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A Comparison of Two Keyboarding Instruction Methods Over 2 Years for Elementary Students

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A Comparison of Two Keyboarding Instruction Methods Over 2 Years for Elementary Students

Abstract

Background: As computer and digital device use continues to grow in prevalence for school and work tasks, it is important for elementary-aged students to develop efficient keyboarding skills to support future academic and vocational success.

Method: A quasi-experimental pre-test and post-test study design was used to compare the effect of two different keyboarding instructional approaches on elementary students over a consecutive 2-year period. One group used Keyboarding Without Tears (KWT; N = 592) both years while the other group used free web-based activities the first year and Keyboarding Without Tears the second year (mixed methods; N = 714). Keyboarding speed, accuracy, and technique were measured at the beginning and end of the 2-year period.

Results: The results showed significant improvements in keyboarding speed and accuracy in both groups for all grades favoring the KWT in second, third, and fourth grade. Improvements in keyboarding technique were also noted for both schools in all grades favoring the KWT group in all grades.

Conclusion: Although improvements were noted with both approaches, this study suggests stronger outcomes from those using KWT over 2 consecutive years, especially beginning in first grade and ending in fourth grade.

Keywords

elementary education, interactive learning environments, teaching/learning strategies, human computer interface

Cover Page Footnote

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Credentials Display

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Keyboarding has become an increasingly important life skill. Many of today's jobs require the use of computer skills. Furthermore, computers are used for more than work. Email, instant messaging, social media, and online services require the use of keyboarding skills. Eighty-one percent of adults now do their finances online; banking and online shopping, for example, are becoming increasingly popular (Jenkins, 2016). Overall, keyboarding proficiency is necessary in work, social, and consumer settings and is "crucial to the development of 21st century skills" (Poole & Preciado, 2016, p. 8).

Keyboarding skills are important not only for adults but also for students. A variety of studies have shown that students using keyboarding skills to input information produced larger writing gains than when writing by hand and that keyboarding, specifically, had a positive effect on writing output and quality for students in elementary school to college (Graham & Perrin, 2007). Furthermore, for students experiencing difficulty with writing, word processing (keyboarding) has been shown to enhance these students' motivation to write and improve their writing quality, organization, length, and mechanical correctness (Morphy & Graham, 2012). However, limited research studies exist in the 21st century addressing computer use in the classroom. Elementary school teachers indicated that barriers to computing skills and technology use were a lack of teacher training and problems with functioning equipment. Teachers believed keyboarding to be an important skill, but their instruction did not aid in developing keyboarding skills (O'Neal et al., 2017). In addition, as important as these skills are in today's society, there is limited research indicating when and how these skills should be taught.

Keyboarding Instruction

Limited research on keyboarding instruction is currently available despite the widespread use of computer technology. Past research suggests that formal keyboarding instruction should begin as early as kindergarten when students are first asked to input information into the computer (McEntee, 1994). Hoot (1986) suggested that kindergarteners have the capability to develop speed and accuracy through keyboarding programs and that keyboarding instruction may be useful for kindergarten students to learn letter identification. Keyboarding instruction for students in kindergarten to second grade should primarily aim to help students locate keys on the keyboard (Jackson & Berg, 1986). Some studies indicate that third grade is generally the most effective time to begin keyboarding because these students have demonstrated an interest in learning keyboarding and have reached the physiological development necessary to be proficient keyboarders (Behymer & Echternacht, 1987; Jackson & Berg, 1986; Kercher & McClurg, 1985; King & Alloway, 1993; Tenney & Osguthorpe, 1990). Freeman et al. (2005) indicated that keyboarding instruction should begin around 10–12 years of age. Furthermore, a meta-analysis examining the effects of various writing instruction indicated that keyboarding instruction provided to students in the first through sixth grade produces positive effects for both students struggling with or performing well in writing (Graham et al., 2012).

Although research on the timing of when keyboarding instruction should occur is inconclusive, research shows that as students progress through elementary grades, an increase in instructional time and complexity is suggested for keyboarding skills so that students can improve their form, speed, and accuracy (Donne, 2012). Research also suggests that a child's initial keyboarding instruction should be followed with further instruction to reinforce the skill effectively (McEntee, 1994).

Historical research has shown that computer software and teacher-led instruction are equally effective; however, computer software is the preferred method of keyboarding instruction as it allows the teacher to play a support role in the keyboarding instruction process and better monitor students' keyboarding techniques (McClurg & Kercher, 1989; Russin, 1995). Regardless of the teaching method,

keyboarding programs that contain subgoals and allow students to experience intermediate steps to success are the most effective because student persistence is a major factor that has been found to underlie keyboarding success (Sormunen, 1993).

Success in keyboarding is often reported by speed (which may or may not account for accuracy). A generally accepted measure of success in keyboarding is for the speed to be at least as fast as handwriting (Connelly et al., 2007; Freeman et al., 2005). An analysis and synthesis of 26 research studies measuring keyboarding speed in elementary school students illustrates the broad range of speeds for each grade level. For example, keyboarding speeds ranged 4.7–70 words per minute (WPM) for fifth graders and 7.1–30 WPM for fourth graders (Freeman et al., 2005). Therefore, researchers suggest using handwriting speed as a "basis for estimating keyboarding speed targets" (Freeman et al., 2005, p. 124). A synthesis of 10 studies considering handwriting speed yields the following target ranges for first through fifth grade, respectively: 3.5–4.1 WPM, 4.8–11 WPM, 5–11.2 WPM, 6.8–16.4 WPM, 7.6–16.6 WPM (Freeman et al., 2005). Since the range of handwriting speeds for each grade level is narrower, handwriting speed targets provide a useful reference for identifying keyboarding speed targets.

Motor Learning Theory and Keyboarding

There are three stages of motor learning that outline the progression of motor control acquisition (Fitts & Posner, 1967). During the first stage, the cognitive stage, the individual may be familiar with the task but unfamiliar with how to perform the task and will have to use conscious effort to attend to the task requirements (Fitts & Posner, 1967). Regarding keyboarding, an individual may have some knowledge of keyboarding and its sequence but may be unable to execute the task without explicit instruction, cognitive attention, and visual feedback (Stevenson & Just, 2014). Therefore, instruction at this stage requires extensive practice and explicit teaching and feedback regarding pre-keyboarding exercises, letter identification, and hand positioning to build a proper foundation for keyboarding skills (Stevenson & Just, 2014).

In the second stage, the associative stage, individuals continue to practice so that skills become more refined and performance becomes more consistent with fewer errors (Fitts & Posner, 1967). The individual starts to internalize the motor movements to rely on internal feedback to guide performance. Instruction should adapt to the learner's progress and continue to challenge the learner in a just right manner to promote increased skill level. Individuals at this stage will use the home keys for touch typing, begin developing muscle memory for finger movements, and use good technique to locate letters from the home keys (Freeman et al., 2005).

During the third stage, the autonomous stage, the individual's skills become automatic and internalized. The individual has learned the skill and uses less cognitive effort, specifically fewer attentional demands, to execute the skill (Fitts & Posner, 1967; Zwicker & Harris, 2009). At this stage, the individual does not have to designate as much cognitive effort to the motor control aspects of keyboarding and can shift their cognitive resources to focus on the higher-level functions of the writing process, such as idea development, creativity, organization, and grammar. In addition, keyboarding speed increases and vision is used primarily to locate less frequently used keys or to check for errors on the screen (Freeman et al., 2005).

In summary, limited research regarding the appropriate grades to begin keyboarding instruction and the method by which to provide instruction is currently available, although there are supports for continued instruction after the initial skill is taught. Thus, the purpose of this study is to determine the effectiveness of a structured, grade-based curriculum versus a mixed-methods approach to keyboarding

instruction on keyboarding speed, accuracy, and technique among elementary students. This study also aims to determine if using keyboarding applications for a second year further develops keyboarding skills as prior research has suggested.

Method

This study is a quasi-experimental, pretest and posttest study design that compared the effect of two different keyboarding instructional approaches on students' net keyboarding WPM and keyboarding technique over a consecutive 2-year period. The Keyboarding Without Tears (KWT) group used the program for 2 years, whereas the mixed methods (MM) group used the KWT program only in the second year of the study while using free web-based activities, common practice for this school district, during the first year of the study. This study is an independent study covering 2 years of intervention that is a follow-up to previously published studies on just 1 year of intervention (Donica et al., 2018; Donica et al., 2019).

Participants

The participants were students in two lower and two upper elementary schools in the rural south that were recruited through convenience sampling. One upper and one lower school was the KWT group, and the other upper and lower school was the MM group. Assignment of schools to groups was based on researcher discussion with the county administration. The participants were in first through fifth grade during the second year of the study, and these are the grade levels to which they will be referred in this current study. The KWT group (N = 592) and the MM group (N = 714) included students of all genders and ethnicities who were in first through fifth grade during the second year of the study and who regularly participated in the weekly computer lab class at the school and completed all parts of the pre and posttests. Students excluded from the study were those who did not regularly participate in the computer lab classes. In addition, students that repeated their grade from the first year of the study were excluded. Information on the participants' gender and inclusion in special education services was collected.

Instrumentation

There were no standardized assessments for keyboarding at the time of the study. Therefore, the researchers used non-standardized outcome measures, one measure for speed and accuracy (Typing Test Pro) and another measure for keyboarding technique. The assessors were occupational therapists and occupational therapy graduate students who were trained in KWT and both measures prior to the pretest and posttest and showed competency in scoring through interrater reliability checking. The assessors were on site for collecting data but were not directly involved in the keyboarding instruction at any school.

Typing Test Pro

Typing Test Pro (TypingMaster, Inc., n.d.), a customizable online tool for measuring keyboarding speed and accuracy, was used at pretest and posttest and measured gross WPM, accuracy percentage, and net WPM. Gross WPM is the total number of characters keyed divided by five. The accuracy percentage is the number of characters keyed correctly divided by the total number of characters keyed. Net WPM is a productivity measure that factors in both gross WPM and accuracy percentage: gross WPM minus the number of word errors. Higher numerical scores on this assessment indicate faster gross WPM, a higher accuracy percentage, and a faster and more accurate net WPM. Typing Test Pro has been used in previous studies to assess keyboarding skills (Barkaoui, 2014; Donica et al., 2018; Donica et al., 2019). For this study, we used net WPM from a 1-min keyboarding exercise

at a first grade reading level (Test 1) and a 2-min keyboarding exercise at a fourth grade reading level (Test 2) to measure keyboarding speed and accuracy across all students in all grade levels at pre and posttest.

Keyboarding Technique

To assess keyboarding technique, we used a five-level scale of keyboarding technique used by Weigelt Marom and Weintraub (2015):

1. Keying with one hand and one finger and repeatedly using visual-feedback.
2. Keying with two hands, using one finger on each hand, and repeatedly using visual-feedback.
3. Keying with two hands, using two to four fingers on each hand, and repeatedly using visual-feedback.
4. Keying with two hands, using all fingers of both hands, and repeatedly using visual-feedback.
5. Keying with both hands, using all fingers, while looking at the monitor (and relying on kinesthetic feedback).

One to three assessors were present in each computer class to observe all the students for keyboarding technique while they were completing the Typing Test Pro. Timing of Typing Test Pro segments allowed for the assessors to observe each student. These observations were conducted at pre and posttest.

Interventions

Free Web-Based Activities

During the first year of the study, the MM group used free web-based activities in computer class for up to 27 weeks that were selected by teachers and were the district standard. During the computer class at the lower school, the participants were allowed to play interactive games on the PBS kids website that promoted mouse and keyboarding skills (Public Broadcasting Service, n.d.). The free web-based activities on this website varied depending on the students' grade. For example, the participants in kindergarten and first grade played games that taught mouse functions, such as click and drag, while the second grade participants played games on the keys of the keyboard and keyboarding strokes.

During the first year of the study, the MM upper school participants participated in an online touch-typing program or learned lessons about Microsoft PowerPoint, coding, and keyboarding techniques for touch typing. The online touch-typing program was Beginner Typing online typing lessons from Learn Typing©, which teaches touch typing through activities, games, and tests (LearnTyping, n.d.). There were seven Beginner Typing lessons that progressed from practicing typing letters, to groups of letters, to words, to sentences, and to numbers and symbols. These lessons did not provide feedback when a participant misspelled a word or pushed keys incorrectly. In addition, the participants often took speed typing tests online that measured keyboarding speed and accuracy percentage. No research was found on any of these free web-based activities.

KWT

KWT is a touch-keyboarding program that uses age-appropriate, game-based, and cross-curricular activities to build touch-keyboarding speed and accuracy (KWT, n.d.). The program progresses at the pace of the student, which helps individual students develop keyboarding skills at their own pace. The program has a developmentally-based sequence of games, awards, and checkpoints for motivation to ensure the student is appropriately progressing through the program.

The KWT program uses motor learning principles to progress students through the motor learning stages and ultimately enables them to develop success in keyboarding. The kindergarten and

first grade programs are based on the first stage of motor learning (repetitive practice, keyboard and mouse functions, finger dexterity, and finger-key association). The second and third grade programs are based on the second stage of motor learning (developing muscle memory, practicing common letter combinations, number and function keys, formatting, and writing paragraphs). The fourth and fifth grade program is focused on helping students move from the second to the third stage of motor learning (keyboarding strokes and further strengthening of muscle memory for speed and accuracy). KWT has an optional introductory feature, called "Jump into Keyboarding," that orients students to the KWT program and foundational keyboarding skills for the first 6 weeks of the program (KWT, n.d.).

The participants in the KWT group received the KWT program for 2 years of the study, but the participants in the MM group received the KWT program for the second year of the study only (because of their interest in adding KWT the second year) and the free web-based activities during the first year. During the first year of the study, the KWT group used the program for up to 27 weeks. Similarly, during the second year of the study, the KWT group and the MM group used the program for up to 31 weeks. KWT was used during the students' computer class, which was held once per week and lasted for varying times. The computer class lasted 45 min per week in kindergarten and first grade of the KWT group; 60 min in second grade of the KWT group; 45 min in the upper school of the KWT group; 30 min in the lower school of the MM group; and 45 min in the upper school of the MM group. For both the KWT and MM groups, the KWT program was carried out in addition to a variety of other computer-based activities. Therefore, the students may not have completed KWT activities for the entire class session each week. Computer teachers at all of the schools used supplemental keyboarding activities to address digital literacy, coding, and computer science at all grade levels. The computer teacher at the upper school of the KWT group reported that the students were occasionally given free time to play computer and/or typing games that included games for mouse and cognitive flexibility skills and a racing game that allows students to practice their touch typing skills. The supplemental computer-based activities used in the MM group are unknown.

Each of the four schools had a different technology teacher who each used different reinforcement and teaching strategies. The computer teacher at the lower school of the KWT group used consistent positive reinforcement (stamps and tokens) for activity completion and home row usage. The computer teacher at the upper school of the KWT group provided intermittent positive reinforcement during speed and accuracy checks. The computer teachers of the MM group also used reinforcement strategies but the details of these strategies were not available.

Procedure

After the study was approved by the university institutional review board (#16-000531), we recruited participants from four elementary schools. Information about the study was sent home to parents with the option to opt out from the data usage in the study, and no parent opted out during the 2 years of the study period. Then we attended a computer lab session for each class in each grade of each group to complete the pretest in August–September 2016. We, again, attended computer lab sessions to complete the posttest in May 2018. All computer lab teachers who provided the interventions received training on the KWT program prior to their use of this program with students or were asked to continue to use free web-activities. Occupational therapy researchers were available in person and through phone and email to help answer questions about the use of the program throughout the study.

Data Analysis

Pearson's chi-squared tests were used to check the comparability of the KWT group and MM group in gender and special education status. The data were examined visually using boxplots and QQ-plots, and some data sets showed deviations from normality. Therefore, nonparametric statistical tests were used for data analyses. To compare the pretest to posttest in net WPM and keyboarding technique for each grade for each group, we used Wilcoxon signed rank test. To compare the changes in net WPM and keyboarding technique of the KWT group to those of the MM group, we used a Mann-Whitney U test. Data are also presented in median (Q1–Q3) and bar graphs. For all statistical analyses, an alpha level of 0.05 was used. We used IBM SPSS 26 Statistics for all data analyses.

Results

The participants in all grades in both groups were comparable in terms of the gender and the special education status ($p > .05$) except for special education status in first grade [X^2 (1, N = 236) = 7.17, $p = .007$] (see Table 1). Specifically, there was a higher ratio of participants receiving special education in the KWT group (20 out of 100 participants) than in the MM group (11 out of 136 participants).

Net WPM

The KWT group had a significantly greater improvement in net WPM than the MM group in second grade ($p = 0.007$) and third grade ($p < 0.001$) for Typing Test 1 and in second grade ($p = 0.002$), third grade ($p < 0.001$), and fourth grade ($p = 0.03$) for Typing Test 2. For all grades, except for first grade in Typing Test 1 and second grade in Typing Test 2, the KWT group had greater median changes in net WPM than the MM group (see Table 2 and Figure 1). The participants in all grades in each group showed significant improvements in net WPM of Typing Test 1 and Typing Test 2 between pretest and posttest ($p < .001$) (see Table 2 and Figure 1).

Table 1

Demographic Data

	KWT Group (*N* = 592)				**MM Group (*N* = 714)**			
	Male *n* (%)	**Female** *n* (%)	**Special Ed** *n* (%)	**Total Students** *n* (%)	**Male** *n* (%)	**Female** *n* (%)	**Special Ed** *n* (%)	**Total Students** *n* (%)
First Grade	48 (48.0)	52 (52.0)	20 (20.0)	100 (16.9)	72 (52.9)	64 (47.1)	11 (8.1)	136 (19.0)
Second Grade	59 (51.8)	55 (48.2)	17 (14.9)	114 (19.3)	85 (62.5)	51 (37.5)	15 (11.0)	136 (19.0)
Third Grade	67 (56.3)	52 (43.7)	13 (10.9)	119 (20.1)	74 (49.7)	75 (50.3)	13 (8.7)	149 (20.9)
Fourth Grade	58 (46.4)	67 (53.6)	12 (9.5)	125 (21.1)	76 (56.7)	58 (43.3)	9 (6.7)*	134 (18.8)
Fifth Grade	72 (53.7)	62 (46.3)	7 (5.2)	134 (22.6)	80 (50.3)	79 (49.7)	4 (2.5)*	159 (22.2)
TOTAL	304 (51.3)	288 (48.6)	69 (11.6)	592 (100.0)	387 (54.2)	327 (45.8)	52 (7.2)	714 (100)

Note. KWT = Keyboard Without Tears; MM = mixed methods. * Denotes special education status unknown for three students in fourth grade and one student in fifth grade.

Table 2

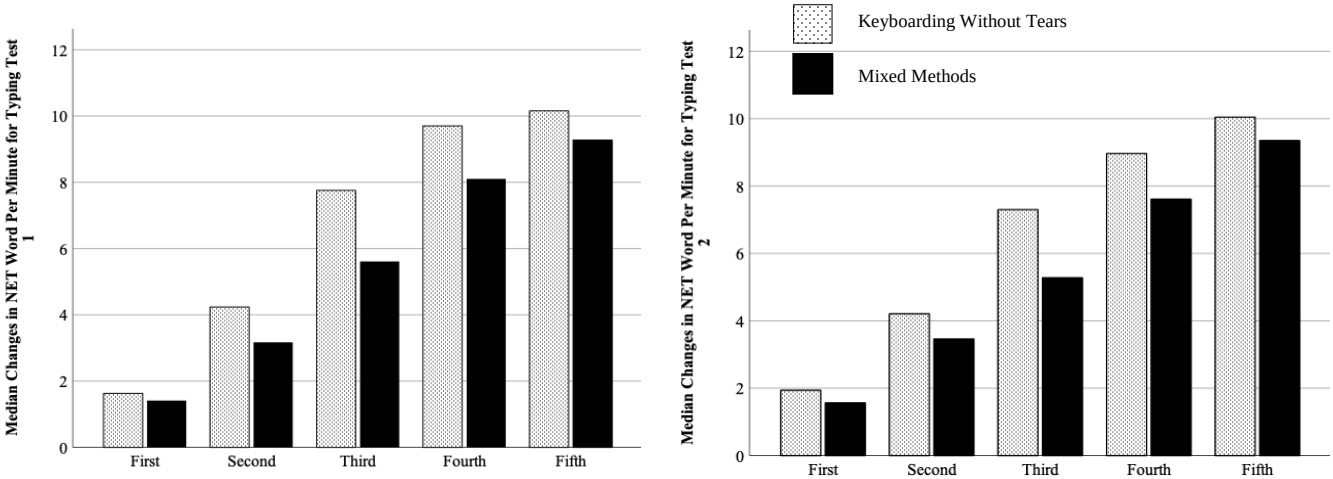
Net Words Per Minute Typing Test 1 and 2

	Net WPM Typing Test 1					Net WPM Typing Test 2				
	Pre Mdn (Q1–Q3)	Post Mdn (Q1–Q3)	Within group z	Within group *p*-value	Between groups	Pre Mdn (Q1–Q3)	Post Mdn (Q1–Q3)	Within group z	Within group *p*-value	Between groups
First Grade										
KWT (n = 100)	0 (0–0)	1 (0–2)	7.51	< .001*	***z*** = 1.37 ***p*** = .17	0 (0–0)	2 (0–3)	7.32	< .001*	***z*** = 1.75 ***p*** = .08
MM (n = 136)	0 (0–0)	1 (0–2)	8.58	< .001*		0 (0–0)	1 (0–3)	8.10	< .001*	
Second Grade										
KWT (n = 114)	0 (0–1)	4 (2–6)	8.82	< .001*	***z*** = 2.68 ***p*** = .007*	0 (0–1)	4 (3–6)	9.20	< .001*	***z*** = 3.08 ***p*** = .002*
MM (n = 136)	1 (0–1)	3 (2–6)	9.38	< .001*		0 (0–1)	4 (2–5)	9.74	< .001*	
Third Grade										
KWT (n = 119)	2 (1–2)	9 (6–12)	9.35	< .001*	***z*** = 3.89 ***p*** < .001*	2 (0–3)	9 (6–11)	9.45	< .001*	***z*** = 5.10 ***p*** < .001*
MM (n = 149)	1 (0–2)	7 (4–9)	10.19	< .001*		2 (0–3)	6 (4–9.5)	10.31	< .001*	
Fourth Grade										
KWT (n = 125)	4 (1–6)	12 (8.5–16)	9.54	< .001*	***z*** = 1.32 ***p*** = .19	4 (2–6)	13 (9–16)	9.60	< .001*	***z*** = 2.15 ***p*** = .03*
MM (n = 134)	2 (1–5.25)	11 (8–15)	9.85	< .001*		3 (1–5.25)	11 (8–15)	9.92	< .001*	
Fifth Grade										
KWT (n = 134)	7 (5–10)	17 (13–21)	9.86	< .001*	***z*** = 1.13 ***p*** = .26	8 (5–11)	16.5 (13–21)	10.00	< .001*	***z*** = 0.70 ***p*** = .49
MM (n = 159)	6 (3–8)	14 (11–20)	10.58	< .001*		6 (4–8)	15 (13–19)	10.88	< .001*	

Note. WPM = words per minute; KWT = Keyboard Without Tears; MM = mixed methods. *$p < .05$.

Figure 1

Median Change in Net Words Per Minute Typing Test 1 and 2



Note. Changes in net words per minute for Typing Test 1 and Typing Test 2 are expressed as median in 592 participants in the Keyboarding Without Tears group and 714 participants in the mixed methods group.

Table 3

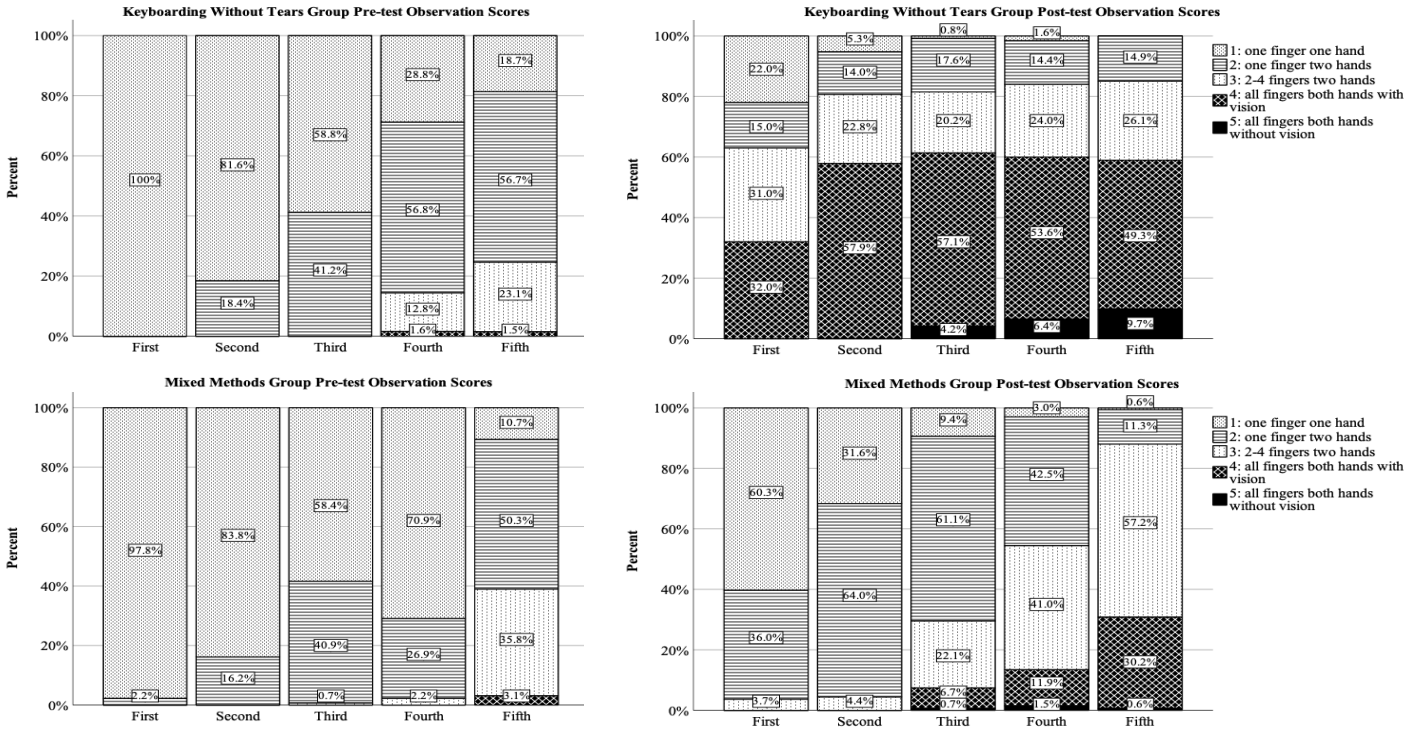
Keyboarding Technique Results

	Pre Mdn (Q1–Q3)	Post Mdn (Q1–Q3)	Within group z	Within group *p*-value	Between groups
First Grade					
KWT (n = 100)	1 (1–1)	3 (2–4)	7.81	< .001*	***z*** = 8.65
MM (n = 136)	1 (1–1)	1 (1–2)	6.77	< .001*	***p*** < .001*
Second Grade					
KWT (n = 114)	1 (1–1)	4 (3–4)	9.02	< .001*	***z*** = 10.75
MM (n = 136)	1 (1–1)	2 (1–2)	7.72	< .001*	***p*** < .001*
Third Grade					
KWT (n = 119)	1 (1–2)	4 (3–4)	9.24	< .001*	***z*** = 9.15
MM (n = 149)	1 (1–2)	2 (2–3)	8.72	< .001*	***p*** < .001*
Fourth Grade					
KWT (n = 125)	2 (1–2)	4 (3–4)	9.04	< .001*	***z*** = 2.31
MM (n = 134)	1 (1–2)	3 (2–3)	9.25	< .001*	***p*** = .02*
Fifth Grade					
KWT (n = 134)	2 (2–2.25)	4 (3–4)	9.26	< .001*	***z*** = 5.05
MM (n = 159)	2 (2–3)	3 (3–4)	8.61	< .001*	***p*** < .001*

Note. KWT = Keyboard Without Tears; MM = mixed methods. *$p < .05$.

Figure 2

Keyboarding Technique of the Keyboarding Without Tears Group and the Mixed Methods Group



Note. The frequencies of each keyboarding technique level by grade for the Keyboarding Without Tears group and the mixed methods group are expressed as percentages in 592 participants in the Keyboarding Without Tears group and 714 participants in the mixed methods group.

Keyboarding Technique

The KWT group had significantly greater improvement in keyboarding technique than the MM group in all grades ($p < 0.001$, except for $p = 0.02$ for fourth grade) (see Table 4 and Figure 2). The participants in all grades in each group showed significant improvements in keyboarding technique between pretest and posttest ($p < .001$). Figure 2 illustrates that, at posttest, the KWT group in first and second grade showed more advanced keyboarding technique scores than the MM group in first and second grade: 0% of students in these grades in the MM group earned a technique score of 4, whereas 32.0% of students in first grade and 57.9% of students in second grade in the KWT groups earned a technique score of 4. Both groups showed comparable keyboarding scores at pretest.

Discussion

In our study, we compared the effectiveness of the structured, grade-based curriculum and mixed methods keyboarding instructional approach in net WPM and keyboarding technique among students in elementary schools. We found that the structured, grade-based curriculum was more effective in improving net WPM and keyboarding technique in most of the grades than the mixed method keyboarding instructional approach. However, all grades in each group improved in net WPM and keyboarding technique over time.

Change in Net WPM Between Groups

The significantly greater improvement was found in the KWT group in second, third, and fourth grades compared to the MM group. Therefore, for most grades, participating in this program for 2 years, compared to 1 year, may have resulted in greater improvements in the KWT group. In addition, the students in second through fourth grades were of the age and developmental level that were most appropriate to benefit from the structured KWT program based on research (Behymer & Echternacht, 1987; Freeman et al., 2005; Jackson & Berg, 1986; Kercher & McClurg, 1985; King & Alloway, 1993; Tenney & Osguthorpe, 1990). Although the participants in second through fourth grade had not yet solidified foundational keyboarding skills at the beginning of the first year, they possessed the cognitive and motor skills to benefit from the developmental and motor learning approach of KWT that helps develop the skills of speed and technique.

The similarity in outcomes in first grade may have resulted from the focus of the KWT kindergarten program that is different from other grades. The KWT kindergarten program is primarily focused on the basic keyboard and mouse functions and not focused on improving keyboarding speed. Similarly, the MM kindergarten group also focused on basic foundational keyboarding skills during the first year and then used the KWT first grade program (same as the KWT group) during the second year. In addition, the KWT license for fifth grade has more emphasis on developing the cognitive and higher-level skills needed for the writing process, rather than speed and accuracy, necessary for entering middle school. In contrast, during the first year, the MM group participated in more generalized keyboarding speed and skill-building activities. Therefore, because of the varying focuses of KWT curriculums in different grades, using additional measures on other constructs, such as basic keyboard and mouse skills or high-level skills, may reflect the changes in other relevant areas.

A generally accepted measure of success in keyboarding is the comparable handwriting speed (Connelly et al., 2007; Freeman et al., 2005). A synthesis of 10 studies considering handwriting speed yields the following ranges for first through fifth grade, respectively: 3.5–4.1 WPM, 4.8–11 WPM, 5–11.2 WPM, 6.8–16.4 WPM, and 7.6–16.6 WPM (Freeman et al., 2005). At the end of this study, the average keyboarding speeds for first through fifth graders, respectively, were: 1.41–1.91 WPM, 3.82–

4.50 WPM, 7.14–9.59 WPM, 11.35–13.37 WPM, and 14.64–17.61 WPM. Thus, after 2 years of either a KWT or MM keyboarding intervention, students in third, fourth, and fifth grade averaged higher keyboarding speeds than the average researched handwriting speeds. This indicates that students who receive keyboarding education are able to achieve a successful and functional speed of keyboarding.

Change in Keyboarding Technique Between Groups

The KWT group showed significantly greater improvements in keyboarding technique compared to the MM group for every grade. Specifically, the KWT group's keyboarding technique was, in general, one to two levels better than that of the MM group. One reason for the KWT group's superior improvement in keyboarding technique compared to the MM group may have been because of the structure of the KWT program. The KWT programs of all grades strongly emphasize using proper keyboarding technique through visual reminders with the program and increased activity repetitions to promote more advanced technique. Conversely, most of the activities in which the MM group participated during the first year did not emphasize proper keyboarding technique. The 2 years of intensive and consistent instruction to promote improved keyboarding technique with KWT may have contributed to the KWT group's significantly greater improvement.

The educational environment also may have been a factor for higher success in the KWT group. The computer lab teacher for kindergarten through 2nd grade of the KWT group used positive reinforcement strategies when students used more advanced keyboarding technique. Conversely, the MM group had three different computer lab teachers during the second year of the study; therefore, there may have been inconsistent levels in or approaches to reinforcement of keyboarding technique. This inconsistency may have been prevented if a structured curriculum, such as KWT, was provided, even by different computer teachers.

The composition of different keyboarding techniques in first through third grade shows the noticeable differences between two groups. Despite the similar compositions of keyboarding technique levels at the beginning of the study, one-third to more than a half of the KWT group in first through third grade used the two highest levels of keyboarding technique compared to zero to one-tenth of the MM group. These results further support beginning a structured keyboarding curriculum in early elementary school, as even students in first through third grade can develop relatively advanced keyboarding technique with structured intervention.

Net WPM and Keyboarding Technique Within Groups

Both groups in all grades significantly improved in keyboarding speed, accuracy, and technique after receiving the interventions. These results suggest that students should begin a keyboarding curriculum as early as kindergarten and continue it for consecutive years. These results are consistent with previous research indicating that a structured curriculum or keyboarding education leads to improvement in elementary school students' keyboarding ability (Sormunen, 1993).

Limitations of the Study

There are a few limitations in this study. The first limitation is the lack of randomization. The subjects were chosen and placed into groups based on the school they attended, and both schools were in the same county. The use of a convenience sample may decrease the generalizability of the study. However, a limited number of computer teachers at each school made the randomization challenging, and having dedicated computer teachers for each intervention may support randomization. In addition, we did not track the number of minutes spent on the interventions, keyboarding-related activities, or supplemental activities because it was not feasible in those educational environments. Therefore, actual

intervention times for each class may vary, and there could be some activities engaged in by both groups in their free time in the class. However, the instructional time focused on the approach followed by the assigned school. The second limitation is that the study was completed in a small, rural area. Although the schools were diverse in terms of demographics, the schools were in a unique culture, thus the sample of students and their performance data may not be representative of a typical elementary school student, thus decreasing the generalizability to students in other parts of the country. In addition, our analysis does not consider socioeconomic status, academic performance of students, participant age, or dosage of each intervention (number of minutes spent directly on keyboarding-related activities) because of a lack of this data. Therefore, the effects of these factors are unknown. Another limitation is that computer use and keyboarding practice outside of the school was not directly accounted for as a potential impact on keyboarding performance in this study. Finally, the instruments used in our study are another limitation. There are currently no standardized assessments for keyboarding in elementary schools. The instruments in our study have been used in research but have not been validated. The development of keyboarding instruments to reliably and accurately measure keyboarding speed, accuracy, and technique is urgently needed.

Implications for Occupational Therapists and Teachers

Occupational therapists and teachers are cautioned in generalizing the findings of our study to their educational environment because of the limitations mentioned in the previous section. Nevertheless, the results of our study provide important information that can be used by occupational therapists, school administrators, and teachers. Occupational therapists' ultimate goal is to help their clients achieve health and well-being and to participate in life through engagement in occupation (American Occupational Therapy Association, 2020). Occupational therapists in the school system play a large role in helping students improve performance in school-related occupations, including keyboarding, through their work with individuals, groups, and even the entire school population. Because of their holistic training, which includes child development and activity analysis, occupational therapists are uniquely equipped to analyze the strengths and challenges of students to assist in maximizing their performance in areas of difficulty. On the individual level, occupational therapists can help students with keyboarding difficulty develop keyboarding skill for academic success. Occupational therapists can also provide keyboarding education as an alternative method of written expression for students who struggle with handwritten expression. On a group or population level, occupational therapists may become advocates and a resource for implementing a keyboarding curriculum in school-wide implementation. Occupational therapists could play a consultative role in which they educate teachers about the motor learning theory, its relationship to keyboarding skill development, and how to help students move through the motor learning stages to develop keyboarding fluency (American Occupational Therapy Association, 2020).

Our findings suggest that using KWT as an intervention to help individual students improve their skills is more beneficial than using a mixed methods approach at any grade level. Thus, regardless of the keyboarding curriculum that a school has adopted, occupational therapists may use a structured keyboarding curriculum, such as KWT, during individual treatment sessions for students who need to develop and/or improve keyboarding skills or need an alternative to handwriting.

For school districts and teachers, our study provides evidence of the benefit of implementing a keyboarding curriculum in elementary school, as early as kindergarten. The results of our study show the positive impact that a keyboarding curriculum has on students' abilities. Although a structured

keyboarding program such as KWT would yield greater improvement in skills, according to our findings, using a mixed methods approach will also improve students' keyboarding abilities in any grade, if school districts and/or teachers do not have the funds to support a program such as KWT for multiple years.

Although previous research is not conclusive about which grade to begin keyboarding instruction, many researchers agree that third grade or later is when keyboarding education should begin (Behymer & Echternacht, 1987; Jackson & Berg, 1986; Kercher & McClurg, 1985; King & Alloway, 1993; Tenney & Osguthorpe, 1990).

Recommendations for Future Research

Future research may want to include additional information about student academic levels for comparison to see if this has an impact on keyboarding skill development. Student reading levels may impact keyboarding skills and would be good to include as a variable. Researchers should consider using an objective measure of time spent for the keyboarding curriculum. This information would provide objective information about the impact that the dosage of keyboarding instruction has on skill improvement and insight into how much time students should spend using a keyboarding curriculum to see the greatest improvement in keyboarding related skills. Lastly, additional measures to accommodate the various focuses of keyboarding instructions at different grades may provide the comprehensive picture of students' overall development in keyboarding and academic skills.

Conclusion

In the current technological era, students must develop keyboarding skills to be successful in school, work, and social occupations. The results of our study indicate that either a mixed methods or structured keyboarding curriculum in elementary school can improve keyboarding speed, accuracy, and technique that may promote current academic and future success. Furthermore, the results of our study indicate that a structured keyboarding program such as KWT is the more effective curriculum for improving students' keyboarding speed, accuracy, and technique. Finally, our study provides evidence to implement a keyboarding curriculum starting as early as kindergarten and throughout elementary school to ensure the continued progression of keyboarding speed, accuracy, and technique essential for academic success.

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