Science for All: Engaging Students with Special Needs in and About Science

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The notion of "science for all" suggests that all students—irrespective of achievement and ability—should engage in opportunities to understand the practice and discourse of science. Improving scientific literacy is an intrinsic goal of science education, yet current instructional practices may not effectively support all students, in particular, students with special needs. Argument-based inquiry approaches, such as the Science Writing Heuristic (SWH), require all students to construct their scientific understandings by engaging in investigations and negotiating their ideas in multiple contexts, such as discussions and writing. Various SWH studies demonstrated that students engaged in appropriating the language, culture, practice, and dispositions of science generally improved their critical thinking and standardized test scores. The implementation of such an approach has several implications for science and special education research and practice, including how learning environments should be established to encourage the inclusion of all students' ideas, as well as how scaffolded supports can and should be used to support science learning.

Over the last 30 years, the attention to scientific literacy and the engagement of all students in the discourse of the discipline has been critical to how researchers and teachers understand teaching and learning in science education. In this special edition of *Journal of Learning Disabilities Research and Practice* focused on science, it is critical that we revisit key ideas in science education that continue to shape our perspectives. Equally important, is that we begin to challenge how our ideas about learning, science, language and pedagogy advance learning and, ultimately, student achievement. In this article, past and current trends in science education will be addressed. We will also discuss how an argument-based inquiry approach has been used in classrooms to increase scientific understandings for students across varying achievement levels. Finally, we offer our perspectives about what supports may be necessary for students with special needs to engage in science classrooms.

BACKGROUND

In 1985, Peter Fensham published an article that used the phrase *Science for All* in which he proposed that there was a need to provide opportunities for students of varying interests and abilities to be able to achieve success in science. It was also during this time that the science community underscored an abating public respect and understanding of science and, as a consequence, the popularization and accessibility of science became a major focus of curricula reform (Turner, 2008). The inclusion of socio-scientific domains, such as the nature of science (NOS) and technology and society (STS), to the traditional content-based curriculum (Millar, 2004) was seen as a way to portray a more holistic picture of science, thereby making the subject interesting and accessible to a greater scope of students. The notion that school science is too abstract, difficult, and irrelevant are familiar criticisms of science education (Millar, 2008) and researchers posit that these negative perceptions not only impact student motivation, but also hinder successful learning and students' ability to make the connection between science and mathematics as it shapes or relates to their worldview (Araujo-Jorge, 2000; Fensham, 2008; Jegede & Kyle, 2007; Keane, 2008; Kozoll & Osborne, 2004). Consequently, there has been a decline in students who pursue careers in the sciences, as well as a decline in how they value science as a life-long interest (Fensham, 2008; Organization for Economic Co-operation and Devleopment, 2003).

Despite these attempts to improve *Science for All*, policy-makers and science educators have agreed that improvements in science education have been largely unproductive (Roberts, 2007) and that education in science and technology has failed to address the societal issues of the 21st century (Fensham, 2008). The ideological push to popularize science encouraged various initiatives to define and shape how everyday citizens and students could understand science (Koulaidis & Dimopoulous, 2002). Some initiatives included the movement to increase a greater public understanding of science (Cross, 1999; Layton, Jenkins, Macgill, & Davey, 1993), history and philosophy of science in science education (Hodson, 1985; Matthews, 1994), and science-technology-society (STS) curricula (Bybee, 1986; Solomon & Aikenhead, 1994). The progression and transformation of these movements led to the operational phrase, Scientific Literacy.

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SCIENCE LITERACY

The review of literature suggests that there have been critical attempts to define and describe the meaning of scientific literacy and that there are multiple interpretations of what the phrase constitutes. Brown, Reveles, and Kelly (2005) broadly categorized a number of intellectual perspectives regarding scientific literacy. These perspectives include: the ability to conceptualize phenomena and reason from a scientific epistemology (Ballenger, 1997; Warren, Ballenger, Ogonowski, Rosebery, & Hudiourt-Barnes, 2000;), to construct scientific ideas and arguments consistent with those of the scientific community (Bazerman, 1988; Latour & Woolgar, 1979), to analyze and interpret evidence (Germann & Aram, 1996; Jackson, Edwards, & Berger, 1993), to participate in the social structures that guide scientific enterprise (Eisenhart, Finkel, & Marion, 1996; Roth & Lee, 2002) and to engage in the specific literacy practices that underscore scientific endeavors (Halliday & Martin, 1993; Heath, 1983; Norris & Phillips, 2003). An amalgamation of these perspectives is reflected in the Organization for Economic Co-operation and Development's (OECD) definition of scientific literacy as:

> an individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material intellectual, and cultural environments, and willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen.

> (OECD, 2006, p. 12)

The extensive list of what it means to be scientifically literate suggests that it has no fixed meaning and perhaps this is another factor that makes it difficult to attain. However, Bybee (1997) and DeBoer (2000) assert that "scientific literacy" is, and always has been, the intrinsic goal of science education. The value of the "scientific literacy" slogan, Bybee (1997) maintains, rests in its ability to initiate contemporary reform and to reaffirm the purpose of science education. Literature suggests that learning science is vital for people to make connections and to understand the natural world (Powell & Arum, 2007) and also to enable citizens to become informed and participate in the public debate about science, technology, and environmental issues within society (Yore, Pimm & Tuan, 2007; Zeidler, 2007). The process of becoming "informed" and "participating", however, suggests that there are specific sets of scientific literacies required of a reflective citizen (Fensham, 2008).

According to Norris and Phillips' (2003) there are two interrelated components of discipline-specific literacy: the fundamental sense and the derived sense. As shown in Table 1, the latter involves knowing, understanding, and applying content and the "big ideas" of science and is dependent on the former that deals with being literate in the discourses or the abilities of speaking, reading, writing in and about science.

In terms of scientific literacy, the fundamental sense refers to the use of language in science contexts, whereas, the de-

TABLE 1
Interacting Senses of Scientific Literacy (from Yore, Pimm & Tuan, 2007, p. 568)

Fundamental Sense	Derived Sense
Cognitive and metacognitive abilities	Understanding the big ideas and unifying concepts of science
Critical thinking/plausible reasoning	Nature of science
Habits of mind	Scientific inquiry
Scientific language arts (reading, writing, speaking, listening, viewing and representing in science)	Technological design
Information communication technologies	Relationships among Science, Technology, Society, and Environment (STSE)

rived sense deals with understandings or abilities relative to science (Norris & Phillips, 2003). While there is agreement on these distinctions and the roles that fundamental and derived senses play in science education (Kelly, 2007; Yore et al., 2007), Lerman (2007) cautions that the compartmentalisation of the fundamental and the derived senses may emulate the problematic and recurrent separation of content and process in science. The 1990's produced similar paradigmatic distinctions: the "cognitive deficit" model which, again, stressed content and an individual's factual understanding of scientific information and principles, and the "contextualist model" which focused on individuals' experiences, needs, expectations and cultures (Turner, 2008). The senses of science, however, are not meant to be viewed as separate and distinct. Rather, the interacting clusters (Yore, 2008) suggest a connection between the "reflective citizen" goals of scientific literacy and the uses of written and spoken language in educational and societal settings (Norris & Philips, 2003).

SCIENTIFIC LITERACY IN THE CURRICULUM

Although the term "scientific literacy" has been used to characterize the aim of science education, there is still considerable uncertainty about its meaning and implications for the curriculum (Millar, 2006). Many science educationists and curriculum developers simply coupled content with methods courses, rather than viewing scientific literacy as a basic level of learning in science (Fensham, 2008). The existing definitions of scientific literacy commonly point to using science for personal or civic decision making (American Association for the Advancement of Science (AAAS), 1993; OECD, 2003), therefore, suggesting that the basic level of science should involve teaching science that is relevant and appears in the popular domain (Solomon, 1993; Thomas & Durant, 1987; Yager, 1992). In addition to teaching within a contextualist model, school science should prepare learners to function in society (OECD, 2003; UNESCO, 1999; Yore, Pimm, & Tuan, 2007).

Efforts to concretize this functional role of science in the curriculum have been advanced by Millar and

Osborne's (1998). Twenty First Century Science curriculum project, which proposes that there is a core set of knowledge and skills of science that all members of society should attain. Their curriculum utilizes contemporary socio-scientific issues as a platform to discuss ideas about science, scientific explanations, as well as scientific evidence and values. The development of rational criteria to test claims (Gott, Duggan, Roberts, & Hussain, 2008) and the meta-cognition required to generate, verify, or refine knowledge (Klein, 2006; Wallace, 2004) are key to making decisions and are central to the scientific endeavor (Yore, 2008).

In addition to addressing ideas about science as it relates to civic and citizenship issues, citizens also require a broad, qualitative grasp of major conceptual themes in the physical, biological, and earth-space sciences (Millar, 2006; Yore & Treagust, 2006). Yet, the question of *what content* and *how much content* is required in the curriculum is a topic of continual debate. In relation to scientific literacy, having a deep conceptual understanding is elemental to making connections and identifying the unifying concepts and themes in science such as the NOS, scientific inquiry, as well as major science explanations. The recognition and development of a knowledge-centered perspective is necessary to realize how these literacies are relevant to particular tasks in social contexts (Brown, Reveles & Kelly, 2005; Yore & Treagust, 2006).

THE LANGUAGE AND LITERACY ASPECT OF SCIENTIFIC LITERACY

The traditional science curriculum, which focuses on content and memorization, should be challenged with a curriculum that aims at addressing scientific literacy and empowering people to be fluent in the discourses of science (England, Huber, Nesbit, Rogers & Webb, 2007; Hand, Prain, Lawrence & Yore, 1999; Yore, Pimm & Tuan, 2007; Yore & Treagust, 2006). Norris and Philips (2003) contend that by strengthening learners' fundamental sense of science, such as their ability to read, write and communicate, the overarching goals of understanding the "big picture" science, or the derived sense of science, will be achieved. Furthermore, if students are to participate and employ scientific "habits of mind" in a wide range of social contexts, communication abilities should be furthered through practice in debates, discussions and the application of scientific concepts to provide effective argumentation and clarify relationships between claims, evidence and warrants (Hurd, 1998; Osborne, Erduran, Simon, Monk & 2001; Webb, Williams, & Meiring, 2008).

Inherent to these ideas, however, is how language plays a principle role in reading, writing, and arguing in science. Science, as a discipline, possesses a specialized language with particular functions, yet students bring their own socio-cultural language to the science classroom (Halliday & Martin, 1993). While students often cross casual/informal, instructional, and scientific language borders (Yore & Treagust, 2006), Wallace (2004) maintains that the measure for successful learning is when a child is able to use scientific language to communicate about personally meaningful science events. As a result, teachers have the responsibility to cultivate the application of scientific language to everyday experience. By providing rich scientific cultures in the classroom, such as investigations, argumentation and negotiation of ideas, students will have a need and a purpose for communicating in scientific discourses (Gee, 2002). Gee (2002) further posits that students who have difficulty communicating in academic genres may not have had sufficient experience in school to foster their authentic use of language.

The notion of the authentic use of language suggests that learning science cannot be a mere transmission of facts stemming from teacher-centered instruction (Crawford, 2000). Rather, it proposes that various pedagogical approaches should enable learners to develop and apply cognitive practices. The applied cognitive science framework of integrating language and science expands the habits of mind required by learners to construct scientific understandings (Cervetti, Person, Bravo & Barber, 2006; Yore, Bizanz & Hand, 2003; Yore & Treagust, 2006). Furthermore, these understandings can be applied to realistic societal issues and used to inform and persuade other people to take action based on these ideas (Yore & Treagust, 2006).

ARGUMENT-BASED INQUIRY FOR ALL

Current efforts in science education highlight the need for writing to learn strategies in science classrooms (Yore, Bisanz, & Hand, 2003). These strategies recognize the value of having students articulate their understandings in different ways as a means to construct a richer conceptual framework of science knowledge. In particular, the focus on scientific "big ideas" allows students with specials needs a holistic picture of the unifying concepts in science, as opposed to learning a set of vocabulary and discreet facts to memorize. The development of concept maps provides these students the opportunity to make connections of their current understandings and to develop understanding through a focus on the ideas of greatest importance. Importantly, these strategies are based on incorporating authentic writing tasks that extend students' needs to engage with the demands of science, rather than seeing writing as note-taking, fill-in-the-blank, or complete-the-sentence type of exercises (Prain & Hand, 1996). Writing to learn tasks incorporate the need for students to access canonical science knowledge and engage the NOS, and their epistemologies and reasoning strategies as a framework to build understanding (Hand, Prain, Lawrence, & Yore, 1999). The Science Writing Heuristic (SWH) is an example of this type of writing activity.

The SWH approach was developed by Hand and Keys (1999) as a means to explore the idea of trying to build a framework that would link inquiry, argumentation, and an emphasis on language. The SWH approach consists of a framework for learning to guide activities as well as metacognitive support to prompt student reasoning about data. Similar to Gowin's Vee heuristic (1970), the SWH approach, as outlined in Table 2, provides learners with a heuristic template to guide science activity and reasoning in writing. Further, the SWH provides teachers with a template of suggested strategies to enhance learning from laboratory activities. As a whole, the activities and metacognitive scaffolds

TABLE 2
The Two Templates for the Science Writing Heuristic Approach: The Teacher Template and the Student Template

A template for teacher-designed activities to promote laboratory understanding.	*A template for students.*
1. Exploration of pre-instruction understanding through individual or group concept mapping.	1. Beginning ideas—What are my questions?
2. Pre-laboratory activities, including informal writing, making observations, brainstorming, and posing questions.	2. Tests—What did I do?
3. Participation in laboratory activity.	3. Observations—What did I see?
4. Negotiation phase I—writing personal meanings for laboratory activity (e.g., writing journals).	4. Claims—What can I claim?
5. Negotiation phase II—sharing and comparing data interpretations in small groups (e.g., making group charts).	5. Evidence—How do I know? Why am I making these claims?
6. Negotiation phase III—comparing science ideas to textbooks or other printed resources (e.g., writing group notes in response to focus questions).	6. Reading—How do my ideas compare with other ideas?
7. Negotiation phase IV—individual reflection and writing (e.g., creating a presentation such as a poster or report for a larger audience).	7. Reflection—How have my ideas changed?
8. Exploration of postinstruction understanding through concept mapping.	

seek to provide authentic meaning-making opportunities for learners.

The negotiation of meaning occurs across multiple formats for discussion and writing. For example, the concept maps are able to provide a visual representation to allow students, especially with learning disabilities, to organize their scientific understandings based on their prior knowledge. The SWH is conceptualized as a bridge between informal, expressive writing modes that foster personally constructed science understandings, and more formal, public modes that focus on canonical forms of reasoning in science. In this way the heuristic scaffolds learners in both understanding their own lab activity and connecting this knowledge to other science ideas. For students with special needs the concept map becomes a working tool to develop and restructure their newly constructed knowledge to their previous understandings. The template for student thinking provides structure and prompts learners to generate questions, claims, and supporting evidence. It also prompts them to compare their laboratory findings with others, including their peers and information in the textbook, Internet, or other sources. The template for student thinking also prompts learners to reflect on how their own ideas have changed during the experience of the laboratory activity. The SWH can be understood as an alternative format for laboratory reports, as well as an enhancement of learning possibilities of this science genre. Instead of responding to the five traditional sections—purpose, methods, observations, results, and conclusions—students are expected to respond to prompts eliciting questioning, claims, evidence, description of data and observations, and methods, and to reflect on changes to their own thinking.

While the SWH approach recognizes the need for students to conduct laboratory investigations that develop their understandings of scientific methods and procedures, the teachers' template also seeks to provide a stronger pedagogical focus for this learning. In other words, the SWH is based on the assumption that science-writing genres in school should reflect some of the characteristics of scientists' writing, but also be shaped as pedagogical tools to encourage students to unpack scientific meaning and reasoning. Although students with learning disabilities may have difficulty with the writing tasks, the approach affords students with special needs the opportunities to engage in meaningful and concrete hands-on activities. The connection to these activities allows students to reason through the hands-on nature of inquiry activities and students are encouraged to express their reasoning through multimodal formats and writing supports (e.g., peer tutoring, assistive technology, associate support). The SWH approach is intended to promote both scientific thinking and reasoning in the laboratory, as well as metacognition, where learners become aware of the basis of their knowledge, and are able to monitor more explicitly their learning. Because the SWH focuses on canonical forms of scientific thinking, such as the development of links between claims and evidence, it also has the potential to build learners' understandings of the NOS, strengthen their conceptual understandings, and engage them in the authentic argumentation process of science.

The SWH approach emphasizes the collaborative nature of scientific activity, that is, scientific argumentation, where learners are expected to engage in a continuous cycle of negotiating and clarifying meanings and explanations with their peers and teacher. In other words, the SWH approach is designed to promote classroom discussion whereby students' personal explanations and observations are tested against the perceptions and contributions of the broader group. For all students, but especially those with special needs, alternate conceptions can be addressed through quality feedback in the process of questioning and critiquing of ideas. Learners are encouraged to make explicit and defensible connections between questions, observations, data, claims, and evidence. When students state a claim for an investigation, they are expected to describe a pattern, make a generalization, state a relationship, or construct an explanation. For students with special needs, this type of dialogical interaction promotes modeling of socially appropriate behaviors (Scruggs & Mastropieri, 2007).

The SWH approach promotes students' participation in setting their own investigative agenda for laboratory work, framing questions, proposing methods to address these questions, and carrying out appropriate investigations. Students

with special needs benefit from this immersive approach in that the activities provides direct and concrete conceptual and procedural understandings in science. Furthermore, participating in investigations may reduce frustration for students with learning disabilities in that they are engaged in the process of knowledge generation and not expected to simply read text that is often above their ability levels. Such an approach to laboratory work is advocated in many national science curriculum documents (e.g., National Research Council (NRC), 1996) on the grounds that this freedom of choice will promote greater student engagement and motivation with topics. However, in practice much laboratory work follows a narrow teacher agenda that does not allow for broader questioning or more diverse data interpretation. When procedures are uniform for all students, data are similar, and claims match expected outcomes, then the reportage of results and conclusions often lacks opportunities for deeper student learning about the topic or for developing scientific reasoning skills. To address these issues the SWH approach is designed to provide scaffolding for purposeful thinking about the relationships among questions, evidence, and claims.

IMPLEMENTATION

A number of quasi-experimental studies have been conducted to test the efficacy and impact of the SWH approach. These include:

Comparison between traditional teaching approaches and the SWH approach. Traditional teaching refers to the approaches that the teachers were using at the time of the study. In the first study this involved didactic teaching and some laboratory activities, while in the second study this involved using student recipe-type laboratory activities and report formats and in the third study a comparison between traditional laboratory approach and the SWH approach was examined.

(1) A study by Akkus, Gunel, and Hand (2007) examined whether there was a difference in middle and secondary student test performance between classrooms with high levels of traditional science teaching and classrooms with high-quality SWH implementation, with 7 teachers. The tests included multiple choice and short-answer conceptual questions. The results from the teacher-generated tests were very interesting, in that the study measured the difference between students who were high achievers and low achievers in each group. The difference in mean performance between students who were high achievers in each group was not significant—they were essentially equal. However, when comparing the effect size difference in performance between students who were high and students who were low achievers the following results were obtained: for students in classrooms where teachers used high levels of traditional teaching the effect size difference was 1.23 between high and low student achievers, while for students in classrooms where teachers used high levels of SWH teaching the effect size difference was only 0.13. These results are encouraging, and indicate that the SWH

approach may be effective for all learners in the classroom.

(2) A study by Greenbowe, Rudd II, and Hand (2007) was carried out to determine the effectiveness of using the SWH approach in university freshman general chemistry laboratory activities compared to the traditional formats used in such classes, with particular focus on the topic of equilibrium. To determine whether students in the SWH or standard sections exhibited better understanding of the concept of chemical equilibrium, the student explanations on the lecture exam problem were analyzed using mean explanation scores. Using the baseline knowledge score as a covariate, the ANCOVA results ($F = 4.913$; $df = 1$, 49; $p = 0.031$) indicated a statistically significant association between higher explanation scores and the SWH format. The SWH-instruction sections demonstrated a greater ability than standard-instruction sections to identify the equilibrium condition and to explain aspects of equilibrium despite these sections having a lower baseline knowledge score.

(3) A study by Hohenshell and Hand (2006) examined the difference in student performance with tenth-grade biology students who completed the laboratory activities using traditional approaches, versus the SWH approach. The study examined students' test performance immediately after completing all the laboratory activities and then after completing a written summary report of the unit of study. Results from the first round of testing indicated that there were no statistically significant differences on recall and conceptual questions scores between the control (traditional laboratory approaches and report format) and the treatment group (SWH approach). However, on the second round of testing, after completing the summary writing activities the SWH students scored significantly better than the control students on conceptual questions ($F(1,43) = 5.53$, $p = 0.023$, partial $\eta^2 = 0.114$).

Examining the impact of the quality of implementation of the SWH approach on student success on examinations. The purpose of these studies was to begin the process of determining the importance of adopting the particular strategies required when using the SWH approach. Rather than comparing the SWH approach to traditional approaches, these studies compared student performance resulting from different levels of implementation of the SWH approach.

(1) A National Science Foundation-funded project to adapt the SWH approach to freshman general chemistry laboratory activities for science and engineering majors demonstrated that the quality of implementation impacts performance on standardized tests, and positively impacts the performance of females and low-achieving students—two groups that are viewed as disadvantaged in science classrooms. When comparing the difference between low and high implementation of the SWH approach, students' scores on American Chemical Society (ACS) standardized

TABLE 3
Student tests scores since the district adopted the SWH approach after the 2001–2002 academic year

Year/Grade	Less than Proficient	Proficient	Advanced	Proficient or Above	Number of Students
1999–2000/Grade 8	31.5%	55.5%	13.0%	68.5%	200
2000–2001/Grade 8	33.5%	53.0%	13.5%	66.5%	200
2001–2002/Grade 8	32.2%	54.3%	13.5%	67.8%	199
2002–2003/Grade 8	19.6%	68.0%	12.4%	80.4%	225
2003–2004/Grade 8	22.6%	60.9%	16.6%	77.5%	217
2004–2005/Grade 8	18.6%	65.2%	16.2%	81.4%	204
2005–2006/Grade 8	20.0%	65.7%	14.3%	80.0%	175

tests, the following results were obtained. On the pretest (ACS California diagnostic test) the difference, measured as Cohen's d effect size statistic, was 0.07 between students with high-implementing teaching assistants (TAs) and low-implementing TAs. At the end of the semester the difference between the two groups on the ACS End of Semester 1 test was 0.45 (a medium effect size difference). The gap between males and females decreased from 0.45 (medium effect) on the pretest to 0.04 (no effect) on the posttest; while the gap between high- and low-achieving students decreased from 2.7 (large effect) to 0.7 (medium effect, bordering on large) (Poock, Burke, Greenbowe, & Hand, 2007).

(2) In a study by Mohammad (2007) of a one-semester freshman chemistry course for students in the "soft" sciences (agriculture, food science, etc.) at the same university, similar results were obtained. In particular, benefits were shown to females from high-implementation use of the SWH approach.

(3) In a study of six middle/secondary school science teachers, Gunel (2006) tracked the impact of implementation of the SWH approach on students' performance on ITBS/ITED science tests across a 3-year period. His results show that for teachers who remained at a low level of implementation across the period, the magnitude of effect size change in students' scores ranged from 0 to 0.4. For the teacher who shifted from traditional instruction to high-level SWH implementation, there was an effect size change in his students' scores of 1.0 across the 3 years.

Impact on Iowa Tests of Educational Development scores for one school district moving to adopt the SWH approach for teaching science. The impact of adopting the SWH approach within science classrooms in a single small school district is noted by eighth-grade students' ITBS performance (three science teachers for years 7 and 8). As indicated in Table 3, in the 4 years since the school district adopted this approach within their science classrooms, there has been a marked decrease in the number of students who are performing at the less than proficient level

Impact at the elementary level. Results from work done at the elementary level reflect those obtained from the other studies at the middle/secondary and college levels.

Results from a 3-year State of Iowa-funded project involving 32 K-6 teachers who implemented the SWH approach

for teaching science again supported the previous results when examining the quality of implementation. The results reported are for the first 2 years of the project. Teachers' ratings (low or medium; no teacher was rated as high) of their level of SWH implementation and student ITBS science performance were tracked. Grade equivalency growth scores were calculated and used as the dependent variable compared between teachers at low or medium levels of SWH implementation regardless of grade level. The results show that there were significant differences in ITBS science scores between students whose teachers are low and medium implementers of the SWH approach. This effect size gap increased from 0.0073 in year 1 to 0.268 in year 2. It is important to note that this effect size difference was between two treatment groups. A much larger effect size difference would be expected had a traditional control group (i.e., traditional classroom instruction) been utilized. The effect size gap in low-SES students' performance between low- and medium-implementation classrooms in year 1 ($d = 0.291$) was almost the same as in year 2 ($d = 0.284$). The effect size gap between students' with special needs performance in low- and medium-implementation classrooms grew from year 1 ($d = 0.158$) to year 2 ($d = 0.229$). Initial analysis of the third year of this project indicates that the difference between low and medium implementation remains the same, with the added benefit of impact on the language scores on the ITBS test.

Overall results from the 3-year Iowa-funded grant and the dramatic improvements over a seven year period for districts that have implemented the SWH approach indicate that the approach has the potential to increase elementary student achievement as much as or more than increases seen for students in high school and postsecondary education.

SUMMARY

As part of this special issue, we have tried to set the scene in science education by suggesting that there is much work to be done if educators, researchers and the science community realize the significance of *Science for All*. We believe that students with learning disabilities, along with general education students, can succeed in science if teachers are challenged to understand the critical elements necessary for success. All students need to be engaged in appropriating the language, culture, practice and dispositions of science in environments where—as an established part of the classroom culture and norms—students are required to pose questions,

make claims based on evidence, and do so in a multitude of forums.

Science for All assumes learning environments which are evaluative and nonthreatening. However, fostering these environments, as with establishing pedagogical practices which are genuinely aligned with learning, language and evaluative beliefs about science, does not simply happen overnight. Students with learning disabilities will require scaffolded structures to support maximum participation within the classroom, thus allowing further engagement in broader science issues outside of the formal learning environment. This implies that special education teachers understand which approaches and resources to employ to reach these goals. Classroom practice can only be improved by continued research regarding effective science learning and teaching for students with special needs. As researchers and educators, we need to continuously work towards- and challenge—how we understand learning in science and other subjects as an act of constructed meaning.

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