Cognitive Tools for Writing: Scaffolding the Performance of Students through Technology

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Abstract. This study entailed the implementation and evaluation of a Web-based technology designed to support the writing performance of fourth- and fifth-grade students with learning disabilities (LD). The technology, Technology-Enhanced Learning Environments on the Web (TELE-Web), was implemented in a resource room setting involving 12 students with LD in the upper elementary grades. To evaluate the effects of the scaffolds on performance, students wrote personal news stories in three conditions: Scaffolded Personal News, Unscaffolded Personal News, and paper and pencil. The results revealed that the scaffolding condition significantly improved writing performance, particularly with respect to students’ abilities to produce organized texts.

Helping students acquire writing proficiency requires attention to text structure and text organization. Text structures function at the global or macrostructure level to help writers communicate the logical connections in text by organizing ideas into clusters of related ideas that are signaled to readers through written propositions. Text structures include genres such as written reports (factual texts organized by main ideas and details), procedures (explanation of a process), compare/contrast (comparing and contrasting two or more concepts or people), persuasion (expressing a certain position), and narrative (nonfactual or personal experience) (Halliday & Martin, 1993; Meyer, 1975; Meyer, Brandt, & Bluth, 1980; Spivey, 1997). Each text structure answers different types of questions (e.g., explanation texts answer the questions “What is being explained? What is the setting? What are the materials? What are the steps in the process or procedure? What is the outcome?”). Furthermore, each text structure uses different signals or key words to help readers locate or reference the information (e.g., explanation texts signal the steps through key words such as first, second, third, and last). To teach students to use text structures is to equip them with the metaknowledge related to how texts are organized to achieve a particular purpose, and how the attendant information is selected, packaged, sequenced, and signaled (Cope & Kalantzis, 1993; Halliday & Martin, 1993; Williams, 2003).

Well-written expository texts also are developed at the local level through the provision of introductory statements that orient the readers to the topics, text structure, and purpose of the text, and that set the stage for the information that will follow (Halliday & Martin, 1993). Each of the supporting subtopics or textual units then is signaled by introductory or preparatory statements and further embellished with relevant details that offer topical breadth and depth (Halliday & Martin, 1993). Recursively, therefore, written text contains introductory and concluding or summary statements that offer a wavelike function through the text, simultaneously setting up and wrapping up the subtopical presentations of information for readers to achieve effective communication (Halliday & Martin, 1993). Practically, in classroom settings, teachers often refer to the organizational devices that help writers develop and convey the local structure and meaning relationships through the concepts of main ideas, details, and conclusion sentences. The intention is that these language and
symbolic concepts will help young writers understand the discursive conventions associated with effective communication of ideas at the local and global levels.

Text structure instruction has been shown to be a highly effective tool in improving the writing performance of elementary writers for both narrative and expository texts (Gersten & Baker, 2001; Graham & Harris, 1989, 1993; Vaughn, Gersten, & Chard, 2000; Williams, 2003; Wong & Berninger, 2004; Wong & Wilson, 1984). Through text structure instruction, students acquire a better knowledge of how texts are conventionally structured, what patterns are used in a particular kind of text, what types of information are required, and how signal words enhance text cohesion and readability (Spivey, 1997). As a result of such explicit instruction, students produce texts that have been found to be more syntactically complex, better organized, and better connected for the reader (Englert et al., 1991; Graham & Harris, 1989, 1993; Spivey, 1997).

Among the most challenged group of writers are students with language and learning disabilities. Students with learning disabilities experience a number of difficulties that impact writing performance, including their difficulties identifying and employing text structures (Englert, Raphael, Fear, & Anderson, 1988; Englert & Thomas, 1987; Graves, 1991; Wong & Wilson, 1984), providing relevant details that support a given structure (Englert, Hiebert, & Stewart, 1988; Englert et al., 1988; Thomas, Englert, & Gregg, 1987), performing the subroutines of the writing process (Graham & Harris, 1997; Graham, Schwartz, & MacArthur, 1993), determining the main idea (Williams, 2003; Wong, 1979), and self-regulating their writing performance (Graham & Harris, 1989, 1993; Graham, MacArthur, Schwartz, & Page-Voth, 1992; Wong, Wong, & Blankinsop, 1989).

Instructional interventions that have focused on the improvement of text structure knowledge have been found to improve the writing performance of students with disabilities (Vaughn et al., 2000; Wong, 1997). Meta-analyses of writing interventions conducted with students with high-incidence disabilities over the past decade suggest the importance of writing programs that enhance students’ knowledge and employment of text structures (Gersten & Baker, 2001). The explicit teaching of the conventions of particular text structures offers a useful guide to students with disabilities in undertaking the writing task, and the application of that knowledge results in the improvement of the expressive writing abilities among students (Englert et al., 1991; Vaughn et al., 2000; Wong, 1997).

Affordances of Technology for Students with Disabilities

The challenge remains for the provision of supports that prompt and extend students’ uses of text structure while they are in the act of text construction. To address the writing challenges of students with disabilities, some educators are turning to technology (Edyburn, 2003).

Instructional technologies offer several advantages that might be useful in enhancing a writing program. First, technology can be used to offload some of the cognitive work from the inexperienced writer onto the computer, just as a calculator might be used to offload some of the cognitive demands on students in mathematics (Lajoie, 2000; Pea, 1993; Perkins, 1993; Salomon, 1993). In the case of text structures, for example, technology can be used to make visible the text structures of written language in ways that make them accessible, thereby furthering their use as conscious objects by students (White, Shimoda, & Frederiksen, 2000). By reminding students of the topical patterns, topic sentences, related details, and concluding sentences that stage a particular type of text, technologies can reduce the cognitive demands by supplying an organizational framework that might help students with disabilities to generate, sequence, and arrange information to suit a given writing purpose (see Baker, Gersten, & Scanlon, 2002; Sturr & Rankin-Erickson, 2002). In this fashion, computer technology can function as an instructional partner by prompting cognitive resources and tools that complement and extend the current abilities of a student (Hauser & Malouf, 1996; Pea, 1993; Wertsch, 1998).

Second, technology offers the potential to mediate students’ performance through the provision of prompts or scaffolds to elicit cognitive processes or information that might not be employed by writers with disabilities (Anderson-Inman, Knox-Quinn, & Horney, 1996; Pea, 1993). The concept of scaffolding is based on the notion that with assistance, students can accomplish tasks or apply strategies that they could not perform independently (Stone, 1998, 2002). Baker et al. (2002) refer to such cognitive scaffolds that support performance as procedural facilitators. Procedural facilitators include questions, prompts, or procedural steps that offer students a strategic plan to help them emulate the performance of more expert learners. Given the fact that students with learning disabilities often do not employ writing strategies, procedural facilitators that are incorporated into a computer technology may help them apply strategies outside of the teaching contexts in which they were first learned. For example, computers might offer reminders of the types of information that might be important for a given writing topic or purpose, such as providing a lexicon or word bank that might be germane to a given topic, or supplying a series of questions that might prompt idea generation or text-monitoring processes. In this manner, technology can function as a type of cognitive platform upon which writers can recall writing procedures, invoke cognitive routines, and direct text generation and evaluation tasks. By incorporating procedural facilitators into the software, students might be able to shift from writing with the extensive support of the teacher to writing with computers that prompt them to direct and self-regulate their own performance (Bahr, Nelson, & Van Meter, 1996; Englert, Manalo, & Zhao, 2004).

Third, technologies can offer basic tools that support writing performance. By making text-to-speech
or spelling functions accessible, for example, students might find it easier to read, write, and edit their texts in order to clarify potential confusions. Through the use of such skill-enabling tools (Daniels, 2001), students with disabilities can bolster their performance and exhibit conventional writing practices that are in advance of what they could produce in unassisted situations (Borgh & Dickson, 1992; Day & Edwards, 1996; MacArthur, 1990). These types of assistive technologies have been used with practical benefits for many years.

In summary, technologies might be employed to help less proficient writers advance their writing skills through the provision of online anchors, tools, strategies, and assistance technologies. Technologies can prompt a repertoire of tools that might support writers’ thoughts and actions in advance of independent performance. According to Stone, such scaffolding environments are effective because they enable a novice to solve a problem, carry out a task, or achieve a goal that would be beyond his solo efforts (Stone, 2002). However, little research has been conducted to examine the effects of scaffolding in Web-based environments on students’ performance. Web-based environments are universally available, which make them an especially intriguing environment to examine in terms of their potential utility or limitations in improving the writing performance of students with disabilities.

The purpose of this research was to investigate the effects of a Web-based software, the Technology-Enhanced Learning Environments on the Web (TELEWeb; Englert & Zhao, 1996). TELE-Web was designed to support the writing development of students with high-incidence disabilities in the elementary grades. TELE-Web offers instructional scaffolds that mark some of the criterial features of the text structure, thereby making the organization of text visible at the global and local levels for writers with disabilities. In addition, TELE-Web offers prompts and text-to-speech functions that support students’ abilities to monitor their texts. The question underlying this study was: Does the provision of text structure scaffolds in a Web-based scaffolding environment influence the writing performance (e.g., use of genre features) of students with learning disabilities? To address this question, the effectiveness of the Web-based scaffolding environments was evaluated by requiring students with learning disabilities (LD) to write a personal narrative (personal news) paper under three conditions: (1) paper and pencil, (2) unscaffolded and unsupported writing on the computer, and (3) supported Web-based writing using the TELE-Web scaffolds.

**METHOD**

**Subjects**

The study took place in an upper elementary resource room in an urban school of a medium-sized city in Michigan. Twelve students with school-identified LD participated in the experiment. Approximately 86 percent of the students in this school received free or reduced-price lunches. Forty-seven percent of the school population were African American, 26 percent were Hispanic, 2 percent were American Indian, 1 percent were Asian, and 24 percent Caucasian. Seven students were in fourth grade and five in fifth grade.

All participating students received at least 2 hours of daily instruction in the resource room for reading and writing. All students were diagnosed with LD according to the district guidelines for eligibility requirements for LD, which required that students demonstrate severe discrepancies between their actual and expected levels of achievement based on intellectual capacity in one or more of seven academic areas (oral expression, listening comprehension, basic reading skills, reading comprehension, written expression, mathematics calculation, and mathematics reasoning). The decision for eligibility was made by the multidisciplinary team. Additional student information is provided in Table 1. Grade-equivalent reading scores of the students, based on the Slosson Oral Reading test (Slosson & Nicholson, 1990), ranged from 0.8 to 5.5, with a mean of 2.8.

Nine students completed the Test of Written Language (TOWL; Hammill & Larsen, 1988) prior to the start of the study. On the TOWL Story Construction task, students obtained percentile rankings ranging from 0 to 37%, with an average percentile rank of 21.88%. On the other hand, their Contextual Language percentile scores ranged from 2 to 9%, with an average percentile rank of 4.7%. As a group, therefore, the students with LD tended to perform below average across the subtests, indicating a need for instructional support in the area of writing. In fact, all students had Individualized Education Plan goals and objectives in writing.

**Procedures**

The expectation for the Personal News activity was based on a narrative text structure. The students were asked to provide descriptive or expository information about a newsworthy event or topic. The specific information required for this text structure included: who are the main characters, what is the topic of the event, where and when did the event take place, what happened, what are the essential details related to the topic, and why it is important. However, students were expected to provide informational details and relevant ideas that provided explanatory content about their experience or event. In this sense, the paper was a hybrid text that bridged expository and narrative text structures. The teacher had familiarized students with the text structure of personal news and the supporting skills or strategies, which had been introduced in guided and interactive lessons during the 2 months preceding the design experiment.

The teacher also guided students in learning the organizational strategies that they should apply in writing their informational texts across the three conditions,
TABLE 1  
Student Characteristics

<table>
<thead>
<tr>
<th>Student</th>
<th>Ethnicity</th>
<th>Gender</th>
<th>Grade Level</th>
<th>Reading Level&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Context Lang&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Story Const&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Disability</th>
<th>Other Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gus</td>
<td>AA</td>
<td>M</td>
<td>11-3</td>
<td>4</td>
<td>2.8</td>
<td>2%</td>
<td>25%</td>
<td>LD</td>
</tr>
<tr>
<td>Tony</td>
<td>C</td>
<td>M</td>
<td>12-1</td>
<td>5</td>
<td>4.2</td>
<td>9%</td>
<td>16%</td>
<td>LD</td>
</tr>
<tr>
<td>George</td>
<td>H</td>
<td>M</td>
<td>10-10</td>
<td>4</td>
<td>2.3</td>
<td>1%</td>
<td>9%</td>
<td>LD</td>
</tr>
<tr>
<td>Jack</td>
<td>C</td>
<td>M</td>
<td>11-7</td>
<td>4</td>
<td>2.4</td>
<td>2%</td>
<td>9%</td>
<td>LD</td>
</tr>
<tr>
<td>Cody</td>
<td>H/AA</td>
<td>M</td>
<td>11-0</td>
<td>5</td>
<td>5.5</td>
<td>2%</td>
<td>9%</td>
<td>LD</td>
</tr>
<tr>
<td>John</td>
<td>C</td>
<td>M</td>
<td>11-7</td>
<td>4</td>
<td>1.7</td>
<td>5%</td>
<td>37%</td>
<td>LD</td>
</tr>
<tr>
<td>Britt</td>
<td>C</td>
<td>F</td>
<td>10-5</td>
<td>4</td>
<td>2.8</td>
<td>9%</td>
<td>37%</td>
<td>LD</td>
</tr>
<tr>
<td>Bob</td>
<td>AA</td>
<td>M</td>
<td>10-10</td>
<td>5</td>
<td>3.9</td>
<td>9%</td>
<td>5%</td>
<td>LD</td>
</tr>
<tr>
<td>Brandon</td>
<td>AA</td>
<td>M</td>
<td>11-8</td>
<td>5</td>
<td>0.8</td>
<td>1%</td>
<td>0%</td>
<td>LD</td>
</tr>
<tr>
<td>Anthony</td>
<td>AA</td>
<td>M</td>
<td>10-10</td>
<td>5</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>LD</td>
</tr>
<tr>
<td>Brie</td>
<td>AA</td>
<td>F</td>
<td>10-2</td>
<td>4</td>
<td>2.4</td>
<td>–</td>
<td>–</td>
<td>LD</td>
</tr>
<tr>
<td>Fatima</td>
<td>AA</td>
<td>M</td>
<td>9-10</td>
<td>4</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>LD</td>
</tr>
</tbody>
</table>

<sup>a</sup>Reading scores are reported for the Slosson Reading Test (Slosson & Nicholson, 1990).  
<sup>b</sup>TOWL Contextual Language reported as percentile score.  
<sup>c</sup>TOWL Story Construction reported as percentile score.

Note: Ethnicity: C = Caucasian, AA = African American, H = Hispanic, As-A = Asian American, H = Hmong. Gender: M = Male, F = Female. SSW = social service worker.

emphasizing that students should: (1) write down the main idea of their paragraph as the topic sentence, (2) provide two to three supporting detail sentences that give additional information related to the premise of the topic sentence and that address the Wh-questions, (3) use transition words (e.g., first, next, and finally), and (4) check the story by reading their paragraph(s). The teacher reminded students to monitor and reread their texts in order to produce a well-written, informative, and interesting news story. Students were told that they should write a story about a newsworthy experience or topic, and they could produce a text of any length.

Each student was randomly assigned to the three conditions across the 3 weeks to counterbalance the order of the conditions. Similar oral instructions were provided to all students across the three conditions. In fact, identical oral instructions were provided simultaneously to all students in the classroom. The students were told that they would be writing three personal news papers in three different ways over the course of 3 weeks. One-third of the students were sent to their desks to write their papers using paper and pencil; one-third of the students wrote their texts in TELE-Web to parallel a word processing task but without cognitive supports; and one-third of the students wrote their texts using the scaffolded and mediated conditions of TELE-Web. The conditions were rotated according to the random assignment until each student had written a paper in each of the conditions. Because there were only a limited number of computers in the classroom, it was natural for a group of students to rotate to the computers to write their texts while another group wrote their texts at their desks. (There were six MacIntosh computers in the classroom that were used during the study.) All students involved in the study handed in their writing at the termination of each session, but students were allowed as much time as they needed to write their texts.

### Supported News Condition

The TELE-Web Supported News offered structural reminders to prompt students’ attention to the local organization and signaling of their ideas. To help students with the staging of their ideas, a topic sentence box was provided at the top of the computer screen (see Figure 2) to prompt students to generate an introductory sentence for their texts. Immediately following the topic sentence box was a supporting details text box that was intended to cue students to compose details that adhered to their chosen topic. Each time students chose to Add Paragraph, a new topic sentence and supporting details text box appeared. Finally, a concluding sentence box was provided near the bottom of the computer screen in which students could compose a summary statement to wrap up or conclude their texts. Figure 1 shows an example of the student interface during the Supported News condition.

TELE-Web allowed students to see teacher prompts, which were brief reminders prepared by the teacher about the topical content, genre-related questions, strategies, or key words of a particular text structure. These teacher prompts appeared in a pop-up window when students clicked on the word Prompts. The prompts disappeared when students returned to the composing area of an activity, thereby offering students a temporary rather than permanent scaffold. In this study, the teacher provided the following genre-related prompts: “Use Who, What, When, Where, How to help you,” “Use exciting words to make your paragraph
interesting,” and “Repeat your topic sentence at the end in a different format to cover your main idea again.”

Teachers also customized their instructions to students using the instruction box, which appeared at the top of the screen. In this study, the following reminders of the teachers’ emphasis on the text structure features and targeted writing skills were incorporated into the written instructions: (1) “Write down your first main idea as the topic sentence of your paragraph,” (2) “Write down supporting ideas for your topic sentence,” (3) “Use words like first, next, and finally to start your supporting sentences,” and (4) “Read your paragraph out loud.”

In addition to the teacher scaffolds that highlighted the topic and structural features of the personal news story, there were four additional features of the TELE-Web environment that allowed students to access online support. These were controlled by students. First, TELE-Web allowed students to self-employ a spelling checker that matched words against an online dictionary. The dictionary bolded potential misspellings by indicating words that were not in the dictionary, but it did not offer alternative spellings. Second, students could check their text by having the computer read back their texts using a text-to-speech function. The text-to-speech function permitted them to compare the realized spoken words against their intended words. Third, students had the option of sharing their work with other students, including a friend, the whole class, another classroom, or the entire TELE-Web community. This TELE-Web function provided a public area that allowed students to post their drafts in order to receive feedback that they might incorporate into their final drafts. Fourth, once an assignment was completed, it was handed in to the teacher through the online submission feature of TELE-Web. Teachers could provide feedback and communicate when an assignment was finished, which meant that students could publish their final drafts in TELE-Web, although during the study, the teacher did not provide written feedback on TELE-Web in order to standardize the feedback procedures across conditions.

Although students were provided with various scaffolds, students still maintained control of the Supported News activity. Students determined the length and format of their text by inserting new paragraphs on an
as-needed basis. When students chose to insert a new paragraph, new topic sentence and detail sentence boxes appeared. Therefore, students were positioned to be active agents who made decisions about the nature, quantity, and quality of their texts. When students completed their written text, the individual structural elements of their texts (topic sentences, detail sentences) were merged by the program into a single unified text. In this manner, students were prompted by the scaffolding features of TELE-Web to generate the global and local elements of the text structure in the Supported News condition, but these scaffolds disappeared when they completed or submitted their texts. Students could see a full version of their final texts in a print-ready form without the prompts or instructions, and this version could be shared with other students.

Unsupported News Condition

For the Unsupported News condition, students wrote their texts on the computer using TELE-Web. They received the same oral directions and prompts from the teacher because the instructions were provided to all the groups at once, but students did not have access to the visual and genre-related scaffolds associated with the Supported News condition (e.g., topic sentence box, detail sentence box, paragraph boxes), with the exception of two boxes: a title box and text box. Thus, the Unsupported News condition paralleled a word processing condition, in which students typed a story on a computer after receiving oral instructions provided by the teacher. As with all the conditions, students in the Unsupported News condition were told to provide as much information about their newsworthy event in order to thoroughly explain their topic to their readers. Similarly, they were reminded to apply the various strategies or skills that they had learned for writing well-formed texts, which included brainstorming, organizing, composing, and editing strategies, as well as the organizational features of the Personal News text structure (Englert & Dunsmore, 2002; Mariage, 2001). In the Unsupported News condition, students had access to the text-to-speech and spelling checker functions.
They could Save, Preview, and Share their texts, although sharing and feedback features were not used by students or the teacher during this study.

**Paper and Pencil**

For the paper-and-pencil condition, the students were given lined paper and were required to write about any newsworthy topic of interest. The teacher reinforced his expectation for the Personal News activity that writers were to provide descriptive or expository information about a newsworthy event or topic. Thus, the topic and genre expectations were the same across all three conditions because students were told to choose a newsworthy topic from their personal lives and write about that topic for a distant audience. However, no prompts or scaffolds were visible to the students during the paper-and-pencil condition. The students writing in this condition spent time working individually on their personal news story, after which they turned in their story. This procedure was held constant across conditions. They, too, were reminded to use the skills, strategies, and text structure elements that had been previously modeled and presented in the classroom. Again, these instructions were provided to all students at once.

**Scoring Procedures**

Papers were evaluated to determine the quality of each paper based upon a primary-trait scoring scheme developed by Englert, Gover, Dunsmore, and Conway (2000). This rubric (see Table 2) incorporated the following major genre-related features marking the quality of a good personal narrative essay: (1) the title, (2) introduction to the paper’s topic, (3) the inclusion of related details, (4) conclusion, and (5) overall organization (introduction, details, and conclusion parts). With the exception of the details and titles, each trait was assigned a value from 0 to 3 to indicate the extent to which the primary trait was present or absent. To score the provision of related details, a count of each nonrepetitive and nonredundant detail was calculated for each text.

To evaluate the rater’s reliability in applying the rubric, a second rater randomly selected and scored 33 percent of the scored texts. Individual papers were typed so that the two raters were blind to the writing.

**TABLE 2**

<table>
<thead>
<tr>
<th>Rubric for Scoring Papers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
</tr>
<tr>
<td><strong>Introduction to the paper’s topic</strong></td>
</tr>
<tr>
<td><strong>Conclusion</strong></td>
</tr>
<tr>
<td><strong>Overall organization</strong></td>
</tr>
<tr>
<td><strong>Provision of details and images</strong></td>
</tr>
</tbody>
</table>
condition. The agreement between the two raters for cell-by-cell comparison across subjects ranged from 80 to 98 percent, with an average overall agreement of 95 percent.

Finally, to evaluate the effects of the condition on productivity and text generation, counts of words and text lines were measured using the Word Count feature of Microsoft Office Word. This ensured a comparable standard of performance across conditions, and a scoring reliability for these two variables of 100 percent.

RESULTS

First, an analysis was conducted on the text structure quality of students’ written texts. Students’ written texts were scored on the five primary traits and then analyzed using a multivariate analysis of variance (MANOVA) to test the effect of the three conditions while taking into account the interrelatedness among the variables. If the overall multivariate analysis was significant, then the individual univariate $F$ tests were examined to see which made the greatest contribution to the statistically significant multivariate test.

The results revealed a statistically significant main effect for condition, $F(10, 46) = 3.806, p = .001, ES = .485$, that was significant at the .01 level. The effect size statistic, based on the partial $\eta^2$ statistic, was considered large in magnitude (Cohen, 1988).

Next, we examined the univariate $F$ ratios to determine which dependent variables made the greatest contribution to the overall statistically significant multivariate effect. Three variables made a statistically significant contribution: (1) Titles, $F(2, 35) = 5.836, p = .008, ES = .302$; (2) Inclusion of related detail sentences, $F = 8.637, p = .001, ES = .390$; and (3) Organization, $F = 10.02, p = .001, ES = .426$. Of these, the largest contributing factor was the overall organization of children’s texts, which accounted for 43 percent of the variability in performance. In all cases, the effect size was moderate to large.

To test the specific differences among the three conditions for each of these significant dependent variables, a Bonferroni post hoc analysis was performed on each of the significant variables. The Bonferroni test was selected because it adjusted the significance level based on the fact that there were multiple comparisons, and it offered a more powerful test when there are a smaller number of pairs. In the analyses of students’ uses of \textit{titles}, the Bonferroni test results revealed that students included significantly ($p < .05$) more titles in the Supported News ($M = .92$) and Unsupported News ($M = 1.00$) conditions than the paper-and-pencil ($M = .50$) condition. However, their performances in the two Web-based computer (TELE-Web Supported, Unsupported) conditions were virtually identical ($p > .05$). When students were provided with title text boxes, they included titles on a nearly uniform basis. However, in the absence of title boxes, students were only likely to title their texts 50 percent of the time.

The Bonferroni test was applied to the \textit{related detail} scores of students. The results revealed that students produced significantly ($p < .05$) more details in the Supported News ($M = 5.18$) condition than the paper-and-pencil ($M = 2.75$) and Unsupported conditions ($M = 3.36$). This finding suggested that the scaffolding condition had a substantial effect on students’ inclusion of details. Students produced more informative and nonduplicating details in the presence of scaffolds than in the same Web-based environment in the absence of scaffolds.

The Bonferroni test was applied to the \textit{organization} scores of students. This score represented the extent to which students had incorporated the overall macrostructure of a personal narrative in their text, including at least two of the three parts of a well-organized paper, for example, introduction, body, conclusion. Again, students showed their highest level of performance when they were writing in the Supported News condition (2.64), which was significantly superior ($p < .05$) to their performance in the paper-and-pencil condition ($M = 1.13$). On the other hand, their performance in the Unsupported News condition was in the mid-ranges of performance ($M = 1.91$), which was not significantly different ($p > .05$) from their performance in the other two conditions. Clearly, the availability of scaffolds improved the overall organization of the personal narratives of students with LD, relative to their performance in the paper-and-pencil condition. Although students seemed to show some gains when given the opportunity to type their texts on TELE-Web, their performance in the Unsupported condition was less than that attained when students had access to reminders and procedural facilitators that focused their attention on the organization and features of the text structure.

Finally, to evaluate productivity, we performed a MANOVA on the length of stories by analyzing the number of words and text lines across condition. The MANOVA was not significant, $F(4, 52) = 2.048, p > .05$. Students produced a similar number of words across the three conditions (Supported $M = 53.36$, Unsupported $M = 42.00$, paper and pencil $M = 43.25$). Similarly, the number of text lines was not significantly different across conditions (Supported $M = 3.09$, Unsupported $M = 2.55$, paper and pencil $M = 2.25$).

Examples of Effects of Conditions on Students’ Performance

As a follow-up to the overall analysis, we calculated the number of students who showed a decided advantage for one of the three conditions (Supported News vs. Unsupported News vs. paper and pencil). A simple count of the students with LD who achieved their best performance in each of the three conditions was calculated based on their aggregated primary trait scores (see Figure 3). Of the 11 students with LD, 54 percent achieved their highest total ratings in the Supported News condition, suggesting that they benefited most from the provision
of text structure and genre-related strategy scaffolds. Four students (36 percent) performed equally well in the TELE-Web Supported News and Unsupported News conditions, but only 1 student (9 percent) showed a decided advantage based on the total primary trait scores for the Unsupported News condition, and no student with LD obtained his or her highest score in the paper-and-pencil condition.

To concretely represent some of the differences in the types of texts produced, we selected a student, Jack, who achieved scores proportionately relative to the students’ average performance in each of the three conditions. Although slightly higher than the overall mean, the student’s relative performance across the conditions paralleled the differences found in the group. For the Supported News condition, Jack chose the topic, “Michi-
gan.” His story is shown below.

Michians Praduets

I am going to tele you about Michigan! First I am going to tell you about Michigan. Michigan has many products made in the state. Michigan makes millions of things. Michigan has the biggest factory in Lansing. Its name is General Motors. Second I am going to tell you about some of the things that Michigan makes. They make many things, such as corn, car, cereal, and other things too. Last but not least Michigan make many more things all over the state of Michigan. by Jack. that is Michigan

Jack titled his story, “Michians Praduets” (sic), and then he proceeded to frame his story by providing relevant details related to this topic, which he signaled in his topic sentence: “I am going to tele (tell) you about Michigan!” Jack’s story included fairly specific details about several things related to his topic, including content that addressed the “where” or location of his subtopics: “Michigan has the biggest factory in Lansing.” He also provided specific names pertaining to “what” (“Its name is General Motors”). Later Jack named the things that Michigan makes, “such as corn, car, cereal, and other thing too.” Throughout his text, Jack made good use of the signal words, “First, I am going to tell you about Michigan”; “Second I am going to tell you about some of the things that Michigan makes”; and “Last but not lest (least) Michigan make many more thing all over the state of Michigan.” Jack closed his story with a rudimentary concluding sentence that represented his attempt to close or wrap up his topic: “That is Michigan.”

For the Unsupported News condition, Jack produced a rather broad title that framed his entire paper. His paper is shown below.

My Weekend

My family went fishing. My brother and I did not fish. My mom, dad and my sister fished. My sister caught the biggest fish. It was a catfish. It was 24 inches long and weighed almost 30 pounds. It’s whiskers were as long as a number 2 pencil!

Jack chose to write about “My Weekend,” and he provided a topical introduction with his topic sentence: “My family went fishing.” The rest of his paragraph provided details about his topic, but the paragraph lacked the level of detail and signaling produced during the Supported News condition. He informed his readers about who are the main characters of his story (mom, dad, sister), but he did not name his topic’s location. He provided the greatest detail about the fish, stating that “It was a catfish. It was 24 inches long and weight almost 30 pounds.” Jack failed to generate a concluding sentence. Overall, the paper lacks some of the complexity in structure and signaling of embedded subtopics as exemplified in his Supported News paper.

Finally, Jack’s paper-and-pencil story is shown below.

“Snaks”

Do you like snakes. I do? That are cool! My favorer is the King Koderu (Cobra). I like the way that backs blow up. It is cool! I like snaks! By Jack M.

Jack entitled his story, “Snaks (Snakes)”. His introduction appeals to his readers in a way that might not have been evident in his other TELE-Web texts. He wrote, “Do you like snakes. I do? That are cool!” The snake story takes on an egocentric and personal tone, focusing
on Jack’s interest in snakes. There is more passion about his topic, although it lacks the level of detail that characterized his Supported News story. Although he was truly enthusiastic about his topic, Jack delivered only one piece of information about his topic (“I like the way that backs blow up”). The topical development across the text was fairly weak, and he did not lead the reader to different aspects of his topic through techniques associated with framing or staging his ideas. Jack possessed quite a bit of knowledge about snakes, but his deeper knowledge of his topic was not prompted. In many ways, his snake topic lent itself to a more expository stance to the topic, but he delivered a narrative perspective on the topic.

Interestingly, Jack’s spelling accuracy across the texts was greatest in the TELE-Web conditions. His accuracy on the two TELE-Web texts was 96 percent, whereas his spelling accuracy in the paper-and-pencil story was 78 percent. Students did seem to avail themselves of the spelling checker option to locate spelling errors. In fact, students showed a decided interest in perfecting their texts on TELE-Web, and they invested great personal effort in monitoring their texts and problem solving to ensure that their texts were satisfactory. The following set of observations from the observer’s fieldnotes revealed Jack’s interest in revising his story and making use of the various functions (e.g., spelling checker and text-to-speech) during the TELE-Web Supported News condition.

Jack: [After finding that ‘millions’ was misspelled in his Michigan paper] Mr. Black, how do you spell “millions”? 
Jack: [uses the text-to-speech function to reread his text, and fixes several things in his text: Capitalizes ‘m’ in Michigan and adds the ‘g’ in Michigan.] 
Jack: [uses the spellchecker, then fixes ‘pradets’ (products)] 
Jack: “It still doesn’t recognize my name.” [after employing the text-to-speech function] 
Teacher: It’s okay. You can keep that. 
Jack: But I want it to be perfect! 
Jack: [clicked on “preview” and then said to the observer: This is what I did!] 
Jack: [Again after listening to the text-to-speech functions]: Oh, “in Lansing.” I am going to go back and change it. I’m gonna make it sound better. [He changes the repetitious phrase in the sentence “Lansing has the biggest factory in Lansing” to “Michigan has the biggest factory in Lansing”.] 
Jack: Mr. Black, Can you print this? 
Mr. Black: Yeah. 
Jack: All the words are correct. I fixed it, but I didn’t hand it in. 
(From March 28th, 2001 Field Note)

Writing on TELE-Web, Jack was able to take an executive attitude toward his text. He wrote with attention to the details and the meanings that he was trying to communicate. It appeared that he had an audience in mind other than the teacher, displaying great ownership of the text and final product (“I want it to be perfect!”). He monitored his text and authenticated its accuracy (“All the words are correct. I fixed it”). TELE-Web tools seemed to bring him closer to the end-product by offering him tools to control the process of drafting and revising his written work. Although students with learning disabilities tend to be passive and dependent on others with respect to evaluating their academic performance, Jack adopted a more metacognitive stance to his work. Taking advantage of the mediational potentials of TELE-Web and the student-controlled help systems, Jack was able to display a higher level of performative, metacognitive, and developmental abilities when he was writing in the Supported rather than the paper-and-pencil condition—a condition that was perhaps more representative of the situational conditions that surround the performative act of writing alone in many school settings.

Of course, the ultimate question is to what extent students internalize the scaffolds to become autonomous writers. This is a legitimate question for interventions that involve Web-based scaffolds, because the question about internalization is foremost in evaluating long-term efficacy. To shed some light on this question, Jack was asked to write a Personal News story in an Unsupported writing condition at the end of the year. The story he wrote is shown below:

The mud bogs

Wet, brown, and mucky, what am I talking about? I am talking about mud, mucky mud! Do you Know what goes good with mud? trucks, 4x4 trucks big, powerful, loud and very cool! I like the mud bogs. I watch my dad’s friend go mud bogging at another friend’s house in the country. I go in the trucks too. They get stuck a lot! That was the time I went mud bogging.

Jack’s story has a title and introduction to his topic that engages his audience (“Wet, brown, and mucky, what am I talking about?”). He even answered his own question with a response (“I am talking about mud, mucky mud!”). In the next segment of the text, he again used a question to introduce and to engage his audience with the next subtopic pertaining to trucks (“Do you Know what goes good with mud?”). Jack then provided a number of related details that flesh out his topic: “4 X 4 trucks;” “big, powerful, loud and very cool!”). He generated a statement that, simultaneously, wrapped up and introduced the next chunk of details: “I like the mud bogs.” The final set of details described his experience with mud bogs, concluding with the sentence that summarized his entire experience: “That was the time I went mud bogging.” Overall, his story offers a series of staging and wrapping devices that take the reader through his text and the topic. The details
DISCUSSION

This study was undertaken to explore the potential benefits of Web-based scaffolding on the writing performance of students with LD. The findings suggested that computer-supported environments could mediate and scaffold their performance. By making writing tools and text structure strategies available during text construction, students were prompted to incorporate the various properties associated with well-organized texts. Students with LD were more likely to include more details related to their topics and to organize their texts globally by generating a macrostructure consisting of at least two parts that corresponded to the paper's introduction, body of related details, and/or conclusion. The organizational quality and structure of students' stories were affected, while overall production was not affected.

The observational data further suggested that students took advantage of the task-specific hints available to them through the software. Students were observed accessing the spelling checker and text-to-speech tools to support their execution of metacognitive and self-monitoring tasks. They incorporated the textual elements that were prompted by the genre-related properties of the software. The mediation of their performance through the use of such goal-embedded tools supported text production in ways that were not fully realized by the same students writing under traditional paper-and-pencil writing conditions.

Jonassen and Carr (2000) suggest that cognitive tools are devices that support students' cognitive processes by bolstering some of the performative aspects of a task, as well as by freeing students' memories for higher-order thinking, or by reminding and prompting students to apply strategies in the context of problem solving. TELE-Web did seem to offer several cognitive tools. These included an explicit spatial representation or template of the text structure genre, which provided a cognitive anchor on which students could organize and stage their ideas and information. The presence of this mediating structure might have meant that students were not required to hold the text structure in memory because the organizational pattern was modeled and guided by the software. Consequently, information that might otherwise be omitted in paper-and-pencil tasks was present or developed in the Supported News condition. In this respect, TELE-Web might allow students to offload some of the memory and strategic requirements of the writing process onto the machine (Sugrue, 2000). In collaboration with the mediational environments of a technology tool, students with LD might be guided to perform at levels in advance of their performance in more solitary and independent writing conditions.

In addition, what might be especially helpful in the design of mediational devices in writing contexts is the provision of cognitive support embedded in the situated act of text generation. The technology pointed out the specific locations where specific lexical or staging devices should be located. For example, reminders about topic and concluding sentences were embedded in the locations where the associated practices were expected to be utilized. In other words, the scaffolds were not removed from the writing process (e.g., cue cards or posters), but they were embedded in the very fabric of the writing task and the structural organization of the
In addition to prompting students’ knowledge about texts, TELE-Web supported students’ executive and regulatory skills related to monitoring their texts. Students could access user-controlled and receive embedded help for assistance with spelling or to access the text-to-speech functions (Sugrue, 2000). This feedback made it possible for many students to detect the writer–reader breakdowns that might result from spelling or grammatical (syntactic and semantic) miscues. The case study student, for example, used these self-checking features to take executive responsibility for monitoring his text and for achieving a writing standard that he was then able to establish for his work. TELE-Web allowed him to coordinate and regulate the writing process in ways that promoted his ownership of the final product and the means by which it was obtained. Interestingly, however, none of the students in the classroom shared their texts during the study, and none received feedback from their peers.

Theoretically, TELE-Web offers an example of a scaffolding tool that could be custom-made to support students. Teachers could offer heuristics, rubrics, or goals that might prompt students during the text generation and evaluation processes. These scaffolds could be customized for particular individuals or groups of students. Similarly, by highlighting or controlling aspects of the task that were beyond or at the edge of the learner’s capacity, students could concentrate upon those elements that were within their grasp (Stone, 1998). Operating with such tools, students could assume greater control of their texts and the text construction process. Executive decisions about the nature of their topics, the relevant details, the length of their texts, and the staging devices remained with the authors. TELE-Web remained a tool that interacted with, but ultimately was controlled by, the user.

In addition, the implementation of TELE-Web within the design experiment pointed to a new conceptualization of the role of the computer as a form of assessment. The criss-crossing of different types of scaffolds made it possible to conduct a dynamic assessment to see what supports benefited particular students. In a concrete way, it was possible to examine the zone of proximal development where students were assisted or supported to achieve at levels of performance that surpassed their unassisted performance. The technology presented interesting opportunities for providing assessment-like tools to determine the effect of scaffolds on performance, and the learner’s sensitivity to or independence of different mediational devices.

There are several limitations of this research that warrant deeper consideration. First, although TELE-Web offered cognitive resources for students with LD, it is important to realize that the technology itself was not sufficient to teach or to effect long-term changes independent of the classroom instruction. For maximum success, teachers will need to provide instruction on the underlying text structure, as well as model the language and processes associated with the performance of the various aspects of the task (e.g., topic sentence, concluding sentence, etc.). As Stone (1988) has suggested, for scaffolding to be successful, students must enter the interactive context with a prior understanding of what must be accomplished and how. TELE-Web resources only served as functional aids to intelligent performance when they were perceived as such by students (Claxton, 2002). In this study, the teacher had pretaught the text structure genre, and students had prior experience with the TELE-Web environment so that they had minimal questions about navigating through the system during the study. The teacher also remained available to answer questions while students wrote, but the teacher’s availability to and engagement with students during writing was identical across the three conditions. In this manner, we tried to isolate the effects of the conditions. Nonetheless, it was apparent that for the scaffolds to be effective, students needed to understand where cognitive tools were located and how they might be usefully employed to assist performance. Thus, the affordances of the software depended on the prior instruction and apprenticeship of the student into the nature and language of the writing process, and into the explicit functions of the writing tools and technology. Conversely, effective internalization of the mediating structures depends on the gradual withdrawal of scaffolds to promote the growing writing independence of students.

Second, TELE-Web seemed to influence children’s behavior by eliciting particular writing strategies that would not have been maximally employed without scaffolds. However, for students who might possess the requisite strategy and genre-related strategies, the benefits might not be fully realized because the scaffolds would not trigger strategies that were underutilized or at the developmental edge of students’ current abilities. In such cases, requiring the use of scaffolds might blunt the development of students’ metaknowledge about how to control the writing process or delay the developmental progression from technology-mediated performance to independent performance. Scaffolds must be tailored to the individual user and instructional history of students, and all students require developmentally appropriate mediational prompts and language tools for maximal performance.

Third, there were a relatively small number of subjects who participated in the study, and this limited the statistical power. The number of participants is directly related to power and effect size. Although a number of our hypothesized effects were in the predicted direction,
some variables failed to reach statistical significance, which might be attributable to the study’s sample size. The fact that several differences reached statistical significance with the relatively small sample size may suggest that the TELE-Web scaffolding may be a fairly potent intervention. However, a study of the intervention involving a larger sample size and conducted over a longer time period would more likely maintain the adequate power to truly test the efficacy of the program.

Finally, research needs to be conducted to address the specific question as to how TELE-Web functions to scaffold writing performance. Certainly, the simple act of writing on the computer was not sufficient to account for the results of this study, because the unscaffolded condition did not improve the writing performance of many writers with disabilities relative to writing with paper and pencil. Further, students’ writing productivity was similar across the three conditions. Thus, the scaffolded conditions of TELE-Web seemed to support writing performance by prompting and guiding the cognitive work of generating, organizing, and producing ideas in an enterprise that was, ultimately, controlled by the user in conjunction with the technology. It is likely that the scaffolding helped students retrieve and implement writing procedures that had been previously introduced, but which were not enacted by students without prompts that connected the strategies to the writing task. The results suggest that many writers with LD might benefit from scaffolded conditions that support performance while they are in the act of composing texts. In fact, the researchers have been converging evidence from several design experiments involving larger data sets that indicate the powerful effects of scaffolding on the writing performance of students with LD (Englert, Zhao, Collings, & Wolbers, 2005). Furthermore, other studies of the TELE-Web’s potential to transfer to traditional measures of writing performance (e.g., paper-and-pencil papers) on writing posttests suggest that the scaffolds available to students with LD during the year are internalized to influence posttest performance relative to control students (Englert, Zhao, & Collings, 2005).

Writing continues to be a challenging instructional domain, especially for young writers. The findings of this study showed the potential for strategically supported Web-based environments to offer cognitive resources to students with school difficulties. In particular, operating with mediational technology might demonstrate more sophisticated levels of performance (Wertsch, 1998) than the same student writing without access to such scaffolds, such as writing with paper and pencil. Further research into the potentials of mediation through technology seems crucial in supporting the literacy development of writers with LD. In accordance with this view, the report of the National Commission on Writing in America’s Schools and Colleges (2003) strongly urged that new technologies be developed to advance both the teaching and learning of writing and that programs be designed to help students develop at least moderate competence as writers. TELE-Web seems particularly well suited to fill the need for Web-based software that could be easily accessed by teachers and students. Its universal application to a number of ability and grade levels is tied to the fact that its learning scaffolds and activities can be customized to suit the curricular and learning needs of users. The potential of Web-based environments to support and mediate the performance of students with writing challenges makes this a fruitful and exciting area that warrants further educational and federal initiatives.

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