A comprehensive review of research was conducted on teaching science to students with significant cognitive disabilities. Guidelines from the National Science Education Standards were used to identify categories of studies based on the strands of science. A total of 11 studies were identified from the 20 years of literature searched. In general, work in the area of science is sparse for students with significant cognitive disabilities. Eight of the 11 studies fell in Content Standard F: Science in Personal and Social Perspectives. Single subject experimental designs were the methodology used in all of the studies and outcomes suggest that this population benefits from instruction in highly specific skills with modeling and errorless learning strategies like time delay. The interventions found in the 11 studies that linked to science incorporated systematic response prompting methods similar to those found in evidence-based reading and math research for students with significant cognitive disabilities. Additional research is needed to identify methods to teach science to this population that includes both broader content and additional skills that link to state standards.

DESCRIPTORS: access to the general curriculum, science, inquiry, significant cognitive disabilities

In 1983, A Nation at Risk was published, calling for reform in science education based on the committee’s claim that the educational performance of American students in scientific areas was mediocre (National Commission on Excellence in Education, 1983). Following the report, the American Association for the Advancement of Science (AAAS, 1990) began an initiative entitled Project 2061: Science for all Americans. The purpose of the initiative was to develop a scientifically literate society by the year 2061. The National Research Council (NRC) published the National Science Education Standards (NSES) in 1996. The purpose of the document was “...science standards for all students...regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science” (NRC, 1996, p. 2). All three of these landmark publications used terminology that called for the scientific education of all students. Despite the focus on all students, the idea that students with significant cognitive disabilities should also receive access to science instruction and how this might be achieved was not discussed. In fact, only recent textbooks on teaching this population have begun to address science (i.e., Browder & Spooner, 2006; Snell & Brown, 2006).

Individuals With Disabilities Education Act Amendments (IDEA, 1997) required that students with disabilities have access to general curriculum and participate in state and district assessments. Some states included science in early alternate assessments developed for students with significant cognitive disabilities (i.e., New York, Washington, Texas; National Center for Education Outcomes, 2006). These early alternate assessments marked the beginning of a concerted effort to teach science to this population. Then, No Child Left Behind Act (NCLB, 2001) required that all students be assessed in science by 2007. Subsequent regulations permitted using alternate achievement standards to determine adequate yearly progress for students with significant cognitive disabilities who participated in alternate assessments (U.S. Department of Education, 2003). Most states have recently been engaged in planning science assessments for this population to meet the requirements of NCLB.

The question that arises, given the current emphasis on science education, is what research exists to guide educators in teaching science to students with significant cognitive disabilities? Our review found limited literature on teaching science to students with significant cognitive disabilities. One exception, Siegel-Causey, McMorris, McGowen, and Sands-Buss (1998), provided what may be the first description of how to include students with significant cognitive disabilities in science classes. However, while providing important information on general curriculum access, their focus was on the...
student's inclusion plan versus strategies for teaching science per se.

There is some research supporting the idea that this population can learn academic content. Comprehensive reviews of the literature in reading (Browder, Wakeman, Spooner, Ahlgrim-Delzell, & Algozzine, 2006) and mathematics (Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakeman, 2007), although limited in scope, provide multiple examples of students acquiring academic skills. Typically, the instructional interventions have included systematic prompting and feedback with many teaching trials across a subset of specific responses such as a list of sight words or counting the next dollar amount.

The purpose of this review was to provide a comprehensive review of research that provides instructional interventions in science to students with significant cognitive disabilities. In our first attempt at this search (conducted simply by searching using the search terms “science” and disability-related terms such as autism, mental retardation, severe disabilities, developmental disabilities, multiple disabilities), we could only locate one study that provided an intervention for teaching science to students with significant cognitive disabilities (Utley et al., 2001). Although we realized that the literature on teaching science to this population might be limited, we were not satisfied with the results of our search. We then became conscious of the fact that our search term “science” was too broad and that in order for educators of students with significant cognitive disabilities to plan science lessons based on research evidence, we would need to determine what specific concepts in the research literature relating to students with significant cognitive disabilities. To provide us with guidance in determining what science concepts are typically taught in general education classrooms, we worked with a general education science researcher. Using the NSES (NRC, 1996), he helped us determine key science concepts which were then used as search terms. Specifically, our purpose was to conduct a comprehensive review of intervention literature relating to the instruction of students with significant cognitive disabilities and specifically pertaining to science concepts that link to the standards of science identified in the NSES.

Method

Literature Search Procedures and Selection Criteria

The first step was to ground the literature review in a conceptual framework of science. We used the seven Science Content Standards identified by the NSES (1996) to search and organize the literature. Search terms for each of the standards of science were derived from the descriptions of the NSES Science Content Standards. Each content standard was examined for terms relating to the main concepts. Key terms were determined and agreed upon by a science education researcher and the second author for inclusion in the study (see Table 1).

The literature search was conducted using PsychINFO and ERIC databases from 1985 to 2005. In addition to the content descriptors shown in Table 1, multiple population descriptors were used such as “moderate,” “severe,” “autism,” “retardation,” “handicapped,” “disabilities,” “developmental disabilities,” and “intellectual disabilities.” References from the identified studies were examined to locate additional pertinent sources. The following journals were also hand searched to obtain the most recent literature (2004–2005): Exceptional Children, Education & Treatment of Children, Journal of Special Education, Remedial and Special Education, Education and Training in Developmental Disabilities, Research and Practice for Persons With Severe Disabilities, and Focus on Autism and Other Developmental Disabilities.

Only studies which had a recognized experimental research design and were published in refereed journals were included (i.e., we excluded descriptive studies, doctoral dissertations, presentations). A study had to include at least one student with moderate to severe/profound disabilities (IQ of 55 or below) to be included and to focus on school age students (ages 5–21). The studies were selected based primarily on the dependent

<table>
<thead>
<tr>
<th>Science content standard</th>
<th>Science search terms&lt;sup&gt;a&lt;/sup&gt;</th>
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</thead>
<tbody>
<tr>
<td>A: Science as Inquiry</td>
<td>Scientific inquiry, inquiry, investigation, equipment, tools, instruments, time, watches, rulers, scales, microscopes, thermometers, weight, calculators</td>
</tr>
<tr>
<td>B: Physical Science</td>
<td>Position, motion, light, heat, electricity, magnets, sound</td>
</tr>
<tr>
<td>C: Life Science</td>
<td>Animals, organisms, plants, life cycles, horticulture</td>
</tr>
<tr>
<td>D: Earth and Space Science</td>
<td>Fossils, sun, moon, stars, weather, clouds, earthquakes</td>
</tr>
<tr>
<td>E: Science and Technology</td>
<td>Tools, computers, problem, solution</td>
</tr>
<tr>
<td>F: Science in Personal and Social Perspectives</td>
<td>Safety, abuse, injury, exercise, nutrition, drugs, pollution, health</td>
</tr>
<tr>
<td>G: History and Nature of Science</td>
<td>Career, scientist, history</td>
</tr>
</tbody>
</table>

<sup>a</sup>All science search terms were also cross-searched with the following disability search terms: moderate, severe, autism, mental retardation, disabilities, handicapped, developmental disabilities, and intellectual disabilities.
variable (i.e., only studies which included measures of achievement of science-related skills, as indicated by the NSES, for students with moderate or severe/profound disabilities). Achievement in skills that were primarily mathematics content (National Council of Teachers of Mathematics, 2000) was not included even if sometimes also found in science content (e.g., time telling). Studies that included the key words but did not include assessment of science skills as a dependent variable were not included (e.g., the use of a computer program to teach language arts skills).

Results

Eleven studies were located that adhered to the inclusion criteria. These studies were then summarized in Table 2 classified by the strands of science in Table 1. The science education researcher and the second author reviewed and agreed with each of the included studies as clearly focusing on the acquisition of science skills and also agreed with the exclusion of several questionable studies. Studies were deemed questionable if the skills being investigated were not skills that would typically be taught in a general education classroom. For example, an investigation of teaching generalized safety skills was located during the search (Collins, Stinson, & Land, 1993). This study was not included because the skills taught involved crossing the street and using a public pay phone to call home, which are not skills that are typically taught in general education classes. Safety skills instruction more closely aligned to what is taught in a general education classroom were included. For example, Taber, Alberto, Hughes, and Seltzer (2002) examined the ability of students to identify when they are lost in the community. Although the students were instructed to use a payphone (again, a skill not typically taught in general education), they were also instructed to verbally describe their surroundings. This skill of defining relative position is taught in general education as part of physical science units.

The instructional skills taught in 8 of the 11 studies fell under Content Standard F (Science in Personal and Social Perspectives) of the National Science Education Content Standards. Two studies conducted research that included describing relative position (Taber et al., 2002; Taber, Alberto, Seltzer, & Hughes, 2003), which fell under Content Standard B: Physical Science. One study (Browder & Shear, 1996) conducted research about teaching weather-related sight words that fell under Content Standard D (Earth and Space Science). No empirical studies were found for students with significant disabilities in the remaining content areas (Science as Inquiry, Life Science, Science and Technology, and History and Nature of Science; see Table 2).

All of the studies located were investigations that used a single subject research design and most used either multiple probe or multiple baseline designs. Although the research literature was searched through 2005, the most recent study was published in 2003. Reliability was reported for all studies with interobserver agreement means that ranged from 92.4% to 100%. Treatment fidelity was reported for 7 of the 11 studies and ranged from 88.9% to 100%.

The number of participants in each study ranged from 3 to 14, with 58 students total. Of the 58 students, 31 were female and 27 were male. The ages of the participants ranged from 6 to 21 years old. The IQ scores of the participants ranged from >30 to 90. Interventions took place in a variety of settings including an institution, public separate schools, self-contained classrooms, community-based instruction sites, and a summer program. None of the interventions were applied in general education classrooms.

The foci of instruction during the interventions varied widely. The responses included weather words read per minute, percentage of correct words read and safety responses made, number of correctly performed steps in task analyses of first-aid skills, length of time to complete first-aid skills, percent correct on health tests, mean scores relating to self-protective behavior, number of steps correctly performed in task analyses of safe handling and disposing of materials, and number of independent correct responses in task analyses of answering/calling using a cell phone and describing location when lost.

Discussion

The research identified on teaching science skills to students with significant cognitive disabilities is sparse and mainly focused on skills that fall into the Personal and Social Perspectives Content Standard of the National Science Education Content Standards (NRC, 1996). With the passage of NCLB and the mandate of academics (i.e., reading, math, and science) for ALL children, the field of special education must begin to think about how science can be taught to students with significant cognitive disabilities. As researchers and practitioners in the area of significant cognitive disabilities learn more about science in relation to this population of students, it is likely that more of the science content standards will be explored. The literature identified in this review raises several critical issues for this future work in science for this population including: (a) the need for special educators to better understand general science including both typical instructional contexts and content standards, and (b) consideration of how students’ need for effective instructional support can be provided.

An important issue is the need for special educators to understand more about general science and the contexts in which it is typically taught. The lack of focus on teaching science content to students with significant cognitive disabilities in the past could be due to the
<table>
<thead>
<tr>
<th>Study/citation</th>
<th>Focus of instruction</th>
<th>Participants/setting</th>
<th>Intervention</th>
<th>Results/findings</th>
</tr>
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<tbody>
<tr>
<td><strong>Content Standard B: Physical Science</strong>&lt;br&gt;Taber et al. (2002)</td>
<td>Acquisition of use of cell phone to indicate when lost (by dialing a phone and indicating location)</td>
<td>14 sts (5 female, 9 male; ages 11–14); IQ range 43–55</td>
<td>Role-playing activity to determine what “lost” meant; 5-level, least-to-most prompting system in conjunction with total task presentation</td>
<td>All students met criterion for number of steps correct (80% or better); 4 of 5 students completed 100% of the steps during a generalization probe to the teacher</td>
</tr>
<tr>
<td><strong>Taber et al. (2003)</strong></td>
<td>Acquisition of use of cell phone to indicate when lost (by using speed dial and indicating location)</td>
<td>6 sts (3 female, 3 male; ages 14–18); IQ range 41–48</td>
<td>Role-playing activity to determine what “lost” meant; 5-level, least-to-most prompting system in conjunction with total task presentation</td>
<td>All students met criterion for number of steps correct (80% or better); 3 of 6 students were able to perform 100% of the steps in two different community settings</td>
</tr>
<tr>
<td><strong>Content Standard D: Earth and Space Science</strong>&lt;br&gt;Browder and Shear (1996)</td>
<td>Acquisition of weather-related sight words</td>
<td>3 sts (2 females, 1 male; ages 16, 12, 13); IQ 45, 42, 42, respectively</td>
<td>1:1 lesson (sight word test, interspersal drill, story starter to teach phrase reading, generalization probe)</td>
<td>All students learned the 10 new sight words in 2–6 weeks of school; Some progress across intervention for reading a passage for the newspaper</td>
</tr>
<tr>
<td><strong>Content Standard F: Science in Personal and Social Perspectives</strong>&lt;br&gt;Collins and Griffen (1996)</td>
<td>Performance of safe, age-appropriate responses to dangerous products and acquisition of sight words on product warning labels</td>
<td>4 sts (2 females, 2 males; ages 8–11); IQ range 42–45</td>
<td>CTD procedure combined with multiple exemplars of product warning labels and settings (safety)</td>
<td>All students achieved mastery in 6–14 sessions; postintervention probes: student performed at 29–86%</td>
</tr>
<tr>
<td><strong>Collins and Stinson (1995)</strong></td>
<td>Acquisition of key words found on product warning labels and exposure to definitions of the words presented in context</td>
<td>4 sts (3 females, 1 male; ages 16–20); IQ range &lt;40–63</td>
<td>PTD procedure with student dyads</td>
<td>All students reached criterion for correct word responses; during final probe condition all sts maintained criterion on target words; % of word definitions learned incidentally ranged from 33 to 100</td>
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<tr>
<td>Reference</td>
<td>Description</td>
<td>Setting</td>
<td>Sample Characteristics</td>
<td>Procedure</td>
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<tr>
<td>Gast et al. (1992)</td>
<td>Application of first aid to a minor cut, a burn, and an insect bite</td>
<td>Setting: public separate high school</td>
<td>4 st (2 females, 2 males; ages 17–21); IQ range 40–55</td>
<td>Orientation lecture and CTD procedure; instruction provided at the same time to all students in a small group</td>
</tr>
<tr>
<td>Marchand-Martella, Martella, Christensen, Agran, and Young (1992)</td>
<td>First-aid training for abrasions using puppets and self</td>
<td>Setting: 8-week summer program at a local elementary school</td>
<td>4 st (1 female, 3 males; ages 6–12); IQ range 40–90</td>
<td>Social modeling procedure (modeling, practice, and probe) with partial sequence withdrawal of components also used</td>
</tr>
<tr>
<td>Spooner, Stem, and Test (1989)</td>
<td>Four safety/first aid skills: dialing 911, first aid for a minor injury, applying a bandage, and applying first aid for choking</td>
<td>Setting: public separate school</td>
<td>3 st (1 female, 2 males; ages 16–17); IQ range 43–51</td>
<td>Systematic replication of experimental procedure by Matson (1980) involving instructions, modeling, feedback, rehearsal, and social reinforcement</td>
</tr>
<tr>
<td>Utley et al. (2001)</td>
<td>Acquisition and comprehension of names of body parts, body functions, poisons, dangerous situations, drugs and their effects</td>
<td>Setting: public separate school</td>
<td>5 st (4 females, 1 male; ages 7–9); IQ range 52–57</td>
<td>Classwide peer tutoring during a 30-minute health and safety period 3 days per week compared to teacher's usual instruction</td>
</tr>
<tr>
<td>Watson, Bain, and Houghton (1992)</td>
<td>Acquisition of self-protective skills, generalization of skills to nontraining situations, and maintenance of skills over time</td>
<td>Setting: elementary school/SC classroom</td>
<td>7 st (5 females, 2 males, ages 6–8 years); IQ available for 4 students (range &gt;30–55)</td>
<td>Modeled after ACCEPTS Social Skills Curriculum (Walker et al, 1983); behavior chained to complete No! Go! Tell! sequence</td>
</tr>
<tr>
<td>Winterling et al. (1992)</td>
<td>To teach students to remove and dispose of broken materials safely from three contexts (sink, floor, and countertop)</td>
<td>Setting: SC classroom</td>
<td>4 st (2 females, 2 males; ages 17–21); IQs not specified—note that intelligence and adapted behavior measures placed the st in moderate range of MR</td>
<td>Each task taught as a total task with a treatment package consisting of orientation lecture, pretask demonstration, and 5-second CTD procedure</td>
</tr>
</tbody>
</table>

Note: st(s) = student(s); MR = mental retardation; CTD = constant time delay; PTD = progressive time delay; SC = self-contained.
No research studies found in these areas: Content Standard A: Science as Inquiry; Content Standard C: Life Science; Content Standard E: Science and Technology; Content Standard G: History and Nature of Science.
following: (a) the low expectations for the population; (b) the lack of strategies for engaging students with communication challenges in this instruction; and (c) the lack of models for how to adapt science content for this population. Siegel-Causey et al. (1998) provide important guidance on how to include students in general education science classes. For example, these authors found that collaboration of a team of educators (e.g., planning, selecting classes, and accommodating) led to a successful inclusive experience for a junior high school student with severe disabilities in an earth science class. Cooper-Duffy and Perlmutter (2006) expand on this guidance to give examples of how to teach science content in general education classes. The authors provide both a rationale for teaching science and offer strategies derived from their field work. For example, in order to teach students to make an ecosystem, the authors suggest the use of a variety of methods including teaching students to use a checklist, the use of task-analytic instruction, picture sequencing of the steps, and the use of cooperative learning to promote working together. Future research is needed to evaluate strategies like these to provide schools with evidence-based practices for inclusive science instruction. Special educators also need deeper understanding of the content standards of science through collaboration with general educators and preservice/inservice training on this topic.

One of the challenges in planning science instruction will be determining how to provide students with the intensive 1:1 or small group instruction that may be needed for some students to master the concepts and skills. The interventions found in the 11 studies in this review incorporated systematic response prompting methods similar to those found in reading and math research for students with significant disabilities (Browder et al., 2007; Browder et al., 2006). One instructional strategy found across these studies was time delay. Time delay was used to teach safety skills (Collins & Griffen, 1996; Collins & Stinson, 1995; Winterling, Gast, Wolery, & Farmer, 1992) and first-aid skills (Gast, Winterling, Wolery, & Farmer, 1992) to the students involved in the studies.

Although most systematic instruction of skills for students with significant cognitive disabilities is teacher directed, typical science instruction often involves hands-on discovery through inquiry-based instruction. The 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, 1996, p. 214). Within the NSES, inquiry is described as a critical component of a science program because students learn science in a way that represents how science actually works. Inquiry-based instruction requires more than hands-on activities and also incorporates a problem-solving process that is used in the real world. Most inquiry-based instruction requires sophisticated language skills, and almost by definition students with significant cognitive disabilities have language-related deficits. This creates a challenge for our field. In an effort to combine inquiry and language instruction, teachers could provide increased opportunities for communication while encouraging experimentation, offering choices, and following the lead of the student. Currently, there is at least one example that appears to be congruent with an inquiry approach that has been found in the literature. Wehmeyer, Palmer, Agran, Mithaug, and Martin (2000) have described a self-determined model of learning for students with disabilities that may be especially compatible with the inclusion of students in inquiry-based science lessons. Instruction in setting goals and making decisions, as described in this model, holds promise for encouraging student participation in science lessons.

Although the current review offers some guidance for planning future research and instruction in science, its limitations should also be noted. One limitation is the small number of students involved in the studies. Of the 58 students with whom the research was conducted, 42 had moderate disabilities and 7 had severe/profound disabilities. The remaining students were described as having developmental disabilities (5), mild disabilities (3), and a behavioral disability (1). The small numbers compromise the generalization of the results to other students with significant cognitive disabilities. A second limitation is the lack of recent studies in this area. Although the search was conducted through 2005, the most recent study found was published in 2003. Federal mandates require instruction and assessment in science for students with significant cognitive disabilities, but the research is lagging behind what must now be current practice. A final limitation is the lack of research available in science content standards other than Content Standard F: Science in Personal and Social Perspectives. In order for special educators to become proficient in science instruction, all content areas of science should be explored.

In summary, the research guidance for developing science instruction and assessments is nearly nonexistent. In contrast, there is more research on teaching reading (Browder et al., 2006) and mathematics (Browder et al., 2007), which suggests that this population can learn academic content. In our review, we searched the intervention literature for studies that can be cross referenced with the NSES content standards and found 11 studies. This literature suggests that students with significant cognitive disabilities benefit from instruction in specific skills with modeling and errorless learning strategies like time delay. Other strategies may also be identified as research in this area increases. Students with significant cognitive disabilities need instruction that promotes generalization across science content and to general education contexts. For example, inquiry-based instruction is
recommended by the NRC (1996) and needs to be explored further for students with significant cognitive disabilities. Further, we need to explore the applicability of research in the instruction of other academic areas to the science area. For both research and practice, special educators are encouraged to collaborate with science educators to target skills that have meaningful and sound science content.

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