Occupational therapists working in school-based settings have become increasingly involved in the remediation of children’s illegible handwriting (Amundson, 2001). An estimated 12% to 21% of school-age children struggle with handwriting skills (Alston, 1985; Rubin & Henderson, 1982). Many children continue to demonstrate difficulty with handwriting despite months of intervention. Written communication allows the child to express what he or she knows. When a child struggles with the process of writing, the actual expression of knowledge can be compromised (Rubin & Henderson, 1982). As a result, children with poor handwriting often are given poorer grades on the content of their written work than good handwriters (Briggs, 1980). Relationships also have been shown between poor handwriting and difficulties in many other areas of academic learning (e.g., spelling, writing composition, grammar) (Berninger, Mizokawa, & Bragg, 1991; Campbell, 1973). With the increasing numbers of computers available in elementary and secondary schools, word processing is a viable option for students who struggle with handwriting.
Use of Computer-Based Word Processing in Schools

As early as 1926 in first-grade classrooms at the Horace Mann School at Columbia University, educators considered the value of using typewriters within the educational curriculum (Sinks & Thurston, 1972). Early studies in the United States demonstrated that the use of a typewriter in the elementary classroom had a positive effect on academic learning (Conard, 1935; Rowe, 1959; Tate, 1942; Wood & Freeman, 1932). This initial enthusiasm for typing as a tool for enhancing academic learning subsided with the realization of the cost and effort required to incorporate it effectively into the elementary classroom (Balajthy, 1988).

In the mid-1980s, computers began to appear in public school programs (Cochran-Smith, 1991). In the 1990s, the number of computers in schools and homes increased substantially. It was recently estimated that one in three American homes has a personal computer (Belsie, 1995) and that 75% of the public schools have computers, with one computer available for every nine students (Brown, 1995). This accessibility to computers has added new learning options for students in a variety of academic areas.

The use of word processors for written communication is an emerging academic area in the public school curriculum that has recently received considerable attention by educators and school administrators. Many public school systems have recognized these benefits and have mandated keyboarding (i.e., word processing using a computer keyboard) instruction in elementary schools (Balajthy, 1988; Nieman, 1996).

Comparison of Keyboarding and Handwriting

Findings from a number of studies have demonstrated the functional benefits of keyboarding in the development of writing and reading skills in elementary school children who are typically developing and children with disabilities (Campbell, 1973; Dybdahl & Shaw, 1989; MacArthur & Graham, 1987; Sinks & Thurston, 1972). Cochran-Smith (1991) reported that students’ composing skills improve when they use word processors. Students reportedly made a greater number of revisions, although these were usually surface-level rather than meaning-level revisions. Students also tended to write longer and more error-free texts as well as wrote for longer periods.

Word processing appears to have a number of distinct advantages when compared with handwriting (Cochran-Smith, 1991). The advantages include increasing the ease of editing, increasing content quality and quantity of written work, and increasing the legibility of written work. Surveyed elementary school students reported a preference for keyboarding because pushing a button was easier than writing a letter (Kahn & Freyd, 1990). By simplifying text production, children appear to concentrate on the content and meaning of composing.

For keyboarding to be considered a possible alternative to handwriting, a certain level of keyboarding performance is necessary. According to Balajthy (1988), “For touch typing to be useful, the process must be automatic and students must reach a typing speed at least equivalent to their handwriting speed” (p. 41). Dunn and Reay (1989) demonstrated this concept in a study of 52 12-year-old and 13-year-old students identified by their teachers as having difficulty in writing composition. They examined the relationship of handwriting and typing transcription rates and found that students whose typing speed equaled or exceeded their handwriting speed showed greater competence in the content of narrative writing when using a word processor than when handwriting. Conversely, when students’ typing speed was less than their handwriting speed, they demonstrated less competency in the content of the narrative writing when using the word processor than when handwriting.

Studies have found that handwriting speed correlates with keyboarding speed: Those students who write quickly also tend to be relatively strong initial keyboarders (Kahn & Freyd, 1990). Pisha (1993) found that students who wrote quickly tended to develop keyboarding skills more quickly than students who wrote slowly. Handwriting speed typically never approached the same levels as keyboarding. Freeman (1954) reported that the average adult can handwrite legibly 130 letters per minute (or approximately 26 words per minute [WPM]). For advanced typists, however, typing speed can reach and exceed 100 WPM (West, 1969).

Occupational therapy practitioners seem to agree about the importance of keyboarding as an alternative form of written communication for students who struggle with handwriting (Amundson, 2001; Penson, 1990). Few guidelines, however, are provided to therapists to determine when a student should use keyboarding as an alternative to handwriting. Being able to identify a child who can benefit from computer word processing and initiating early keyboarding instruction may help that child to avoid the compositional writing disabilities often associated with dysgraphia (Berninger et al., 1991).

The purpose of this study was to investigate the relationship between handwriting and keyboarding performance in sixth-grade children who had received a standard instructional program in keyboarding. Specifically:

1. Does handwriting speed and legibility relate to keyboarding speed and accuracy?
2. Can handwriting speed and legibility correctly categorize students as slow or fast in keyboarding?
Method

Participants

The sample of convenience consisted of sixth-grade students from a central Ohio elementary school. All students participated in the school’s computer keyboarding classes, which were taught by one keyboarding instructor. Students with sensory, motor, cognitive, or social–emotional impairments were excluded from the sample. Of the 98 children who met these criteria, 41 returned the consent form to participate in the study. Of these, 1 student was unable to complete the testing. Table 1 provides comparative demographic data about the 40 study participants.

Instrument

Handwriting legibility was assessed by scoring a timed handwriting sample using the Test of Legible Handwriting (TOLH; Larsen & Hammill, 1989). This test was designed to measure the holistic legibility of students’ handwriting in grades 2 to 12. Writing samples can be taken in any number of ways, including samples from verbal prompts, from picture prompts, or from the child’s previous written work. The sample is compared with one of three scoring guides for a rating score of 1 to 9. In the current study, the scored handwriting samples were taken during the handwriting speed test as described in the next section.

Handwriting and keyboarding speed were assessed using 2-min samples of each. To assess handwriting speed, participants were asked to copy a poem in their “usual cursive handwriting” until told to stop. The poem was a modified version of “Twinkle Twinkle Little Star.” The participants were told not to erase or mark out words. If they paused before the 2-min period ended, they were encouraged by verbal prompts to continue writing. To derive a WPM score, a score for letters per minute was first computed then divided by 5 (i.e., this method assumes that the average length of a word is 5 letters).

Keyboarding speed was measured using the same model as that used in the handwriting speed test. Participants were instructed to type a modified version of the poem “Twinkle Twinkle Little Star” using a printed model. They were instructed to type the poem in their “usual way” until told to stop. The number of keystrokes per minute was computed and divided by 5 to calculate the WPM score. Keyboarding errors were calculated on the basis of omitted key strikes (letters, punctuation marks, spaces), additional key strikes (letters, punctuation, spaces, shifting to capitalize), or incorrect key strikes (misspelled words). Each omitted key strike counted as one error. Completely skipped lines of text were not penalized.

Procedure

Students in the sample participated in the keyboarding instruction class required by the school for 12 weeks. The class met for 30 sessions (40 min per session), which were integrated into the language arts class. The formal class included group instruction using a textbook on keyboarding and word processing and a self-paced computer instructional program (Mavis Beacon Teaches Typing)1. In the final 3 weeks of the keyboarding class, language arts assignments were integrated into the program. Students were tested in the final week of this class so that each would have a baseline of instructional background to keyboarding and would have achieved a basic level of competence.

Data Analysis

Means, ranges, and standard deviations were computed for all measures. Pearson product-moment correlations were used to determine the relationships among keyboarding speed, keyboarding errors, handwriting speed, and handwriting legibility. A discriminant analysis was done to determine the ability of the handwriting performance scores to identify correctly a student’s group membership as either slow or fast in keyboarding.

Results

Means and standard deviations for the measures are presented in Table 2. Examination of mean scores revealed 2 participants who had keyboarding scores that were approximately 25 WPM higher than the mean scores. These 2 were considered outliers and were eliminated from the analyses. The correlations among measures are presented in Table 3.

Keyboarding speed correlated with handwriting legibility ($n = 38$, $r = .361$, $p = .026$) and handwriting speed ($n = 38$, $r = .342$, $p = .036$). These correlations indicate that leg-
The participants were categorized as slow keyboarders if speed was less than 15 WPM or fast keyboarders if speed was 15 WPM or greater. Slow or fast keyboarding speed was predicted by handwriting legibility and handwriting speed ($X^2 = 7.7, df = 2, p = .021$). The standardized canonical discriminant function coefficient was .532 for handwriting speed and .661 for handwriting legibility. When combined, handwriting performance correctly classified 71.4% of the students in the slow keyboarding group and 70.6% of students in the fast keyboarding group. Overall, 71.1% of the original grouped cases were correctly classified.

**Discussion**

**Handwriting Performance**

The 38 participants exhibited a mean handwriting speed of 46.3 letters per minute (range = 17–81.5 letters per minute), or 9.3 WPM. The range of handwriting speeds of sixth-grade students across the studies reviewed (Groff, 1961; Hamstra-Beltz & Blote, 1990; Phelps, Stempel, & Speck, 1985; Ziviani & Elkins, 1984) was 46.1 to 66 letters per minute. The mean handwriting speed in these studies was 54.7 letters per minute. Variations in the methods used to obtain the handwriting samples most likely contributed to the wide range of handwriting speeds across these studies. In our study, the participants were asked to copy a poem in their “usual way” and were timed for 2 min. In other studies (e.g., Graham, Berninger, Weintraub, & Schafer, 1998; Sassoon, Nimmo-Smith, & Wing, 1986), students were asked to copy as fast as they could, possibly accounting for faster speeds.

Participants’ handwriting legibility was assessed with the TOLH, obtaining a standard mean score of 11.58. This score was within the average range (8–12; Larsen & Hammill, 1989). Throughout the testing, several students complained about writing in cursive and stated that manuscript was their preferred form of handwriting. Graham et al. (1998) found that when given a choice of handwriting style in a copying test, 50% of sixth-grade students chose manuscript or a mixed style of primarily manuscript. Because students were required to use cursive in the present study, legibility scores and handwriting speeds may have been decreased.

**Keyboarding Performance**

The participants’ mean keyboarding speed after a 30-session keyboarding instruction program was 14.9 WPM (more than 5 WPM more than handwriting) with a range of 6.2 to 33.9 WPM. These speeds are consistent with the mean keyboarding speeds of other sixth-grade students who received 12 to 15 sessions of keyboarding instruction (Sormunen, 1988). In studies by Sormunen (1988) and Kahn and Freyd (1990), the mean keyboarding speed was 13.90 WPM, or 1 word less than the mean handwriting speed for our participants.

Keyboarding errors were also considered in this study as a function of keyboarding performance. Overall, the errors were minimal. The participants demonstrated a mean keyboarding error rate of 5.71 with a range of 0 to 18. Errors consisted of reversed letters, omitted spaces, additional spaces, omitted letters, and additional letters.

**Relationship of Handwriting and Keyboarding**

Handwriting speed and legibility demonstrated low to moderate correlations with keyboarding speed. Although these relationships were significant, the handwriting variables accounted for less than 15% of the variance in keyboarding. This level of correlation suggests that the two skills not only have some common elements (e.g., motor performance), but also have many elements that differ, which may include differing levels of motor planning, perceptual-motor skill, visual-motor integration, visual memory, and cognitive processing. The low level of correlation suggests that some children with relatively poor handwriting legibility can be effective in keyboarding.

Handwriting performance as measured by legibility and speed demonstrated a moderate ability to predict whether a participant was a slow or fast keyboarder. Among children who are typically developing, a good handwriter will often demonstrate speed and competence in keyboarding. Five participants (29.4%) whose handwriting performance indicated that they should be slow in keyboarding were fast keyboarders, meaning that between one quarter and one third of the participants with low legibility and low handwriting speed became fast keyboarders (i.e., > 15 WPM).

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**Table 3. Correlations Between Handwriting and Keyboarding Measures**

<table>
<thead>
<tr>
<th>Measure</th>
<th>TOlh (r)</th>
<th>Handwriting Speed (r)</th>
<th>Keyboarding Speed (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handwriting speed</td>
<td>.487**</td>
<td>.361*</td>
<td>.421*</td>
</tr>
<tr>
<td>Keyboarding speed</td>
<td>.213</td>
<td>.261 (.113)</td>
<td>.203 (.222)</td>
</tr>
<tr>
<td>Keyboarding errors</td>
<td>.261 (.113)</td>
<td>.203 (.222)</td>
<td></td>
</tr>
</tbody>
</table>

*Note. TOlh = Test of Legible Handwriting.*

*p < .05. **p < .01.
Pisha (1993) and Kahn and Freyd (1990) also found moderate correlations between handwriting speed and keyboarding speed. Combined, these results suggest that handwriting performance is a moderate predictor of keyboarding performance. In our study, 70% of the students produced more text using keyboarding versus handwriting. Of the 20 slowest handwriters, 75% achieved faster text production using keyboarding rather than handwriting. Because keyboarding is more legible than handwriting, students with illegible handwriting would almost certainly have more legible written production with keyboarding.

**Limitations**

This exploratory study examined the relationship of handwriting performance to keyboarding performance. A sample of convenience was used with limited diversity in ethnicity, socioeconomic status, and ability. A larger sample and broader range of participants may increase the expression of relationships and would produce results with greater generalizability.

**Conclusion**

The low to moderate association between handwriting legibility and speed and keyboarding speed and errors suggests that some children with difficulty in handwriting may nonetheless become proficient in using a keyboard to word process. Teaching children with poor handwriting to word process may simplify their text production. This simplification of text production may allow certain children to concentrate on content and meaning when composing and encourage them to engage in compositional writing. The low correlations also suggest that additional studies are needed to identify the variables that predict a child’s ability to use a keyboard.

**References**


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