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Evidence-Based Practice for Teaching Academics to Students With Severe Developmental Disabilities

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Abstract

A review of the literature was conducted for articles published between 2003 and 2010 to build a case for the degree to which evidence-based practices were documented for teaching academic skills to students with severe developmental disabilities. This review extended earlier comprehensive work in literacy, mathematics, and science for the population in question. A total of 18 studies met the Horner et al. (2005) quality indicator criteria. In general, time delay and task analytic instruction were found to be evidence-based practices. In addition, specific target responses were defined to show academic learning, with the most prevalent target responses being discrete responses; the type of systematic prompting and feedback used most often was time delay, while the component used least often was stimulus fading/shaping; and teaching formats used most often were massed trials and one-to-one instruction.

Keywords

evidence-based practices, academic skills, students with severe developmental disabilities

One of the important advances in recent years for students with severe developmental disabilities is the opportunity to learn general curriculum content. Students who have access to the general education curriculum are expected to make progress in the academic content areas of literacy, mathematics, and science and teachers are expected to teach academic skills using evidence-based practices (Individuals with Disabilities Education Improvement Act [IDEA], 2004; No Child Left Behind [NCLB], 2002). Despite the legislative call for using evidence-based practices, the determination of what constitutes an evidence-based practice in special education has not yet been clearly defined.

The term *evidence-based practice* stems from the field of medicine. According to Sackett, Rosenberg, Gray, Haynes, and Richardson (1996), evidence-based medicine is the integration of individual clinical expertise and external clinical evidence from systematic research. Sackett et al. note that neither clinical expertise nor clinical evidence alone is enough to provide the best patient care. Following the focus on this concept in medicine, special education legislation such as the Individuals with Disabilities Education Improvement Act (IDEA, 2004) and No Child Left Behind (NCLB, 2002) required educators to use scientifically based or evidence-based instructional practices when providing instruction for students with disabilities. Specifically, NCLB defines scientifically based research as "research that involves the application of rigorous, systematic, and objective procedures to obtain reliable and valid knowledge relevant to education activities and programs" (Title IX, Part A, Section 9101 [37]).

As a consequence of NCLB, considerable work has been dedicated to defining evidence-based practices (Cook, Tankersley, & Harjusola-Webb, 2008; Smith, 2003; Tankersley, Harjusola-Webb, & Landrum, 2008; Whitehurst, 2001). According to Tankersley et al. (2008) evidence-based practice refers to instructional strategies or educational programs shown to produce consistent positive student outcomes. Similarly, Cook et al. (2008) suggest that it is an essential goal of special education to use instructional strategies that have been shown to increase student learning and improve behavior outcomes over time. In another proposed definition, Whitehurst (2001) defines evidence-based practices as "the integration of professional wisdom with the best available in empirical evidence in making decisions about how to deliver instruction (p. 3)."

The determination of what is an evidence-based practice is dependent on two components: the quantity of available

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evidence and the quality of this evidence. To date, there have been at least three major efforts to describe and validate evidence-based practices in the discipline of special education ("Criteria for Evidence-Based," 2005; "Evidence-Based Practices," 2009; Spooner, 2003). In 2003, Spooner led a collection of contributions that addressed perspectives on defining scientific-based research. Odom et al. (2005) set the context for the development of guidelines for defining quality indicators for research methodologies used in special education (e.g., single-case designs; Horner et al., 2005; qualitative methodologies, Brantlinger, Jimenez, Klingner, Pugach, & Richardson, 2005; group and quasi-experimental methods, Gersten et al., 2005). Cook, Tankersley, and Landrum (2009) extended the effort in CEC's second collection ("Evidence-Based," 2009) with a set of examples on applying the quality indicator strategies that were delineated in 2005 (e.g., severe developmental disabilities, Browder, Ahlgrim-Delzell, Spooner, Mims, & Baker, 2009; emotional and behavior disorders, Lane, Kalberg, & Shepcaro, 2009; learning disabilities, Chard, Ketterlin-Geller, Baker, Doabler, & Apichatabutra, 2009).

In the area of severe developmental disabilities the predominant methodology that has been used to substantiate research outcomes is single-case design (Browder et al., 2009; Horner et al., 2005; McDonnell & O'Neill, 2003; Spooner & Browder, 2003). The application of single-case research methodology in an examination and investigation of a question(s) has two underlying tenants: (a) the individual participant is the unit of analysis and (b) visual inspection is the primary method to analyze behavior change (e.g., Cooper, Heron, & Heward, 2007; Johnston & Pennypacker, 1980; Tawney & Gast, 1984). The initial description of an examination of quality indicators for single-case design research was conceptualized by Horner et al. (2005). The Horner et al. (2005) criteria specify: (a) a minimum of five single-case studies that meet minimally acceptable methodological criteria document experimental control, and have been published in peer-reviewed journals, (b) the studies are conducted by at least three different researchers across at least three different geographical locations, and (c) the five or more studies include a total of at least 20 participants.

The effort to evaluate evidence-based practices for teaching literacy, mathematics, and science to students with severe developmental disabilities has been a recent line of investigation, but one important for schools to meet legislative requirements like those of NCLB (2002) for schools to report students' progress in these content areas. The documentation of evidence-based practices is critically important to bridging the research-to-practice gap and assisting practitioners to use validated practices in instructing children with severe developmental disabilities. Kauffman (1996) and Cook and Schirmer (2003) suggest that many teachers of students with disabilities have implemented teaching practices shown to have little effect on student outcomes. Vaughn and Dammann (2001) further suggest that students with disabilities require the application of effective procedures to maximize learning. If this is case for students with more mild disabilities, it is even more critical to use only the most efficient and effective procedures in teaching students with severe developmental disabilities who may require longer to master target objectives (Sontag, Burke, & York, 1973; Spooner & Brown, 2011). Based on recent comprehensive reviews, more research is available for teaching literacy (Browder et al., 2009, 30 experiments; Browder, Wakeman, Spooner, Ahlgrim-Delzell, & Algozzine, 2006, 128 experiments) than mathematics (Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakeman, 2008, 68 experiments), and more for mathematics than science (Spooner, Knight, Browder, Jimenez, & DiBiase, in press, 17 experiments).

Browder et al. (2006) examined the literature from 1975 to 2003 to investigate the degree to which literacy was taught to students with severe developmental disabilities and using a 28-year period found 128 experiments which were compared to the National Reading Panel's components (NRP, 2000, phonemic awareness, phonics, fluency, vocabulary, and comprehension). The Horner et al. (2005) and the Gersten et al. (2005) quality indicator criteria were used to judge the characteristics of the instructional procedures. Although the research was focused more on teaching sight words than the NRP components of literacy, overall evidence was found for using systematic prompting techniques in a repeated trial format.

In a second literacy-related review, Browder et al. (2009) examined the literature from 1975 to 2007 for the use of time delay to teach words and picture recognition to students with severe developmental disabilities. A total of 30 experiments were analyzed using the quality indicators for single-case design research (Horner et al., 2005). In general, it was found that time delay was an evidence-based practice for teaching literacy to this population. Browder et al. (2009) also noted that comparing the literature to the theoretical foundations was a necessary and important component of the investigative process. Recommendations for defining evidence-based practices were to define the practice, clarify the boundaries of the review, refine the quality indicators for the practice to be reviewed, and plan for coding.

Similar to the literacy reviews, Browder et al. (2008) also investigated the degree to which mathematics has been taught to students with severe developmental disabilities across a 30-year time span (1975–2005). The Horner et al. (2005) and the Gersten et al. (2005) quality indicator criteria again were applied to examine the characteristics of the instructional procedures across the National Teachers of Mathematics Standards (NCTM, 2000; numbers and operations, algebra, measurement, geometry, data analysis, and probability). Sixty-five articles yielding 54 single-case

and 14 group studies were identified for an overall total of 68 experiments. Evidence was found that students with severe developmental disabilities could learn mathematics based on an overall strong effect size. Articles also were found that addressed all five NCTM components of mathematics, but most addressed numbers and computation or measurement. Within the computation studies identified, most focused on counting, calculation, or number matching.

To round out the academic trilogy (literacy, mathematics, and science), Spooner et al. (in press) expanded on the work of Courtade, Spooner, and Browder (2007) by examining the literature from the years 1985 to September 2010 in an effort to evaluate whether the use of systematic instruction was an evidence-based practice in teaching students with severe disabilities academic content in science. An electronic search including 27 terms (e.g., inquiry, physical science) yielded 17 articles linked to the National Science Education Standards (National Research Council, 1996) in which the authors then coded, based on the criteria for determining an evidence-based practice outlined by Horner et al. (2005). Of the 17 studies included, Spooner et al. (in press) determined 5 studies to include a "strong" level of evidence and 9 studies to meet a "moderate" level of evidence, thus determining systematic instruction to be an evidence-based practice for teaching science content to students with severe developmental disabilities.

Although these studies provide insights about the literature in each content area, additional analyses are needed to provide guidance for overall planning of academic learning for students with severe developmental disabilities. With the exception of the study by Browder et al. (2009) on time delay, the other reviews focused on the dependent variable (e.g., literacy components) to derive potential practices (independent variable). The purpose of each of these reviews was to provide a comprehensive review of the academic content area. While together these reviews offer promise for the use of systematic instruction, they do not analyze the evidence for specific practices. In contrast, to build a case of evidence for a *practice*, it is not necessary to conduct an exhaustive search of the literature, but it is necessary to identify a sufficient number of studies of acceptable quality that support the practice. This number can sometimes be identified through a much smaller span of time than used in comprehensive reviews. By focusing on a recent span of time, the reviewer is more likely to capture the most current applications of the practice. Applying the Horner et al. (2005) criteria, if five studies across multiple researchers and regions are identified that meet the guidelines for quality, the practice can be recommended as evidence-based.

The purpose of the current review was threefold. First, we updated methods of instruction that can be used to teach academic content (e.g., literacy, mathematics, and science) to students with severe disabilities by starting at the ending date of prior reviews (i.e., literacy, 2003; mathematics, 2005; science, 2005). Second, we built on these prior reviews by gleaning from them specific practices (e.g., time delay) that had an evidence base to ask questions of the current research. Third, we provided the first analysis of these practices across content areas to determine if these are emerging as generic forms of instruction that are effective for literacy, mathematics, or science.

The following research questions were addressed in this review:

1. Is the use of task analytic instruction with systematic prompting and feedback an evidence-based practice for teaching a variety of academic skills (e.g., steps in an inquiry-based science lesson)?
2. Is the use of discrete responses represented as an evidence-based practice for teaching a variety of academic skills? If so, which target responses are most prevalent?
3. Is the use of time delay to teach a set of discrete responses considered an evidence-based practice for teaching a variety of academic skills (e.g., mathematics facts, science vocabulary definitions)? Can these skills be embedded into the general education classroom?

Method

Literature Search Procedures

The specific practices to be searched included task analysis, discrete responses, and time delay as identified in prior comprehensive reviews on literacy (Browder et al., 2006; Browder et al., 2009), mathematics (Browder et al., 2008), and science (Courtade et al., 2007; Spooner et al., in press). The practices were also cross-referenced through reviewing several textbooks in the area of special education pertaining to teaching students with severe developmental disabilities to note how they were described (e.g., Browder, 2001; Browder & Spooner, 2006; Collins, 2007; Westling & Fox, 2009). This literature review updated previous searches by conducting a search of the literature from the ending dates of the science, mathematics, and literacy reviews: (a) for literacy, a search of the literature was conducted from the time period 2003 to 2010; (b) for science, a search was performed from 2005 to 2010; (c) and for mathematics, a search was conducted from 2005 to 2010.

To expand and update the collection of experiments in the three content areas, comprehensive list search procedures used in previous reviews in literacy (Browder et al., 2006; Browder et al., 2009), mathematics (Browder et al., 2008), and science (Courtade et al., 2007; Spooner et al., in press) were repeated. Identical search terms used in the previous reviews were applied to this review for all content areas and to characterize individuals with severe developmental

disabilities (e.g., autism, moderate mental retardation, severe disabilities). Similar to the previous reviews in reading, search terms related to specific programs (e.g., Edmark, Distar/Reading Mastery), and instructional strategies in reading (e.g., least to most prompting, constant time delay) were used. Consistent with the mathematics literature review, mathematics search terms were organized using the literature from the NCTM (2000) components of mathematics. Finally, search terms in science were derived from the eight Science Content Standards identified by the National Science Education Standards (NSES) similar to the science review. In addition, we added search terms based on the recommended instructional practices from the review of textbooks (e.g., embedded instruction, video-modeling). The literature search was conducted using both electronic print sources (e.g., PsycINFO, Masterfile Premier, ERIC; *Education and Training in Developmental Disabilities*, *Journal of Applied Behavior Analysis*, *Focus on Autism and Other Developmental Disabilities*, and *Research and Practice for Persons with Severe Disabilities*).

Inclusion Criteria

To be included in the review, the following inclusion criteria were met: (a) published in a peer-reviewed journal in English between the years of 2003 and 2010 (depending on the content area); (b) at least one participant was labeled as having a severe disability (e.g., autism or other developmental disability; moderate, severe, or profound intellectual disability [mental retardation]); (c) the study included acquisition of a targeted skill in literacy, mathematics, or science (e.g., studies in which the dependent variable was not specifically content related were excluded); (d) use of a single-case design demonstrating experimental control (e.g., ABAB); and (e) "quality" or "acceptable" studies was derived from the Horner et al. (2005) criteria using the National Secondary Transition Technical Assistance Center's (NSTTAC, 2010; Test et al., 2009) decision rules. Group designs were excluded because prior reviews indicated group designs were rarely applied in research on these topics with this student population.

Once new studies were added to the sets of studies identified by the prior comprehensive reviews, quality indicator criteria were applied to select a subset of studies to answer the research questions. Only studies that met Horner et al. (2005) criteria for "quality" or "acceptable" studies were retained for analysis as shown in Table 1. A total of 18 experiments that taught academic content in literacy, mathematics, science, and other content areas (e.g., social studies) to students with severe developmental disabilities met inclusion criteria and were retained for further analysis. Application of the Horner et al. (2005) quality indicator criteria for single-case studies to the included investigations will be discussed in the next section (see Table 1).

Application of the Horner et al. (2005) Quality Indicators for Single-Case

The determination of whether or not the included studies were "quality" or "acceptable" studies was derived from the Horner et al. (2005) criteria using the National Secondary Transition Technical Assistance Center's (NSTTAC, 2010; Test et al., 2009) decision rules for conducting a literature review (see Table 1). For example, to be considered a high-quality study, it must meet all quality indicators (QIs), whereas acceptable studies meet all QIs except Items 2 (participant selection), 11 (procedural fidelity), and one of Items 17 to 20 (social validity). In addition, all of the studies retained for further analysis met all of the items listed under the indicator for results, graph, and design according to Horner et al. (2005). In other words, the results indicator was considered critical.

Coding

Once the above inclusion criteria were met and studies were evaluated based on Horner et al. (2005) quality indicator criteria for evidence-based practice, researchers developed a review form to record the characteristics of the studies as shown in Table 2. Each experiment was screened and coded on (a) content area (i.e., literacy, mathematics, or science), (b) instructional methods used (e.g., Self-Determined Learning Model Instruction, embedded instruction, time delay), (c) use of a defined specific target response demonstrating student learning (e.g., chained, discrete), (d) systematic prompting and feedback (e.g., system of least prompts, stimulus fading), (e) teaching trial format (e.g., massed, embedded), and (f) training for generalization and maintenance (i.e., across people, materials, and settings; see Table 2).

Method to Establish Interrater Reliability on Quality Indicators and Characteristics of Studies

Researchers established interrater reliability on six experiments (33%) across the 18 literacy, mathematics, and science studies included in the review using the same coding criteria used to originally code studies (see Table 1). A second doctoral student served as the subsequent rater and independently evaluated the experiments. This second doctoral student had more than 10 years' experience working with students with severe disabilities and has served as an investigator and author on research reports that have been published in peer-reviewed journals on the topic of evidence-based practices and single-case design research. Each experiment was compared using an item-by-item method of recording agreements and disagreements scored

Table 1. Quality Indicators Identified in Each Study

Indicator	Ayres, Langone, Boon, & Norman (2006)[a]	Browder, Trela, & Jimenez (2007)[b]	Cihak, Alberto, Taber-Doughty & Gama (2006)[a]	Collins, Evans, Creech-Galloway, Karl, & Miller (2007)[a]	Courtade, Browder, Spooner, & DiBiase (2010)[a]	DiPipi-Hoy & Jitendra (2004)[b]	Falkenstine, Collins, Schuster, & Kleinert (2009)[a]	Hansen & Morgan (2008)[a]	Hetzroni & Shalem (2005)[b]	Jameson, McDonnell, Johnson, Riesen,… Polychronis (2007)[b]
Participants										
Described sufficiently	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Selection described sufficiently	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Setting										
Setting described sufficiently	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Dependent variable (DV)										
Described with replicable precision	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Quantifiable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Measurement described to replicable precision	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Measurement occurred repeatedly	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Interobserver agreement data reported	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Independent variable (IV)										
Described with replicable precision	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Systematically manipulated	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Procedural fidelity described	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
Baseline procedures										
Phase provided evidence of pattern, prior to intervention	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Described with replicable precision	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Results										
Three demonstrations of experimental effect	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Design controlled threats to internal validity	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Effects replicated, indicate external validity	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Social validity										
DV socially important	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Magnitude of change in DV due to intervention socially important	N	Y	N	Y	Y	Y	N	Y	Y	Y
IV is cost effective/practical	N	Y	Y	N	N	Y	N	Y	Y	Y
IV is implemented over time, typical contexts /typical agents	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Indicators met/ total Indicators	18/20	20/20	19/20	19/20	19/20	20/20	18/20	19/20	20/20	20/20
Major Variable Indicators	7/7	7/7	7/7	7/7	7/7	7/7	7/7	7/7	7/7	7/7

(continued)

Table 1. (continued)

Indicator	Jameson, McDonnell, Polychronis, & Riesen (2008)[a]	Jimenez, Browder, & Courtade (2008)[a]	McDonnell et al. (2006)[a]	Mechling (2004)	Mechling, Gast, & Krupa (2007)	Polychronis, McDonnell, Johnson, Riesen, & Jameson (2004)[b]	Riesen, McDonnell, Johnson, Polychronis, & Jameson (2003)[b]	Tucker Cohen, Wolff Heller, Alberto, & Fredrick (2008)[b]
Participants								
Described sufficiently	Y	Y	Y	Y	Y	Y	Y	Y
Selection described sufficiently	Y	Y	Y	Y	Y	Y	Y	Y
Setting								
Setting described sufficiently	Y	Y	Y	Y	Y	Y	Y	Y
Dependent variable (DV)								
Described with replicable precision	Y	Y	Y	Y	Y	Y	Y	Y
Quantifiable	Y	Y	Y	Y	Y	Y	Y	Y
Measurement described to replicable precision	Y	Y	Y	Y	Y	Y	Y	Y
Measurement occurred repeatedly	Y	Y	Y	Y	Y	Y	Y	Y
Interobserver agreement data reported	Y	Y	Y	Y	Y	Y	Y	Y
Independent variable (IV)								
Described with replicable precision	Y	Y	Y	Y	Y	Y	Y	Y
Systematically manipulated	Y	Y	Y	Y	Y	Y	Y	Y
Procedural fidelity described	Y	Y	Y	Y	Y	Y	Y	Y
Baseline procedures								
Phase provided evidence of pattern, prior to intervention	Y	Y	Y	Y	Y	Y	Y	Y
Described with replicable precision	Y	Y	Y	Y	Y	Y	Y	Y
Results								
Three demonstrations of experimental effect	Y	Y	Y	Y	Y	Y	Y	Y
Design controlled threats to internal validity	Y	Y	Y	Y	Y	Y	Y	Y
Effects replicated, indicate external validity	Y	Y	Y	Y	Y	Y	Y	Y
Social validity								
DV socially important	Y	Y	Y	Y	Y	Y	Y	Y
Magnitude of change in DV due to intervention socially important	N	N	N	N	N	Y	Y	Y
IV is cost effective/practical	Y	Y	Y	Y	N	Y	Y	Y
IV is implemented over time, typical contexts /typical agents	Y	Y	Y	Y	Y	Y	Y	Y
Indicators Met/ Total Indicators	19/20	19/20	19/20	19/20	18/20	20/20	20/20	20/20
Major Variable Indicators	7/7	7/7	7/7	7/7	7/7	7/7	7/7	7/7

Note: Y = Yes; N = No.

a. Acceptable level of evidence.

b. High quality of evidence (as defined by the National Secondary Transition Technical Assistance Center).

Table 2. Instructional and Procedural Components of Quality Studies in Teaching Academic Skills

	Ayres, Langone, Boon, & Norman (2006)	Browder, Trela, Jimenez (2007)	Cihak, Alberto, Taber-Doughty, & Gama (2006)	Collins, Evans, Creech-Galloway, Karl, & Miller (2007)	Courtade, Browder, Spooner, & DiBiase (2010)	DiPipi-Hoy & Jitendra (2004)	Falkenstine, Collins, Schuster, & Kleinert (2009)
Specific response							
Chained response		✓	✓		✓	✓	✓
Discrete responses	✓			✓			✓
Systematic prompting and feedback							
Time delay		✓		✓		✓	✓
System of least prompts		✓	✓		✓		
Stimulus prompting/Fading	✓						
Use of error correction and praise	✓	✓	✓	✓	✓	✓	✓
Use of a chaining procedure		✓	✓		✓	✓	
Teaching trial format							
Use of a task analysis		✓	✓		✓	✓	
Massed trials	✓			✓			✓
Embedded trials				✓			
Distributed trials				✓			
Naturalistic teaching			✓	✓		✓	
1:1	✓					✓	
Group		✓	✓	✓	✓		✓
Context of instruction							
General education				✓			
Special education	✓	✓	✓	✓	✓		✓
Community	✓		✓			✓	
Other school (e.g., cafeteria)							
Training for generalization and maintenance							
Generalization	✓	✓	✓	✓	✓	✓	✓
Maintenance		✓	✓	✓			

	Hansen & Morgan (2008)	Hetzroni & Shalem (2005)	Jameson, McDonnell, Johnson, Riesen, & Polychronis (2007)	Jameson, McDonnell, Polychronis, & Riesen (2008)	Jimenez, Browder, & Courtade (2008)	McDonnell et al. (2006)	Mechling (2004)
Specific response							
Chained response	✓				✓	✓	✓
Discrete responses		✓	✓	✓			✓
Systematic prompting and feedback							
Time delay			✓	✓	✓	✓	✓
System of least prompts					✓		✓
Stimulus prompting/fading		✓					
Use of error correction & praise	✓	✓	✓	✓	✓	✓	✓
Use of a chaining procedure	✓				✓		✓
Teaching trial format							
Use of a task analysis	✓				✓		✓
Massed trials		✓	✓		✓		✓
Embedded trials			✓	✓		✓	

(continued)

Table 2. (continued)

	Hansen & Morgan (2008)	Hetzroni & Shalem (2005)	Jameson, McDonnell, Johnson, Riesen, & Polychronis (2007)	Jameson, McDonnell, Polychronis, & Riesen (2008)	Jimenez, Browder, & Courtade (2008)	McDonnell et al. (2006)	Mechling (2004)
Distributed trials			✓	✓		✓	
Naturalistic teaching				✓			
1:1	✓	✓	✓	✓	✓		✓
Group						✓	
Context of instruction							
General education			✓	✓	✓	✓	
Special education			✓		✓		✓
Community	✓						✓
Other school (e.g., cafeteria)	✓	✓					✓
Training for generalization and maintenance							
Generalization	✓	✓		✓	✓		✓
Maintenance	✓	✓			✓		

	Mechling, Gast, & Krupa (2007)	Polychronis, McDonnell, Johnson, Riesen, & Jameson (2004)	Riesen, McDonnell, Johnson, Polychronis, & Jameson (2003)	Tucker Cohen, Wolff Heller, Alberto, & Fredrick (2008)	Total number of studies
Specific response					
Chained response					9 studies
Discrete responses	✓	✓	✓	✓	11 studies
Systematic prompting and feedback					
Time delay	✓	✓	✓	✓	13 studies
System of least prompts					5 studies
Stimulus prompting/fading					2 studies
Use of error correction and praise	✓	✓	✓	✓	18 studies
Use of a chaining procedure					7 studies
Teaching trial format					
Use of a task analysis					7 studies
Massed trials	✓			✓	9 studies
Embedded trials		✓	✓		6 studies
Distributed trials		✓	✓		6 studies
Naturalistic teaching		✓	✓		6 studies
1:1				✓	9 studies
Group	✓	✓	✓		9 studies
Context of instruction					
General education		✓	✓		7 studies
Special education				✓	10 studies
Community	✓				6 studies
Other school (e.g., cafeteria)			✓		4 studies
Training for generalization and maintenance					
Generalization	✓	✓	✓	✓	16 studies
Maintenance					8 studies

by both researchers. Mean interrater reliability was 98.3% (95%–100%). Results of coding articles according to Horner et al. (2005) quality indicator criteria are presented in Table 1 (see Table 1).

Determination of Evidence-Based Practices

To make the determination of a specific practice (e.g., least to most prompting) as being evidence-based for teaching academics, the researchers reviewed the "quality" and "acceptable" studies to examine the degree to which the practice met the criteria for an evidence-based practice (Horner et al., 2005). In addition, the definition of a practice in this review was consistent with Horner et al. recommendations that the practice must be operationally defined such that it permits replication by researchers other than the original developers. The NSTTAC (2010) decision rules provide some flexibility in judging strong and moderate (acceptable) levels of causal inference (see Table 1). Strong levels of causal inference should meet all QIs for the Horner et al. (2005) criteria and that there is a sufficient quantity of studies and participants (i.e., five studies, three investigative teams, and geographic regions totaling 20 participants across studies). For acceptable or moderate levels of causal inference all QIs should be met, except there is some leeway on Item 2 (participant selection), 11 (procedural fidelity), and one of Items 17 to 20 (social validity), and three strong or acceptable studies and one or two investigative teams.

Overall, authors analyzed the 18 studies. Of these, 7 studies were determined to have a strong level of evidence, and an additional 11 appeared to meet a moderate level of evidence. These 18 studies were then considered to address the research questions.

Results

Characteristics of the Single-Case Studies

Of the 18 studies retained, authors included 8 students with a diagnosis of autism, 31 students with mild or moderate intellectual disabilities, 20 students with severe disabilities, and 5 students with multiple disabilities. Within the 18 studies, the types of designs researchers applied included one multiple-baseline across-participants design, nine multiple-probe across-participants designs, two multiple-probe across-behavior designs, and six alternating treatment designs. Although the majority of studies were implemented in a special education setting (n = 11, 61.1%) authors also reported implementation of their studies in seven general education settings (38.9%), six community settings (33.3%), and four other settings (22.2%, e.g., cafeteria or home). In comparison to three previously conducted literature reviews (Browder et al., 2006, 2008; Spooner et al., in press), the studies included show an increase in the number of investigations implemented in the general education and community settings. In addition, 16 of the 18 studies assessed generalization across materials, people, and settings. Only 8 studies collected data on student maintenance or performance over time.

> *Research Question 1:* Is the use of task analytic instruction with systematic prompting and feedback an evidence-based practice for teaching a variety of academic skills (e.g., steps in an inquiry-based science lesson)?

A practice identified in both the mathematics review (Browder et al., 2008) and recommended in several texts (e.g., Cipani & Spooner, 1994; Collins, 2007; Snell & Brown, 2006) is task analytic instruction. Task analytic instruction can be defined as the step-by-step teaching for a chain of responses to complete an activity (e.g., to solve an algebraic equation or make a purchase). To qualify as task analysis for this review, the intervention description had to include the name or number of steps and a prompting method that was applied to each response in the chain of responding. The use of task analytic instruction with systematic prompting and feedback was used to teach a variety of academic skills in 7 of the 18 total studies (e.g., Jimenez, Browder, & Courtade, 2008; Mechling, 2004) as shown in Table 2. Two studies used task analytic instruction with systematic prompting and feedback to teach literacy skills (i.e., Browder, Trela, & Jimenez, 2007; Mechling, 2004), 4 studies used task analytic instruction with systematic prompting and feedback to teach mathematics skills (i.e., Cihak, Alberto, Taber-Doughty, & Gama, 2006; DiPipi-Hoy & Jitendra, 2004; Hansen & Morgan, 2008; Jimenez et al., 2008), and 1 study used task analytic instruction with systematic prompting and feedback to teach science/other academic skills (Courtade, Browder, Spooner, & DiBiase, 2010). For example, Browder et al. (2007) taught special education teachers to follow a literacy lesson plan in order to increase student performance within the lesson plan. Cihak et al. (2006) used static and video prompts along with an alternating treatment design to teaching acquisition of purchasing and banking skills. Furthermore, the combined studies met the criteria for an evidence-based practice based on the Horner et al. (2005) requirements. In all, there were 7 studies, six research teams in five different geographical areas, and a total of 29 participants (see Table 2).

> *Research Question 2:* Is the use of discrete responses represented as an evidence-based practice for teaching a variety of academic responses? If so, which target responses are most prevalent?

Given that task analytic instruction is an evidence-based practice, we also posed the question of whether there was evidence for teaching discrete responses. Discrete responses can be defined as "responses that consist of a single step" (Collins, 2007, p. 353). Although 7 studies noted in the prior question all used task analytic instruction, in the other 11 studies, researchers defined the target behavior as a discrete response (Ayres, Langone, Boon, & Norman, 2006; Collins, Evans, Creech-Galloway, Karl, & Miller, 2007; Falkenstine, Collins, Schuster, & Kleinert, 2009; Hetzroni & Shalem, 2005; Jameson, McDonnell, Johnson, Riesen, & Polychronis, 2007; Jameson, McDonnell, Polychronis, & Riesen, 2008; Mechling, 2004; Mechling, Gast, & Krupa, 2007; Polychronis, McDonnell, Johnson, Riesen, & Jameson, 2004; Riesen, McDonnell, Johnson, Polychronis, & Jameson, 2003; Tucker Cohen, Wolff Heller, Alberto, & Fredrick, 2008). The most prevalent target responses were sight words or simple facts like state capitals. These 11 studies were conducted in six regions by eight research teams with 33 participants fulfilling the criteria for evidence-based practice. The way these discrete responses were presented as teaching trials varied. Nine studies used a massed trial format of instruction (Ayres et al., 2006; Collins et al., 2007; Falkenstine et al., 2009; Hetzroni & Shalem, 2005; Jameson et al., 2007; Jimenez et al., 2008; Mechling, 2004; Mechling et al., 2007; Tucker Cohen et al., 2008), 6 studies used distributed trials (Collins et al., 2007; Jameson et al., 2007; Jameson et al., 2008; McDonnell et al., 2006; Polychronis et al., 2004; Riesen et al., 2003), and 6 studies used embedded trials (Collins et al., 2007; Jameson et al., 2007; Jameson et al., 2008; McDonnell et al., 2006; Polychronis et al., 2004; Riesen et al., 2003). In some cases, researchers delivered instruction using both distributed trials and massed trials in order to compare their effects and therefore are counted in both categories of delivery of instruction (e.g., Jameson et al., 2008). Embedded trials were distributed within the context of a general education lesson. In addition, 6 studies used naturalistic teaching procedures in which the trial was embedded in a typical daily routine (Cihak et al., 2006; Collins et al., 2007; DiPipi-Hoy & Jitendra, 2004; Jameson et al., 2008; Polychronis et al., 2004; Riesen et al., 2003). Furthermore, the combined studies met the criteria for an evidence-based practice based on the Horner et al. (2005) requirements. In summary, for Research Question 2, there were 11 studies, eight research teams in six different geographical areas, and a total of 33 participants.

Research Question 3: Is the use of time delay to teach a set of discrete responses considered an evidence-based practice for teaching a variety of academic skills (e.g., mathematics facts, science vocabulary definitions)? Can these skills be embedded into the general education classroom?

One of the most prevalent practices identified by prior literature reviews (Browder et al., 2006; Browder et al., 2008; Spooner et al., in press) and recommended in textbooks (e.g., Browder & Spooner, 2006; Collins, 2007) is time delay. The practice known as time delay has been defined in a literature review by Browder et al. (2009) as method of transferring stimulus control where increasing amounts of time are systematically inserted between the task direction and the controlling prompt to create a near errorless procedure. In the current review, time delay was used to teach a set of discrete responses across a range of academic skills in 13 of the 18 total studies (e.g., Collins et al., 2007; Falkenstine et al., 2009; Jameson et al., 2007). All 13 met the definition for a time delay practice. Three studies used time delay to teach literacy skills (i.e., Mechling, 2004; Mechling et al., 2007; Tucker Cohen et al., 2008), 1 study used time delay to teach discrete mathematics skills (DiPipi-Hoy & Jitendra, 2004), and 5 studies used time delay to teach discrete science/other academic skills (e.g., Collins et al., 2007; Jameson et al., 2008; McDonnell et al., 2006). For example, Mechling (2004) taught participants to read 12 grocery items. DiPipi-Hoy and Jitendra (2004) taught participants purchasing skills in community settings. Collins et al. (2007) taught participants functional and core content sight words. There was a sufficient range of studies to identify time delay as an evidence-based practice for teaching academic content based on the Horner et al. (2005) criteria. In all, there were a total of 13 studies, five research teams in five different geographical areas, and a total of 24 participants in these 9 time delay studies. It should be noted that time delay was often used as a component of a treatment package that included other variables. For example, DiPipi-Hoy and Jitendra (2004) used parent-delivered constant time delay in addition to naturalistic teaching strategies to teach purchasing skills in grocery store settings. Similarly, Mechling (2004) used constant time delay in addition to multimedia programs with simulations to increase participants' fluency in grocery shopping.

The evidence for using time delay embedded within a general education classroom was found in 4 studies (e.g., McDonnell et al., 2006; Riesen et al., 2003) in one geographic location (i.e., Utah) with 12 participants. This makes the specific use of embedded time delay instruction to be a promising practice. To establish embedded instruction as an evidence-based practice, in accordance with Horner et al. (2005) criteria, there is still a need for further research studies implemented in at least two other geographic regions with a minimum of eight participants.

Discussion

From this synthesis, a review of practices used to teach academic content, some general recommendations emerge. In the prior comprehensive reviews (Browder et al., 2006;

Browder et al., 2008; Spooner et al., in press), a pattern surfaced for using systematic instruction to teach academic content. Systematic instruction uses principles of behavior analysis in planning and implementing interventions. In systematic instruction, an observable, measurable response, set of responses, or response chain is targeted. In this review, we found that both the use of a chained response (task analysis) and a discrete response are evidence-based practices. In some of this literature, the response has been a daily living activity (purchasing items, Cihak et al., 2006; DiPipi-Hoy & Jitendra, 2004; reading grocery items, Mechling, 2004). In others, the responses have been more academic in focus, like solving an algebraic equation (Jimenez et al., 2008), evaluating states of matter (boiling, melting, freezing, Jameson et al., 2007), and word decoding (Tucker Cohen et al., 2008).

Once the observable, measurable response or response chain (task analysis) has been created, a second point for planning is the method of systematic prompting. In this review, there was strong evidence for the use of time delay. In time delay (method of transferring stimulus control), increasing amounts of time are systematically inserted between the task direction and the controlling prompt to create a near errorless procedure (Snell & Gast, 1981; Touchette, 1971). This method can be used with both discrete and chained responses. As Table 2 indicates, although most ($n = 13$) studies identified in this review used time delay, the remaining five used a system of least-intrusive prompts (Browder et al., 2007; Cihak et al., 2006; Courtade et al., 2010; Jimenez et al., 2008; Mechling, 2004). In the system of least-intrusive prompts, the instructor first waits about 5 seconds for the student to respond independently and if no response occurs, delivers the first prompt in the hierarchy (e.g., verbal prompt). The instructor continues down the hierarchy of prompts (e.g., model, physical) until the student responds correctly (Collins, 2007). It is interesting that the system of least prompts has been used less frequently than time delay in this recent academic research given its strong foundation in earlier life skills research (Farlow & Snell, 2006; Spooner & Test, 1994; Spooner & Wood, 2004). The need exists for an analysis of the evidence base for the system of least-intrusive prompts in teaching academic content to students with severe disabilities. This analysis also might consider whether these applications differ when the focus is on academic responding (e.g., answering a comprehension question) rather than a motor response (e.g., pointing to a sight word).

In addition, those studies analyzed that measured a discrete response, the discrete response were most often teaching sight word identification of grade-aligned vocabulary words. The identification of sight words often does not include instruction promoting comprehension of the meaning of those words. One investigation included in the analysis (Courtade et al., 2010) suggested the need for more studies that not only teach identification of vocabulary but also linking of those vocabulary words to meaningful activities in order to demonstrate comprehension of the meaning of vocabulary terms. For example, a teacher while teaching the vocabulary term *landform* might also present a student with a variety of models of landform, or ask the student to create a model of a landform. As an extension activity, the student could then pour water or blow wind on the landform to demonstrate how landforms change over time when forces of erosion act on it.

In applying this evidence base to planning academic instruction, it should be noted, that whether the researchers used time delay or a system of least prompts, the prompting procedures always were combined with methods for reinforcement (typically praise). Sometimes there were special methods for correcting errors (Hansen & Morgan, 2008), but often the instructor simply reintroduced the prompt (Jimenez et al., 2008). Thus, this collection of studies supports treatment packages that (a) target either a chain or discrete academic responses, (b) use some method of systematic prompting and fading, and (c) provide feedback in the form of differential reinforcement and some type of correction. A limitation of this review is that the contribution of these additional variables to the overall student learning outcomes is unknown. There remains a need for studies that include analysis of each component of the intervention package so that readers can determine the most effective components and those components can be further investigated in replication studies.

Another important consideration in planning academic instruction is to teach for generalization. In the current review, generalization across materials in literacy was evaluated in three studies (e.g., Hetzroni & Shalem, 2005; Mechling et al. 2007; Tucker Cohen et al., 2008), generalization across materials in mathematics was evaluated in five studies (e.g., Ayres et al., 2006; DiPipi-Hoy & Jitendra, 2004; Falkenstine et al., 2009; Hansen & Morgan, 2008; Jimenez et al., 2008), and generalization across materials in science was evaluated in four studies (e.g., Jameson et al., 2008; Polychronis et al., 2004; Riesen et al., 2003). This generalization across materials helps to support the effectiveness of the interventions in producing learning of an academic concept rather than a memorized response.

Generalization across settings also was demonstrated in several studies. Students generalized their academic responses from special education to general education settings in four studies (i.e., Jameson et al., 2007; Jimenez et al., 2008; McDonnell et al., 2006; Riesen et al., 2003), from classroom to community settings in five studies (i.e., Ayres et al., 2006; Cihak et al., 2006; DiPipi-Hoy & Jitendra, 2004; Hanson & Morgan, 2008; Mechling, 2004), and from a testing setting to a classroom setting in one study (i.e., Hetzroni & Shalem, 2005). These measures of generalization are especially important to show that students can use newly acquired academic skills in real-life settings and in inclusive settings.

In summary, with this investigation, we have looked more globally across academic content areas (e.g., literacy, mathematics, and science) as opposed to examining a single content area (e.g., mathematics; Browder et al., 2008) in a comprehensive review. The purpose of the current investigation was to develop a case of evidence for a practice (e.g., task analytic instruction with systematic prompting and feedback, time delay to teach discrete responses in a variety of academic skills) by building on prior comprehensive reviews and recommendations in textbooks. Through this current review, we have extended what we know about teaching academic content to students with severe developmental disabilities in the quest to document evidence-based practices.

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