Math and Science Standards for All

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Abstract

The National Council of Teachers of Mathematics and the National Science Education Standards have emphasized the importance of math and science instruction, respectively, for all students. However, grade level core content math and science instruction has been predominantly unavailable for students with an intellectual disability. Four programs, *Early Numeracy*, *Teaching to Standards: Math*, *Early Science*, and *Teaching to Standards: Science*, have been developed to teach grade level core content mathematics and science as inquiry for elementary grades, and for middle and high school grades. All four programs have been validated through classroom trials. Research demonstrates that these programs are effective in teaching grade aligned core content math and science as inquiry to individuals with an intellectual disability.

Key Words

Standards, Intellectual Disability, Math, Science

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Introduction

Over the past decade, teaching academic skills aligned to state standards to students with moderate and severe disabilities has evolved from participation and engagement in grade-aligned content (e.g., Carter, Sisco, Melekoglu, and Kurkowski) to demonstration of grade-specific content mastery (Browder, Trela, Courtade, Jimenez, Knight, and Flowers). Fostered by No Child Left Behind legislation (NCLB, 2002) and the Individuals with Disabilities Education Act (IDEA, 2004), US students with significant intellectual disabilities are expected to show progress on their state's content standards in the areas of English/language arts, math, and science. In response to such initiatives, and the need to expand the experimental research literature of math and science instruction for students with significant intellectual disabilities, four instructional programs were developed as a result of research conducted by the University of North Carolina at Charlotte under two separate projects: First --Reading, Writing, Math, and Science for students with significant cognitive disabilities and, Second --Project Mastery. The four resulting programs are *Teaching to Standards: Math, Teaching to Standards: Science, Early Numeracy* and *Early Science*. The Attainment Company has been the publishing partner for products that have resulted from these research efforts.

Studies conducted under both grants have responded to the need to develop models of assessing the general curriculum in math and science emphasizing (a) standards-based IEPs, (b) alignment to grade level general curriculum, and (c) use of research-based instructional strategies to teach academic skills to students with significant disabilities. In the content domain of math, the National Council of Teachers of Mathematics established that

> All students, regardless of their personal characteristic, backgrounds, or physical challenges must have opportunities and support to learn mathematics. Equity does not

> mean that every student should receive identical instruction; instead, it demands that reasonable and appropriate accommodations be made as needed to promote access and attainment for all students. (NCTM, 2002)

Research conducted by Browder, Jimenez, and Trela, and Jimenez, Browder, and Courtade has demonstrated that such accommodations as the use of manipulatives, graphic organizers, and task analytic instruction can provide middle and high school students with intellectual disabilities access to demonstrate mastery of grade-aligned math content.

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). 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 2). The National Research Council (NRC) asserts that "inquiry is a set of interrelated processes by which scientists and students pose questions about the natural world and investigate phenomena; in doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models, and theories" (NRC 214). Within the National Science Education Standards (NSES), inquiry is described as a critical component of a science program. Through inquiry-based instruction, students can learn in a way that represents how science actually works. In inquiry-based instruction, students follow a problem-solving process that is applicable to the real world. Using an inquiry-based approach to teach science allows students with significant disabilities to experience and understand the environments they live in and have the opportunity for access to the same instruction that their general education peers are receiving.

Discussion

Four different research studies are summarized to demonstrate the academic success of students instructed under *Early Numeracy*, *Teaching to Standards: Math*, *Early Science* and *Teaching to Standards: Science*. Research studies were conducted with students identified as having a significant intellectual disability (IQ 55 or below). Additionally, each study focused on including students with multiple disabilities and intensive communication needs (e.g., use of alternative communication devices). In addition, all programs were developed with direct alignment to national standards (NCTM; NSES). Using alignment criteria developed by the National Alternate Assessment Center (Browder, Wakeman, Flowers), programs were developed to align to national standards using alternate achievement standards. While more recent standards have been developed in math (Common Core State Standards) and science (Next Generation Science Standards), the alignment of these programs has remained strong, and in some ways has become even greater. For example, the Next Generation Science Standards builds upon the NSES to provide greater emphasis on the inquiry process in science education, which is illustrated in both *Early Science* and *Teaching to Standards: Science.*

Early Numeracy

Research shows that early knowledge in mathematics is indicative of success in mathematics in later years of life (National Mathematics Advisory Panel). For most students, these early numeracy skills are developed prior to any formal schooling as a result of their interactions and experiences; however, for students with moderate and severe disabilities, this may not be the case. This population of students may need formal instruction to develop these skills (Bruer). Just as phonemic awareness builds the foundation of reading in very early grades, early numeracy skills build the foundation in mathematics. *Early Numeracy* is a curriculum

designed to build number sense in elementary-aged students with disabilities, including students with intellectual disabilities and autism. The program was designed to be used with students who lack a solid foundation, or need to build fluency of early numeracy skills. *Early Numeracy* provides strategies to improve skills in the areas of counting with one-to-one correspondence, number identification from 1 to 10, rote counting, creating sets, beginning addition with sets, symbol use, identifying and creating ABAB patterns, calendar skills, nonstandard units of measurement, and standard units of measurement with a ruler. *Early Numeracy* is based on the premise that it is not too late to develop early numeracy skills in children with moderate and severe disabilities and in doing so students will be able to gain greater access to grade level standards. The content for *Early Numeracy* was selected based primarily on recommendations from the *Early Childhood Mathematics Education Research: Learning Trajectories for Young Children*, developed by Sarama and Clements in 2009. *Early Numeracy* also aligns with four of the five content standards set forth by the National Council of Teachers of Mathematics (NCTM): *Numbers and Operations, Algebra, Geometry, and Measurement* (NCTM).

Based on the research conducted to develop *Early Numeracy,* Saunders, Bethune, Spooner and Browder suggest using six separate steps to develop instruction targeting mathematics acquisition for students with moderate to severe disability. These steps are: 1. Create Objectives, 2. Identify a real-life activity, 3. Incorporate evidence-based practices, 4. Include instructional supports, 5. Monitor progress, and 6. Plan for generalization. With these six steps as the framework for *Early Numeracy,* Browder, Jimenez, Spooner, Saunders, Hudson, and Bethune conducted an exploratory single-subject study. A multiple probe research design was used across three math units with seven elementary aged students with moderate and severe disabilities, including autism. Three special educational teachers taught the math curriculum in

small groups in addition to three special education paraprofessionals who facilitated instruction in an inclusive setting. Results demonstrated that all seven students made gains in all three units, both in the small group setting and in the trials embedded in the general education class by the paraprofessional.

Teaching to Standards: Math

For students with intellectual disabilities in middle and high school, a review of research indicated that most studies focused on numbers and operations or money skills (Browder, Spooner, Ahlgrim-Delzell, Wakeman, and Harris), which is a small subset of the standards for grade aligned content in mathematics. In a comprehensive literature review using the National Council of Teachers of Mathematics (NCTM) core areas of math, findings identified geometry, algebra, and problem solving as areas in need of evidence-based instruction in order for older students with significant disabilities to gain access to NCTM math standards. Based on these findings, the research team developed interventions to teach grade level academics aligned with general education curriculum to students with significant disabilities. The resulting product was *Teaching to Standards: Math.*

Multiple research studies were conducted to develop and evaluate *Teaching to Standards: Math* (Jimenez, Browder, and Courtade; Browder, Jimenez, Trela; Browder, Trela, Courtade, Jimenez, Knight and Flowers). Specifically, Browder, Jimenez and Trela investigated the effects of the curriculum with four students identified as having a moderate or severe disability, ages 11 to 13, with IQ's ranging from 30-41. The research took place within a self-contained classroom in a general education middle school. The research protocol was a multiple probe across math units, with mathematics instruction (lessons from the curriculum) as the independent variable and acquisition of math responses as the dependent variable. The research demonstrated that all

four students showed significant gains across all four units: Geometry, Algebra, Data Analysis and Measurement.

Early Science

Using the literature reviews of science conducted by Courtade, Spooner, and Browder, and Spooner, Knight, Browder, Jimenez, and DiBiase, evidence-based instructional strategies to incorporate in the *Early Science* curriculum were pinpointed. Courtade and her colleagues' 2007 review of 11 studies that had some intersection with science standards outlined by the NSES 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. The research reviews also noted the need for instructional supports to develop science instruction that address more breadth and depth of science education (e.g., not only vocabulary instruction). All research findings were integrated into the product, *Early Science*. With the *Early Science* curriculum, students are provided with access to science content that has been streamlined and prioritized, giving students an opportunity to learn grade-level content with alternate achievement. The curriculum specifically embeds repeated practice, evidence-based systematic instruction practices, and builds students' inquiry processes throughout each unit.

Early Science research was conducted with three elementary students identified with a severe disability, including one student who was non-verbal. The three students' ages ranged from 6 to 8 years old. Students were served within a self-contained classroom in their neighborhood elementary school. In this research effort, Smith, Spooner, Jimenez and Browder used a single-subject multiple probe research design across behaviors (science units) to investigate the effect of the curriculum on student science vocabulary and concept attainment.

The research findings demonstrated significant gains across all four science units with all three students.

Teaching to Standards: Science

Similar to the development efforts of the *Early Science* curriculum, researchers reviewed the literature on teaching science to this population, finding great need to expand the literature base to support instruction in inquiry science across the national standards. For *Teaching to Standards: Science,* teachers of students with intellectual disabilities taught four science units representing three of the eight national science content standards. A forth standard, science as inquiry, was embedded within each of the units. The science content standards included life science, physical science, and earth science. Classroom research included 21 students ranging in age from 14 to 20 years with IQ's ranging from 33 to 53. Ten students were identified as having a severe intellectual disability while 11 were classified with an autism spectrum disorder (Browder et al, "Teaching Mathematics"). Twenty lesson plans were executed in a small group setting in each of the special education classrooms. The pre-test / post-test in the quasi-experimental design measured a 14% gain in scientific inquiry and a 16% gain in scientific vocabulary. In a social validity measure, teachers agreed that the intervention was useful, practical, and beneficial to students.

Conclusions

As noted by the National Council of Teachers of Mathematics, all students, including students with disabilities, must have opportunities and support to learn mathematics. Research studies conducted with *Early Numeracy* and *Teaching to Standards: Math* demonstrate that students with an intellectual disability can and do learn grade level content standards in

mathematics when provided with appropriate supports and instruction (Browder et al, "A Meta-Analysis;" Browder et al, "Teaching Mathematics").

In science, engaging students in the inquiry process helps students develop an understanding of scientific concepts, an appreciation of "how we know" what we know and an understanding of the natural world of science. As a result, students achieve the skills necessary to become independent inquirers about the natural world. Students at all grade levels and in every domain of science, regardless of disability, should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry. These goals are achieved for students with an intellectual disability with both *Early Science* and *Teaching to Standards: Science*.

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