Systematic Review

Single-Case Writing Interventions for Students with Disorders of Intellectual Development: A Systematic Review and Meta-Analysis

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Abstract: Students with disorders of intellectual development (ID) often experience writing difficulties, and effective interventions are highly needed. This systematic review and meta-analysis of single-case experimental design (SCED) studies summarize the effects of writing interventions for students with disorders of ID aged 4–19 years. We conducted a systematic search of seven databases, ancestral and forward searches of relevant sources, and contacted well-known authors in the field. Fifteen and 10 studies were included in the systematic review and meta-analyses, respectively. The overall results indicate that the participants improved their writing skills, with a large between-case standardized mean difference (BC-SMD) effect on the number of words and sentences written (BC-SMD = 1.22) and on the quality of paragraph and story writing (BC-SMD = 1.39). Students with disorders of ID can benefit from writing interventions, and the study results may provide practitioners with important insight into promising writing instructions and materials. There is a need for high-quality research targeting encoding (i.e., transforming sound into letters) skills for early school-age students with disorders of ID.

Keywords: intellectual disability; effect; single-subject research; special needs education; writing instruction; written language

1. Introduction

"Language by hand" [1], the act of transcribing our thoughts into text, requires functional written expression skills, such as encoding (transforming sound into letters) and linguistic production (generation and/or organization of ideas) [2,3]. For many students with disorders of intellectual development (ID), developing writing skills is challenging [4]. According to the World Health Organization's 11th revision of the International Classification of Diseases and Related Health Problems (ICD-11), the term "disorders of intellectual development" has been suggested to replace the terms "intellectual disability" and "mental retardation" [5]. Disorders of ID are characterized by significant impairments in adaptive behavior and intellectual functioning, which are approximately two or more standard deviations (SD) below the mean [5]. Students with disorders of ID may have difficulty acquiring and understanding complex academic skills [5], and research indicates that only one in 10 of these students has functional writing skills [6]. In today's technological society, limited writing skills may seriously impact a person's quality of life [7]. By contrast, functional writing skills among students with disorders of ID may positively influence academic skills, education, and employment [8], as well as support the creation of shared meaning [4]. Functional writing skills may also provide these individuals with access to social media, which are important social and knowledge-sharing arenas in modern society.

Despite the importance of writing skills for social and independent living, Bakken et al. [9] concluded from their systematic review and meta-analysis of experimental group design

studies that research based on the direct effects of writing interventions for students with disorders of ID is non-existent. To contribute knowledge to the field of practice, they recommended exploring the effects of writing interventions using a single-case experimental design (SCED). Individuals with disorders of ID comprise about 1% of the population [10], and cognitive and adaptive challenges vary within the group [5]. In SCED, each individual serves as their own control [11], which makes this a particularly relevant design for assessing intervention effects for individual students or small groups within low-frequency and heterogeneous populations [12]. SCED is considered the predominant methodology for evaluating causal relations between interventions and target behaviors in special education [13].

According to What Works Clearinghouse (WWC), SCED studies must be replicated several times with different samples and by different research teams to determine whether the results from these studies are valid across samples, implementers, and researchers [14]. However, not all studies met the quality standards set by WWC. Study replications are also limited, and systematic reviews and meta-analyses are among the ways to increase knowledge of effective interventions [15]. WWC provides detailed descriptions to review and summarize the quality of education research [14,15]. In this study, the WWC Standards [15] and WWC Procedures [14] developed for SCEDs guide the process of identifying existing research on relevant writing interventions, evaluating the quality of this research, and summarizing and reporting evidence from studies that meet WWC standards. The aim of the present study is to explore existing interventions that have used SCED and to determine what constitutes effective writing interventions by combining a qualitative systematic review and a quantitative meta-analysis.

1.1. Challenges with Writing Skills for Students with Disorders of ID

Although students with disorders of ID usually experience writing difficulties, their performance varies widely. Ratz and Lenhard [6] conducted a survey among the teachers of 1269 students with disorders of ID (intelligence quotient (IQ) not reported, and the study included a small group of students without disorders of ID) aged 6–21 years. According to this study, 33.1% of the students did not write at all, 16.9% wrote in the logographic stage (i.e., recognition of words based on visual cues), 36.5% wrote in the alphabetic stage (i.e., knowledge and use of phonemes and graphemes and their correspondences), and 13.5% wrote on the orthographic stage (i.e., writing automatically by recalling a word's grammatical and orthographic spelling).

In students with disorders of ID, limitations in basic skills, such as phonological awareness (e.g., segmenting skills) [16], phonological short-term memory (i.e., the ability to process and store sound-based information for short periods of time), letter–sound knowledge [17], and vocabulary, have been associated with poor writing skills in students with disorders of ID [16,18]. This group of students may also have challenges with visual and auditive perception, visual motor integration and kinesthesia [4], and fine motor control [19]. These problems may affect the production of handwritten text, keyboarding, and spelling [20]. Linguistic skills involved in written text production also seem associated with writing development in students with disorders of ID [4]. Cognitive skills involved in linguistic production, such as rehearsing, conceptualizing (e.g., generating new ideas or connecting sets of ideas with previous experiences), transferring, planning, organizing, and monitoring [19] may further hamper their written text production [20]. As a result, challenges that are typical for students with disorders of ID may complicate their development of functional writing skills [18]. Historically, educators and researchers have had low expectations concerning the abilities of students with disorders of ID to develop their writing skills beyond the level of early writing [7]. They often have reduced opportunities to engage in writing activities [18], and the writing instructions used may be inappropriate and seldomly research-based [4].

1.2. Previous Reviews of Writing Interventions for Students with Disorders of ID

To our knowledge, there are only three meta-analyses of writing interventions that include students with disorders of ID that mainly use SCED [21–23].

A newly published meta-analysis by Rodgers and Loveall [23] included 52 studies of writing interventions with 424 participants from elementary to post-secondary school (age M = 14.1 years) with intellectual and developmental disabilities (IDD) with and without disorders of ID (IQ M = 62.9, based on *n* = 24 reporting the participants' IQ levels). Of the included studies, 40 used SCEDs, and 12 used experimental group designs to review interventions testing out a wide range of writing instructions. They also accepted early skills, such as word matching, that do not require encoding skills. The overall results of the meta-analysis indicated a significant improvement in participants' writing skills.

Another meta-analysis by Rodgers [22] identified through our search in grey literature included 38 studies (35 SCED studies and three group studies) with a total of 147 participants from elementary to high school (age M unknown) with IDD with and without disorders of ID (IQ M = 66.5, based on *n* = 18 reporting the participants' IQ levels). The results of the meta-analysis of the 35 SCEDs indicated a moderate effect of the writing intervention. A subgroup analysis suggested that students with disorders of ID may benefit from writing interventions in a comparable way to participants with autism spectrum disorder (ASD) [22].

In their meta-analysis, Graham and Harris [21] included 18 SCED studies on writing interventions (IQ unknown, school grades 3–8) that used self-regulated strategy development (SRSD). The results indicated an overall positive effect of the SRSD writing interventions. However, only one of the included studies involved one participant with disorders of ID, so the results gave no indication of whether the tested writing interventions were effective for this student group.

In addition to these meta-analyses, there are three relevant narrative reviews on writing interventions involving students with disorders of ID [19,24,25]. Joseph and Konrad [19] included nine studies without control groups (six single-case designs and three pretest–posttest group design studies) with a total of 31 participants with and without disorders of ID (IQ M = 62.7, aged 6–18 years). Although most studies showed positive results by purposefully using a variety of writing instructions (e.g., SRSD, computer-assisted instruction, and sentence combination), the authors were hesitant to draw conclusions about the effects of the interventions because of the small number of experimental studies and participants included across the studies. Nevertheless, the results suggested that SRSD writing interventions resulted in positive outcomes for students with disorders of ID.

Both Cook and Bennett [24] and Taft and Mason [25] included only single-case design studies that mainly focused on students with different disorders, such as attention deficit hyperactivity disorder (ADHD), ASD, and developmental language disorders and students with disorders of ID. Taft and Mason [25] included 15 studies with a total of 57 participants (IQ unknown, aged 7–17 years), of which two studies involved a total of five participants with disorders of ID. Cook and Bennett [24] conducted a review of 14 studies with a total of 51 participants (IQ unknown, school grades 9–12), of which three studies involved 12 participants with disorders of ID. The overall results of these two reviews indicated that SRSD writing interventions combined with explicit writing instruction demonstrated positive results for the participants with disorders of ID and their writing outcomes.

All these earlier reviews attempting to summarize the effects of writing interventions have included samples with diverse conditions (e.g., ASD with and without disorders of ID within the same review). This may make it hard to tease out the effects of the interventions on specific target groups. Thus, to understand how to help students with disorders of ID develop their writing skills, studies that synthesize the results of interventions for this distinctive group only are necessary.

1.3. The Present Study

In the present systematic review and meta-analysis, we synthesized SCED studies that implemented writing interventions with writing as the primary outcome for students with identified disorders of ID aged 4–19 years.

The following research questions were investigated:

1. What characterizes writing interventions using SCEDs that meet the WWC standards [15] for students with disorders of ID?
2. What are the effects of writing interventions on the dependent writing variables within each study, and what is the magnitude of change across the participants?

2. Materials and Methods

The study was conducted and reported in accordance with the WWC Handbooks [14,15] and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) [26]. The study is preregistered at the Open Science Framework (OSF), URL: https://osf.io/fhks9 (registered on 30 August 2021).

2.1. Inclusion Criteria

To be included in this review, the studies had to meet the following criteria:

- Reported on a minimum of three students [14] with identified disorders of ID based on standardized tests (i.e., IQ $\leq 69 +/- $ SD), independent of other conditions (e.g., Down syndrome [DS] or ASD). If a mixed sample of students with and without disorders of ID was recruited in the study, only the individual data for students with disorders of ID were included in the review.
- Students aged 4–19 years.
- Used a core single-case experimental design (i.e., treatment reversal/withdrawal, changing criterion, multiple baseline design (MBD), or multiple probe design (MPD], and alternating treatment).
- Reported one or more elements of writing instruction targeting encoding and/or linguistic production using handwriting, keyboarding, signs, movable letters, or alternative pencils (e.g., alphabet eye gaze frames). Studies that used matching instructions alone were excluded.
- Met WWC design standards with or without reservation [15].
- Reported the results of the interventions on writing outcomes (encoding and/or linguistic production) with visual and/or statistical analysis, or it was possible to retrieve the data from the corresponding author.
- Published in English.
- To be included in the meta-analysis, studies also had to report relevant immediate (i.e., baseline and intervention phases) outcome data in raw scores, a format suitable for the required dependent writing variables in a multiple probe/baseline design across participants, or a treatment reversal design [14].

2.2. Search Strategy

After the search terms were piloted, final searches were conducted without a time limit, together with a university librarian with expertise in search strategies. The ERIC, PsycINFO, Social Science Premium Collection in ProQuest, Scopus, and Web of Science databases were searched from December 21 to 23, 2020, based on the following search terms:

A. Disorders of ID: cognitive, development, disability, impairment, intellectual, learning, mental, disorder.
B. Writing: dictation, encoding, handwriting, orthographic, print, spelling, sentence combination, typing, writing.
C. Participants: adolescent, child, pupil, student.
D. Method: alternating treatment design, changing criterion design, comparative design, concurrent schedule design, experimental single-case, multiple baseline design, multi-

element baseline design, multiple probe design, multiple schedule design, replicated single-case, simultaneous treatment design, time-series design.

Controlled keywords/thesaurus words were searched in ERIC, PsycINFO, and the Social Science Premium Collection. Text words were searched in summaries, and title fields and truncations were used as appropriate search words. These searches resulted in 698 hits.

To reduce the risk of publication bias (i.e., studies with positive effects tend to be published more frequently), we searched for grey literature (e.g., dissertations and conference papers) in Base and OpenGrey on 27 December 2020, which resulted in 41 hits. We conducted a search of well-known author names within the field of writing research, resulting in 10 hits (29 December 2020). Ancestral searches of the included studies, relevant reviews and meta-analyses, and other appropriate sources from the process of full-text screening were conducted (27 December 2020, and 1 May 2021), resulting in 40 hits. In addition, a newly published review [23] was searched ancestrally (9 September 2022), producing three hits (two unpublished doctoral theses and one article) that were included. These ancestral searches resulted in a total of 43 hits. Forward citation searches of the included studies were conducted in Google Scholar and generated 34 hits (5 May 2021). We also contacted 18 authors in the field (9 May 2021); of the 12 respondents, one author reported a newly published study [27] and another reported a study that was included [28].

Manual searches were completed on all issues of the following journals from January 2010 to May 2021: Assistive Technology, Assistive Technology Outcomes and Benefits, Education and Treatment of Children, Education and Training in Autism and Developmental Disabilities, Exceptional Children, Focus on Autism and Other Developmental Disabilities, Intellectual and Developmental Disabilities, Journal of Applied Behavior Analysis, Journal of Behavioral Education, Journal of Computer Assisted Learning, Journal of Developmental and Physical Disabilities, Journal of Intellectual & Developmental Disability, Journal of Special Education Technology, Reading and Writing, Remedial and Special Education, Research in Developmental Disabilities, The Journal of Educational Research, The Journal of Special Education, and Perceptual and Motor Skills. This search resulted in 30 hits and was updated on1 July 2022, with zero hits.

The total search yielded 858 hits—698 through database searches and 160 through other searches. Removing duplicates resulted in 569 candidate studies. For an overview of examples of excluded candidate studies, see Supplementary Material: Excluded Studies S1. Figure 1 shows an overview of the study selection process.

2.3. Inter-Assessor Agreement

We adopted inter-assessor agreement procedures in three stages, as first tested by Ninci et al. [29]: (1) the screening process (i.e., title and abstract screening and full-text screening), (2) reviewing against WWC standards, and (3) coding of the characteristics and results of the included studies. We also coded inter-assessor agreement in a fourth stage: the calculation of the between-case standardized mean difference (BC-SMD) and corresponding standard error (SE) used for meta-analysis.

All included studies were coded by the first author at all stages. Seventy-five percent of coding variables in all stages were coded in collaboration with the third author. Twenty percent of the included studies randomly selected were double-coded in all stages by an independent coder (the fourth author) to calculate inter-assessor agreement.

The overall inter-assessor agreement rate was separately calculated in percent for all variables and was reported consecutively under the description of each stage. In all stages, disagreement was resolved by consulting the primary paper and discussing it until a consensus between the two coders was met.
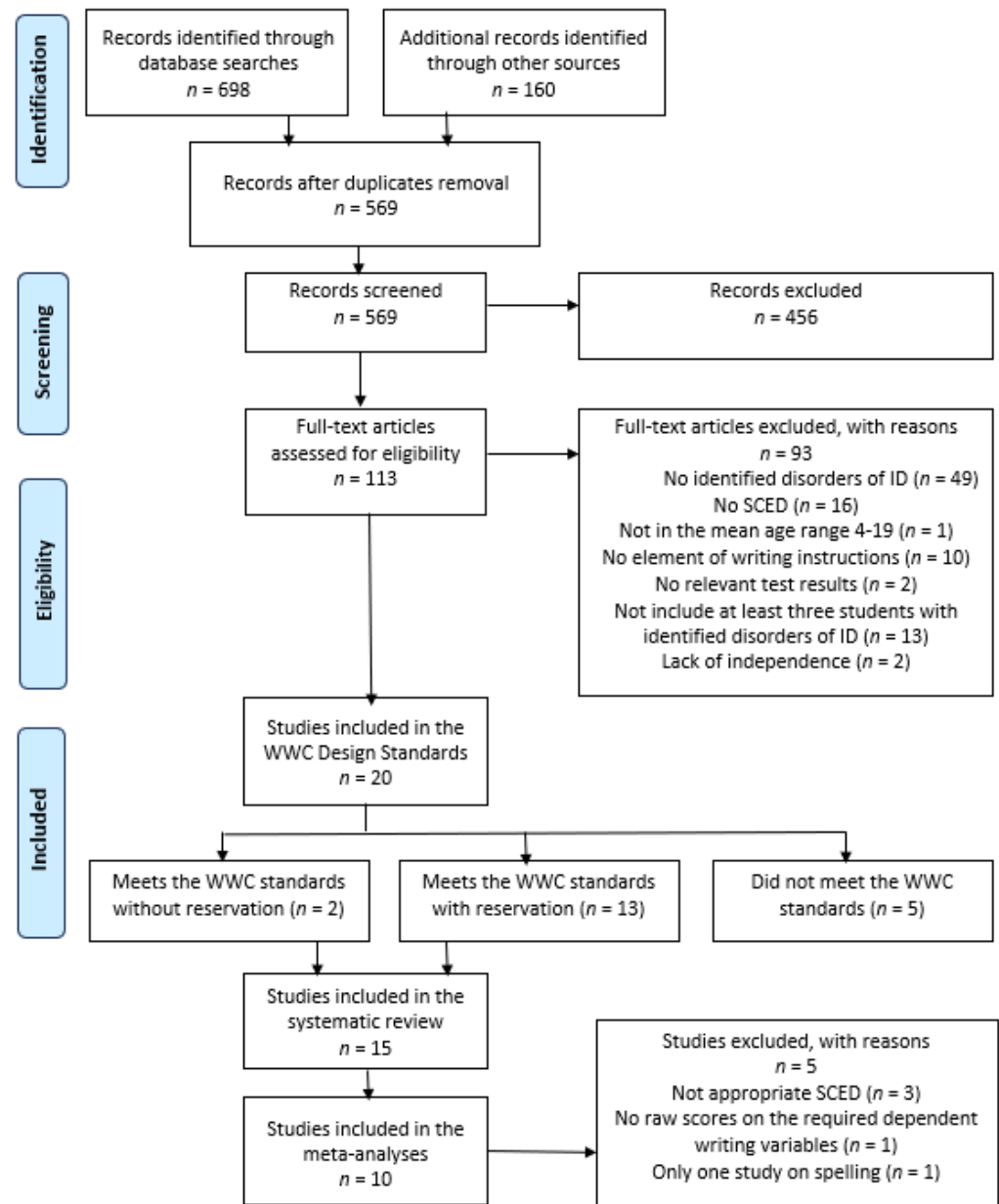
Figure 1. PRISMA flowchart of the study selection process.

2.4. The Screening Process

The screening process utilized the systematic review software DistillerSR [30] for title and abstract screening and full-text screening. The titles and abstracts of the total sample of 569 hits were screened. Studies that met the inclusion criteria and those that potentially met the criteria were included in the screening for full-text eligibility. A total of 113 hits went on to full-text screening. In cases of multiple publications of the same study sample, the study that was first published was included [22,31]. There was a 92% agreement on the inclusion of studies for the title and abstract screening. Full-text screening resulted in an 86% inter-assessor agreement.

2.5. Reviewing against WWC Standards

Studies that met the inclusion criteria in the screening process were included in stage 2: Reviewing Against WWC Standards [15] for evaluating SCED. For an overview of the rating of the WWC Standards, see Table S1 in Supplementary Materials.

In this stage, 20 studies were coded according to the WWC Standards [15] using a dichotomous scale (i.e., present/not present) for the assessment of basic design quality according to the following criteria: (a) data availability (i.e., graphical or tabulator data); (b) systematic manipulation of the independent variable (i.e., the researcher decides when and how the independent variable changes); (c) collection of inter-assessor agreements for at least 20% of sessions across all phases and cases with an average of 80% agreement and 0.60 if measured using a kappa index; and (d) residual treatment effects (if applicable). Then, the demonstration of the effect over time (i.e., at least three attempts to demonstrate an effect at three different time points) and the assessment of data points per phase were coded on a trichotomous scale (i.e., meets standards without reservation, meets standards with reservation, or does not meet standards [15]).

After coding, five of the 20 studies were rated as "does not meet standards" and were thus excluded. The two studies that met WWC Standards without reservation [32,33] and the 13 studies that met WWC Standards with reservation [22,28,31,34–43] were subjected to variable coding for study characteristics and included in the systematic review. The inter-assessor agreement was 100% on both classifying the rigor of the included studies and demonstrating their effect over time.

2.6. Characteristics and Results of the Included Studies

In stage 3, each study was coded for the following variable categories: (a) authors, year, and location; (b) design; (c) description of the participants: number of participants in the primary study and number of participants fulfilling the inclusion criteria and included in the current review, age, IQ, adaptive skills, comorbid condition, verbal and writing skills at study entry; (d) description of the writing intervention: independent variable (short description of the intervention, for example, use of technology-based instructions), content components (encoding or linguistic production), materials (both low-technology and high-technology), method of writing, organization and location, interventionist, duration and the number of sessions, whether writing intervention was originally developed for students with disorders of ID, and supplemental instructions; and (e) results: measurements, immediate results, maintenance results, and generalization results.

Across all variable categories, the overall inter-assessor agreement rate was 95.2%. A 100% agreement was reached for the variable categories design, total number of participants, number of participants included in this review, gender, age, IQ, adaptive skills, comorbidity, writing skills, independent variable, material, writing method, organization and location, interventionist, writing intervention developed for students with disorders of ID, supplementary instructions, measurements, and generalization results. For the following variable categories, the inter-assessor agreement was 66.7% for verbal skills due to one of the coders missing information in a table, 83.3% for content components due to one coder coding this category as writing an essay instead of paragraph writing, 50% for the duration because of insufficient reporting of both duration and the number of sessions in two of the primary studies, 98.1% for immediate results due to different results for two students in one study, and 81.8% for maintenance results because one of the coders registered the decreased effect instead of the stable effect for two students.

2.7. Calculation of BC-SMD

In stage 4, as an estimation of the overall magnitude of change across the participants, each immediate writing effect size was calculated as the BC-SMD [11,44]. The BC-SMD effect size was calculated as the mean difference between outcomes from different treatment conditions based on a two-level hierarchical linear model, standardized by the square root of the sum of within-case (level one) and between-case (level two) variance components [44]. This standardization places BC-SMD on the same scale as and should be interpreted similarly to Cohen's *d* used in experimental group designs [14,44,45].

At least three participants were required to calculate BC-SMD [14]. Studies including fewer than three participants tend to provide unstable data across individual variance,

which is essential to the BC-SMD [45]. In addition, BC-SMD can only be calculated for identical measured outcomes in MPD or MBD across participants or treatment reversal/ABAB design [45]. Three of the included studies in the systematic review used other SCEDs (i.e., MPD across-behavior: [34,38,39]) and were therefore excluded from the meta-analysis. The study by Mims et al. [35] was also excluded because of the lack of raw scores regarding the required dependent writing variables.

In line with the WWC procedures [14] for visual analysis of the dependent variables that met the inclusion criteria, we used graph-digitizing software to extract the individual points from the baseline and intervention phases depicted in the graphs in addition to manual plotting. BC-SMD calculation requires the specific values of the individual outcome data extracted from the baseline and the intervention phases (eventually outcome data on maintenance and generalization phases were not extracted) [14]. Raw data for 20 visual analyses nested from 11 SCED studies were extracted using WebPlotDigitizer [46], a software program that digitizes and scans graphs to provide X and Y coordinates for each data point from the baseline and intervention phases [11]. The extracted data for all the visual analyses were downloaded into Excel files (see Tables S2–S4 in Supplementary Materials).

Based on these data, we calculated the overall BC-SMD and corresponding SE across participants within a study for each of the immediate dependent variables using the web-based calculator R package scdhlm [47]. We used the recommendations by Valentine et al. [45], similar model specifications were used for all studies included in the meta-analysis: restricted maximum likelihood. This is because the estimator is considered to be the most flexible in the assessment of data in small and heterogeneous samples. This estimator is specified with both the fixed effect and random effect models because of the wide variation across the participants within a study concerning the baseline and intervention phases, the type of time trend assessed as a level in the baseline, and the change in level during the intervention phase [45].

The inter-assessor agreement for the calculation of the BC-SMD and SE was 100%. We allowed a deviation of 0.01 because of the sensitivity of plotting in WebPlotDigitizer [48], and one BC-SMD and one SE had deviations of 0.01.

2.8. Meta-Analysis Procedures

The dependent variables that met the inclusion criteria were grouped based on the measured outcomes in the same domain [14]. We performed two meta-analyses: one synthesizing effect sizes on the number of words and sentences written (i.e., the participants' improved skills in writing a number of words and sentences without spelling accuracy) and one on writing quality (i.e., the participants' improved skills in writing coherent text).

We used the Comprehensive Meta-Analysis (CMA) software, version 3 [49], for the meta-analysis. In CMA, the standard difference in means is similar to the BC-SMD. For each dependent writing variable, we plotted the BC-SDM and the corresponding SE using the fixed-effect meta-analytic estimate in line with default WWC procedures [14]. In the fixed-effect meta-analysis model, each effect size is weighted by the inverse of its variance, which yields a weight that could be used in a meta-analysis of SCEDs [14,45].

3. Results

3.1. Study Characteristics

For a description of the interventions, see Table S5 in the Supplementary Materials.

3.1.1. Study Year and Location

The studies were published from 1986 to 2020 and were conducted in Turkey (*n* = 2), Australia (*n* = 1), and the US (*n* = 12).

3.1.2. Design

Thirteen of the included SCED studies used MPD: nine MPDs across participants, three MPDs across behaviors, and one MPD across participants and classrooms. Two studies used MBD across participants.

3.1.3. Participants

A total of 49 students were included in this review. All studies reported the participants' exact IQ levels, except for Mims et al. [35], who reported that one participant had an IQ < 50, one had an IQ < 40, and the last had an exact IQ. For the two with an approximate IQ, 50 and 40 were used in the calculation of the mean IQ. Across all the included studies, the IQs ranged from 40 to 74, with an average of 54.7, which corresponds to mild disorders of ID (c.f., [50]). Only three studies [33,34,42] reported participants' adaptive skills (Konrad et al. [41] reported adaptive skills in only two of five participants), describing them as mild and moderate adaptive difficulties (c.f., [50]). All included studies reported the participants' genders and ages. Twelve (24%) participants were girls, and 37 (76%) were boys. Their ages ranged from 6 to 19 years, with an average of 13.2 years. Twenty-seven of the participants (55%) had different comorbid diagnoses: ASD ($n = 13$), ADHD ($n = 3$), apraxia ($n = 1$), DS ($n = 4$), of whom one also had comorbid Hashimoto's disease, traumatic brain injury ($n = 1$), cerebral palsy and cortical vision impairment ($n = 1$), specific learning disability ($n = 2$), and other health impairments ($n = 2$).

In the nine studies reporting on participants' verbal language, it was found that these skills varied both within and across the studies. The participants used verbal language to varying degrees; in one study, they used augmentative and alternative communication. Writing skills also varied greatly within and across the studies. At the start of the intervention, the participants generally had limited writing skills in handwriting, typing, and spelling, and a few participants could write sentences with help. One study distinguished itself by requiring that all participants could write five sentences independently at study entry [41]. Three studies [32,33,35] did not report the level of writing skills at study entry.

3.2. *Description of the Writing Interventions*

3.2.1. Description of the Independent Writing Variables

Writing methods: Six studies developed the writing intervention solely for students with disorders of ID [22,33,35,37,39,40], and nine studies adapted the existing writing intervention to this group of students [28,31,32,34,36,38,41–43]. Three studies used an adapted version of the SRSD model: two focused on cognitive strategy instruction [41,42], and one included mnemonics and peer revision strategies [28]. Six studies used typing as the method of writing [31,32,34–36,40], and two studies included participants who used typing or handwriting [37,38]. The remaining studies used solely handwriting.

Encoding skills: Only two studies focused solely on encoding, specified as spelling instructions, in which participants learned to spell a certain number of words [34,43]. In addition, Park et al. [36] included spelling together with instructions on paragraph writing.

Linguistic production: Thirteen studies focused on linguistic text production: two focused on story/essay writing [28,37], six on paragraph writing [22,31,35,36,41,42], two on sentence construction [32,40], two on sentence combining [33,38], and one on sentence writing [39].

Technology-based writing interventions: Eight studies used writing technology. In two studies, the participants typed on computers: Park et al. [36] tested the SOLO Literacy Suite's writing program, which included text-to-speech, word prediction, and spell checking, whereas Brady [31] tested a web-based graphic organizer with embedded self-regulated learning strategies and additional brainstorming supports. Six studies delivered writing interventions on tablets, three of which used the app Clicker Sentences (which features a digital word bank, symbols, and a read-out-loud function) for selecting words to construct and combine sentences [32,38,40], in which one of the participants in the studies used a paper and pencil in addition to a tablet. Ault et al. [34] used the app Spell-a-word

(audio and visual feedback on words, letters, and student responses), and Mims et al. [35] used the app GoBook (text-to-speech). In Pennington and Koehler's study [37], one participant used the app Spell Better (word prediction), whereas other participants used paper and pencil.

Materials: In addition to the reported technology, all studies except Pennington et al.'s [38] used low-technology materials, such as graphic organizers, different templates for writing or constructing/combining sentences, pictures, letters, words, graded reading books, and cards with illustrations. None of the studies reported fonts or font sizes.

Supplemental instructions: All but two studies [28,42] included other systematic instructions and behavioral response prompting techniques beyond the actual writing instruction to meet the students' cognitive and adaptive difficulties. These included constant time delay, verbal praise, behavioral training, modeling, schedules, and various forms of prompting.

3.2.2. Description of the Duration, Interventionist, and Organization

Duration: For 10 studies [22,31,32,34,37–42], it was possible to code the number of sessions (based on the reported number or by calculating from the reported data), and the duration of the interventions varied from seven to 25 sessions ($M = 16.8$, SD = 7.5). For 11 studies [22,31–37,40–42], it was possible to code the minutes per session (based on the reported minutes or by calculating from the reported data), and the sessions varied from 10 to 73 minutes ($M = 32$, SD = 17.7).

Interventionist and organization: Two studies by Guzel-Özmen, [41] who organized the intervention individually, and Stewart and Singh [43] did not report where the intervention was carried out. Ten studies [22,31,33–40] organized the intervention individually in the participants' classrooms or in rooms at their schools. One study [28] organized the intervention in the participants' classrooms together with their non-disabled peers and classroom teachers, and another study [42] organized the intervention both individually and in small groups. One study [32] organized the intervention in the participants' classrooms or in nearby rooms together with one non-disabled peer who delivered the intervention under the instruction of the researcher.

In seven studies, the interventions were led by teachers [34,36–40,43]: two by teachers from the research staff [34,36] and four by teachers from the participants' schools [37–40], and one by the teacher together with a graduate student [43]; in five of the teacher-led studies, the teachers were qualified special educators. One study did not report the application and education of the interventionist [33]. The remaining interventions were researcher-led; six of these were delivered by a researcher (of whom two were qualified special educators) and one by a research assistant [22,28,31,32,35,41,42].

3.3. Immediate Results of the Writing Interventions

Eighteen BC-SMDs nested from 10 studies were included in two meta-analyses depicted as forest plots (i.e., graphical display of estimated effects of the included studies) of the effects on the participants' linguistic production skills: effect on the number of words and sentences written and effect on the quality of paragraph and story writing. Only one of the two studies that reported data on spelling fulfilled the inclusion criteria for meta-analysis [43]. One study reported data on spelling without visual analysis or a table, which made it impossible to calculate the BC-SMD [36], and we did not receive the relevant outcome data in raw scores upon request. Therefore, it was not possible to perform a meta-analysis on spelling. In line with WWC procedures [14] for meta-analyses, the effect sizes assessing the same domain (i.e., writing topic) within a study were collapsed to a mean BC-SMD before synthesizing to an overall mean BC-SMD across the studies. See Table 1 for an overview of the effects of the interventions on the dependent writing variables.

Table 1. Effects of the Interventions on the Dependent Writing Variables.

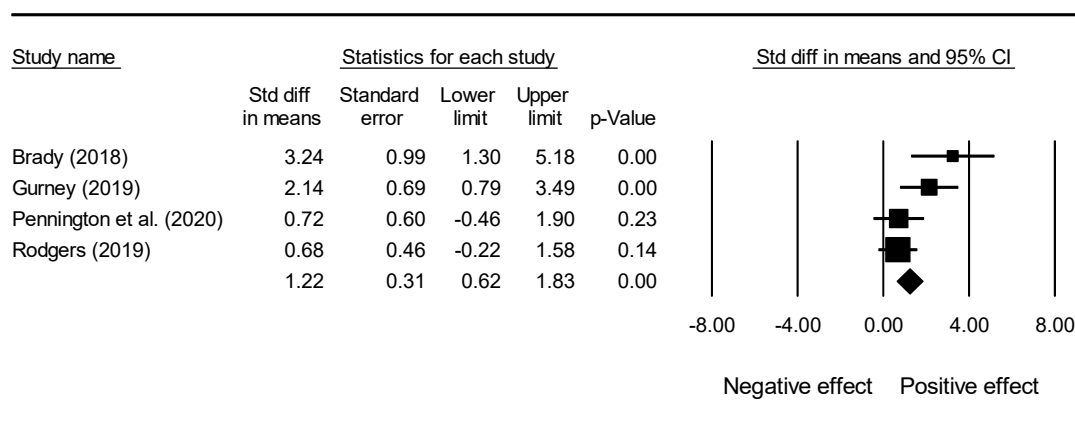| Authors	Dependent Variables [1] Measured with Non-Standardized Tests	BC-SMD	SE	BC-SMD ˆ	SE ˆ
Number of words spelled correctly					
Stewart and Singh [43]	List A words spelled correctly	0.24	0.38	0.85	0.39
	List B words spelled correctly	1.46	0.40		
Number of words and sentences					
Brady [31]	Number of words written	2.36	0.75	3.24	0.99
	Number of sentences written	4.12	1.23		
Gurney [32]	Number of sentences written	2.14	0.69		
* Pennington et al. [40]	Percentage of word selection	0.72	0.60		
** Rodgers [22]	Number of words written	0.50	0.44	0.68	0.46
	Number of writing sequences	0.85	0.47		
Qualityof paragraphs and story writing					
Brady [31]	Number of holistic writing quality	2.63	1.37	4.14	1.80
	Number of transition words	5.64	2.22		
*** Bülbül and Özmen [28]	Number of points of narrative elements	6.28	3.38	6.37	2.42
	Number of points of narrative quality	6.46	1.45		
*** Guzel-Özmen [41]	Number of text structure elements	5.07	1.71		
Konrad et al. [42]	Quality points of expository paragraphs	0.61	0.30	2.74	0.76
	Quality points of IEP paragraphs writing	3.18	0.91		
	Quality points of IEP goal paragraphs	4.44	1.07		
**** Park et al. [36]	Percent of quality points	0.78	0.68		
Pennington and Koehler [37]	Number of story elements in narrative writing	1.05	0.62		
Rodgers [22]	Score of paragraph text writing rubric	1.31	0.86		
Rousseau et al. [33]	Number of adjectives per T-unit	1.18	0.27		

Note. [1] = immediate effects, BC-SMD = between-case standardized mean difference, ˆ = collapsed BC-SMD and SE within the study, IEP = individualized education program, SE = standard error, * = two probes excluded because of the 0-delay instruction probes at the start of the intervention phase, ** = one effect size that measured the incorrect writing sequences was excluded because it was not possible to calculate the number of correct responses, *** = post-instruction measurements, **** = the reported statistic on spelling is excluded from the meta-analysis because of missing standards for calculating BC-SMD.

The meta-analyses of the effects of the writing interventions included 37 participants. The overall mean chronological age at pretest was 14.1 years (SD = 2.6), ranging from 10 to 19 years. The overall mean IQ was 55.5 (SD = 8.9), ranging from 40 to 72.

In the forest plots, the squares show the estimated BC-SMD. The abbreviation "Std diff in means" in the forest plots is similar to the BC-SMD. The horizontal bar for each square predicts a 95% confidence interval (CI). The size of the square indicates the weight of each BC-SMD, and the diamond indicates the overall mean BC-SMD.

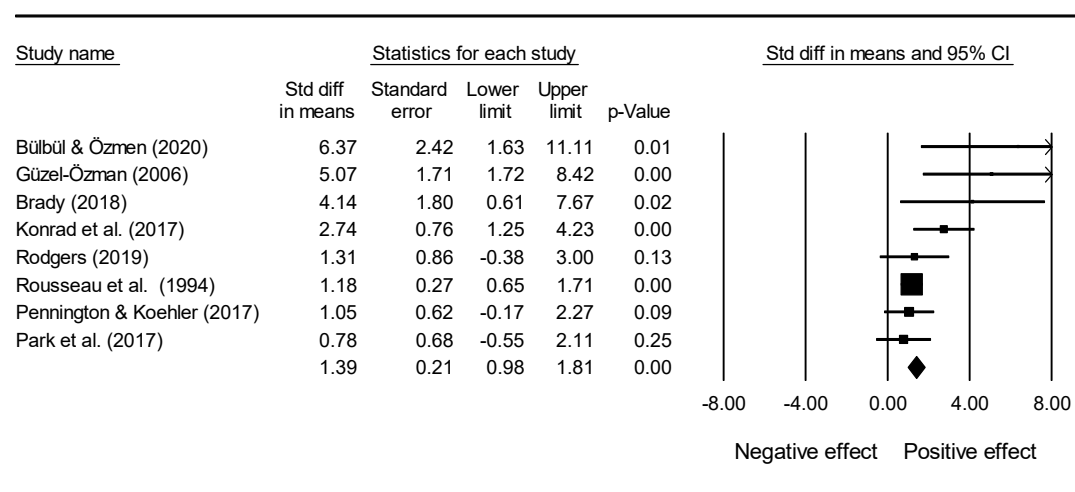3.3.1. Effects of the Interventions on the Number of Words and Sentences

In this meta-analysis, four studies with a total of 12 students were included. The overall mean chronological age at pretest was 14.3 years (SD = 2.9), ranging from 10 to 18 years. The overall mean IQ was 55.4 (SD = 8.2), ranging from 43 to 72. The overall mean BC-SMD was computed from four effect sizes on the number of words and sentences written. Figure 2 shows that the overall mean effect size was BC-SMD = 1.22 (SE = 0.31, 95% CI = (0.62, 1.83), $p < 0.001$), suggesting that the interventions improved the students' number of word and sentence writing skills to a large degree.

Study name	Statistics for each study					Std diff in means and 95% CI
	Std diff in means	Standard error	Lower limit	Upper limit	p-Value	
Brady (2018)	3.24	0.99	1.30	5.18	0.00	
Gurney (2019)	2.14	0.69	0.79	3.49	0.00	
Pennington et al. (2020)	0.72	0.60	-0.46	1.90	0.23	
Rodgers (2019)	0.68	0.46	-0.22	1.58	0.14	
	1.22	0.31	0.62	1.83	0.00	

-8.00   -4.00   0.00   4.00   8.00

Negative effect   Positive effect

Figure 2. Forest plot of the effects of the interventions on the number of words and sentences [22,31,32,40].

3.3.2. Effects of the Interventions on Writing Quality

In this meta-analysis, eight studies with a total of 25 participants were included. The mean age at pretest was 14.6 years (SD = 2.7), ranging from 10 to 19 years. The overall mean IQ was 58.3 (SD = 8.6), ranging from 40 to 72. The overall mean BC-SMD was computed from eight effect sizes on the quality of paragraph and story writing. Figure 3 shows that the overall mean effect size was BC-SMD = 1.39 (SE = 0.21, 95% CI = (0.98, 1.81), $p < 0.001$), which clearly suggests that the interventions improved the students' writing quality.

Study name	Statistics for each study					Std diff in means and 95% CI
	Std diff in means	Standard error	Lower limit	Upper limit	p-Value	
Bülbül & Özmen (2020)	6.37	2.42	1.63	11.11	0.01	
Güzel-Özman (2006)	5.07	1.71	1.72	8.42	0.00	
Brady (2018)	4.14	1.80	0.61	7.67	0.02	
Konrad et al. (2017)	2.74	0.76	1.25	4.23	0.00	
Rodgers (2019)	1.31	0.86	-0.38	3.00	0.13	
Rousseau et al. (1994)	1.18	0.27	0.65	1.71	0.00	
Pennington & Koehler (2017)	1.05	0.62	-0.17	2.27	0.09	
Park et al. (2017)	0.78	0.68	-0.55	2.11	0.25	
	1.39	0.21	0.98	1.81	0.00	

-8.00   -4.00   0.00   4.00   8.00

Negative effect   Positive effect

Figure 3. Forest plot of the effects of the interventions on writing quality [22,28,31,33,36,37,41,42].

3.4. Maintenance and Generalization Results of Writing Interventions

The maintenance results coded in the systematic review were set to a minimum of two weeks after the last intervention session. Ten studies measured maintenance effects after two and up to 24 weeks. One of these studies reported stable or increased effects for all participants up to 24 weeks after the end of the intervention [43], and one study reported an increased effect for two participants and a decreased effect for one participant after two to four weeks [22]. For the rest of the studies reporting maintenance, the effects were varied [22,28,34,35,37,40–42]; nearly all participants demonstrated a decreased effect, and a minority of the participants demonstrated a stable effect in the targeted writing skills.

Only four studies measured the generalization effect. The students were instructed to use the target words in the novel text [34,38], write about a self-selected topic [39], or

complete a narrative when presented with a novel story [40]. As shown in the systematic review, all participants in these four studies demonstrated generalization skills.

4. Discussion

Our results show that students with disorders of ID can improve their linguistic writing skills by participating in predesigned writing interventions. The included interventions showed some common features, such as writing instructions and materials that were adapted to the individual participants' technical, cognitive, and adaptive skills. The results offer limited insight into the effects of the interventions on the early development of writing skills for early school-age students with disorders of ID on encoding skills and on generalization and maintenance effects.

4.1. Students with Disorders of ID Can Benefit from Writing Interventions

The results from this systematic review and meta-analysis are promising and indicate that the development of writing skills for students with disorders of ID may be improved with the use of appropriate writing interventions together with supplemental instructions and the provision of iterative opportunities to practice and improve writing skills. Although the students with disorders of ID had limited cognitive and adaptive skills, as well as weak writing skills at study entry, they managed to improve their skills by participating in these interventions. The fact that the content of the interventions also varied across the studies highlights the importance of exposure/stimulation for these students.

4.2. Immediate Effects of the Writing Interventions on Linguistic Production

We found promising effects of the interventions on the participants' writing skills. Still, our criteria for including participants and calculating writing outcomes reveal that our results are in line with the meta-analyses of Rodgers and Loveall [23] as well as Rodgers [22]. It should be noted that there are some differences in the detail reporting in overlapping studies, possibly due to variations in inclusion and possibly phases included in the calculations. We did not include maintenance or generalization, since not all SCED studies include these phases. Our results with a large effect on the participants' linguistic text production may have been influenced by the fact that all measurements were performed using non-standardized tests, which tend to yield larger effect sizes compared to standardized tests [51].

There was a broad variation in effect sizes across the primary studies (BC-SMD = 0.50–6.46) included in the meta-analysis. The two studies with the highest BC-SMDs used a post-intervention measurement procedure [28,41] that may have yielded larger effect sizes. However, the BC-SMD from these two studies was only slightly larger than the largest effect sizes in two of the other included studies that did not use a post-intervention measurement procedure. Across the included studies, the writing interventions were specially adapted to meet individual students' levels of writing skills at study entry and their cognitive and adaptive needs, which may contribute to steep learning of the targeted writing skills. In addition, only the isolated targeted writing skills were measured. This means that our results may be somewhat overestimated and should be interpreted with caution.

4.3. Maintenance Effect and Generalization Effect of the Writing Interventions

As shown from the systematic review, most of the participants had decreased effects from the intervention period to the follow-up, with a few exceptions. The information reported about the participants' writing education in the maintenance phase was incomplete, and because of the wide variation in the last maintenance measurements (from two to 24 weeks), making clear assumptions about the long-term effects of the interventions was difficult. Therefore, more knowledge about the maintenance effects of writing interventions for students with disorders of ID is necessary both in terms of the maintenance phase timeline and the long-term effects of different writing interventions.

The four studies that reported generalization effects indicated that the participants used the targeted skills in novel writing tasks, such as the use of the targeted words in writing a sentence about novel pictures. On the basis of previous studies on students with disorders of ID that found that they may have difficulties with applying acquired skills to novel tasks (c.f., studies reported in [52]), it is important to extend our knowledge on the instructions these students have to learn to be able to generalize learned writing skills to new situations.

4.4. Limitations and Further Research

We included only 15 studies in the systematic review and 10 studies in the meta-analysis, while, for example, Rodgers and Loveall [23] included 52 studies in their review. Therefore, our inclusion criteria may be considered rigorous. At the same time, this ensured a more uniform sample regarding etiology, which makes our findings more relevant to the group of students with disorders of ID. However, both the limited sample size and a number of research studies indicated, on the one hand, that our findings should be regarded with caution. On the other hand, the findings highlight the need for more writing research on these students. This is in line with the results of the systematic review and meta-analysis on writing interventions using experimental group designs by Bakken et al. [9], which also revealed a limited focus on writing interventions for students with identified disorders of ID.

The application of WWC standards and procedures [14,15] may be considered another limitation of this review. Especially for students with disorders, WWC recommendations for SCEDs have been criticized for undermining both the uncovering and dissemination of the most accurate information on research-based interventions and educational programs [53]. For instance, the adoption of BC-SMD as the primary means of assessing a functional condition can lead to several unintended outcomes (e.g., the exclusion of outcomes from MPD across behavior) that potentially reduce the contributions from SCEDs to the evidence base [14,53]. Despite, these potential challenges, the WWC standards are developed especially for educational research and procedures considered an important contribution and valuable tool that addresses limitations in a research field [53]. In the current review, the WWC recommendations, for example, resulted in the exclusion of three studies on spelling either from the systematic review or the meta-analysis. Encoding is an essential part of early education and of writing development and text production [3], but few of the included studies had measures of encoding, and few included components of encoding in the interventions. This may be explained by the mean age of the students included in this review, which was quite high. A limited number of writing intervention studies for young children may deprive them of opportunities for early and intensive stimulation. Writing interventions that are initiated early on may utilize the possible plasticity and sensitive periods for learning in the young brain that has been identified for learning other linguistic aspects (e.g., [54]) to optimize writing development for students with disorders of ID. Therefore, interventions that focus on this group of students' encoding skills at an early school age may be necessary.

SCEDs often result in larger effect sizes compared with randomized controlled trials [55] and can lead to unrealistic expectations of interventions tested with this design. Existing SCED studies targeting writing interventions with promising results may therefore be suitable for replication with SCED or as pre-group piloting studies [56]. Furthermore, unstable and insufficient data in the baseline phase and unclear implementation procedures threaten internal and external validity [14,15]. Thirteen of the 15 included studies met the WWC standards with reservation, which indicates the need to improve the quality of future SCED studies that target writing interventions for students with disorders of ID. However, SCED is particularly suitable for the assessment of the effects of special education interventions for low-frequency student groups [13] and may increase the quality of writing interventions through more accurate assessments of what works for individual students with disorders of ID.

This systematic review and meta-analysis contribute a summary of the best available SCED research on writing interventions for students with disorders of ID. Less is known about how the effects of these interventions vary according to the individual characteristics of students. As students with disorders of ID form a heterogeneous group both in their needs for and responses to writing instructions [4], finding the right match between individual prerequisites and available writing interventions is a pivotal part of presenting research-based instruction. More research is needed to help educators identify a good fit between effective, research-based interventions on the one hand and students' personal preferences and needs on the other.

4.5. Implications for Practice

Our results showed that although students with the disorders of ID have both cognitive and adaptive challenges, they may have the potential to learn to use written language to formulate text. Teachers can therefore set academic goals for the development of writing skills in students with disorders of ID. It should be emphasized that the participants' IQ (range 40–74) and adaptive skills (mild and moderate based on *n* = 3) varied across the studies. On average, the participants had mild disorders of ID; the benefit of the intervention may differ for students with severe disorders of ID.

These students can struggle with a wide range of writing skills [19], which makes them require different types of writing interventions throughout the school years. Therefore, it seems promising that the results of the present study showed that different types of writing interventions can be effective, such as modified SRSD, technology-based interventions, and the use of writing frames and response prompting.

Since the interventions are given as "combined programs" consisting of different components and because they vary in terms of methods of instruction, the skills targeted, material, duration, and number of sessions, it is difficult to point to one or a few specific components that may have contributed to the positive result in this systematic review and meta-analysis. However, common features found in the systematic review indicate the importance of regular and planned sessions organized individually or in small groups, scaffolding material, interventionists who are experts themselves or have access to professionals with expertise in students with disorders of ID and writing interventions, and to a large extent adapting the intervention to individual students' writing performance. In addition, it should be noted that most studies used behavioral response prompting techniques (e.g., time delay and system of last prompts).

Finally, the writing technology (i.e., both hardware and software) used in the technology-based interventions was adapted to both the students' writing skills and their learning objectives in the writing interventions. Using the opportunities that writing technology can provide may be supportive, considering these students' challenges with verbal comprehension, working memory, and processing speed [57,58].

5. Conclusions

This review showed that students with disorders of ID can have the potential to improve their writing skills by participating in predesigned interventions. The meta-analysis indicated that participants improved their linguistic writing skills in terms of the number of words and sentences written and writing quality with large effect sizes. However, these SCED studies should be replicated several more times with different samples of students with disorders of ID and by different research teams to examine whether the results are valid across samples, implementers, and researchers.

Although the current study has closed an important gap in the research literature in this regard, it offers limited insight into the effects of the interventions on writing skills in these students at an early school age and in the long run. More knowledge is needed on the effects of encoding, as well as on generalization and maintenance of the targeted writing skills. These aspects should be investigated further in high-quality research so that students with disorders of ID may receive optimal writing interventions in the future.

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