The looming presence of the standards that shows up repeatedly throughout these reflections demonstrates that these teachers are always keenly aware of their responsibility to fulfill their role as implementer of the standard, validating what we saw earlier through our examination of power at the institutional level with teachers assuming a subordinate role to the authors of the standards.

Politics

Gee defines politics as the distribution of what he refers to as *social goods* that, in the case of education, could include everything from knowledge and information, access to athletic and academic scholarships, or a degree upon graduation. For the purposes of our discussion, the social goods these teachers' self-reflections seem to gravitate toward are that of control over their students and the direction that lessons take in their classroom, as seen in these excerpts from Ms. Cooper, Ms. Evans, and Ms. Adams' reflections:

> *By that I mean that although **I have it planned out**, **the directions the students take it may be different.***
> *My students were very excited to see **their questions leading our unit** and had **high ownership** with the related projects.*
> *… during the third class session, **the students began asking great questions** and **bringing their own ideas into the discussion**. At this point, I backed off, and tried to only facilitate the conversation*

These reflections would seem to suggest that the teachers' old approach to the planning and guiding of classroom activities must now give way to a new environment where the students have a greater say in the way that social goods are distributed, again speaking to the notion of the power struggles taking place at the instructional level.

Ways of Knowing

The last of Gee's building tools of language that I mention is the way in which language gets used to privilege certain ways of knowing, commonly known as epistemology. Young (1981) argued that teachers' views of knowledge, their epistemologies, affect the way they organize and transmit information in the classroom. It would appear to be the case that, based on the self-reflections shown here, these teachers are still operating within an objectivist epistemological framework, where knowledge is seen as existing separate from the learner and can be

obtained only through experience (Driscoll 2005), as evidenced by this line from Ms. Baker's reflection to the second prompt:

> *Giving them **more control with finding the big idea** then having negotiations was scary to think about.*

Ms. Baker's language suggests that prior to implementing the ASSIST approach, she had been the one in *control* of supplying the *big ideas* that would serve as the central theme around which a lesson gets planned. From the standpoint of epistemology, Ms. Baker seems to still be getting acquainted with the pragmatist, or interpretivist, epistemological views that informed the development of the ASSIST approach, where knowledge is seen as something that is negotiated through reasoning and constructed within the learner as an individual and socially among their peers through argumentation.

Discussion and Implications

We have been able to demonstrate, through our critical analysis of the language these teachers use to reflect on their experience implementing the argument-based ASSIST approach, that there exist struggles for power occurring at the institutional, instructional, and intrapersonal levels. Teachers' struggles for power see themselves played out over state-mandated standardized performance expectations, control over learning and lesson planning, and internal battles related to their role in the classroom. It has been shown that, central to these power struggles, there exists a structural reorganization of the figured worlds these teachers bring with them as participants in the ASSIST program. Within the context of our teacher participants and the struggles they communicate through their self-reflections, we claim that given their proclivity to reflect back on the apparent lack of control they are experiencing as they implement the ASSIST approach, coupled with their repeated appeals to the authority of the standards they have been tasked with upholding, indicates that these teachers continue to maintain an educational ideology that is more closely aligned with the conservative, traditional, and cultural transmission ideologies cited in the literature. These teachers are still developing their own fluency with the languages of science promoted by the NGSS and ASSIST, built on a constructivist view of learning and structured largely within the framework of progressive, liberal, or inquiry-based educational ideologies. We claim that the figured worlds these teachers have developed throughout their careers in education (first as students and now as instructors) are deeply rooted in their educational ideologies. Ideologies and the figured worlds they construct do not just change overnight, and it is our view that the challenges these teachers face, and the struggles for power they seem to be communicating as they reflect on their experience implementing an argument-based approach to science teaching, are driven largely by the rather abrupt set of changes that are taking place at the heart of their figured world in response to their involvement with the ASSIST program, directly challenging their existing educational ideology. At the heart of the changes taking place within the figured worlds of these teachers are the challenges, being offered up by NGSS and ASSIST, to these teachers' existing educational ideologies, which, we argue, both inform and are informed by their epistemological orientations.

What does this mean for us as developers of teacher professional development moving forward? First, we need to make the epistemological framework and corresponding educational ideologies that shaped the ASSIST program and the NGSS standards these teachers are being held responsible for, explicit in our materials to help participating teachers confront their

existing views about learning and knowledge early on in the ASSIST sequence. There is research to suggest that giving teachers a space to reflect on their own theories of learning at the beginning of a professional development program can help overcome long-held, traditional beliefs about the amount of control they have over their students' learning (Hand and Treagust 1994), and ASSIST participants need to be given the same opportunity. It has also been theorized that in order for teachers to successfully implement immersive, argument-based approaches to science learning, their epistemic orientations need to first undergo a shift to become more aligned with their content knowledge and pedagogical practices, with a greater focus on the critical role that language plays in the learning process (Hand et al. 2016b, 2018). The findings reported on here would appear to provide evidence in support of that claim.

Secondly, the results of this study suggest that giving teachers additional points of access to the NGSS standards they are expected to uphold may help them to overcome their perceived identity, where the standards have somehow been elevated to an authoritative position, with the teachers assuming the subordinate role of implementer of the standards. One goal of the ASSIST program is to provide a vehicle by which the NGSS standards can be implemented, and teachers should be brought to a place where they view the standards not as something they are supposed to do, but rather as a set of tools and practices that provide students with a means of developing comfort with the languages of science in the spirit of constructing science literacy. This will likely prove to be easier said than done. We have seen evidence that the traditional ideologies that teachers cling to are a powerful force that will not just change with the snap of a finger. Rather, teachers need to be put into a situation where their existing beliefs are allowed to grapple with new ways of seeing the world of education over a long period of time, providing them with a chance to become more familiar with the theories of language and learning that wrestle for control over the educational landscape. Coordinating with our partners from around the world to achieve the scientific and technological advances needed to help solve the problems of the twenty-first century requires that we have scientifically literate thinkers at the table. Without teachers who are empowered to help meet those demands, we become less capable as a global society. It will be up to programs like ASSIST to help make sure that the teachers of today are prepared to help shape the scientists of tomorrow.

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