RESEARCH FOUNDATION FOR EARLY SCIENCE

Over the past decade, teaching academic skills to students with moderate-to-severe disabilities aligned to their state standards has evolved from participation and engagement in grade-aligned content (e.g., Carter, Sisco, Melekoglu, & Kurkowski, 2007) to demonstration of grade-specific content mastery (Browder, Trela, Courtade, Jimenez, Knight, & Flowers, 2012; Jameson, McDonnell, Polychronis, Riesen, 2008; Knight, 2010). Fostered by No Child Left Behind legislation (NCLB, 2002) and the Individuals with Disabilities Education Act (IDEA, 2004), students with significant cognitive disabilities are expected to show progress on their state's content standards in the areas of English/language arts, math, and science.

Specifically, in the content domain of science, national initiatives have been focused on achieving a scientifically literate society (American Association for the Advancement of Science, AAAS, 1989). This initiative followed the 1957 launch of Sputnik and the 1983 publication *A Nation at Risk* (National Commission on Excellence in Education, 1983). In 1996, the National Research Council (NRC) publication of the National Science Education Standards (NSES) not only acknowledged this goal but extended AAAS's philosophy promoting scientific literacy "regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science" (NRC, 1996, p. 2).

In response to such initiatives, and the need to expand the experimental research literature of science instruction for students with significant intellectual disabilities, *Early Science* was created. With the *Early Science* curriculum, students are provided with access to science content that has been streamlined and prioritized, giving them an opportunity to learn grade-level *content* but with alternate *achievement*.

Development of Early Science

Early Science was developed based on comprehensive reviews of research literature and then evaluated in applications by teachers in programs for students with developmental disabilities, including those with intellectual disabilities and autism. Using the literature reviews of science conducted by Courtade, Spooner, and Browder (2007) and Spooner, Knight, Browder, Jimenez, and DiBiase (2011), research-based instructional strategies to incorporate in the *Early Science* curriculum were pinpointed. Courtade and her colleagues' (2007) review of 11 studies that had some intersect with science identified systematic prompting and feedback as an important research-based practice. In contrast, these reviewers also advocated for new methods that could be used to teach scientific inquiry.

Building on the review of Courtade et al. (2007), Spooner et al. (2011) found 17 experiments where science content was taught to students with significant cognitive disabilities. Using criteria for evidence-based practice developed by Horner, Carr, Halle, Mcgee, Odom, & Wolery (2005), Spooner and his colleagues determined that 14 of the 17 studies had high or adequate quality. From this evidence-based practice review, the authors identified systematic instruction, including systematic prompting and feedback, as being not only research-based, but also as meeting the rigorous criteria of being evidence-based. In this review, specific components of systematic instruction, such as the systematic prompting method known as "time delay" and the task format called "task analytic instruction," were analyzed and found to have their own research base to support their use in teaching science content.

Early Science is grounded in this research foundation of systematic instruction. The lessons are written to follow a task analysis. In a task analysis, the teacher provides step-by-step instructions on a chain of responses to complete the activity. In the case of the *Early Science* lesson plans, each section of the lesson forms the task analysis (e.g., identify what students want to know, conduct experiment). This basic task analysis serves as a framework in which to embed the science content developed from the National Science Education Standards (NRC, 1996). Each lesson plan follows the same steps of the task analysis while addressing new content across science standards (e.g., Earth and Space Science, Life Science, Physical Science, Inquiry).

Early Science also incorporates the recommendations and feedback of science education experts. The National Research Council (NRC, 1996) recommends an inquiry approach to science. Because the field of science is ever-changing and expanding, inquiry-based instruction teaches students to be active participants in the world that is changing around them.

Recent evidence has demonstrated that teachers are able to implement inquiry-based lessons so that students with significant developmental disabilities can gain increased independence to participate in these lessons (Courtade, Browder, Spooner, & DiBiase, 2010; Browder et al., 2012). Courtade et al. (2010) investigated the effects of training teachers to deliver inquiry-based science lessons using a task analysis on teacher fidelity of implementation and student participation and achievement. Results of this study suggest that teachers can use inquiry-based science to teach students with severe disabilities, and students can acquire inquiry skills using such an approach.

Lesson Design

Each lesson with the *Early Science* curriculum addresses the inquiry process skills and also the "big idea" of the unit and lesson. Although not every elementary science standard is contained in this resource, the curriculum offers content in several standards and "big ideas" of science to illustrate how adaptations can be made across curricular areas.

After using *Early Science,* teachers will know a format that can be used to develop lessons for additional science content. This format includes: (1) teaching key vocabulary and science concepts; and (2) following the inquiry task analysis to develop increased skill in inquiry across content. The methods (e.g., time-delay procedure) introduced to teach key vocabulary and science concepts (e.g., Soil is made of many things) are modeled after, and supported by, recent studies in science instruction for students with severe developmental disabilities (Browder et al., 2010; Jimenez et al., 2012; Jimenez, Browder, & Courtade, 2009).

In addition to the research-based components of an inquiry task analysis that frames the lesson, and the use of systematic prompting like time delay to teach key vocabulary and concepts, a "wonder story" is used to introduce each science lesson. Based on previous research in math and language arts, stories may provide students a way to connect with the facts and concepts presented in the grade-level content (Anderson, Spiro, & Anderson, 1978; Browder et al., 2010; Browder, Trela, & Jimenez, 2007; Jimenez, Browder, & Courtade, 2009; Zambo, 2005). Using this literacy-based approach to teach a science lesson as a simple wonder story can help to promote meaning and personal relevance for the science content.

As an elementary-level curriculum, this resource provides the foundation of skills needed for an upper-level curriculum like *Teaching to Standards: Science* (Courtade, Jimenez, Trela, & Browder, 2008). Browder and colleagues (2010) identified that one component of science inquiry secondary students often have trouble mastering is the ability to describe their findings using science descriptors (e.g., change, different, heavy, hot). *Early Science* embeds opportunities for concept development during each lesson specific to the science concepts being taught within the lesson itself. Englemann and Carnine (1991) and Kaméenui & Simmons (1990) describe modeling with examples and non-examples and model-lead-test as one way to teach concepts to students with disabilities. Modeling using examples and non-examples is an errorless learning strategy that teaches students to recognize multiple exemplars of the concept as well as multiple non-examples (e.g., This is ______, this is ______, this is ______, this is not ______, and this is not ______). This explicit instruction is conducted at a rapid pace and implements a model-lead-test sequence within each trial (Archer & Hughes, 2011; Bursuck & Damer, 2011).

Knight, Smith, Spooner, Jimenez, and Browder (in press) investigated the effects of explicit instruction on acquisition and generalization of science descriptors of three elementary students with autism eligible for the alternate assessment based on alternate achievement standards (AA-AAS). Results of the study indicated that explicit instruction using modeling of examples and non-examples was an effective method for acquiring science descriptors, and for generalizing science descriptor knowledge across a novel set of objects and within a science inquiry lesson. In a second study, Knight (2010) also found support for using explicit instruction of science concepts, but with an extension to computer-mediated instruction.

Besides systematic instruction of vocabulary and concepts, an inquiry task analysis, a wonder story, and explicit instruction of concepts, the final research-based component of *Early Science* is the combination of these procedures into teaching scripts. When used in combination with explicit instruction and other research-based methods (e.g., simultaneous prompting, error correction procedures, and thinning of reinforcement schedules), scripted lessons have been shown to be an effective strategy for teaching academic content to students with mild disabilities (Gunter & Reed, 1997). Research has demonstrated that the use of scripted lessons also benefits students with severe disabilities in learning math and science content (Browder et al., 2012; Jimenez, Lo, & Saunders, 2012). For example, Jimenez et al. (2012) examined the effects of scripted lessons (i.e., 18 lesson plans from the *Early Science* curriculum) in combination with guided notes during science instruction on students' science quiz scores for elementary students with moderate-to-severe autism and intellectual disabilities. Results indicated that the scripted lessons were effective in increasing all students' science quiz scores across all 18 lessons.

Research Summary

Early Science is a multi-component intervention. Table 1 provides a summary of each component and the research on which it was developed.

In addition to this research, *Early Science* was field-tested with three teachers and nine students in a large urban school system to determine teacher fidelity and acceptability. When given inservice days to introduce each unit, teachers were able to teach the curriculum with high fidelity (range 71–100%; mean 95.7%) and provided a positive appraisal of its overall acceptability. In 2011, Smith, Spooner, Jimenez, and Browder (in press) conducted a study with three elementary-age students with multiple disabilities. The students were taught units from the *Early Science* curriculum via inquiry-based lessons, and effects were measured by a multiple-probe design across behaviors (units). Visual analysis showed a functional relationship between the introduction of the intervention and a change in each participant's responding. This study demonstrated the effectiveness of using the *Early Science* curriculum to assist elementary students who have severe developmental disabilities in learning science vocabulary and concepts linked to grade-level standards. This study was unique in that is was conducted with students who had communication and motivation factors that typically make general curriculum access increasingly difficult due to extensive support needs (e.g., concrete representation of vocabulary, adapted text). Experimental research on *Early Science* is ongoing and updates can be obtained at the Attainment Company website.

TABLE 1 Research Foundation for the Components of Early Science

Component	Brief Explanation	Supporting Studies
Inquiry task analysis	All lessons follow a series of steps to engage students in inquiry; the expectation for student engagement in inquiry increases as they progress through the units and lessons.	Courtade, Browder, Spooner, & DiBiase (2010) Browder et al. (2010)
Science vocabulary and concepts	Time delay and systematic prompting and feedback are used to teach students to master science terms and "big ideas."	Browder et al. (2010) Jimenez, Browder, Spooner, & DiBiase (2012) Jimenez, Lo, & Saunders (2012)
Literacy-based approach	Science wonder stories are used to give the science lesson a real-life context.	Browder et al. (2010) Browder, Trela, & Jimenez (2007)
Descriptors and concepts needed to describe scientific observations	Explicit instruction is used to teach general concepts, like on/off.	Knight (2010) Knight, Smith, Spooner, Jimenez, & Browder (in press)
Scripted lessons	The components are embedded in scripted lessons so teachers learn how to develop a science lesson.	Browder et al. (2012) Smith et al. (in press)

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