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Published online: 22 Aug 2018.

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Keyboarding instruction: Comparison of techniques for improved keyboarding skills in elementary students

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ABSTRACT

Using computers and keyboarding skills for written communication have been common adaptations recommended by occupational therapists which are now important for all students. We used a quasi-experimental, pre-test/post-test design to examine the effectiveness of a developmentally based curriculum, Keyboarding Without Tears®, as compared to free web-based activities for learning keyboarding skills in students (general and special education) in grades kindergarten through fifth. Overall, students learning the developmentally based curriculum demonstrated improved speed and accuracy, especially in the upper elementary grades and improved keyboarding method in the lower elementary grades as compared to the free web-based activities.

In today's classroom, students are expected to produce handwritten work and computer-generated work as necessitated by demands of assignments and testing. Students who have difficulty handwriting and keyboarding may face challenges meeting these student occupational demands. Students struggling with handwriting development often have difficulty completing classroom assignments and may avoid academic tasks all together, thus decreasing overall occupational performance in school (Cahill, 2009; Freeman, Mackinnon, & Miller, 2005). With increasing numbers of computers available in the classroom and at home, keyboarding is an accessible option for students of all abilities. For keyboarding to be an effective alternative to handwriting, a level of keyboarding proficiency is required (Preminger, Weiss, & Weintraub, 2004). Students are expected to write essays using word processors (Poole & Preciado, 2016) in addition to computer-based testing. Since school curriculums are incorporating more assignments and projects that require keyboarding skills, keyboarding competency is important for all students (Barkaoui, 2014; Rogers & Case-Smith, 2002).

Computer-based testing is one requirement of many elementary students across the country and is incorporated into both summative and formative methods of evaluation. This form of testing may require proficient mouse skills in addition to free-text entry relying on efficient keyboarding skills (Shute & Rahimi, 2017). In addition to computer-based testing, digital textbooks are becoming more commonplace that include features allowing students to

annotate and complete digital memo and note writing within the digital text (Lim, Song, & Lee, 2012). Depending on the digital book, creating these digital notes may require keyboarding skills. Using technology in the classroom positively impacts student learning, thus will likely continue to evolve (Coleman, Gibson, Cotton, Howell-Moroney, & Stringer, 2016).

Since it is commonplace for all students to be using computers to meet educational demands, it is critical that effective keyboarding instruction be determined (Poole & Preciado, 2016) both for struggling and non-struggling students. Keyboarding instruction and sufficient practice opportunities are crucial for developing keyboarding proficiency in students struggling with handwriting skills (Freeman et al., 2005). Research suggests benefits to introducing touch-keyboarding instruction at an early elementary age, because these students have potential to develop the higher-level keyboarding style (Britten, 1988; Chwirka, Gurney, & Burtner, 2002; Cowles, Hedley, & Robinson, 1983; Hoot, 1986). Conversely, previous research suggests that younger students require more time and supervision making instruction less practical. Pisha's (1993) study on students in grades third through sixth found that older students developed keyboarding abilities at a faster rate than the younger students. Alternatively, Nichols' (1995) determined that students in the third grade were able to improve keyboarding abilities from keyboarding lessons; however, it was more of a challenge to keep younger students engaged. Ultimately, keyboarding should be introduced prior to the grade level when computers are used for academic work (Freeman et al., 2005; Kisner, 1984).

Keyboarding Expectations

Common Core State Standards (CCSS; 2016) identify keyboarding as first required in the writing standards for third grade to produce and publish writing. Additionally, in fourth grade, students must "demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting" (CCSS, 2016, p. 21) while fifth grade students must complete a minimum of two pages (CCSS, 2016). Kindergarten through third grade writing standards remain unclear regarding keyboarding usage but require use of a digital tool to produce writing (CCSS, 2016). CCSS suggest the importance of introducing keyboarding instruction at least by the third-grade level, if not sooner, to begin introduction to digital tool use.

The International Society for Technology in Education (ISTE) developed additional guidelines that enable educators to prepare students to perform at a level necessary to be successful in the era of rapidly advancing technology. According to the ISTE Standard 1.d., (empowered learner), students should understand fundamental concepts of technology operations including how to use devices and basic knowledge of software applications (ISTE, 2016) to become more self-sufficient in setting and achieving learning goals. Standard 6.b, (the creative communicator), requires students to create original works or responsibly repurpose digital resources into new creations (ISTE, 2016). These standards require computer competency and keyboarding skill for composing and creatively expressing ideas digitally.

Keyboarding Speed

Current keyboarding speed norms are difficult to determine, because of the absence of a standardized keyboarding assessment and the variability of keyboarding instruction per grade level (Freeman et al., 2005). Freeman et al. (2005) published a summary of keyboarding speed norms from a collection of research. Research has indicated second grade

students type an average of 5 word per minute (WPM) (Chwirka et al., 2002). Students in grades first through third were keyboarding at an average of 9 WPM. Third graders could reach speeds up to 30 WPM, fourth grade students to keyboard between speeds of 7.1 WPM to 30 WPM, and fifth grade students were keyboarding at an even broader range from 4.7 WPM to 70 WPM (Freeman et al., 2005). In addition, students who keyed 20 WPM in fifth grade were able to maintain that level of proficiency in seventh grade (Ertl, 2007). Keyboarding speed norms in research are highly variable and difficult to generalize; however, an overall trend in increasing speeds with increased grade level can be concluded (Freeman et al., 2005; Pisha, 1993). Researchers do concur that keyboarding skills should be as fast as handwriting to be functional (Freeman et al., 2005; Pisha, 1993; Stevenson & Just, 2014).

Keyboarding Method

The most primitive keyboarding method, hunt and peck, is where one visually locates each key and uses one finger on one hand or one finger on each hand to depress the keys (Hoot, 1986). While this is not the most efficient way of keyboarding, it can be a functional method for beginners or students with fine motor challenges (Niles-Campbell, Tam, Mays, & Skidmore, 2008). However, the more automatic the keyboarding process, the more the individual can focus on content over mechanics (Pisha, 1993).

Evidence suggests touch-typing, or touch keyboarding, is a more automatic process (Freeman et al., 2005; Pisha, 1993; Rogers & Case-Smith, 2002). Touch keyboarding requires bimanual finger placement on the home row keys and reliance on kinesthetic feedback rather than visual for locating keys (Freeman et al., 2005). Compared to the hunt and peck method, the touch method involves both hands and all fingers working synchronously to navigate and press the keys. Additionally, the shift from visual to kinesthetic feedback allows the individual to focus attention on the task instead of the components of the task, thus improving the occupational performance (Freeman et al., 2005). Acquisition of touch keyboarding may be the most proficient and efficient way for producing quality work (Pisha, 1993).

Motor Learning Theory and Keyboarding

Keyboarding is a learned skill that involves the integration of visual and kinesthetic feedback for locating keys to produce written work (Freeman et al., 2005). This skill is a complex motor task that involves the internalization of motor sequences to become efficient (Schmidt & Lee, 2011). Motor skill habituation initially begins with relying on cognition and vision to influence motor performance, eventually leading to muscle memory of the motor pattern and self-corrections to increase precision (Stevenson & Just, 2014). Fitts and Posner (1967) outline this motor learning process into three stages consisting of cognitive, associative, and autonomous development.

Cognitive Stage

Initially, students understand the idea of the movement required but do not know how to replicate it (Zwicker & Harris, 2009). During this stage, the student attempts to understand what strategies need to be done to complete a task. Effective strategies are internalized and ineffective movements are discarded until the student develops a pattern

(Gillen, 2014). In keyboarding, different movement patterns of the keys are being learned with visual feedback and remediation to initiate the acquisition process (Weiglt Marom & Weintraub, 2015).

Associative Stage

During the associative, or retention stage, motor skills learned from the cognitive stage are refined and internalized and the individual begins to rely more on kinesthetic feedback than visual stimuli (Gillen, 2014; Weiglt Marom & Weintraub, 2015; Zwicker & Harris, 2009). Practice is critical at this stage for the refinement and improved consistency of keyboarding performance. During the beginning stages of motor learning, students may benefit from learning and practicing skills in parts then incorporating the individual skills into a whole task (Zwicker & Harris, 2009). Eventually, with practice and exposure, the skill becomes internalized and requires little cognitive effort.

Autonomous Stage

The final stage of motor learning involves performing a motor skill relying solely on kinesthetic feedback (Weiglt Marom & Weintraub, 2015; Zwicker & Harris, 2009). In addition to requiring less visual cues for locating keys, students' keyboarding speed and accuracy should increase with practice and muscle memory (Stevenson & Just, 2014). At this level, the skill is automatic and can be performed with little distraction from other activities and even while engaging in other tasks (Gillen, 2014; Zwicker & Harris, 2009). Students who key at a functional level are able to invest more attention into the thought process of the writing composition, and may ultimately become more successful at these computer-based tasks.

Summary

The purpose of this study was to conduct research exploring the benefits of two different keyboarding instructional approaches in improving keyboarding skills of elementary students in general and special education to inform occupational therapy practice. Keyboarding is a meaningful occupation for students in a technology-rich classroom environment. Research supports the functional benefit of keyboarding over handwriting for students with handwriting difficulties when students are keyboarding at an equivalent speed or higher than handwriting abilities (Freeman et al., 2005; Rogers & Case-Smith, 2002). Keyboarding instruction is crucial for developing functional keyboarding skills; in fact, research suggests that without proper instruction, keyboarding may be more of a hindrance (Freeman et al., 2005). By understanding the effect of time spent enhancing keyboarding abilities per grade level, keyboarding instruction and intervention can be replicated in classrooms, homes, and community centers to develop critical student skills.

With this study, we can begin to understand the questions: (1) Is the improvement in keyboarding abilities (net words per minute and keyboarding method) greater for students who have completed developmentally-based Keyboarding Without Tears® (KWT) curriculum instruction as opposed to those who have completed free web-based activity keyboarding instruction? (2) Is there a relationship between number of activities completed on the KWT® application and keyboarding speed and accuracy?

Methods

Design

This quasi-experimental, pre-test/post-test design examined the effectiveness of the developmentally based KWT® curriculum compared to free web-based activity keyboarding instruction for students in grades kindergarten through fifth by measuring change in keyboarding abilities (keyboarding speed and accuracy and keyboarding method) from the beginning to the end of the school year using two different instructional approaches.

Participants

The inclusion criteria consisted of attending any of the four elementary schools participating in the study, grades kindergarten through fifth, who completed pre- and post-testing sessions. Students who received special education were included in the study unless they were in self-contained classrooms.

The KWT schools were selected due to one researcher's affiliation with the schools. The free web-based activity schools were chosen based on the administration's recommendation and research team's selection regarding schools most comparable in proximity, geographical location, demographic representation, annual household income, and grades to the KWT schools. All four schools were in suburban southern United States in a county with the ethnic distribution of 56.7% White, 38.2% African American, 2.8% Hispanic, 2.3% Asian, and .1% American Indian (United States Census Bureau, 2017).

Instrumentation

There are no standardized assessments for keyboarding performance. Keyboarding performance has been documented by speed, accuracy, and method (Freeman et al., 2005). Keyboarding speed and accuracy were measured in this study through keyboarding samples using the online tool, Typing Test Pro (Barkaoui, 2014; Typing Master, Inc., 2016). Keyboarding method was recorded by the researchers through an observation of method used to complete the keyboarding sample. Both measurements were taken pre-test and post-test. In addition, demographics were collected through school records and usage data from the KWT application was collected. These measures were selected based on prior research and feedback gathered through a pilot study by the research team.

Typing Test Pro

To collect keyboarding speed and accuracy data, Typing Test Pro was programmed to include three timed passages for the student to copy via keyboard. Each passage was displayed on the top half of the screen and copied into a blank text box below the passage. Students were instructed to copy the text from the passages by keying them as quickly and accurately as possible within the allotted time (Barkaoui, 2014). The assessment utilized a copying paragraph task to control for individual differences in spelling and written expression abilities to reduce effect of individual differences (Weigelt Marom & Weintraub, 2010). The first passage, considered a warm-up, was an excerpt from a first-grade reading text with a one-minute time limit included to reduce students' anxiety toward keyboarding thus minimizing the experimenter effect. The next passage was

another excerpt from a first-grade reading text with a 1-min time limit, which is the basis for analysis in this study. The last passage was an excerpt from a fourth-grade reading text with a two-minute time limit. All students were presented the same passages. The backspace was disabled, as was done in prior research, which helped researchers collect a more accurate WPM calculation (Barkaoui, 2014).

Three measurements were generated by Typing Test Pro: gross WPM, accuracy percentage, and net WPM (Barkaoui, 2014). The gross WPM represented the number of keyed WPM regardless of errors. Accuracy percentage was the percentage of words keyed correctly out of all the words keyed. Net WPM was the number of correct words keyed per minute and used for analysis (Barkaoui, 2014; Typing Master, Inc., 2016).

Keyboarding Method Observation

Keyboarding method observation was recorded while the student completed the Typing Test Pro. Trained researchers completed the observation rating using the following 5-point scale used in prior research and in the research team's pilot study. The scale included (1) keying with one finger on one hand repeatedly using visual-feedback; (2) keying with one finger on each hand while repeatedly using visual-feedback; (3) keying with two to four fingers on each hand repeatedly using visual-feedback; (4) keying with all fingers of both hands repeatedly using visual-feedback; (5) keying with all fingers on both hands without using visual-feedback but relying on kinesthetic feedback (Weiglt Marom & Weintraub, 2015).

Descriptive Data

The school provided records of gender, grade level, race, and if the student qualified for special education for the students in the research study. Students were coded based on their assigned lunch number, to ensure confidentiality. KWT application provided the number of activities completed for each student just prior to post-testing.

Procedure

Approval to conduct this study was obtained from the University & Medical Center Institutional Review Board and from school officials. All schools were provided information letters that were sent home with the students regarding the study. The information letter, with researcher contact information, detailed the study and provided parents/guardians with the option to opt-out from participating in the study. However, no students opted out. Students in all four schools received free 1-year access to KWT the year following this study regardless of their inclusion in the study.

The computer lab teachers at the KWT schools attended a 5-hr training session led by one of the researchers about the KWT curriculum. Free web-based activity instruction teachers did not receive additional training since they were using their instructional approach for computer lab from the prior year.

Researchers began pre-testing at the KWT schools the week of August 15–19, 2016 during regularly scheduled computer lab time. Students at the free web-based activity schools were pre-tested primarily September 12–19, 2016. Little keyboarding instruction occurred at the KWT schools prior to September 12 due to mandatory computer-based testing. Only one of the trained researchers who pre-tested at a KWT school was able to pre-test and score keyboarding method for both free web-based

activity schools due to location and time constraints. Near the end of the school year during the week of May 8–12, 2017, approximately 27 weeks into the KWT program, researchers administered post-testing to all four schools using the same instruments as pre-testing.

Intervention

Keyboarding Without Tears®

Touch keyboarding was taught using KWT®, a self-directed, student-led, web-based application that teaches pre-keyboarding and keyboarding skills to students. This developmentally based curriculum helps foster computer competency through activities based on the motor development pattern previously described which are fun and meaningful for the student. KWT offers a grade-based 36-week curriculum designed for instruction in 5–10 min a day or 30 min a week, targeted for grades kindergarten through fifth. The approach to instructing letter location and finger movements is consistent through every age (Olsen & Knapton, 2015). This developmental approach is unique to KWT which enables students to progress as they acquire grade-appropriate keyboarding skills.

At the KWT schools, the KWT application was used as instruction for 24–29 weeks during the students' weekly computer lab time. The amount of time spent using the application varied based on class and grades. The scheduled class time varied by grade: kindergarten was 60 min while first through fifth grade was 45 min. However, none of the classes spent the entire class session on KWT.

Free Web-Based Activity Instruction

At the free web-based activity schools, kindergarten through second grade students completed activities on FreeTypingGame.Net which offered free keyboarding lessons and tests. The lessons included 30 different two-key combinations for rote practice while the games offered 40 different combinations of letters (FreeTypingGame.Net, LLC., 2018). These lessons do not require a log-in and do not track student performance. In addition, they played interactive games on the PBSkids website (www. PBSkids.org) that promoted mouse and keyboarding skills (Public Broadcasting Service, 2017).

Grades third through fifth used Beginner Typing online typing lessons from Learn Typing© (http://www.learntyping.org) that teaches touch keyboarding through activities, games, and tests (Holding, 2007). However, this website does not provide feedback for errors in keyboarding lessons nor track performance. In addition to the online activities, students attended classroom lessons including topics on Microsoft PowerPoint, coding, and keyboarding strategies for touch keyboarding. Students took speed tests online that measured keyboarding speed (WPM) and accuracy percentage (Groeber, 2017).

Students at the free web-based activity schools received instruction during weekly computer class time. The scheduled class time for kindergarten through second grade was 30 min a week and third through fifth grades was 45 min a week. The entire class time was not spent on keyboarding activities at either school.

Data Analysis

After data collection, we entered data into IBM SPSS Statistics (Version 22; IBM Corp., Armonk, NY) for analysis. Prior to pre-test and post-test, inter-rater reliability for keyboarding method observation among raters was determined using a two-way mixed, consistency, average-measures intra-class correlation coefficient (ICC; Hallgren, 2012). Raters individually watched 10 sample videos of keyboarding and rated the keyboard method for all samples. An ICC value below .40 is poor agreement, between .40 and .59 is fair agreement, between .60 and .74 is good agreement, and between .75 and 1.0 is excellent agreement.

The significance threshold was set at .05 for all analyses. To address the change in keyboarding speed and accuracy through net WPM, box plots and scatter plots were generated for each grade level. After reviewing the visualizations, independent *t*-tests were performed for each grade level to determine a statistically significant difference in net WPM change. To control for the main effect of KWT treatment for grade levels, a two-way analysis of variance (ANOVA) was then used to test if the mean changes on the Typing Test Pro between the KWT schools and free web-based activity schools were supported for grades third through fifth. The decision to control for grades third through fifth was based on the limited variation within the lower grade levels and did not significantly differ in relation to the KWT factor.

Next, to analyze change in keyboarding method bar graphs segmented by percentage of students that increased keyboarding method observation for each grade level were produced. After reviewing the visualizations, contingency tables were produced to determine the odds ratio of improvement on keyboarding method observation score between the KWT and free web-based activities approach instruction schools. Fisher's exact test was generated to provide confidence intervals for the odds ratios.

In addition, the relationship between KWT activities completed on change in net WPM for the KWT schools was analyzed by generating scatter plots depicting the relationship between KWT activities completed and change in net WPM. A linear regression was performed to test the amount of variability explained for every increase in KWT activities completed to the improved score on the Typing Test Pro.

Results

Inter-rater reliabilities for keyboarding method observation among three (pre-test) and four (post-test) raters were excellent (ICC = 0.97 and 0.98, respectively), suggesting the keyboarding method observations were scored similarly among the researchers. There were total of 1908 students who participated in this study: 888 students from the KWT® instructional schools (one school includes kindergarten through second and the other includes third through fifth grades) and 1,020 students from the free web-based activity instruction schools (one school includes kindergarten and the other includes third through fifth grades). See Table 1 for demographic data.

Improvement in Net WPM

Change in net WPM on the Typing Test Pro through independent t-test was greater in the KWT schools as compared to the free web-based activity schools for all grades

Table 1. Participant demographics.

		Gender, n (%)		Ethnicity, n (%)					Education, n (%)	
Grade	School	Male	Female	White	Black	Hispanic	Asian	American Indian	General	Special
Kindergarten	KWT	73 (50.7)	71 (49.3)	116(79.9)	19 (13.2)	3 (2.1)	6 (4.2)	0 (0.0)	133 (78.5)	30 (20.8)
	Free	91 (55.2)	74 (44.8)	137 (83.0)	20 (12.1)	2 (1.2)	6 (3.6)	0 (0.0)	151 (91.5)	14 (8.5)
First	KWT	69 (48.3)	74 (51.7)	112 (78.3)	16 (11.2)	5 (3.5)	8 (5.6)	1 (0.7)	113 (79.0)	29 (20.3)
	Free	93 (57.4)	69 (42.6)	123 (75.9)	28 (17.3)	2 (1.2)	8 (4.9)	0 (0.0)	138 (85.2)	23 (14.2)
Second	KWT	78 (56.1)	61 (43.9)	102 (73.4)	19 (13.7)	9 (6.5)	9 (6.5)	0 (0.0)	120 (87.0)	18 (13.0)
	Free	89 (48.6)	94 (51.4)	137 (74.9)	38 (20.8)	1 (0.5)	7 (3.8)	0 (0.0)	165 (90.2)	18 (9.8)
Third	KWT	63 (43.8)	81 (56.3)	111 (77.1)	25 (17.4)	4 (2.8)	4 (2.8)	0 (0.0)	131 (91.0)	13 (9.0)
	Free	94 (56.3)	73 (43.7)	120 (71.9)	30 (18.0)	6 (3.6)	5 (3.0)	0 (0.0)	151 (90.4)	10 (6.0)
Fourth	KWT	87 (56.1)	68 (43.9)	128 (82.6)	16 (10.3)	3 (1.9)	8 (5.2)	0 (0.0)	142 (91.6)	13 (8.4)
	Free	91 (50.3)	90 (49.7)	145 (80.1)	31 (17.1)	1 (0.6)	1 (0.6)	0 (0.0)	171 (94.5)	7 (3.9)
Fifth	KWT	80 (49.1)	83 (50.9)	29 (79.1)	23 (14.1)	1 (0.6)	10 (6.1)	0 (0.0)	155 (95.1)	8 (4.9)
	Free	76 (46.9)	86 (53.1)	100 (61.7)	42 (25.9)	4 (2.5)	3 (1.9)	0 (0.0)	135 (83.3)	13 (8.0)

Note. KWT is Keyboarding Without Tears and Free represents the schools using free web-based activities.

and significantly greater for first, third, fourth, and fifth grades as evidenced in Table 2. The two-way ANOVA for third through fifth grades indicated the interaction terms were not statistically significant, so the two-way ANOVA was re-run with just main effects. Results of the two-way ANOVA with grade level (third, fourth, and fifth) and instruction (KWT and free web-based activities approach) revealed a main effect of grade, $F(2, 968) = 2.54$, $p = 0.079$, and KWT instruction, $F(1, 968) = 52.82$, $p < 0.001$. The true mean of improvement in net WPM for grades third through fifth based on the 95% confidence interval exists within 1.57 WPM and 2.74 WPM. These results supported the statistical difference noted in the independent sample t-tests.

Improvement in Keyboarding Method

To visualize changes in keyboarding method, the students were dichotomized into two groups: (1) improvement by at least one and (2) no improvement or digression (see Fig. 1). In the two-way frequency table, the grades that demonstrated greater improvement in keyboarding method were KWT kindergarten through second and free web-based activity approach third through fifth as evidenced in Table 3. Results of the Fisher's exact test indicated the odds of improved method score for KWT grades kindergarten through second grade were approximately 25, 8, and 15 times than the free web-based activities instruction grades, respectively. Alternatively, for

Table 2. Change in net words per minute by intervention.

	Group							
	KWT		Free Activity					
Grade	M(SD)	n	M(SD)	n	95% CI for Mean Difference	t	df	Cohen's d
Kindergarten	0.39 (0.56)	144	0.24 (0.57)	165	0.03, 0.28	2.37	307	.27
First	1.45 (1.95)	143	0.50 (1.24)	162	0.59, 1.32	5.17*	303	.58
Second	1.91 (2.56)	139	1.46 (2.20)	183	−0.07, 0.97	1.69	320	.19
Third	4.10 (3.85)	144	2.15 (3.57)	167	1.14, 2.80	4.67*	309	.52
Fourth	4.94 (5.14)	155	2.55 (4.54)	181	1.35, 3.43	4.52*	334	.49
Fifth	4.98 (5.75)	163	2.89 (4.47)	162	0.97, 3.22	3.66*	323	.41

Note. KWT is Keyboarding Without Tears and Free represents the schools using free web-based activities.

grades third through fifth, The KWT grades were less likely to improve, odds are approximately 0.4 times the free web-based activities approach instruction group for each of the grades. Difference in scores were statistically significant for all grade levels ($p < 0.001$).

Lastly, based on the scatter plots depicting the net WPM scores and number of KWT activities completed, there was a weak, positive, linear relationship. Linear regression was calculated to predict change in net WPM based on the average KWT activities completed for the KWT schools. Overall, a significant regression equation was found ($F(1, 886) = 38.298$, $p < 0.001$), with an r^2 of 0.041. Students' predicted improvement in net WPM was equal to $-0.290 + 0.015$ (time spent using KWT application) WPM when time spent using KWT application was measured in amount of completed KWT activities. Net WPM increased 0.015 WPM for each KWT activity completed. The square of the regression line for the Typing Test Pro sample demonstrates a great deal of variation from the regression line. The number of KWT activities per grade level ranges from 409 to 578.

Discussion

Improvement in Keyboarding Speed and Accuracy

These results support the benefit of introducing the KWT application to improve keyboarding speed through repetitive exposure to motor patterns throughout the structured scaffolding of the application. Changes in net WPM were greater in the KWT schools at all grades but statistically significant at first, third, fourth, and fifth grades. Improvements
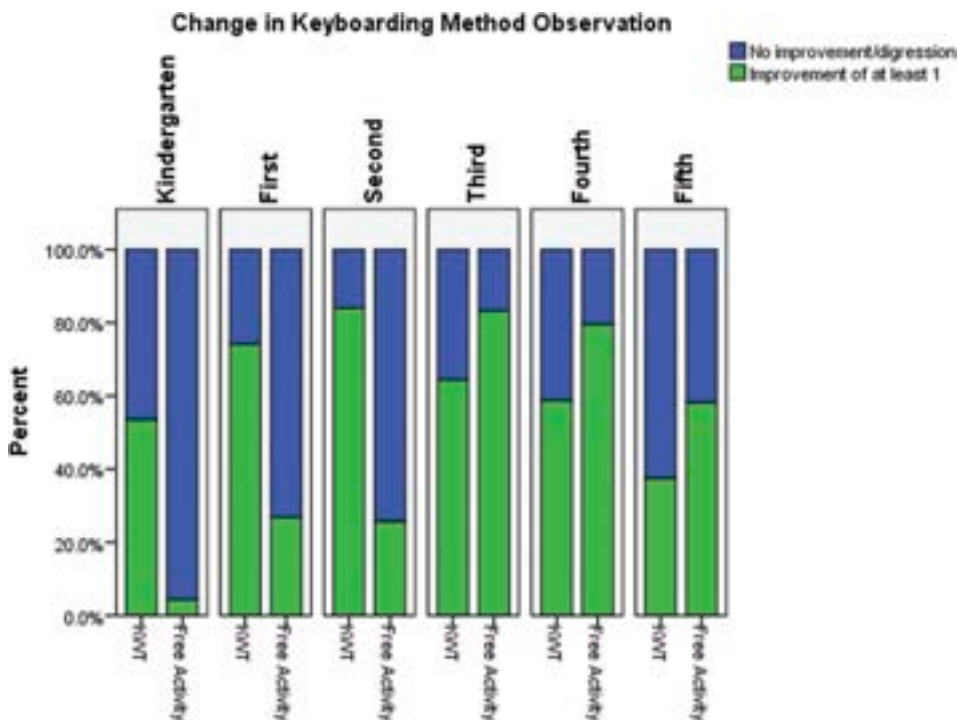
Figure 1. Change in keyboarding method. This figure illustrates the percentage of students who improved keyboarding method versus those who did not from pre-testing to post-testing.

Table 3. Results of two-way frequency table depicting change in keyboarding method.

Grade	Intervention	Improvement n (%)	No Improvement n (%)	Estimated Odds Ratio	95% CI	p-Value
Kindergarten	KWT	77(53.47)	67(46.53)	25.29	10.95, 68.47	0.00
	Free Activity	7(4.29)	156(95.71)			
First	KWT	106(74.13)	37(25.87)	7.75	4.56, 13.45	0.00
	Free Activity	44(26.83)	120(73.17)			
Second	KWT	116(84.06)	22(15.94)	15.09	8.41, 28.07	0.00
	Free Activity	47(25.68)	136(74.32)			
Third	KWT	94(64.38)	52(35.62)	0.37	0.21, 0.63	0.00
	Free Activity	144(83.24)	29(16.76)			
Fourth	KWT	91(58.71)	64(41.29)	0.37	0.22, 0.61	0.00
	Free Activity	148(79.57)	38(20.43)			
Fifth	KWT	61(37.42)	102(62.58)	0.43	0.27, 0.69	0.00
	Free Activity	96(58.18)	69(41.82)			

Note. KWT is Keyboarding Without Tears and Free Activity represents the schools using free web-based activities.

were almost double for the significant grades. These findings are not surprising because the focus of KWT for the earlier grades involves an introduction to the keyboard and mouse functions, developing finger-key associations, and muscle memory of the finger movement sequences (Olsen & Knapton, 2015), which was not reflected in the net WPM measurement but align with the cognitive stage of motor learning. However, the focus of KWT for third through fifth grade is keyboarding performance and efficiency, components of the associative and autonomous stages. It is at these levels that the focus of KWT is supported by the significant differences in net WPM changes for the KWT students over the free web-based activities approach students.

Improvement in Keyboarding Method

The two-way frequency tables indicated KWT grades kindergarten through second grade demonstrated greater improvement in keyboarding method compared to their counterparts at the free web-based activities school, whereas, the control grades third through fifth demonstrated greater improvement in keyboarding method. Incongruences between the upper and lower grades may be due to individual teacher differences in reinforcing proper keyboarding method and the age-related content in KWT application for the lower grades that places more emphasis on hand placement, key location, with a thorough introduction to touch keyboarding (Olsen & Knapton, 2015). KWT application for the upper grades focuses on the development of keyboarding speed and accuracy. Therefore, it is expected that there would be greater improvements in keyboarding method for lower KWT grades than the upper grades.

Relationship Between KWT Activities Completed and Keyboarding Speed

Results of the linear regression do not indicate a significant correlation between KWT activities completed and improved keyboarding speed. Students' participation on the activities and prior level of performance may influence the validity of this analysis. Students' participation on the activities impacts his or her retention of the material in the application. Since the application is student-led, they have the option to advance

through the application at their own pace impacting the students' focus and retention of the material. Furthermore, students' prior keyboarding performance may also be a confounding variable with the effect time spent on the application has on change in net WPM. Therefore, it was difficult to determine the association between WPM improvement and number of KWT activities completed.

Limitations

There are several limitations to this study. The sample was taken from a single southern state in a suburban location which decreased the generalization of our results to other populations. Another limitation was the researchers' inability to be blinded to the instructional group assignment. Due to the nature of the instruction assignments on a school wide level, blinded assessment was not feasible.

Researchers discovered limitations regarding keyboarding assessments across the grade levels. Typing Test Pro© was a simple and effective testing instrument that produced a statistic accounting for both speed and accuracy to quantify keyboarding abilities. Unfortunately, the kindergarten students at the lower elementary schools, particularly at the beginning of the school year during pre-testing, faced challenges with letter identification decreasing the reliability of the assessment. Furthermore, the completion of KWT activities as a measurement of the student's participation in the KWT application was another limitation to the study. The amount of time students spent per KWT activity varied as did the challenge and length of each activity, the motivation to complete the activity, and the students' attention to the activity. Additionally, there was no comparable measure for the free web-based activities approach instruction group.

Implications for Occupational Therapy

Establishing effective keyboarding instruction is valuable to inform occupational therapy practice by contributing to the evidence used by occupational therapy practitioners to enhance occupational performance of students to meet their written communication needs. As use of computers increases in the classroom for assignments, note-taking with digital books, and computer-based assessments, keyboarding proficiency is increasingly more important for all students. In addition, occupational therapy practitioners have often recommended keyboarding as an alternative to handwriting, but little evidence exists to aid in determining effective approaches to help students develop keyboarding skills. This study indicates the importance of using a developmentally-based comprehensive keyboarding curriculum to improve the skills of students; including those in general education and special education (Ashburner, Ziviani, & Pennington, 2012; Preminger et al., 2004). When considering the evidence to determine appropriate written communication interventions for students, the results of this study combining a group of students in general education and special education supports:

- Students keyboarding skills improve with exposure to keyboarding instructional tools.
- Promising evidence of KWT effectiveness to improve net WPM over free web-based activities, especially for grades third through fifth as the application is designed.

- Promising evidence of KWT effectiveness to improve keyboarding method over free web-based activities for grades kindergarten through second, as the application is designed.
- Although the predictability is limited, students who use the full KWT application have the potential to increase their keyboarding net WPM by 6 based on the predictive improvement from the linear regression.

Recommendations for Future Research

This study is the first of its kind to look at potential instructional methods to improve keyboarding skills of elementary-aged children. Additional research should continue to explore the relationship between the KWT application and the impact on keyboarding abilities. By expanding the sample to other regions, the sample population will become more diverse and increase the generalizability of the results. Future research may consider incorporating simple letter keyboarding tasks more suitable for kindergarten students to improve validity of the speed and accuracy assessments. Additionally, future research should be done to better quantify time spent using the KWT application to examine the relationship between KWT and improvement in keyboarding speed.

Conflict of interest statement

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