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Proofreading for Students With Learning Disabilities: Integrating Computer and Strategy Use

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We investigated the impact of integrated proofreading strategy training, combining the use of a computer-based spelling checker and student strategies, on the proofreading performance of students with learning disabilities (LD). Three high school students with LD were taught to apply a 5-step proofreading strategy with controlled materials and in a variety of generalization activities. A multiple-probe, across-subjects design was used with 3 phases: baseline, intervention, and maintenance. Results provided evidence of increases in strategy use and percentage of spelling errors corrected on both controlled proofreading materials and on compositions written by the students. Postintervention, all 3 students produced written texts with final spelling error rates that fell within the performance range of nondisabled peers.

Students with learning disabilities (LD) produce more spelling errors in their written work than do their nondisabled peers, and they detect and correct fewer of these errors (Blandford, 1990/1991; Deshler, Ferrell, & Kass, 1978; McNaughton, Hughes, & Clark, in press). These incorrect spellings restrict the ability of writers with LD to communicate effectively in writing (Arms, 1984; Hinds, 1985); written output that is deficient in spelling and other writing conventions is difficult to read and has a strong negative influence on overall judgments of quality (Grobe, 1981; Moseley, 1989; Tindal & Hasbrouck, 1991). For many students with LD these difficulties persist over time despite extensive remedial intervention. The production of spelling errors is the most frequently reported problem of adults with LD (Dunham, 1987), and it often precludes full participation in academic and vocational settings (Hoffman et al., 1987).

Proofreading provides a final opportunity for the author to detect and correct spelling errors in a written text. In current approaches to writing instruction, effective proofreading skills take on special importance. Students are encouraged to ignore misspellings during the initial composing stages of the writing process and to make spelling corrections during the final editing stage (Hine, Goldman, & Cosdan, 1990; Reynolds, Hill, Swassing, & Ward, 1988).

There is evidence, however, that effective proofreading is challenging for students with LD. Although students with LD frequently focus their editing and revising efforts on the detection and correction of mechanical errors (rather than substantive changes in meaning), their correction attempts have little impact on the number of errors in their written work (Graham & MacArthur, 1988; MacArthur, Graham, & Schwartz, 1991). Deshler et al. (1978) found that grade school students with LD detect significantly fewer spelling mistakes than do nondisabled students, even when given explicit instructions to search for errors. Recent research suggests that these difficulties persist into adulthood (McNaughton et al., in press).

To date, nine studies have reported proofreading interventions for students with LD: Six studies focused on interventions that teach students proofreading strategies (e.g., carefully checking each word in a sentence for spelling errors), and three studies investigated the use of assistive technology (e.g., a computer-based spelling checker).

LEARNING STRATEGY INTERVENTIONS

Learning strategy interventions proceed from the assumption that students with LD are deficient in the use of effective and efficient strategies for the completion of the task of proofreading.

Interventions Using a General Revising Strategy

Strategy instruction in a broad set of revision behaviors (including evaluation criteria for written compositions, specific revision strategies, and an overall strategy for regulating the revision process) was examined in a series of studies by Graham and MacArthur (1988); MacArthur, Schwartz, and Graham (1991); and Stoddard and MacArthur (1993). Results from these studies indicate that the revising strategies were successfully learned and were used to improve some aspects of writing quality by students with LD in Grades 4, 5, and 6 (Graham & MacArthur, 1988; MacArthur, Schwartz, & Graham, 1991) as well as by students in Grades 7 and 8 (Stoddard & MacArthur, 1993). Students were also successful in using the strategies independently (Graham & MacArthur, 1988) and in working in pairs with peers (MacArthur, Schwartz, & Graham, 1991; Stoddard & MacArthur, 1993).

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The students with LD in these studies learned to make use of the strategies to make substantive revisions affecting content, organization, and style. For both age groups, and in both the independent and peer conditions, postinstruction compositions were judged to be higher in quality than were preinstruction compositions. In all three of the studies, however, long-term success at independently detecting and correcting spelling errors was improved only slightly by the instructional intervention. It is unclear whether the strategy instruction enabled students with LD and severe spelling difficulties to independently detect and correct spelling errors at levels comparable to that of their nondisabled peers. The impact of the remaining spelling errors on perceptions of quality also is unclear because the instructions for scoring quality in two of the studies (MacArthur, Schwartz, & Graham, 1991; Stoddard & MacArthur, 1993) contained specific directions to ignore mechanical errors unless they interfered with comprehension.

Interventions Using the Error Monitoring Strategy

The Error Monitoring strategy is a multistep proofreading procedure designed to assist students in correcting a variety of mechanical errors in their written work, including errors of capitalization, punctuation, spelling, and handwriting legibility. Schumaker et al. (1981) and Shannon and Polloway (1993) produced evidence of improved performance following instruction, although studies reporting successful implementation of the Error Monitoring strategy are difficult to interpret with respect to proofreading for spelling errors. The error score calculated as the dependent variable in the studies by Schumaker et al. and Shannon and Polloway collapsed spelling, punctuation, capitalization, handwriting appearance, and spacing errors into a single score. When a change in error scores is reported, therefore, it is not possible for the reader to determine if this change represents an improvement in handwriting, spelling, or any of the other variables. In addition, the Error Monitoring scoring system specifically excludes contextual spelling errors (i.e., correctly spelled words used incorrectly in a given context, e.g., *there* for *their*) from the error count. Because these errors may make up as much as 31% of the spelling errors produced by students with LD (McNaughton et al., in press), the Error Monitoring error data may underrepresent the actual spelling errors in a text. The Error Monitoring strategy also contains provisions for students to seek assistance from peers or from an instructor in correcting spelling errors. In reviewing the final error scores reported, it is not possible for the reader to determine how many of the errors were corrected by students independently and how many were corrected through the external assistance of peers or instructors.

Interventions That Generate Alternative Spellings

In the Blandford (1990/1991) study, students were directed to detect errors independently and to generate three alternative spellings for each word that they believed to be misspelled. Although all students demonstrated increased use of the proofreading strategy, proofreading performance on the students' own compositions was variable. Only one of the three students clearly demonstrated improved performance with respect to error detection. The percentage of detected errors corrected improved for all three subjects. However, so few spelling errors were actually detected and corrected that there was no perceptible change in spelling quality for the students' written work as rated by the classroom teacher.

ASSISTIVE TECHNOLOGY INTERVENTIONS

Concerns about the poor independent error detection and correction performance of students with LD prompted research into the use of assistive technology to assist in the proofreading process. McNaughton et al. (in press) investigated the use of a variety of assistive spelling technologies by college students with LD and reported that the use of a word-processor-based spelling checker assisted students in both detecting and correcting a higher proportion of spelling errors than did a no-technology condition. The final spelling error rate of the technology-assisted students, however, was still significantly higher than that observed for nondisabled college students.

Dalton, Winbury, and Morocco (1990) provided training in the use of a word-processor-based spelling checker to two 4th-grade students with LD. Although the use of the spelling checker assisted both students in substantially improving the proportion of errors they were able to detect and correct without the assistance of the technology, both students continued to require external assistance from a peer or the teacher to correct approximately 40% of the "unique" errors (i.e., each misspelled vocabulary item was counted as a single unique error, regardless of how often it occurred) detected by the spelling checker.

More recently, MacArthur, Graham, Haynes, and DeLaPaz (1996) investigated the performance of students with LD in Grades 5 through 8 with a variety of word-processor-based spelling checkers. As in the McNaughton et al. (in press) and Dalton et al. (1990) studies, the use of the spelling checkers increased the percentage of spelling errors corrected. When a correct suggestion for a misspelling was provided by the spelling checker, this option usually was selected by the students. The spelling checker failed to identify one third of the spelling errors because errors were other words correctly spelled; these misspellings were neither identified nor corrected by students.

All three assistive technology intervention studies indicated that assistive technology alone, although of benefit, was insufficient to remediate the gap between the proofreading performance of individuals with LD and nondisabled individuals.

SEARCH AND ERROR DETECTION PERFORMANCE RESEARCH

Research from the field of human perception on the search and error detection performance of nondisabled individuals may provide important guidance to the development of effec-

tive proofreading strategies. Error detection is optimized in situations with the following conditions: First, the error or target is well known to the subject, and there is a low level of target uncertainty (Craig, 1984); second, the individual makes efficient use of attentional resources and devotes sufficient attention to the task to detect known errors (Fisk, Ackerman, & Schneider, 1987); third, the subject has a good understanding of acceptable levels of performance and is motivated to reach these levels (Craig, 1984); fourth, the subject works with a display in which clutter has been reduced as much as possible; and finally, the subject makes use of a systematic scan path in the search for errors.

These factors associated with improved error detection can be applied to proofreading instruction in the following manner: First, the error or target should be well known to the subject; in the case of proofreading, performance should be enhanced if the subject knows whether a word was spelled correctly or incorrectly, or if only a limited number of different types of errors are to be considered at any one time. Spelling checker technology should assist in target certainty by assisting in the detection and correction of noncontextual errors (i.e., words that are spelled incorrectly regardless of the context, e.g., *kat* for *cat*).

Second, routines should be developed that reduce the attentional demands on the individual; the individual should be trained to make full use of available resources in error detection and correction activities. In the case of proofreading, the use of the spelling checker to detect (and assist in correcting) the noncontextual errors in a text should "free up" the proofreader to concentrate attentional resources on other proofreading activities (e.g., detecting contextual errors). Furthermore, training and repeated practice in specific proofreading steps should promote efficient allocation of attentional resources. For example, students should be instructed to read for specific spelling errors (e.g., subject–verb agreement) and not for comprehension.

Third, the subject should have a clear understanding of acceptable levels of error detection and should be motivated to reach these levels. With respect to proofreading, the subject should have a clear understanding of an acceptable spelling error rate for a given text and should have a good understanding of how a low spelling error rate enhances the reader's perception of writing quality.

Fourth, the clutter on the display should be reduced to enhance search activities. In the case of proofreading, this may involve narrowing the search area by reading sentence by sentence. Finally, a well-defined search path should be used by the subject to search for errors; proofreading instructions should provide suggestions for the use of an orderly search path.

These modifications serve to facilitate the search process and to reduce attentional demands on the observer, leading to faster and more effective error detection. It was hypothesized that the incorporation of these factors into proofreading instructional activities would enhance the error detection component of proofreading performance. This study, therefore, examined the use of an integrated proofreading strategy approach incorporating elements of past learning strategy and assistive technology interventions as well as activities identified as optimizing search and error detection performance generally. The study addressed the following issues: (a) the participants' ability to master the application of the proofreading strategy, (b) the effects of strategy instruction on the participants' correction of spelling errors with controlled proofreading activities, and (c) the effects of strategy instruction on the participants' correction of spelling errors in generalization activities.

METHOD

Participants

Three students participated in the study. The selection of participants was based on six criteria: Each participant was (a) between the ages of 15 and 18, (b) identified as having a learning disability as defined by the Commonwealth of Pennsylvania for the purposes of providing special education services, (c) experienced in the use of Microsoft Word word processing software and able to demonstrate basic competency in spelling checker use, (d) identified as having a functional disability in spelling as indicated by a spelling error rate more than 2 standard deviations below the spelling performance of their peers even when a spelling checker was used, (e) assessed as having a spelling score that was 2 standard deviations below that of their academic peers on a standardized norm-referenced test of spelling, and (f) referred by the learning disabilities resource room teacher for instruction in proofreading skills. Additional demographic information is provided in Table 1.

TABLE 1
Characteristics of the Participants

	Participants		
Characteristics	*Stuart*	*Tammi*	*Wanda*
Demographic			
Gender	Male	Female	Female
Age	18	16	16
Grade	12	10	10
Achievement			
Spelling[a]			
Predictable words	83	72	77
Unpredictable words	68	78	80
Combined	75	74	75
Composition error rate[b]			
Without spelling checker	13.5%	15.5%	9.8%
With spelling checker	4.9%	11.4%	6.6%
Reading[c]	96	72	84
Writing[d]	76	64	87
Dictation subtest	64	58	61
Grade point average	3.1[e]	3.1[e]	1.8
English grade	C–	C	C–
Aptitude[f]			
Verbal	91	—[g]	95
Performance	92	—[g]	102
Full	90	81	96

[a]All scores reported as standard scores as measured by performance on the Test of Written Spelling–Revised (Larsen & Hammill, 1986). [b]As measured by mean performance on word-processed writing composition. [c]All scores reported as standard scores as measured by performance on the Woodcock–Johnson Test of Achievement (Woodcock & Johnson, 1989). [d]All scores reported as standard scores as measured by performance on the Woodcock–Johnson Test of Achievement (Woodcock & Johnson, 1989). [e]Includes grades for courses with reduced academic expectations. [f]All scores reported as standard scores as measured by the Wechsler Intelligence Scale for Children–Revised (Wechsler, 1974). [g]Subtest score not available.

The participants were enrolled in a high school in a small, northeastern college town. All three students attended a learning support program for at least some of their academic day. Stuart was completing coursework to prepare for attendance at a junior college; the school programs for Tammi and Wanda focused on vocational skills. The need to improve proofreading and editing performance was identified in the Individual Education Program objectives for all three students.

Materials

Both controlled and student-generated materials were used in the instructional activities. Controlled materials were used to allow the students to focus their full attention on the strategy to be used and to build confidence and fluency with standardized materials. Student-generated materials (developed during Generalization Activities 1 and 2) were used to practice the strategy with the types of materials (i.e., student essays) used in the criterion environment (Lenz, Schumaker, Deshler, & Beals, 1993) in order to promote transfer and generalization of the integrated proofreading strategy to a wide variety of writing activities.

Controlled proofreading materials. A set of 24 controlled proofreading materials was created by David McNaughton. These materials were used both for instructional and probe activities as well as for providing corrective feedback to participants. Each set of proofreading materials included a passage containing spelling errors representative of those made by individuals with LD (Hughes, Clark, & McNaughton, 1993) and a list of words identified as problematic spelling items for high school and college students (Furness & Boyd, 1958).

Each proofreading passage was approximately 200 words in length and was modified so that certain spelling features simulated typical errors made by individuals with LD (as identified by Hughes et al., 1993). Twenty errors were interspersed throughout the passage; these 20 errors were further divided among three error types. There were 8 noncontextual errors for which the spelling checker option window produced the correct suggestion; these words are referred to as *noncontextual errors, correct suggestion provided.* Four noncontextual errors were included that did *not* result in the production of the correct response by the spelling checker; these words are referred to as *noncontextual errors, no correct suggestion provided.* Eight *contextual errors* were also inserted into the passage. The proportion of error types was based on past research with students with LD (Hughes et al., 1993). Passages were prepared as word processing documents for use by the students in the proofreading activities, and they were read aloud to students prior to proofreading to ensure comprehension of the material and familiarity with the text because lack of familiarity with a text may lead to reduced proofreading performance (Levy & Begin, 1984). In order to assess student performance on "challenging" vocabulary, 10 spelling items randomly selected from the Furness and Boyd (1958) list of common misspellings were also dictated to the participants (who transcribed the words using a word processing package) for use in the probe proofreading activities.

Generalization Activity 1. During Generalization Activity 1, students wrote a composition on an assigned topic. The topics for the student compositions were developed in consultation with the classroom teacher and were designed to appeal to the interests of this age group (e.g., "If I were in charge of this high school, I would ...") without requiring the use of specialized topic-specific vocabulary that might have been unfamiliar to the students. Topics were randomly selected and assigned to students with the provision that each topic was used only once for each student.

Generalization Activity 2. During Generalization Activity 2, students transcribed onto a computer a passage dictated by the instructor. The passages were taken from writing samples produced by same-age peers who were judged to be average or above average in language arts, as reflected by a grade of C or better. The dictation passage was used to augment the information provided by the student composition. Current research provides evidence that students with LD use a limited word set (Gajar, 1989). Use of a restricted vocabulary appears to represent a conscious effort by students with LD to stick to words that are easier to spell (Cowen, 1988). When dictating stories, for example, students with LD have been observed to use a wider variety of vocabulary than they use in their written work (MacArthur & Graham, 1987). The use of a limited vocabulary in an attempt to avoid spelling errors is ultimately self-defeating, however, because the number of different words used in a composition has been identified as a strong predictor of holistic ratings in postsecondary settings (Gajar, 1989). The written work of nondisabled peers was used for this activity to evaluate the impact of the proofreading strategy on a wide range of age-appropriate vocabulary items.

Experimental Design

A multiple-probe across-subjects design (Tawney & Gast, 1984) was used to evaluate the effectiveness of the proofreading instruction. The study included three phases: baseline, intervention, and maintenance. Data were collected on strategy use, spelling error correction rates, and final error rates during probes in all three phases. In addition, generalization data on student-generated compositions (Generalization Activity 1) and student-transcribed compositions (Generalization Activity 2) were collected during baseline and maintenance.

Independent Variable

The independent variable was the instruction in the five-step proofreading strategy InSPECT. The following procedures were used in developing the strategy: (a) identification of spelling errors common in the writing of students with LD, (b) identification of important proofreading skills specified in previous proofreading research with nondisabled students and students with LD, and (c) examination of the factors that optimize search and error detection performance as defined in the human perception literature.

The five steps of the InSPECT strategy (after students were "In their document") were (a) Start the spelling checker, (b) Pick correct alternatives, (c) Eliminate unrecognizable words, (d) Correct additional errors, and (e) Type in your corrections. Figure 1 contains the steps and substeps for the strategy. The first step, Start the spelling checker, directed the student to begin the spelling checker routine at the beginning of the document. Classroom teachers reported that starting the spelling checker routine from a later point in the text (and thereby failing to review at least some of the errors) is a common student mistake (B. Wilson, personal communication, December 22, 1993). Use of the spelling checker technology provided students with a means to detect noncontextual spelling errors and with access to a large store of correct spellings, thus serving as a prosthesis to compensate for their own difficulties in detecting and correcting spelling errors. Use of the spelling checker technology also served to maximize the attentional resources available by freeing students to focus their attention on the selection of correct spelling alternatives for noncontextual errors and the detection and correction of contextual errors. The detection of noncontextual errors, which account for the largest proportion of student spelling errors, was completed automatically by the spelling checker. By specifying that the spelling checker should be started at the beginning of the text, the strategy emphasized the need for a systematic scan path; according to error detection theory, reviewing material in an organized manner is superior to a random start-and-stop procedure.

In your document,

1. **S**tart the spelling checker
   a) place the cursor at the start of the text
   b) under the "Tools" heading, select "Spelling"

2. **P**ick correct alternatives
   a) read adjacent text to determine target vocabulary item
   b) wait for all alternatives to appear
   c) review all alternatives
   d) look at beginning and end of alternatives
   e) double-click on target

3. **E**liminate unrecognizable words
   a) correct typos
   b) write out parts of the word that are known
   c) spell word phonetically
   d) use * for unknown sections of the word
   e) use a synonym

4. **C**orrect additional errors
   a) print a copy of text
   b) read from end, look for "wrong words"
      - look at beginning and end of word
   c) read from beginning, look for "subject-verb" agreement
      - slow down and focus on each sentence

5. **T**ype in your corrections
   a) type in your corrections
   b) run spelling checker
   c) print final copy

FIGURE 1 Proofreading strategy steps and substeps.

The second step of the strategy, Pick correct alternatives, assisted the student in reviewing the alternatives presented by the computer. Students often impulsively select the first word suggested by the spelling checker and fail to "page down" through all the alternatives presented (Dalton et al., 1990). Error detection theory suggests that observers typically make random impulsive responses in situations of low target certainty (i.e., limited knowledge about target characteristics) because they question their own ability to perform above chance levels. Students with LD have been observed to make hasty, impulsive responses in situations of high response uncertainty (Gerber & Hall, 1987). By providing students with a structure for reviewing slowly and carefully the alternatives presented by the spelling checker, we hypothesized that improved performance would be observed.

Students with LD may also experience difficulty in selecting the correct spelling when a number of derivational forms that differ only in their suffix (e.g., *compensate, compensation, compensatory*) are provided (Adams, 1990). The options presented by the spelling checker are, in some respects, a "cluttered display" (Monk, 1984, p. 297) in which target and nontarget items compete for attention. It was hypothesized that specific instructions to scan the options using an organized scan path would be of assistance.

The third step of the strategy, Eliminate unrecognizable words, provided the student with strategies to deal with errors detected by the spelling checker for which the spelling checker did not offer the correct alternative. Students were directed to first make changes to address typographical errors. If necessary, students then created closer approximations of the target item (so as to activate recognition by the spelling checker) through the use of existing spelling knowledge (e.g., writing down the parts of the word they knew, spelling the word phonetically). The literature suggests that students with LD often fail to make efficient use of their existing spelling knowledge in approaching new spelling problems (Gerber, 1984). When prompted to give their full attention to a spelling problem (i.e., to allocate additional attentional resources to the problem) and make full use of their existing spelling knowledge, students with LD have demonstrated the ability to make spelling approximations significantly better than those initially produced (Bailet, 1990; Gerber, 1984). Students were also taught to make use of a wild card feature (in which an asterisk could be used to replace unknown letters) to obtain correct spellings for a word when only some of the letters were known.

The fourth step, Correct additional errors, was important for addressing contextual errors that were not detected by the spelling checker. Vacc (1987) reported that the students with mild academic handicaps in his study did not routinely proofread materials before completing writing assignments. The use of a spelling checker may exacerbate this problem because it is commonly believed by students that the spelling checker can be relied upon to detect all errors (Dalton et al., 1990). However, current spelling checker technology fails to identify contextual errors in the text.

In order to detect contextual errors, a broad set of cues (including surrounding context) must be considered by the student. Research provides evidence, however, that errors are

more difficult to detect in situations in which the contextual support for word recognition is strong (Holbrook, 1978). High-level semantic and syntactic knowledge of a text may reduce the need to pay careful attention to the visual features of the individual words (Daneman & Stainton, 1991). The more a reader knows about a topic, the less visual information is necessary to recognize the word (Adams, 1990).

This step of the strategy incorporated the benefits discussed in error detection theory of using an organized scan path (Monk, 1984) and of increasing target certainty by reducing the variety of errors searched for in a single sweep. Students were directed to read sentence by sentence from the end of the passage with the primary goal of detecting "wrong word" errors (e.g., *their* for *there*) and then to read from the beginning to the end in order to detect subject–verb agreement errors (e.g., *I were going*). We hypothesized that the students, by reading sentence by sentence backward from the end of a text, could balance two competing needs most effectively: (a) the acquisition of enough contextual information to support the detection of contextual errors and (b) the limitation of contextual information so as not to reduce the detection of contextual errors.

In the fourth step, students were directed to proofread the text twice because of experimental evidence that indicated the diminishing returns obtained by additional readings are rarely justified by the additional time invested (Reifer, 1991). Students were directed to read from a paper copy to incorporate the research evidence that subjects proofread more effectively and efficiently from a paper copy than from a computer display monitor (Gould & Grischkowasky, 1984).

In the final step of the strategy, Type in your corrections, participants were directed to type in the corrections made on their paper copy, review the text with the spelling checker (to catch any errors made during the transcription process), and print a final copy.

PROCEDURES

A multiple-probe, across-subjects experimental design with three phases (i.e., baseline, intervention, and maintenance) was used. The students participated in all three phases; however, Tammi was unable to complete all of the testing activities identified for the maintenance phase because the school year ended during this phase. Sessions were scheduled to be held three times per week, with the maintenance data collected 1, 2, and 4 weeks after the final intervention session. The total time for each participant involved approximately 4 months of data collection.

Baseline Phase

The baseline condition documented the student's spelling performance prior to intervention while using the computer-based spelling checker. During the baseline condition, participants completed a series of proofreading probe activities (i.e., detecting and correcting errors in texts in which the investigator had inserted errors and on dictated spelling vocabulary). Students also participated in two sets of generalization activities and in norm-referenced testing activities.

All proofreading activities were carried out using a Macintosh computer and Microsoft Word 5.1 word processing software with accompanying spelling checker.

Intervention Phase

Instruction in the integrated proofreading strategy was provided by David McNaughton. This instruction was introduced to the first participant once a stable baseline on the relevant dependent variable (i.e., strategy use) was achieved. The remaining participants remained in the baseline condition until the first participant's data indicated an improving, upward trend for integrated strategy use with the probe materials. Instruction in the integrated proofreading strategy was then introduced with the second participant. The intervention was introduced to the remaining participant after the second student demonstrated an increase in integrated proofreading strategy use. Intervention was continued until the students performed with 80% success for integrated strategy use for three successive probes.

A six-step instructional sequence was developed for training use of the integrated proofreading strategy, following the guidelines for strategy instruction suggested by the University of Kansas Institute for Research in Learning Disabilities (Ellis & Lenz, 1987; Lenz et al., 1993). The six instructional steps are described.

Pretest and make commitments. The investigator and the student examined the student's baseline proofreading performance. The investigator and student then discussed the goal of training (i.e., to detect and correct a greater proportion of spelling errors), why this goal was important, and how a reduction in the number of spelling errors would improve communication between the writer and the reader. Each student was then asked to make a written commitment to learning a strategy for proofreading. In addition, the investigator emphasized his commitment to providing the necessary instruction to achieve student success.

Describe strategy. The investigator described why and how each step of the strategy should be used in proofreading written work. Information on the anticipated benefits of using the strategy and the costs involved (anticipated instructional time) was provided. The five-step InSPECT strategy was introduced to the students using a small chart.

Model the strategy. During the modeling step, a chart outlining the five steps of the strategy was placed in front of the student, and the investigator modeled the use of the strategy while revising one of the student's baseline essays. During this modeling procedure, the investigator demonstrated while "thinking out loud" so that the student could witness the cognitive processes (as reported by the investigator) and the overt behaviors necessary for successful strategy use. The investigator modeled the entire strategy three times. During the second and third model, the investigator asked questions designed to actively involve the students (e.g., identifying the next strategy step to be used and describing the activities involved in the relevant strategy step).

Verbal practice. Students memorized the strategy steps through the instructor's use of rapid-fire verbal rehearsal activities. During the initial stages of training, students had access to the chart listing the steps in the strategy. After two rehearsals with the strategy list in view, the list was removed and students were called upon to list the steps in order both from the beginning and from investigator-selected points (e.g., "What step comes after Eliminate unrecognizable spellings?"). In order to progress to the next stage of training, students had to state each strategy step in order without assistance, and they had to be able to describe in their own words the activities required for the completion of each step.

Practice with controlled and student-produced materials. Participants practiced the use of the strategy with both controlled and student-produced materials; they also received corrective feedback on their errors in following the strategy. The controlled materials were developed by the investigator to provide the students with practice on the detection and correction of spelling errors. The controlled materials included (a) proofreading passages containing contextual and noncontextual errors representative of spelling errors created by students with LD and (b) proofreading spelling attempts for challenging vocabulary (Furness & Boyd, 1958) generated by the students themselves.

The writing samples generated during the generalization activities were reviewed by the investigator and the participant. At these times, the investigator provided positive and corrective feedback. During the corrective feedback activities, the investigator used both the completed proofreading probe materials and the writing samples from the generalization activities to (a) identify specific errors, (b) review strategy steps associated with each error, (c) model the correct use of the step, (d) have the student practice the correct procedure, (e) have the student paraphrase a description of the correct behaviors, (f) have the student provide suggestions for future practice, and (g) communicate positive expectations for future performance.

Provide generalization training. The investigator reviewed student progress with the students individually and congratulated them on their performance. The investigator then obtained a commitment to generalization, and the investigator and participant discussed how the strategy might be used in classroom writing activities.

Maintenance Phase

Proofreading probes with the controlled materials were used to evaluate maintenance in the use of the proofreading strategy and its impact on spelling performance. Probes were collected 1, 2, and 4 weeks following the end of intervention.

Generalization

Subjects' error correction performance on prepared passages may differ from their performance with texts that they wrote themselves (Kelly & Kerst, 1989). Therefore, participants were administered two generalization testing activities during the baseline and maintenance phases of this investigation. During generalization activities, participants were asked to (a) write an extended composition on an assigned topic and (b) transcribe a passage dictated by the instructor. Although the investigator was present when generalization testing took place, no references were made by the investigator to the use of the proofreading strategy.

MEASURES

In the probe activities, the main dependent variable was the percentage of strategy use. Strategy use was selected as the main dependent variable in order to highlight the relation between strategy instruction and strategy use. Information was also collected on the percentage of errors corrected and the percentage of spelling errors in the final proofread text (i.e., the final error rate). Of additional interest was the differential impact of the intervention on (a) noncontextual and contextual errors and (b) noncontextual errors for which a correct suggestion was provided and those for which one was not provided. For Generalization Activities 1 and 2, information was collected on the percentage of spelling errors corrected in the proofread text and the final error rate. To evaluate the social validity of the proofreading instruction, data were collected on the perceived usefulness of the instruction as reported by the participating students. Each of the measures is discussed in further detail.

Strategy Use

Data on strategy use were collected during all probe activities in all three phases to determine the individual strategy behaviors used by the participants. Strategy use is reported as a percentage of the use of the five steps in the strategy. The percentage of strategy use was calculated by scoring students' performance on strategy steps and substeps (see Figure 1). Points were awarded both for strategy steps that occurred only once (e.g., Start the spelling checker) and for strategy use on a previously identified set of errors.

Percentage of Errors Corrected

Writing samples were reviewed for spelling errors, based on the spellings obtained from *Webster's Ninth New Collegiate Dictionary* (Mish, 1990). A spelling error was defined as a word that was spelled incorrectly (e.g., *katch* for *catch*), inappropriate in context (e.g., *hatch* for *catch*, or *their* for *there* in the sentence, "I am going their"), or omitted (Anderson, 1987; Gregg, Hoy, & Sabol, 1988; Leuenberger & Morris, 1990). All writing samples (including the dictation portion of the probe activity) were reviewed for spelling errors both before and after proofreading by the participants. The percentage of errors that were corrected was calculated as the number of errors before proofreading minus the number of errors after proofreading divided by the number of errors before proofreading multiplied by 100%.

Final Spelling Error Rate

Spelling errors were calculated both as frequencies and percentages of total words written for both the pre- and postproofreading versions. The percentage of spelling errors in the final text (i.e., the final error rate) was calculated by dividing the number of spelling errors by the total number of words in the probe or composition and then multiplying the result by 100%. Correctly spelled words that were changed by the participants to incorrect spellings contributed to the minor variation observed between final spelling error rate and percentage of errors corrected.

RESULTS

The results of the study are organized in three sections to address the major questions addressed in this study: (a) the participants' ability to master the application of the proofreading strategy, (b) the effects of strategy instruction on the participants' correction of spelling errors with controlled proofreading activities, and (c) the effects of strategy instruction on the participants' correction of spelling errors in generalization activities. Information also is provided on the usefulness of the strategy from the participants' point of view.

Mastery of the Strategy

All participants increased their use of strategy components following intervention and achieved mastery in the use of the proofreading strategy (i.e., achieved a strategy use score of 80% or greater for three successive sessions). Figure 2 displays the strategy use for the 3 participants in the baseline with spelling checker, instruction, and maintenance conditions. Stuart's percentage of strategy use increased from 39% in baseline to 88% in the maintenance phase, a mean difference of 49%. For Tammi, strategy use increased from 42% (baseline) to 89% (maintenance), a mean difference of 47%. It should be noted that the maintenance data for Tammi are based on a single follow-up session because the end of the school year precluded additional data collection. Wanda's baseline data were the most variable of the 3 participants because she intermittently made appropriate use of the spelling checker during this phase. Because of the variability in Wanda's baseline data, it was necessary to collect additional data to demonstrate acceptable stability in level and trend before introducing the intervention. During a follow-up interview following completion of the baseline phase, Wanda reported that there was no pattern to her use of the spelling checker, she just used it "when she felt like it." In the baseline phase, Wanda had an average strategy score of 26%; this improved to 80% in the maintenance phase, a mean difference of 54%.

Each of the participants required four practice sessions to reach the mastery level (i.e., strategy use score of 80% or greater for three sessions in a row). During maintenance, the average strategy use scores were at 80% or higher for all 3 participants, although Wanda's strategy score dipped to 67% during the final data collection session, 36 days after her last instructional session.

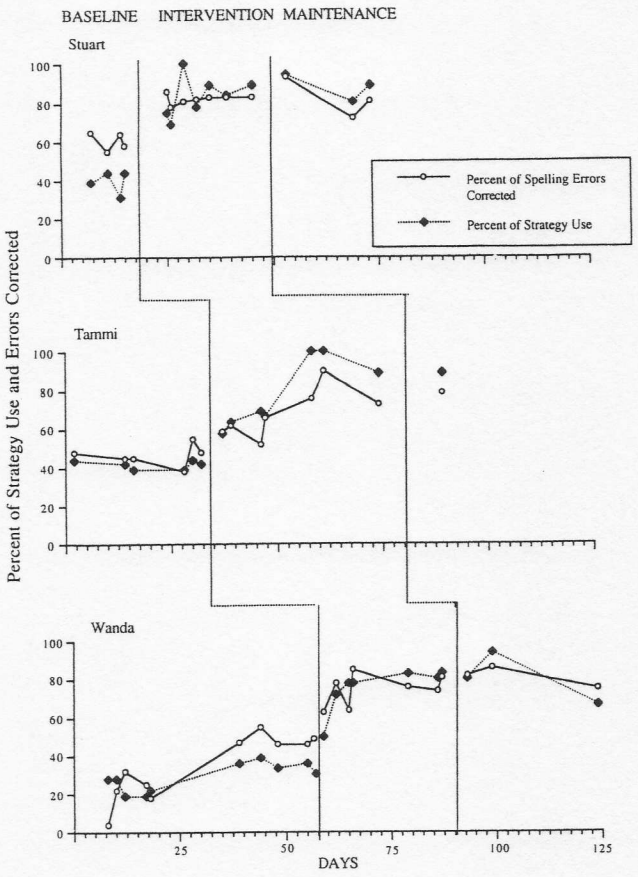

FIGURE 2 Percentage of strategy use and errors corrected during controlled proofreading activities.

Proofreading Performance on Controlled Proofreading Materials

Errors corrected. Figure 2 provides an illustration of the participants' error correction performance on controlled proofreading materials during probes for the three experimental conditions. For all 3 participants the strategy, intervention was associated with an increase in the percentage of errors corrected. The increase in percentage of spelling errors corrected from baseline to maintenance ranged from 21.5% (for Stuart) to 46.5% (for Wanda).

Spelling error rate. Figure 3 provides an illustration of the participants' final spelling error rate on controlled proofreading materials during probes for the experimental conditions. The difference in postproofreading spelling errors from baseline to maintenance ranged from –2.95 (for Stuart) to –5.4 (for Wanda).

Correction of errors by error type. Table 2 provides information on the impact of the intervention on the detection and correction of three spelling error types (viz., noncontextual errors with correct suggestion provided, noncontextual errors with no correction suggested, and contextual errors)

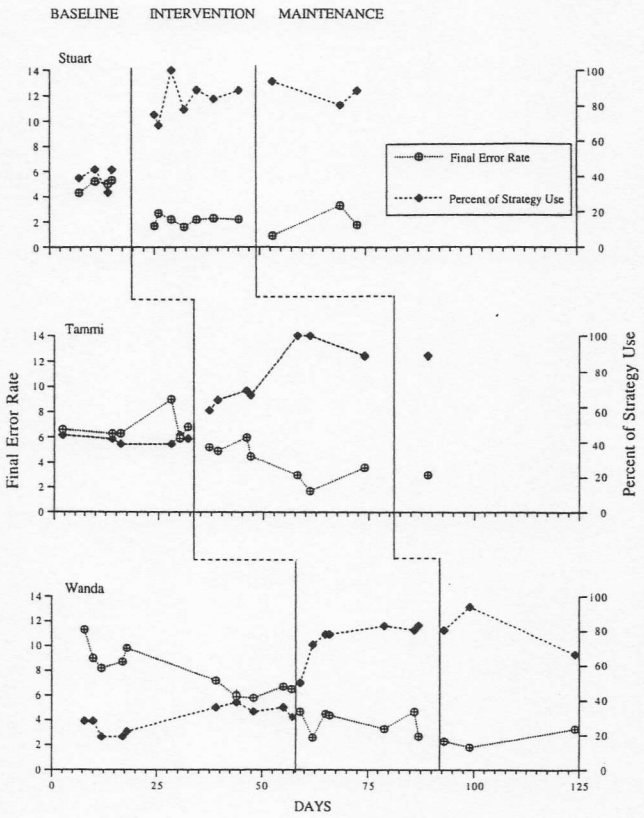

FIGURE 3 Percentage of strategy use and final error rate during controlled proofreading activities.

across the experimental conditions. For all 3 participants, performance improved from baseline to maintenance for all three types of errors.

Although noncontextual errors were corrected more frequently than were contextual errors in both the baseline and maintenance phases, the largest increase in percentage of errors corrected was observed for the contextual error category. In the baseline with spelling checker phase, noncontextual errors (scores of 88%, 78%, and 60% for Stuart, Tammi, and Wanda, respectively) were corrected more frequently than were contextual errors (scores of 14%, 10%, and 4% for Stuart, Tammi, and Wanda, respectively). This pattern of results was observed for all 3 participants. In the maintenance phase, although noncontextual errors again were corrected more frequently (scores of 98%, 92%, and 98% for Stuart, Tammi, and Wanda, respectively) than were contextual errors (scores of 63%, 63%, and 50% for Stuart, Tammi, and Wanda, respectively), the correction of contextual errors showed substantial improvement. This pattern of results also was observed for all 3 participants.

Proofreading Performance on Generalization Activities

Composition. The effect of strategy training on proofreading performance in the generalization composition activities is summarized in Table 3. Because of the variation observed in error rates on the different compositions for each participant, percentage of spelling errors corrected (i.e., the number of preproofreading errors minus the postproofreading errors, divided by the preproofreading errors × 100%) was used as the metric for the comparison of baseline and maintenance phase performances. For each participant, a greater percentage of errors was corrected following the intervention. For Stuart, spelling error correction scores of 65% and 61% for the two baseline compositions improved during the maintenance phase to 72% and 85%. For Tammi, error correction scores of 33% and 22% for the baseline compositions rose to 73% on the single maintenance probe available for this participant. The error correction scores for Wanda improved from scores of 33% and 32% for the baseline compositions to 70% and 73% for the maintenance compositions.

Dictation. During dictation activities, students transcribed a passage dictated by the instructor. Table 3 provides information on the effect of the intervention on proofreading performance on generalization dictation activities. As in the analysis of the compositions produced during the generalization activities, percentage of spelling errors corrected was used as the metric to compare baseline and maintenance performance. Proofreading activities carried out after the strategy training intervention eliminated a greater percentage of errors than did those carried out before the strategy training. For Stuart, error reduction performance improved from 65% (baseline) to 83% (maintenance). No information is available for Tammi because she did not participate in maintenance phase dictation activities. Wanda's error reduction rate improved from a baseline score of 24% to a maintenance phase score of 72%.

Participants' Perception of Strategy Efficacy

All 3 participants reported that the strategy training had improved their proofreading performance and that the use of the strategy was an efficient use of their time. Self-perception of the ability to detect and correct spelling errors following the strategy training ranged from "good" (Tammi and Wanda) to "very good" (Stuart). For all 3 participants, this represents an improvement over preintervention ratings of correction ability (when using a spelling checker) of "adequate" (Tammi and Wanda) and "good" (Stuart). All the participants reported that it would be a good idea for other students to learn the strategy, and they had no suggestions for changing the strategy or the way in which it was taught.

Interrater Reliability

During the baseline, intervention, and maintenance phases of the study, 20% of the participants' probes were randomly selected for rescoring. Each of these 14 probe samples (and the videotape of the participants' probe performance) was scored independently by two judges for the relevant dependent measures (i.e., strategy use, correction of spelling errors, and final error rate). Interrater agreement, as calculated using Cohen's Kappa (Suen & Ary, 1989), was determined for the

TABLE 2
Mean Frequency and Proportion of Corrections for the Three Error Types Across the Experimental Conditions

Participant and Condition	*Noncontextual Error, Correct Suggestion Provided (8 Errors Inserted)*	*Noncontextual Error, No Correct Suggestion Provided (4 Errors Inserted)*	*Contextual Error (8 Errors Inserted)*
Stuart			
Baseline	7.3 (.91)	3.3 (.83)	1.1 (.14)
Intervention	7.7 (.96)	3.9 (.98)	4.5 (.56)
Maintenance	8.0 (1.00)	3.7 (.93)	5.0 (.63)
Tammi			
Baseline	7.7 (.96)	1.7 (.43)	.8 (.10)
Intervention	7.3 (.93)	3.0 (.75)	3.7 (.46)
Maintenance[a]	8.0 (1.00)	3.0 (.75)	5.0 (.63)
Wanda			
Baseline	4.9 (.61)	2.3 (.58)	0.3 (.04)
Intervention	7.6 (.95)	3.8 (.95)	2.9 (.36)
Maintenance	7.7 (.96)	4.0 (1.00)	4.0 (.50)

Note. Parenthetical values are proportions of corrections.
[a]All maintenance scores for Tammi are based on a single follow-up session.

TABLE 3
Spelling Error Rate and Percentage of Spelling Errors Corrected on Generalization Activities

	Baseline			*Maintenance*		
Participant	*Composition 1*	*Composition 2*	*Dictation 1*	*Composition 1*	*Composition 2*	*Dictation 1*
Stuart						
Preproofreading error rate	13.8	13.2	20.7	13.8	14.8	14.4
Postproofreading error rate	4.8	5.1	7.2	3.6	2.2	2.5
Percentage of errors corrected	65%	61%	65%	72%	85%	83%
Tammi						
Preproofreading error rate	11.6	19.5	25.8	9.3	—[a]	—[a]
Postproofreading error rate	7.7	15.1	13.4	2.5	—[a]	—[a]
Percentage of errors corrected	33%	22%	48%	73%	—[a]	—[a]
Wanda						
Preproofreading error rate	12.0	7.5	17.8	14.2	9.6	12.8
Postproofreading error rate	8.0	5.1	13.5	4.2	2.6	3.6
Percentage of errors corrected	33%	32%	24%	70%	73%	72%

[a]End of school year precluded data collection.

participants' use of each of the five steps of the strategy: Scores for each of the five steps ranged from .79 to 1.00, with a mean score of .92. A Cohen's Kappa of .95 was obtained for interrater agreement for participants' corrections of proofreading errors in probe activities. Interrater agreement on the number of final errors in a text was calculated as .93 using Cohen's Kappa.

DISCUSSION

This study was designed to investigate the effects of proofreading strategy training on the spelling performance of high school students with LD. Past proofreading research with students with LD investigated the impact of learning strategy interventions (Blandford, 1990/1991; Schumaker et al., 1981; Shannon & Polloway, 1993) and assistive technology (Dalton et al., 1990; McNaughton et al., in press). However, it is unclear from past learning strategy intervention research whether the intervention closed the performance gap between students with LD and nondisabled students. It is also unclear whether the training resulted in generalized use of the proofreading strategy. In addition, strategies that incorporate the use of peers and teachers to assist in correcting spelling errors may produce enhanced rates of error correction; however, students preparing for higher education or vocational settings must be prepared to work independently (McNaughton et al., in press). Although assistive technology has assisted students in detecting and correcting errors in their written work (Dalton et al., 1990), the isolated use of technology has failed to close the gap between the spelling performance of students with LD and the performance of nondisabled students (McNaughton et al., in press). In this study, therefore, we examined the

reading strategy training (Blandford, 1990/1991). This study demonstrated that high school students can be taught to use an integrated approach to proofreading that enables them to detect and correct a large percentage of their spelling errors without seeking peer or teacher assistance.

As in past research in the areas of proofreading (McNaughton et al., in press) and mathematics (Horton, Lovitt, & White, 1992), this study demonstrates that access to technology in and of itself will not enable students with LD to perform at levels comparable to their nondisabled peers. The final error rate for the baseline with spelling checker condition was far removed from that observed with nondisabled individuals. Specific training in the effective use of the technology, in combination with additional strategies to compensate for current inadequacies of the technology, was necessary to bring performance within the realm of normal limits.

Limitations and Future Research Directions

Although this study makes a contribution to the current knowledge concerning effective instructional practices for students with LD, there are a number of limitations to the study that require consideration. First, the participants were not randomly selected from the population of students with LD; therefore, the results should be interpreted with care until the limits of their generalizability can be determined.

Second, the study does not examine the efficacy of the proofreading intervention in writing in specific content areas that may require the use of specialized vocabulary (e.g., scientific terminology). There may be content-specific vocabulary that students wish to use in their writing that is unknown to the computer spelling checker; additional research is necessary to examine the generalized use of this strategy across a wide variety of writing tasks.

Third, this investigation examines the use of a strategy package that combines a number of specific proofreading behaviors. This study does not include a component analysis of the steps and substeps in order to determine which contributed to the final outcome. Future research should include an examination of the individual components in this proofreading strategy in order to evaluate their contribution to the outcome.

Fourth, this study investigates only one aspect of the editing and revising process: the detection and correction of spelling errors. Students with LD may also need assistance in learning strategies to make substantive revisions in meaning as they edit their written work (Graham & MacArthur, 1988; MacArthur, Graham, & Schwartz, 1991; Stoddard & MacArthur, 1993). Directions to combine the search for errors while making revisions in meaning have typically not resulted in substantive improvements in spelling performance (Graham & MacArthur, 1988). It may be more appropriate to approach revision as a multistep process that involves a number of passes though a document for specific, different purposes (MacArthur, Schwartz, & Graham, 1991; Stoddard & MacArthur, 1993).

With respect to additional directions for future research, it should be noted that the selection of the behaviors chosen for training in the integrated proofreading strategy was based on a review of the literature on proofreading for nondisabled individuals, on proofreading for individuals with LD, and on search and error detection performance. At present, there are a large number of articles that describe what are believed to be "best practices" in proofreading, but only limited empirical validation of these techniques is available. An important line of future research is the identification of strategies, behaviors, and resources that distinguish good and poor proofreaders (Gerber & Hall, 1989).

Future research should also examine the long-term impact of improved proofreading performance on holistic measures of writing performance. It has been hypothesized that in order to develop higher level writing strategies, students with LD must be freed from the struggle to master basic spelling and writing conventions (Rapp, 1988). Future research should examine the impact of improved proofreading performance on other text and writing features.

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