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Effects of POWER Strategy Instruction for Students Supported by Assistive Technology

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Abstract

This study investigated students' use of assistive technology (AT) tools within the context of Plan, Organize, Write, Edit, Revise (POWER) strategy instruction for writing explanations. Instruction took place in a fifth-grade classroom that included four students with learning, attention, or emotional disabilities and 19 peers without disabilities. The purpose of this study was to evaluate instructional effects and method of transcription used in composing science-related explanations. To examine effects of POWER instruction on writing quality and accuracy, researchers used a multiple baseline design across participants. Method of transcription was evaluated through a concurrent time series design. After POWER strategy instruction, participants' explanations earned quality and accuracy scores that were greater than their respective baseline scores. Scores on AT-transcribed responses exceeded those earned on handwritten explanations, with larger effects on accuracy than on quality. Implications are discussed in relation to POWER strategy instruction for students with disabilities who require transcription support.

Key Words: assistive technology; writing strategy instruction; learning disabilities

EFFECTS OF WRITING STRATEGY INSTRUCTION FOR STUDENTS SUPPORTED BY ASSISTIVE TECHNOLOGY TOOLS

Improving written expression through routine writing is an expectation set forth for students with and without disabilities. Often in the intermediate grade levels, students must produce and distribute writing across content areas for a variety of purposes. Students with learning, attention, or emotional disabilities encounter unique challenges with written expression. Among potential sources of writing difficulty (e.g., motivation, idea generation, or organization), the task of transcription itself presents challenges. To represent language in written form, a writer must possess language processing skills, encoding skills, and the ability to produce legible work. A number of researchers have reported the effectiveness of writing strategy instruction for students with disabilities who experience writing difficulties (e.g., Gillespie & Graham, 2014; Kaldenberg, Ganzeveld, Hosp, & Rodgers, 2016; Reid, Hagaman, & Graham, 2014). When a disabling condition impinges on the ability to transcribe text, assistive technology (AT) tools emerge as a viable solution (Peterson-Karlan, Hourcade, & Parette, 2008). The present study is one of the first to explore a combination of AT and writing strategy instruction to support writing needs of students with disabilities.

Assistive Technology Solutions

In a recent meta-analysis of studies conducted primarily in the U. S., Perelmutter, McGregor, and Gordon (2017) found that word processing (with spelling and grammar check) had a large effect on error-rate reduction in transcriptions produced by students with disabilities.

Two studies, not included in Perelmutter and colleagues' (2017) meta-analysis, offer insight into the effectiveness of AT tools as transcription support for students with learning disabilities outside of the U. S. Hetzroni and Shrieber (2004) conducted a study on transcription tools used by seventh-grade students with learning disabilities in a major metropolitan area in Israel. On written materials produced during class (i.e., responses to open-ended, text-dependent questions as well as verbatim note-copying tasks), all three participants showed increases in spelling accuracy and organization when using a word processor as compared to handwriting alone. However, effects of using a word processor showed no change in total words written. Therefore, participants' use of AT tools improved writing accuracy and maintained writing productivity. More recently, in Canada, Corkett and Benevides (2016) evaluated the effectiveness of word processing applications (i.e., the pages app for the iPad) for sixth-grade students with learning disabilities. On essay-writing tasks, all nine participants demonstrated increases in spelling accuracy, number of T-units, and number of ideas expressed, as compared with handwritten essays. Statistically non-significant improvement was noted for participants' writing productivity, number of sentences, and grammatical accuracy.

In addition to word processing, word prediction tools offer viable transcription support for students with writing difficulties. When used alone or in combination with screen reading, word prediction tools prevent spelling errors from occurring, which increases writing accuracy (Maor, Currie, & Drewry, 2011; Perelmutter et al., 2017). Several recent studies, conducted in the U.S., affirm the positive effects of word prediction and screen reading solutions on spelling accuracy, total words written, writing quality, and structure (e.g., Cullen, Richards, & Frank, 2008; Evmenova, Graff, Jerome, & Behrmann, 2010; Silió & Barbetta, 2010). In addition, two studies, conducted in the U. K., extend what is known about word prediction software by incorporating vocabulary- and grammar-smart word prediction tools (Lange, McPhillips, Mulhern, & Wylie, 2006; Lange, Mulhern, & Wylie, 2009). Across both studies, 149 secondary students with low reading ability completed proofreading tasks with greater levels of accuracy when using "smart" word prediction tools. Furthermore, results demonstrated that participants developed the skill of correcting homophone errors when using AT tools as compared to using word processing alone.

Finally, speech recognition tools have been shown to support transcription for students with learning disabilities (Maor et al., 2011; Perelmutter et al., 2017). Speech recognition tools permit students to dictate sentences or paragraphs, which emerge on the screen as text, thereby replacing the need for handwriting or keyboarding, and controlling for spelling accuracy. MacArthur and Cavalier (2004) evaluated speech recognition as an AT tool for secondary students with learning disabilities and reported that speech recognition software and dictation to a human led to higher quality writing, as compared to transcription via handwriting alone. See Table 1 for a summary of eight empirical studies in which researchers from Canada, Israel, the U. K., and the U. S. evaluated the effectiveness of AT tools for students with learning disabilities.

Strategy Instruction to Support Written Expression

In addition to transcription difficulties, writers with learning disabilities, emotional disturbance, or attention difficulties often experience challenges with self-regulatory and organizational aspects of writing (Graham & Perin, 2007). Nearly three decades ago, Raphael, Englert, and Kirschner (1989) found that upper elementary students' awareness of the writing process was influenced by the communicative contexts in which writing took place. Building on this finding, Englert, Raphael, Anderson, Anthony, and Stevens (1991) developed and evaluated a curriculum for cognitive strategy instruction in writing, which facilitated dialogue to elucidate strategies used by effective writers. Participants, including 55 students with learning disabilities and 128 students without disabilities in fourth- and fifth-grade, learned to use cognitive strategies associated with the Plan-Organize-Write-Edit-Revise (POWER) mnemonic. "Think sheets" or self-instructional guides (see Graham & Harris, 2005, p. 111-114 for examples) complemented POWER to mobilize the process of explanatory writing. In a subsequent investigation, Englert, Raphael, and Anderson (1992) found that POWER strategy instruction not only supported students with learning disabilities in articulating their knowledge of the writing process but also engaging in shared meaning-making through conversation or "talking writing" (Lemke, 1982) correlated with performance on comprehension and composition tasks.

More recently, through the self-regulated strategy development (SRSD) model (see Harris & Graham, 1996), researchers have investigated writing interventions that structure discourse around the thinking and organizational processes that are involved in producing extended writing, with the instructional goal of promoting internalized dialogue and self-regulation (e.g. Cuenca-Carlino & Mustian, 2013; Reid et al., 2014). Within the stages of SRSD instruction, students are explicitly taught to set goals, self-monitor, self-instruct, and use positive self-talk as they learn, use, maintain, and generalize a strategy (Harris & Graham, 1996). Compelling evidence documents the effectiveness of strategy-based writing instruction for students with disabilities who experience writing difficulties (Gillespie & Graham, 2014; Kaldenberg et al., 2016); however, no strategy-based writing intervention studies to date have examined outcomes for students who are experienced in operational use of AT tools.

Research Questions

The purpose of this exploratory study was to evaluate effects of POWER explanation strategy instruction for students with learning, attention, or emotional disabilities who used AT tools to support transcription. Four research questions guided the study.

1. What is the effect of POWER explanation strategy instruction on the number of correct writing sequences in explanations transcribed using AT and handwriting?
2. What is the effect of POWER explanation strategy instruction on the quality of explanations transcribed using AT and handwriting?
3. How do quality and accuracy scores differ before and after POWER explanation strategy instruction when transcription is supported by AT tools as compared to handwriting?
4. What reactions do participants have to POWER explanation strategy instruction?

METHOD

Participants

The participants in this study were selected using convenience sampling. Each participant received writing instruction in an inclusive, fifth-grade general classroom. Parental consent and student assent were obtained from four participants (named using pseudonyms) using procedures approved by the authors' institutional review board. One female (Emily) and three males (Max, Tyler, and John) were eligible to receive special education services due to a learning disability, emotional disturbance, or attention deficit/hyperactivity disorder diagnosis. School registration forms indicated "White" as the racial descriptor for all four participants. Three participants were European American, and one participant was a first-generation American of Middle Eastern (Jordan) descent. All participants' *Language Usage* scores on the district's universal screening assessment, Measures of Academic Progress (Northwest Evaluation Association, 2012) when converted to a percentile rank, were in the bottom quartile.

Max, Tyler, and John used laptop computers with Microsoft Word 2010 installed for word processing. Emily used *Google Docs* on a *Chromebook*. All participants used *Kurzweil 3000* or *Read&Write for Google* ™ for screen reading and word prediction. Max, Tyler, and John used *Dragon Naturally Speaking*, speech-to-text software. All participants began using AT transcription tools midway through second grade. Each participant achieved operational competence with AT tools prior to the school year in which the study took place. Characteristics and AT tools for each participant are summarized in Table 2.

General education peers. Among 19 peers in the general education class, 12 were females and seven were males. According to self-reports and school registration forms, one student was Asian, one was Black/African American, two were from a biracial background, one student was Latina, and 14 were White (including three students from Middle Eastern backgrounds who were proficient in Arabic and English). Their ages ranged from 10 years, 4 months to 11 years, 6 months. *Total language* scores varied among students: 12 students scored between the 26th and 50th percentile; four students scored between the 51st and 75th percentile.

Setting

This study took place in a U. S. public elementary school, with an enrollment of 579 students. The school was located near a Midwestern metropolitan area. Students with disabilities comprised 15.2% of the school population, 32% of the school population received free- or reduced-price lunch, and 11.4% of the school population received English-learner services. All elements of the study occurred during a continuous block of literacy instruction in a fifth-grade classroom where digital writing tools (i.e., *Chromebooks*) were available for each of the 23 students. The general education teacher and special education teacher/researcher (first author) collaboratively managed literacy instruction five days per week for 16 weeks. The general education teacher (a White, female with 15 years of teaching experience) led standards-based instruction focused primarily on reading comprehension and vocabulary development, using various instructional formats (e.g., lecture, computer-assisted instruction, and independent reading). The first author (a White female with 14 years of teaching experience) led small-group instruction that focused on writing, science, and technology. The 130-minute literacy block was divided into four intervals to allow small-group rotation through four stations. The general education teacher formed heterogeneous small groups, based on *Language Usage* scores. Each group included one student who scored in the upper-middle quartile, three to four students who scored in the lower-middle quartile, and one participant who scored in the bottom quartile.

Materials

The study's materials related to transcribing explanations of science-related topics. All topics ($n = 40$) appeared on a district-developed list of prompts to elicit explanatory writing. Examples include: *explain how scientists predict earthquakes*, *explain how to conserve water at home,* and *explain how beavers change the environment in helpful and harmful ways*. Digital readings with illustrations and brief video clips accompanied each topic. Topics were selected by the district team on the basis of being covered in the previous year's science labs or readings. To deliver POWER strategy instruction, we used "think sheets" from Englert and colleagues (1991). "Think sheets" corresponded with

Table 1
Evaluation of Transcription Support Tools for Students with Learning Disabilities

Study	Setting	Design	Participants	Tools	Outcomes
Corkett & Benevides (2016)	Canada	paired sample t-tests with visual analysis	9 students with learning disabilities in grade 6	iPad pages application	Increased spelling accuracy, number of T-units, and number of ideas were reported on AT-transcribed essays (compared with handwritten essays); insignificant improvement occurred in writing productivity, number of sentences, and grammatical accuracy.
Cullen, Richards, & Frank (2008)	United States	case study and modified multiple baseline	7 students with learning disabilities in grade 5	word processor, spellcheck, word prediction, and screen reading	On essays, mean increases were reported in spelling accuracy, total words written, and writing quality on essays transcribed with combined AT tools
Evmenova, Graff, Jerome, & Behrmann (2010)	United States	single subject changing conditions	6 students with learning disabilities in grades 3–6	word processors with word prediction	In response to journal writing prompts, total words written and words per min increased while spelling errors decreased when students with learning disabilities used word prediction as compared to a word processor alone.
Hetrzoni & Shrieber (2004)	Israel	single subject ABAB	3 students with learning disabilities in grade 7	word processors	On written materials produced during class, participants showed increases in spelling accuracy and organization (as compared with handwriting alone); no change in total words written.
Lange, McPhillips, Mulhern, & Wylie (2006)	United Kingdom	group experimental (two-factor mixed design)	93 secondary students with low reading ability	screen reading, spellcheck, homophone detection, electronic dictionaries, and word processors	On proofreading tasks, participants who used AT tools made significant improvements in identifying and correcting spelling mistakes and in correcting homophone errors.

Table 1. *continued*

Study	Setting	Design	Participants	Tools	Outcomes
Lange, Mulhern, & Wylie (2009)	United Kingdom	group experimental (two factor mixed design)	56 secondary students with low reading ability	homophone detection and word processors	On proofreading tasks, participants who used AT tools made significant improvements in homophone detection and non-significant improvements in spelling accuracy.
MacArthur & Cavalier (2004)	United States	repeated measures group design	31 secondary students; 21 with learning disabilities	speech recognition software and dictation to a human scribe	On essay responses, students with learning disabilities produced higher quality responses of greater length, with greater lexical complexity, and fewer grammatical errors using speech recognition software and dictation to a human, as compared to handwriting alone. Largest effect sizes for students with learning disabilities occurred when dictating to a human scribe.
Silió & Barbetta (2010)	United States	single subject multiple baseline	6 students with learning disabilities in grade 5; all exited from English-learner services	word processing; word prediction or screen reading alone or in combination	On narrative writing samples, participants using combined word prediction and screen reading on word processors improved total words written, number of T-units, spelling accuracy, and overall organization (with some variation).

planning and editing; these were available in digital and hard copy form. Text structure maps (adapted from Englert et al., 1991, p. 347 and Graham & Harris, 2005, p.112) were used to support organizing. Materials to support transcription included pencil-paper, *Chromebooks*, laptops, and participants' AT tools.

Dependent Measures

Writing accuracy. To measure writing accuracy, the number of correct writing sequences (CWS) was collected from final-draft explanations. CWS scores were generated according to directions stipulated by Powell-Smith and Shinn (2004), wherein a caret marks each unit within a mechanically and syntactically correct writing sequence and scores reflect the total number of carets in a writing sample.

Writing quality. To assess quality of final-draft explanations, we used a district-developed writing rubric. The rubric addressed five writing elements: fluency

Table 2
Participants' Demographic Information

Name Age	Special Education Eligibility	Assistive Technology Tools	*Language Usage* (Winter benchmark)
Max 10:10	Specific Learning Disability	Speech-to-text software (*Dragon Naturally Speaking*); Word Prediction with screen reading (*Kurzweil 3000*); Word processing on a laptop	4th percentile
Emily 10:9	Other Health Impairment (Attention Deficit/Hyperactivity Disorder); Speech Language Impairment	Word prediction with screen reading extension (*Read & Write for Google* ™); Google docs on a Google Chromebook	14th percentile
Tyler 11:0	Other Health Impairment (Attention Deficit/Hyperactivity Disorder)	Speech-to-text software (*Dragon Naturally Speaking*); Word Prediction with screen reading (*Kurzweil 3000*); Word processing on a laptop	2nd percentile
John 11:2	Emotional Disturbance	Speech-to-text software (*Dragon Naturally Speaking*); Word Prediction with screen reading (*Kurzweil 3000*); Word processing on a laptop	16th percentile

(number of complete sentences), ideas (relevance to assigned topic), conventions (capitalization, punctuation, and correct spelling), organization (number of transition words), and structure (introduction, main idea, three details, and conclusion). Elements were defined at five levels: basic, developing, near proficient, proficient, and mastery, with scores that ranged from 0 to 20.

Procedures

Small groups of students progressed through three phases of writing instruction: baseline sessions, POWER strategy instruction, and independent practice sessions. Across phases, small group members had access to digital writing tools and pencil-paper materials. Participants' transcription methods alternated across essay topics and was counterbalanced across groups.

Baseline sessions. Small-group members brainstormed, drafted, revised, and edited explanations across two consecutive 30- to 35-minute sessions. In the first of two sessions, the first author presented a topic related to the science curriculum (e.g., igneous rocks). Images, brief texts, video clips, and dialogue were used to activate students' background knowledge on the topic. Then, the first author read aloud a writing prompt, "Today, we are going to write to explain *how igneous rocks are formed*." Italicized words were replaced with any of 40 science topics. For each small group, topics were randomly selected (without replacement) from a district-developed list. Next, small-group members transcribed explanations without direct instruction. No feedback was provided on drafts. In the second of two consecutive sessions, the first author instructed participants, "Review your writing from yesterday's session. Continue writing, editing, and revising to complete your final draft." Small-group members continued writing or revising their writing on the previous day's topic. This pattern was applied consistently, with the transcription method alternating by topic. Final drafts were scored for accuracy and quality. Scored rubrics were returned to participants within one week.

POWER strategy instructional sessions. The first author taught small groups to use the POWER strategy for writing explanations of science-related topics. Instruction occurred across a 2-week period that preceded independent practice sessions. Instruction followed steps outlined by Graham and Harris (2005, p.111–114). Steps included analyzing and thinking aloud about exemplar writing, explaining and modeling POWER, engaging in dialogue and collaborative writing, and providing practice with feedback. The amount of practice and feedback varied across group members; some wrote independently while others required additional practice.

For the first two stages in POWER (planning and organizing), group members developed a plan for writing explanations. They used Englert et al.'s (1991) "think sheet" in digital or paper form, depending upon personal preference, which required identifying the topic, determining the audience, establishing a purpose for writing, brainstorming ideas, and grouping the ideas into categories. Then, they organized ideas using a text structure map. In the third stage of POWER (writing), small-group members used their text structure maps as a guide for drafting explanations. They had access to a personal copy of a laminated checklist that listed: introduction, topic sentence, key ideas and details, examples, and conclusion. After writing an initial draft, small-group members enacted the final two stages of POWER (editing and revising) by using Englert et al.'s "think sheet" to reflect on their writing and select areas for improvement. Finally, during peer-editing, group members shared their drafts with a peer, asked questions, gave compliments, and offered suggestions.

Independent practice sessions. Small-group members were expected to plan, organize, write, edit, and revise by independently using "think sheets." Two to three explanations were completed each week, with the topic selection procedures used in baseline sessions. For the four participants, one explanation was handwritten across two sessions, and one was transcribed using AT tools across two sessions. The first author presented a brief text, images, and a video clip about a topic related to the science curriculum. Group members read the text and viewed images and video clips. This was followed by discussion of the topic. Then, the first author read aloud a prompt, "Today, we are going to write to explain *how plants make food*." Italicized words were replaced with any of 40 topics (randomly selected without replacement).

Experimental Design

A multiple baseline design across participants (Gast & Ledford, 2010) was used to determine the effects of POWER strategy instruction on quality and accuracy of transcribed explanations. Changes to experimental conditions were based on quality and accuracy scores of the four target participants. Upon achieving stable scores in the baseline condition, POWER strategy instruction began for the first participant's group and lasted for a 2-week period. The remaining groups continued the baseline condition. When the first participant's group completed three independent practice sessions and the second participant achieved stability in the baseline condition, POWER strategy instruction began for the second participant's group. This pattern continued until all four groups moved from baseline to POWER strategy instruction. In addition, we used the concurrent time series design (Parette, Peterson-Karlan, Wojcik & Bardi, 2007) to compare scores across transcription methods. The combined design permitted the evaluation of intervention effects while allowing analyses of the transcription methods.

Procedural Fidelity

Two district-employed interventionists who held Master's degrees as reading specialists collected procedural fidelity data through direct observation in 30% of sessions per group across three phases of the intervention. Using a 15-item checklist, two raters observed instruction and rated whether listed actions occurred. For both raters, the number of observed components was divided into the number of possible components and then multiplied by 100 (Billingsley, White, & Munson, 1980). The mean procedural fidelity rating per group was 97% (range 96–100%).

Interrater Agreement

The first author trained two graduate students in scoring writing accuracy and quality in a 2-hour session that took place prior to the start of the study. During training, both graduate students scored samples of explanatory writing independently and compared scores with those of the first author to discuss disagreements, resolve differences, and establish consistency. Following the completion of data collection, independent scorers rated participants' 110 science explanations. Identifying information was redacted along with information related to the phase of the study. Interrater agreement (IRA) data were calculated for CWS and quality scores using the point-by-point agreement method (Ayers & Ledford, 2014). The total number of agreements between the scores assigned by the independent raters and the scores assigned by the first author were divided by the number of agreements and disagreements and multiplied by 100. Mean IRA for CWS was 83% for Max, 84% for Tyler, and 85% for Emily and John. Mean IRA for quality was 91% for Tyler and 88% for Max, Emily, and John.

Social Validity

Social validation data were collected to examine the procedures and outcomes of the study. After five independent-practice sessions, three Likert-style survey items were provided to participants. They were asked to report their level of satisfaction with the AT tools, the small-group writing instruction, and the explanations they produced with the POWER strategy. Survey items were followed by space for comments.

RESULTS

On measures of writing accuracy (number of CWS) and writing quality (scores on a writing rubric) all four target participants showed improvement over time, relative to their own baseline performance levels. Figure 1 depicts participants' writing accuracy scores on explanatory responses to science writing prompts. Figure 2 depicts

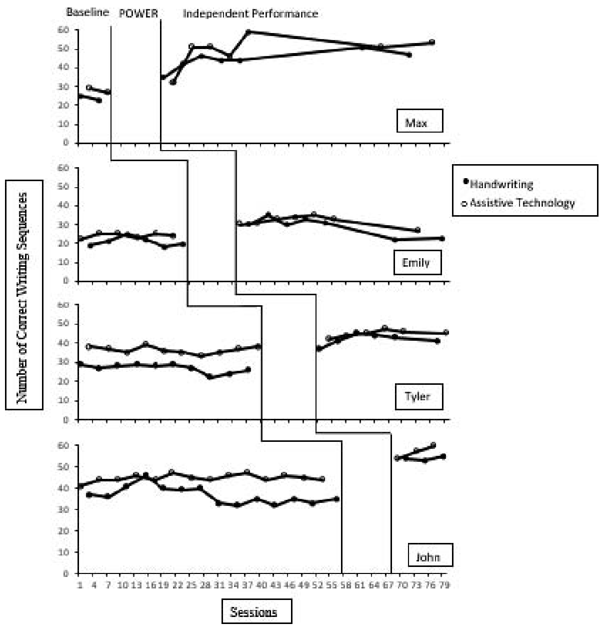

Figure 1. *Number of correct writing sequences on explanatory responses across sessions.*

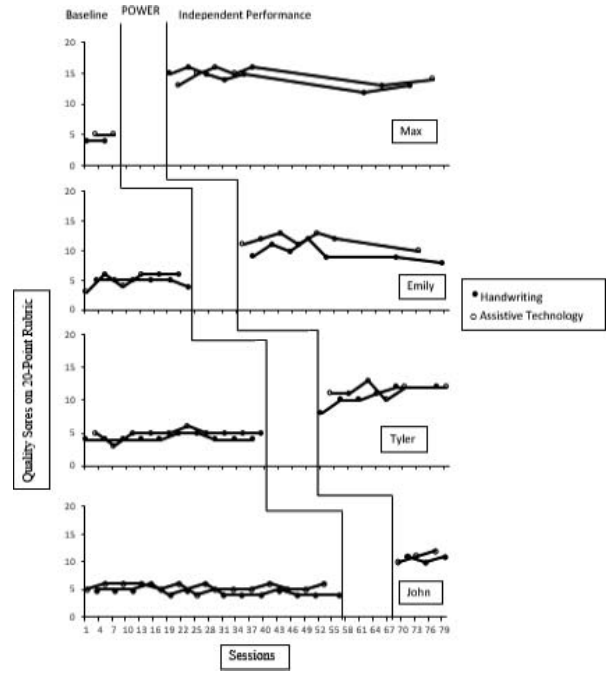

Figure 2. *Quality scores on explanatory responses across sessions.*

participants' writing quality scores on the corresponding science explanations. There was one overlapping data point between baseline and independent practice sessions for Tyler's writing accuracy, which yield 99% as the percentage of non-overlapping data (PND). No overlapping data occurred across conditions on measures of writing quality (i.e., 100% PND). Non-overlapping data indicate the effectiveness of single-subject interventions (Scruggs, Mastropieri, & Casto, 1987). In addition, we calculated *Tau-U* as a single omnibus of effect size for the multiple baseline across participants (Parker, Vannest, Davis, & Sauber, 2011) and generated .95 for writing accuracy and 1.0 for writing quality. Our visual analyses on graphs depicting both dependent measures reveal four demonstrations of effect at four points in time.

Writing Quality and Accuracy across Transcription Methods

Max. Baseline levels of writing accuracy depicted a low, flat trend, with AT scores exceeding scores earned on handwritten explanations. The median baseline score for peers in Max's group was 70 CWS (range = 68 to 75). During the independent practice phase, an immediate level change was followed by an increasing trend in the direction of improvement, with a subtle advantage for AT scores. Max's accuracy peaked at 59 CWS. Meanwhile, the median score earned by peers in his group was 79 CWS (range = 74 to 84).

On the writing quality rubric, Max's baseline scores depicted stability at the basic level for handwritten explanation and at the developing level for AT-transcribed explanations. Meanwhile, his peers' explanations earned a median score of 13 (near proficient) with a range of 11 to 15. During independent practice sessions, Max's scores showed an immediate level change and accelerating trend that reached the proficient level for both transcription methods. During independent practice, his peers earned a median score of 16.5 (range = 15 to 18).

Emily. Baseline levels of writing accuracy depicted a low, flat trend (15 to 18 CWS) on explanations composed with both methods of transcription. Peers in Emily's group earned baseline accuracy scores that ranged from 80 to 88 CWS. During independent practice, her accuracy scores depicted a flat trend at a higher level than baseline scores. Emily achieved a high score of 35 CWS while her peers earned a median score of 91 CWS (range = 87 to 99). Emily's AT accuracy scores were generally better than handwriting accuracy scores across phases.

During baseline, Emily's quality scores ranged from 3 to 6 (basic to developing) on explanations composed with both methods of transcription. Scores on AT-transcribed explanations depicted stability at a low level prior to intervening; scores on handwritten explanations showed a slightly decelerating trend at a low level. Her peers earned a median baseline score of 12 (near proficient) with a range of 11 to 16. During independent practice, Emily's scores reflected a level change and an increasing trend, with scores on AT-transcribed explanations exceeding those earned on handwritten explanations. She reached 13 (near proficient) while peers earned a median score of 16 (range = 15 to 18).

Tyler. Baseline accuracy scores were stable within transcription methods prior to POWER strategy instruction. Consistently in baseline, his AT scores exceeded scores earned on handwritten explanations. His peers' baseline accuracy scores ranged from 83 to 88 CWS. Tyler's accuracy scores in the independent practice phase overlapped initially with his baseline scores. This was followed by a slightly accelerating trend at a slightly higher level than baseline. He earned a high score of 47 CWS while peers earned a median score of 88 CWS (range = 85 to 91). Tyler's scores were similar across transcription methods during independent practice.

During baseline sessions, Tyler's writing quality scores depicted a low, flat trend, with no distinct advantage for either method of transcription. His peers' baseline scores ranged from 10 (developing) to 13 (near proficient). An increasing trend occurred during the independent practice, with Tyler's AT scores generally exceeding his scores on handwritten explanations at a higher level than in baseline. Tyler's highest score reached 13 (near proficient) while peers earned a median score of 15 (range = 11 to 18).

John. During baseline sessions, John's writing accuracy scores depicted stability prior to intervention within transcription method, with a distinct advantage on explanations transcribed with AT. Across transcription methods, his baseline accuracy scores ranged from 36 to 47 CWS while peers' scores ranged from 69 to 76 CWS. A level shift occurred when John advanced into the independent practice phase. His AT scores exceeded scores earned on handwritten explanations during independent practice. John achieved a high score of 60 CWS while his peers earned a median score of 81 CWS (range = 79 to 88).

During baseline sessions, John's quality scores generally fell within the developing range for both methods of transcription. Baseline performance showed a flat trend at a low level. Meanwhile, his peers' quality scores ranged from 9 (developing) to 12 (near proficient). During independent practice, John's writing quality scores reached a higher level and showed a slightly accelerating trend. His scores ranged from 10 (developing) to 12 (near proficient). His peers' achieved quality scores that ranged from 13 (near proficient) to 15 (proficient).

Social Validity

Participants reported a high level of satisfaction with the small-group writing instruction ($M = 4.5$ on a 5-point scale), the assistive technology tools ($M = 4.5$ on a 5-point scale), and with writing outcomes using the POWER strategy ($M = 4.75$ on a 5-point scale). Participants commented that they would be likely to use the POWER strategy in sixth grade, and one participant commented that this strategy "helped [him] write more organized ideas." All participants expressed preference for writing with AT tools over pencil-paper methods. However, Max offered that he experienced delays due to his laptop "loading updates," which was frustrating and made pencil-paper methods seem easier.

DISCUSSION

The main purpose of the study was to evaluate POWER strategy instruction within and across methods of transcription for effects on accuracy and quality of written explanations produced by students with learning difficulties. Data indicated a functional relation between POWER strategy instruction and improved scores on measures of quality and accuracy. Improved writing outcomes occurred after a 2-week period in which POWER strategy instruction was provided with high fidelity for approximately 35 min each school day. Instruction was delivered in a small group with one teacher and six students. Small-groups included writers with and without disabilities. Thus, dialogic instruction of writing processes that undergird the development of effective explanations included voices of students who were already proficient writers. Furthermore, peer-editing conversations that took place between more and less proficient writers to contribute to quality and accuracy improvements on participants' final-draft explanations. Our results align with those reported by Englert and colleagues (1991) and extend to include students with disabilities whose transcription was supported by AT.

In addition to examining effects of POWER strategy instruction, we examined the effects on methods of transcription. All participants developed operational competence with using AT tools prior to the start of the study. This allowed a non-confounded examination of the effects of AT tool use on writing outcomes. That is, participants were not required to learn how to operate AT tools while participating in POWER strategy instruction. On measures of writing accuracy, the compensatory effect of AT tools versus handwriting was apparent during baseline sessions for all participants. This is consistent with past findings indicating that students with disabilities produce more accurate transcription (i.e., fewer spelling errors) with AT tools as compared to handwriting alone (e.g., Corkett & Benevides, 2016; Evmenova et al., 2010; Hetzroni & Shrieber, 2004; Silió & Barbetta, 2010). However, we observed less pronounced effects on writing accuracy after POWER strategy instruction. This is not unexpected given that peer-editing and self-assessment were used to improve final-draft compositions.

On measures of writing quality, participants earned greater scores when using AT as compared to handwriting. This is consistent with past findings reported on improved writing quality and structure when students with learning disabilities used AT tools as compared to handwriting (e.g., Cullen, Richards, & Frank, 2008; MacArthur & Cavalier, 2004). In the current study, writing accuracy was considered when rating writing quality. That is, the category of "conventions" on the district-developed rubric overlapped with CWS procedures for scoring writing accuracy and accounted for up to four of 20 possible points. Similarly, in the quality rubric used by Cullen and colleagues, 12 of 20 possible points were distributed across the categories of spelling, punctuation, and capitalization. To an extent, improved writing accuracy conflates with improved writing quality. Therefore, additional research is needed to examine the dimensions of writing quality (e.g., ideas or word choice) that are influenced by strategy instruction for students with learning, attention, or emotional disabilities who use transcription tools as AT support in international contexts.

Limitations and Suggestions for Future Research

Several factors limit this study's findings. First, the small number of participants and the context in which the study took place limit the generalizability of our findings. The study was conducted in a setting where reliable internet access and relatively new technology tools were available to students for most of their school careers. Minor challenges were noted on social validation surveys related to delays in writing productivity caused by laptop computers that continually ran updates after being powered on. Given the privilege of long-term access to AT tools, participants were accomplished in troubleshooting and problem-solving technology issues. In settings where the functionality of equipment or the reliability of resources differs from what occurred in this study (e.g., in countries where quality of resources is improved or where there is less reliable access to web-based resources), opportunities to demonstrate quality and accuracy when transcribing with AT tools may also be affected.

In this study, explanatory writing was connected to the school's science curriculum. The science-related explanatory-writing prompts may have affected writing outcomes. For example, topics for which participants had acquired more life experience or background knowledge may have allowed more time to focus on writing quality rather than content interpretation. We attempted to mitigate this by using consistent procedures to present audio, visual, and textual stimuli to activate background knowledge on topics prior to having participants compose explanations. However, in the future we recommend using pretesting and self-reports to inventory students' background knowledge about writing topics.

A final limitation stems from the timing of the study's implementation. The study ended in conjunction with the school year, which restricted the opportunity to evaluate the lasting effects of POWER strategy instruction within and across transcription methods. The independent practice sessions spanned approximately two and a half weeks for John to eight weeks for Max. Future research should investigate use of AT applications in the context of writing strategy instruction over an extended period that can allow for maintenance assessment.

Implications for Practice

Effective and efficient teaching strategies appeal to practitioners who aim to meet needs of students with writing difficulties. The POWER strategy, which was feasible to implement with high fidelity, was efficient because it could be taught within a brief period of time (i.e., 10 periods of 35 min each). Moreover, improved writing accuracy and quality were observable for participants by the end of the second week of independent practice (i.e., a 4-week period from the initial intervention session).

Another implication for practice relates to demands placed on participants to produce writing during daily sessions. Writing skills are developed through practice. Graham and colleagues (2012) recommend that students learn a process for writing (e.g., POWER) for a variety of purposes and that students have daily writing experiences. In this study, students with learning, attention, and emotional disabilities wrote for 21 to 26 min per day during small-group instruction (excluding teaching behaviors related to stating the lesson objective or activating background knowledge). All participants made gains in writing accuracy scores and writing quality scores. Therefore, practitioners should incorporate routine opportunities for sustained writing, complemented by strategy instruction, to meet needs of students with disabilities whose transcription methods include handwriting or use of AT tools.

Conclusion

In this study, we implemented instruction in the POWER strategy for writing explanations and examined its effects for students who used AT tools to support transcription. After strategy instruction, all four participants achieved gains in accuracy and quality scores, with scores on AT-transcribed explanations exceeding those earned on handwritten explanations. This study extends past research by demonstrating that the effectiveness of AT tools can meld with specially designed instruction to support students with writing difficulties in producing clear and coherent explanatory writing. Moreover, the study affirms that AT tools in conjunction with writing strategy instruction can be applied in inclusive settings.

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