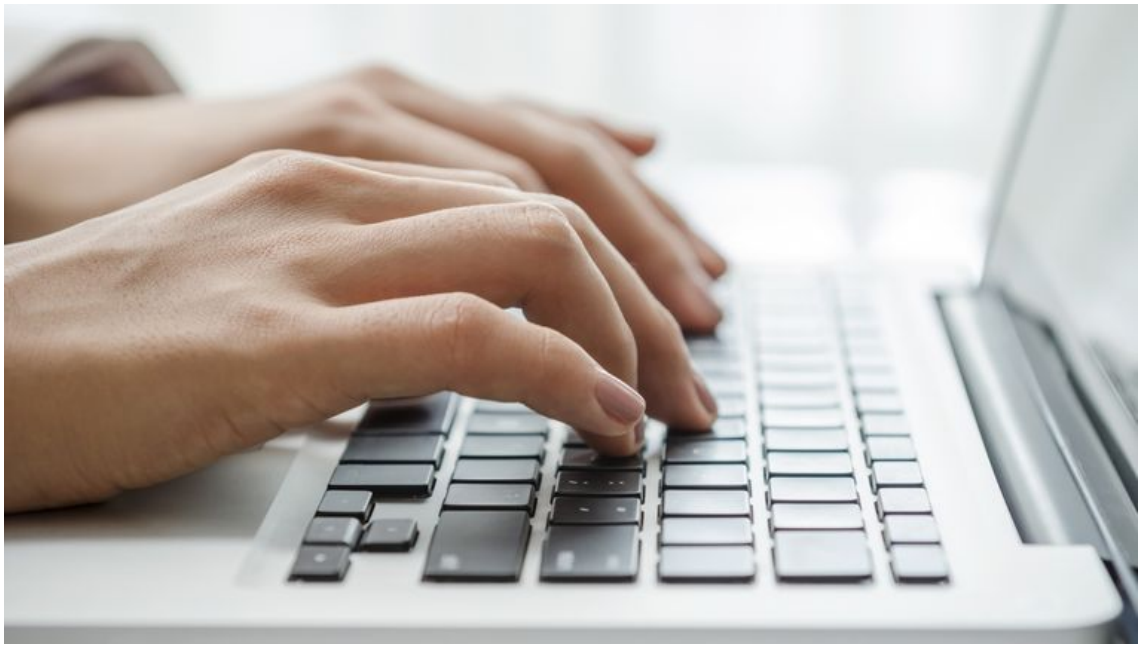
Blind leren typen is ook goed voor je taal

Door een typecursus leren basisschoolkinderen niet alleen blind de juiste toetsen in te drukken. Ze ontwikkelen ook betere spel- en opstelvaardigheden op de computer. Dat schrijven Nijmeegse onderwijskundigen in het vakblad Levende Talen Tijdschrift, op basis van een onderzoek onder 234 basisschoolkinderen van verschillende scholen.

Mickey Steijaert 16 december 2015, 5:00



Beeld Thinkstock

Op school worden opdrachten en toetsen steeds vaker op de computer gemaakt. Kinderen die een typecursus hebben gevolgd zijn daarbij taalvaardiger en dus in het voordeel, aldus hoofdonderzoekster Henny van der Meijden. 'Maar zo'n cursus kost meestal geld. Eigenlijk moet op de basisschool systematische aandacht worden besteed aan blind typen.'

Van der Meijden vergeleek kinderen in groep 6, 7 en 8 die door hun ouders waren opgegeven voor een cursus blind typen met leeftijdgenoten zonder cursus. Voor de cursus nam ze testjes bij de kinderen af om hun taalvaardigheid op de computer te bepalen, met

onder meer een dictee. Ook typten de kinderen een opstel aan de hand van plaatjes.

Opstellen

Na afloop van de typecursus voerde Van der Meijden de testjes nog eens uit bij dezelfde kinderen. Daaruit rolden twee bevindingen. De eerste, weinig verrassend: de kinderen die de cursus hadden gevolgd, konden nu tot wel drie keer zo snel en nauwkeuriger typen.

Vondst twee was opmerkelijker. De cursisten bleken met sprongen vooruit gegaan wat betreft taalvaardigheid op de computer. Zo maakten de blindtypers gemiddeld maar 6 fouten in het dictee (de niet-cursisten maakten er gemiddeld 8) en waren hun opstellen gemiddeld langer en beter.

Invloed

Waarom precies de blinde tikkers uitblinken in taalvaardigheid is niet duidelijk. 'Waarschijnlijk vergt het zoeken naar letters op het toetsenbord veel denkvermogen voor kinderen zonder typecursus. Zo veel, dat ze minder denkkracht besteden aan spellen of goed schrijven', legt Van der Meijden uit. 'Een andere optie is dat de opdrachten in de typecursus zelf invloed hebben. Door de cursus zijn de kinderen toch al gauw10 minuten per dag meer bezig met taal dan andere kinderen.'

Huub van den Bergh, taalonderwijs-specialist aan de Universiteit Utrecht en niet betrokken bij het onderzoek, noemt haar resultaten overtuigend. 'Ik heb wat aanmerkingen bij de meetmethoden, maar de gemeten effecten zijn erg groot. Die vind je waarschijnlijk in replicaties ook wel terug.'

Het schoolcurriculum aanpassen vindt Van den Bergh nog te ver gaan. 'Er liggen te veel vragen open. Eerst moet duidelijk zijn waarom die typecursus zoveel invloed heeft. En dan nog moet je over zoiets heel goed nadenken.'

Van der Meijden hoopt in vervolgonderzoek het verband tussen blind typen en taalvaardigheid te verklaren.

Received: 29 March 2018 | Revised: 10 August 2018 | Accepted: 28 September 2018

DOI: 10.1111/jcal.12323

ORIGINAL ARTICLE

WILEY Journal of Computer Assisted Learning

Touch-typing for better spelling and narrative-writing skills on the computer

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Abstract

This study investigated the effect of a touch-typing course on the spelling and narrative-writing skills on the computer of elementary school students. Data of 207 students in Grades 4, 5, and 6 were analysed using a pretest–posttest design. Students in the experimental group (n = 154) followed a touch-typing course, and those in the control group (n = 53) did not. The experimental group showed more progress in typing, spelling, and narrative-writing skills on the computer than the control group. It can be concluded that the touch-typing course had a positive effect, not only on typing skills but also on spelling and narrative-writing skills on the computer.

KEYWORDS

elementary education, keyboarding skills, narrative writing, spelling, touch-typing

1 | INTRODUCTION

Students are increasingly given the opportunity to work on the computer in both elementary and secondary education. Moreover, in teaching practice, word-processed assignments are more and more requested (Mogey et al., 2008). Quality of the writing product by means of a word-processing program is likely to be higher when typing skills are better (Goldberg, Russell, Cook, & Russell, 2003; Graham, McKeown, Kiuhara, & Harris, 2012). Furthermore, elementary teachers subscribed to the importance of using word-processing programs and of touch-typing skills for students to perform well on standardized tests (Poole & Preciado, 2016). However, touch-typing instruction is not yet part of standard school curricula in most countries (Connelly, Gee, & Walsh, 2007; Poole & Preciado, 2016; Van Gelderen, 2010; Wollscheid, Sjaastad, Tømte, & Løver, 2016), and research on the effects of touch-typing interventions on school performance such as spelling and writing has been limited (Christensen, 2004). Therefore, in the present study, we investigated the effect of a touch-typing course on students' spelling and narrative-writing skills on the computer.

Learning to write in elementary school can be seen as a multidimensional process whether the writing is done with paper and pencil or by typing on keyboard. During this process, three components draw on the same cognitive resources of the working memory: (a) low-level transcription skills (handwriting, keyboarding, and spelling), (b) executive functions (planning and reviewing), and (c) high-level text generation skills (formulating sentences and discourse). An increased demand by one of these components on working-memory resources will limit the availability of it for the other two (Berninger & Winn, 2006). New to-be-learned transcription skills can be automatized and thereby free up working-memory capacity, which in turn can be devoted to high-level cognitive processes of writing whether text is generated via paper and pencil or keyboard (de Graaf-Peters, 2008; Hayes & Chenoweth, 2006).

Writers with beginning keyboarding skills concentrate mainly on key location rather than on composition of the text (Connelly et al., 2007; Johansson, Wengelin, Johansson, & Holmqvist, 2010; Ouellette & Tims, 2014). They often use the visually guided strategy (Yechiam, Erev, Yehene, & Gopher, 2003); they are called "keyboard gazers" searching for the right keys to press, and they do not place their hands and fingers in a fixed position. This visually guided strategy tends to be less efficient than the touch-typing strategy during which hands are placed in a fixed position on the keyboard as a starting point for

pressing particular keys by utilizing up to all 10 fingers without looking at the keyboard (Johansson et al., 2010). It could be argued that cognitive load of touch-typists who have automatized their touch-typing is lower than that of typists who use the visually guided strategy, because touch-typists can read and type simultaneously and therefore focus more on the content rather than on the mechanics of written work production. Consequently, their text output might be of better quality as compared with typists without this automaticity (Alves, Castro, & Olive, 2008; Christensen, 2004; Freeman, Mackinnon, & Miller, 2005; Johansson et al., 2010).

In the literature, there is a debate about the minimum age at which a touch-typing course can or should be taken by students. Some authors have argued that students aged 7 years are old enough to follow a touch-typing course, because at that time, they have sufficient level of fine-motor control, letter recognition, and word identification necessary for computer access (Chwirka, Gurney, & Burtner, 2002). However, a touch-typing course might be more effective when students are between 10 and 12 years old because then they have a shorter learning curve (Freeman et al., 2005; Rogers & Case-Smith, 2002; Stevenson & Just, 2014). Poole and Preciado (2016) found that 48.5% of elementary teachers indicated Grades 1 to 2 as the ideal time to begin teaching touch-typing and 43.5% suggested Grades 3 to 4.

1.1 | Effects of typing on spelling

Research on typing and spelling has mainly focused on the differences between typing and handwriting. A review of studies on this topic by Cochran-Smith (1991) showed that, in general, typed texts were longer and contained fewer spelling errors than handwritten texts. Furthermore, students worked longer on a writing assignment and revised the assignment more often when keyboarding than when handwriting (Cochran-Smith, 1991). It should be noted, however, that only two studies in this review were conducted among elementary school students.

In 1990, Cunningham and Stanovich examined three strategies to develop spelling skills among 7-year-old children: handwriting words, sorting letter tiles, and typing words on a computer (Cunningham & Stanovich, 1990). They found that children in the handwriting condition produced more correctly spelled words than children in the other two conditions. On the basis of this result, they concluded that handwriting was the best strategy to teach children how to spell. However, a replication of this study questioned this conclusion by showing no difference between the three conditions (Vaughn, Schumm, & Gordon, 1993). Furthermore, Masterson and Apel (2006) investigated the effect of typing on spelling in children from Grades 2 to 6. No difference in quality of spelling between the handwriting and typing conditions was found. However, differences were found between more fluent and less fluent typists. The authors argued that the visually guided typing strategy came at the expense of spelling accuracy and that better typing proficiency might reduce the cognitive demands on the working memory and, consequently, might improve spelling accuracy. A similar result was found among 40 students in Grade 2 (mean age 7 years and 5 months) by Ouellette and Tims (2014), who found no difference on a word-recognition and spelling test between the typing and handwriting conditions but also found that slower typists obtained lower scores on these spelling tests than more proficient typists (Ouellette & Tims, 2014).

1.2 | Effects of typing on narrative-writing skills on the computer

Several studies have investigated the relation between typing skills and the quality of a narrative-writing product. Most of them concerned the general use of a word-processing program, rather than the typing fluency and found positive effects of these programs on different writing outcomes from Grades 4 to 12 (Graham & Perin, 2007; Morphy & Graham, 2012). For example, Goldberg et al.'s (2003) meta-analysis on the comparison of writing with computers versus writing with paper and pencil in K-12 students indicated that students who used the computer produced longer texts than students who wrote with paper and pencil. Moreover, the quality of digitally produced work was higher than the handwritten work. On average, the effects were larger for middle and high school students than for elementary school students. More recently, a meta-analysis by Graham et al. (2012) was conducted on writing instruction for students in the elementary grades. In 10 studies, effectiveness of the use of a word-processing program of elementary school children was assessed. Seven out of these 10 studies showed positive effects in favour of the use of a word-processing program on quality of the typewritten product. Instruction of text transcription skills like spelling, handwriting, and keyboarding was beneficial for quality of writing. However, in many of the studies showing no effect of the use of a word-processing program, students had little prior typing experience (Graham et al., 2012). Thus, typing proficiency may be a moderator in the relation between typing and the quality of the typewriting product. This moderating role of typing proficiency was indeed found by Alves et al. (2008) who selected adult writers (N = 34) of low and high typing skills to perform dictation and composition tasks. According to the authors, low typing skill had a "detrimental" impact on text quality, for example, slow typists produced fewer words per minute, shorter texts, less lexical density, and less lexical diversity than fast typists did (Alves et al., 2008). In addition, Connelly et al. (2007) emphasized the importance of typing proficiency. They found that the quality of narrative writing in the handwritten scripts was better than in keyboarded scripts of 300 children in elementary school. However, they also found that handwriting speed was consistently faster than keyboarding speed across all ages. They emphasized the fact that explicit instruction in touch-typing was absent in the classrooms, and they stated that this instruction is needed to develop keyboarding fluency and unlock the full potential of the word processor for children's writing (Connelly et al., 2007).

Only one study by Christensen (2004) investigated the effects of typing on the quality of narrative writing on the computer by including an intervention to improve typing proficiency. In this study, 35 students aged 13 years and 3 months were matched on gender and typing scores and randomly assigned to either an experimental (n = 18) or control (n = 17) group. The experimental group followed a typing-skill program, which provided sequenced practice in typing letters and words. When students reached a criterion of 40 letters per minute, they were advanced to the next level in the program. The control group did not

follow the typing-skill program but instead were encouraged to daily write whatever was significant for them each day to complete a written journal that was typed on a desktop computer using a word-processing program. Quality of typewritten text (next to accuracy of spelling and grammar) was scored on creativity and originality of ideas, logical organization and structuring of ideas, comprehensiveness and elaboration of ideas in relation to the topic, and pragmatic awareness and sensitivity to audience. Results showed that the experimental group made significant more progress than controls on these measures of quality of typewritten text (Christensen, 2004).

1.3 | The present study

From the above, it can be concluded that typing skills are related to elementary school students' spelling and narrative-writing skills on the computer. However, little research has been executed on keyboarding instruction. Only one study investigated whether improving typing skills has a positive effect on narrative-writing skills on the computer, and results indicated that this was the case (Christensen, 2004). As far as we know, no studies have been published in which spelling and narrative-writing abilities are tested in the same sample of elementary school children. This is relevant because according to Olinghouse (2008), mechanisms as handwriting and spelling are important predictors for narrative writing, for example, transcribing ideas into language. In addition, handwriting fluency is related to the quality of composition (Christensen, 2004). Writing skills in elementary school are often assessed in word and sentence dictations. However, dictations give hardly any information about the ability of the child to use language creatively (Van Koss Torkildsen, Morken, Helland, & Helland, 2016). Keeping this in mind, we selected three tasks that had to be performed on the computer: (a) a typing task to assess typing ability (similar to handwriting ability), (b) a dictation task to assess spelling ability, and (c) a narrative-writing task. These tasks were carefully selected, on the basis of their use in Dutch typewriting institutions and the educational system. The typing task was a text used by the *Dutch Alliance of Stenography and Typewriting* for final examination. The spelling task was a dictation test that was commonly used in Dutch education for assessing spelling. The narrative-writing task was a picture elicitation task to elicit written narratives, which reduced the effect of familiarity with written-language schemas that are largely acquired through reading comprehension (Williams & Larkin, 2013). It was a validated Dutch test for assessing writing skills with paper and pencil, with good psychometric characteristics such as reliability, validity, and norms (Verhoeven & Vermeer, 2001).

The present study is the first to investigate the extent to which enhancing typing skills can have an effect on both spelling and narrative-writing skills on the computer. Therefore, the aim of the present study was to investigate the effect of a touch-typing intervention not only on typing skills but also on spelling and narrative-writing skills on the computer. We used a design with an experimental group receiving a complete professional touch-typing course and a control group who did not receive this course. We formulated two research questions. The first question was "To what extent are students' typing skills related to their spelling and narrative-writing skills on the computer?" Evidence for these relationships would strengthen our premise that improving typing skill might also improve these spelling and narrative-writing skills. We expected that typing skills (measured in keystrokes per minute) were related to students' spelling proficiency (Cochran-Smith, 1991; Ouellette & Tims, 2014) and narrative-writing skills (Alves et al., 2008; Connelly et al., 2007). The second research question was "To what extent is there a positive effect of improving touch-typing skills by a professional touch-typing course on elementary school students' spelling and narrative-writing skills on the computer?" We hypothesized that an intervention aiming to improve students' typing skills would have a beneficial effect on these measures (Christensen, 2004) because of a decreased demand on working-memory resources due to the automaticity (Berninger & Winn, 2006).

2 | METHOD

2.1 | Participants

Two hundred thirty-four students in Grades 4, 5, and 6 (from 10 to 12 years of age) were recruited to take part in the experiment. The students attended 20 elementary schools in the east of the Netherlands. Parents of 17 students in the experimental group and one in the control group did not provide permission to take part in this study. Ten students were removed from the dataset for reasons of quitting before finishing the course (n = 4), of missing pretest scores (n = 2), and of missing posttest scores (n = 4). In total, data of 207 students were analysed: 154 in the experimental group and 53 in the control group. Boys and girls were equally divided over the experimental and control group, $X^2(1) = 0.86$, $p = 0.35$, and over grades (4, 5, and 6), $X^2(2) = 3.01$, $p = 0.22$. However, grade level was not equally divided over both groups, $X^2(2) = 8.49$, $p = 0.014$. As can be seen in Table 1, the proportion of children in Grade 5 was the largest in both the experimental and control groups, with 44.2% and 49.1%, respectively. However, in the experimental group, children in Grade 6 formed the smallest group (19.5%), whereas in the control group, children in Grade 4 were relatively underrepresented (17.0%).

2.2 | Measures

On both pretest and posttest, all participants were assessed by three tasks on the computer, that is, a typing, a spelling, and a narrative-writing task.

2.2.1 | Typing task

In the typing task, the participants were asked to retype a text as precisely and as fast as possible including capitals, commas, and full

TABLE 1 Number of participants by grade and group

	Grade			
	4	5	6	Total
Group				
Experimental	56 (36.4%)	68 (44.1%)	30 (19.5%)	154 (100%)
Control	9 (17.0%)	26 (49.0%)	18 (34.0%)	53 (100%)
Total	65 (31.4%)	94 (45.4%)	48 (23.2%)	207 (100%)

stops during 10 min in a Word document that was opened on the computer screen. The text was presented on paper in Times New Roman 12-point font, and the students started typing in a Word document that was opened on the computer screen. After 10 min, participants were asked to stop typing, and after that, the test leader saved the file.

With this typing task, two variables were measured. First, the number of keystrokes per minute was counted while typing up an examination script of the *Dutch Alliance of Stenography and Typewriting*. This was based on guidelines of the alliance: All keystrokes, including spaces and capitals (double stroke), were counted. Second, the number of typing errors was counted. The following errors were considered typing errors: forgotten words or sentences, double spaces, and wrong spellings. They are presented in percentages by the formula (number of typing errors/total number of keystrokes) × 100.

2.2.2 | Spelling task

The spelling task consisted of a dictation with nine sentences; the children had to type these sentences in a new Word document that was opened on the computer screen. These sentences originated from the vocabulary exercise program of the *Centraal Instituut voor ToetsOntwikkeling* (CITO; Central Institute for Test Development; Cito, Citotoets Woordenschat, http://www.leestrainer.nl). The sentences had different levels of difficulty: Three sentences were at Grade 4 level, three sentences at Grade 5 level, and three sentences at Grade 6 level. The number of words per sentence varied between five and nine, and the number of syllables per word varied between one and five. Each sentence was read aloud three times within 45 s before the next sentence was dictated, and the duration of the spelling task was approximately 8 min. Every deviation from the original spelling determined by CITO was scored as a spelling error, and the number of words with one or more spelling errors was counted.

2.2.3 | Narrative-writing task

Narrative writing was measured using a subtask of the Language Proficiency Test for All Children (Verhoeven & Vermeer, 2001), which is a standardized discrete-point test for the assessment of 4- to 10-year-old children consisting of 10 subtests. All of the subtests have been shown to be reliable, with Cronbach's alphas ranging between $\alpha = 0.90$ and $\alpha = 0.97$. Norm scores for Dutch-speaking children were based on a nationwide sample of 727 children (Verhoeven & Vermeer, 2006).

In the narrative-writing assignment, students were asked to type a story based on a comic of eight pictures they received printed on paper. They were given 7 min to typewrite this story in a new Word document that was opened on the computer screen. It was emphasized that they had to come up with their own story but that it should be comprehensible to others who had no access to the comic pictures. The quality of this typewritten text was determined by analysing three characteristics: (a) the total number of words, (b) the quality of the picture description, and (c) temporal and causal relations. The total number of words was counted to assess the length of the text. To analyse the quality of the descriptions of the comic pictures, a protocol was followed. First, the core actions in each picture (e.g., *man is walking* and *girl is eating ice cream*) were counted. This resulted in a score between 0 and 8. On top of that, a maximum of 3 points was given when extra information was provided, such as information on feelings of the subjects (e.g., "sad" or "happy"), relationships between the subjects (e.g., "boy friend"), or person description (e.g., "the ice-cream seller was from Italy"). One point was given when extra information was provided once, 2 points when it was provided twice, and 3 points when extra information was provided three times or more. Thus, for the eight pictures, the total possible score ranged from zero to (8 + 3 =) 11 points. Finally, temporal and causal relations in the text were scored by the number of function words that were used by the students, for example, *so*, *because*, *but*, and *why*. Every time the function word was used by the student, 1 point was scored, except for the function words *and* and *then*. When one of these two words was used, a maximum score of 1 point was given even when they were used more than once.

Two researchers scored all narrative writing assignments of both the pretest and posttest independently in order to account for interpretation effects. Due to the extensive protocol, only in few cases (less than 2%), differences in scores were observed. In these few cases, the researchers deliberated until they reached agreement on the final score.

2.3 | Procedure

Students were only included in the present study when parents provided active written informed consent. The experimental group consisted of students whose parents admitted to take part in a touch-typing course at an educational institute and paid for the course. The control group consisted of classmates who did not take part in any touch-typing course. Reasons for not taking part are unknown.

All tasks were completed in Microsoft Word without using the spelling and grammar check or the autocorrect function. First, all students were assessed with the typing task. They were given 10 min to type a text that was presented on paper. Subsequently, the participants were assessed with the spelling task. Last, they completed the narrative-writing task. All participants (e.g., of the experimental and the control group) were assigned with the three tasks at pretest and the posttest. Assessment of the pretest took place at the beginning of the school year in August 2013. Subsequently, the touch-typing course as intervention started for the experimental group and lasted 7 months. Finally, in April 2014, assessment of the posttest took place for both the experimental and the control groups with another version of the three tasks than the students had completed at the pretest.

2.4 | Intervention: Touch-typing course

The course was taught by a certified teacher from an educational institute. The participants in the experimental group who followed this course had 1.5-hr training sessions every 2 weeks and attended 15 training sessions in total. They were trained with both a textbook *Blindelings* [Blindly] (Van Wees-Bremers, 2008) and an online course *TypeWorld* (Instruct, 2013).

The textbook *Blindelings* was used during the training sessions. It consisted of 15 modules for typewriting and word-processing.

Students learned to touch-type the letters of the alphabet in a structured manner, starting with letters on the fixed "basic position" of the fingers, for example, the letters *f*, *d*, and *s* for the left hand and *j*, *k*, and *l* for the right hand. In each training session, two or three new letters were introduced. First, the exercises comprehended typing series of letters without meaning (i.e., *eded*). After that, small words (i.e., *drie keer eerder* [*three times before*]) were introduced gradually. The students systematically learned how to type all keys without looking at the keyboard. They gradually practiced these new skills in typing their own texts. In the final stage of this course, attention was paid to other typing skills, such as the use of capitals and paragraphs. Every module ended with a test. The students were supervised by the teacher who gave instruction regarding the sitting position and the position of the hand and wrist. Besides that, in the exercises that focused on learning to touch-type the letters, the teacher dictated the letters aloud and the children were stimulated to look at the computer screen only and not at their keyboard.

The children were asked to practice at home with both the textbook assignments and the exercises in the online course *TypeWorld* every day for about 20 min in total. In this online course, children explored an attractive and colourful environment with 20 isles that were "inhabited" with letters, words, and games. The teacher checked students' progress and the quality of their homework. When students had not done their homework, their parents were contacted, and the students had to catch up with their homework. When students fell behind in typing, they attended extra training sessions in one of the intervening weeks between the training sessions.

2.5 | Data analysis

Because of unequal distributions of children over groups (experimental versus control) and over grades (4, 5, and 6), both group and grade levels were taken into account in the analyses. Means and standard deviations were calculated for each grade within each group and at group level. Cohen's *d* (Cohen, 1988) for single-group pretest–posttest designs (with pooled variances) was calculated at group level according to Morris (2008) taking unequal group sizes into account. To answer the first research question, bivariate Pearson product–moment correlations (*r*) were calculated for the relationship between the typing skills and the spelling, and narrative-writing skills at pretest. To answer the second research question concerning the effect of the touch-typing intervention, analyses of covariance (ANCOVAs) were used with group (experimental vs control) and grade (4, 5, and 6) as fixed factors, posttest scores as dependent variable, and pretest scores as covariable. Partial η^2 effect sizes were calculated for the interaction effects Group*Grade and for the main effects of group and grade.

3 | RESULTS

3.1 | Descriptive statistics and comparisons at pretest

Before answering the research questions, descriptive statistics were calculated. Table 2 presents the mean scores and standard deviations at the pretest and posttest for the experimental and control group disaggregated by grade level. It can be noticed that at pretest, the number of keystrokes per minute of both the experimental group (M = 52.85, SD = 19.16) and the control group (M = 62.19, SD = 19.38) was below the threshold of 100 keystrokes per minute to perform at "Junior tying level" according to the Dutch National norms of the European Computer Driver License (ECDL, 2018). However, at posttest, all students of the experimental group (M = 168.34, SD = 43.10) whether they were in Grade 4, 5, or 6 had reached the "Professional typing level" of these norms (e.g., between 150 and 180 keystrokes per minute), whereas all students in the control group (M = 75.55, SD = 23.81) still scored below the threshold of 100 keystrokes per minute (ECDL, 2018). Furthermore, effect sizes for the differences between pretest and posttest scores are presented by group in Table 3.

3.2 | Relation between typing and spelling, and narrative writing on the computer

The first research question concerned the relationship between students' typing skills and their spelling, and narrative-writing skills on the computer. Note that in the typing task, children saw the text they had to type, whereas in the spelling task, they did not. In the narrative-writing task, they only saw the comic of eight pictures. Pearson correlations are presented in Table 4. It can be seen that correlations were moderate to strong (Evans, 1996). Highest correlations were found with keystrokes per minute; when the number of keystrokes per minute was higher, fewer spelling errors were made, the total number of words was larger, the quality of the description of the comic pictures was better, and more temporal and causal relations were present in the text. Less high but still significant correlations were found between percentage typing errors in the typing task on the one hand, and the number of spelling errors and the narrative-writing skills on the computer on the other hand.

3.3 | Effect of the touch-typing course

To determine whether improving typing skills by a touch-typing course had a positive effect on typing, spelling, and narrative-writing skills on the computer, results of ANCOVAs with pretest measures as covariable are presented in Table 5. It can be seen that four of the six interaction effects Group*Grade were nonsignificant indicating that main effects can be interpreted. This was done for Keystroke per minute and the three narrative-writing tasks. Results showed significant main effects when pretest measures were included as covariable. This indicated that there was a significant difference between the experimental and control groups at posttest measures when pretest scores are taken into account. For two posttest measures, for example, percentage typing errors and number of spelling errors, interaction effects were significant in the ANCOVA showing that differences between grade levels were smaller in the experimental group than in the control group. Follow-up analyses were done for these two variables, for each grade separately. There were still differences between the experimental and control groups on percentage typing errors each

TABLE 2 Means and standard deviations on pretest and posttest for the experimental (n = 154) and control (n = 53) groups on typing, spelling, and narrative-writing skills

	Experimental				Control			
	Pretest		Posttest		Pretest		Posttest	
	M	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Typing								
Keystrokes per minute								
All grades	52.85	(19.16)	168.34	(43.10)	62.19	(19.38)	75.55	(23.81)
Grade 4	43.88	(14.41)	165.14	(42.12)	44.89	(18.77)	59.09	(25.32)
Grade 5	55.07	(18.88)	168.81	(43.17)	64.05	(21.05)	77.20	(25.15)
Grade 6	64.67	(20.240	173.27	(45.64)	68.17	(11.41)	81.40	(17.87)
Typing errors in %								
All grades	3.27	(2.48)	0.72	(0.58)	3.45	(3.41)	2.75	(1.65)
Grade 4	3.88	(2.40)	0.61	(0.37)	6.62	(6.96)	3.80	(1.88)
Grade 5	3.33	(2.73)	0.74	(0.49)	2.94	(1.59)	2.74	(1.32)
Grade 6	1.96	(1.36)	0.87	(0.95)	2.61	(1.60)	2.24	(1.80)
Spelling								
Spelling errors								
All grades	10.16	(8.98)	6.00	(3.70)	8.23	(6.32)	7.72	(6.37)
Grade 4	13.07	(8.38)	7.64	(4.11)	17.56	(8.90)	16.11	(9.60)
Grade 5	9.18	(9.87)	5.41	(3.37)	6.19	(3.72)	6.23	(4.12)
Grade 6	6.97	(6.12)	4.27	(2.23)	6.50	(2.98)	5.67	(3.25)
Narrative writing								
Total number of words								
All grades	89.64	(35.80)	150.60	(41.13)	97.11	(34.08)	116.53	(36.20)
Grade 4	78.04	(32.15)	148.44	(44.38)	78.00	(42.67)	109.11	(46.66)
Grade 5	93.38	(32.56)	155.46	(40.36)	101.08	(31.21)	115.77	(34.43)
Grade 6	106.28	(39.33)	143.57	(36.35)	100.94	(32.12)	121.33	(34.34)
Description quality								
All grades	5.69	(1.99)	8.30	(1.57)	6.34	(1.66)	6.38	(1.68)
Grade 4	5.13	(1.87)	8.04	(1.21)	5.11	(1.54)	5.33	(1.80)
Grade 5	5.85	(1.86)	8.27	(1.76)	6.54	(1.48)	6.54	(1.48)
Grade 6	6.40	(2.27)	8.83	(1.62)	6.67	(1.78)	6.67	(1.78)
Temporal/causal relations								
All grades	3.08	(1.95)	4.66	(3.06)	3.11	(1.96)	3.13	(1.86)
Grade 4	2.63	(1.87)	4.89	(3.68)	2.67	(1.50)	2.98	(1.42)
Grade 5	3.29	(2.12)	4.68	(2.71)	2.92	(2.08)	2.98	(2.28)
Grade 6	3.43	(1.57)	4.20	(2.54)	3.61	(1.98)	3.62	(1.88)

TABLE 3 Cohen's d effect size for difference between pretest and posttest according to Morris (2008)

	Cohen's *d*	
	Experimental	Control
Typing		
Keystrokes per minute	3.51	1.29
Typing errors in %	−1.02	−0.23
Spelling		
Spelling errors	−0.65	−0.14
Narrative writing		
Total number of words	1.38	0.68
Description quality	1.22	0.14
Temporal/causal relations	0.50	0.07

TABLE 4 Pearson correlations among typing, spelling, and narrative-writing skills for all participants (N = 207) at pretest

	Typing task	
	Keystrokes per minute	Typing errors in %
Spelling task		
Spelling errors	−0.65**	0.63**
Narrative-writing task		
Total number of words	0.72**	−0.20**
Description quality	0.64**	−0.22**
Temporal/causal relations	0.41**	−0.14*

*p < 0.05.

**p < 0.01.

TABLE 5 Analysis of covariance outcomes with pretest measures as covariable, group (experimental versus control) and grade (4, 5, and 6) as fixed factors, and posttest measures as dependent variables

	Effect	*F*	*df1, df2*	*p*	Partial η^2
Typing					
Keystrokes per minute	Group*Grade	0.29	2, 200	0.750	0.003
	Group	328.64	1, 200	<0.001	0.622
	Grade	1.22	2, 200	0.298	0.012
Typing errors in %	Group*Grade	7.62	2, 200	0.001	0.071
	Group	170.62	1, 200	<0.001	0.460
	Grade	2.33	2, 200	0.100	0.023
Spelling					
Spelling errors	Group*Grade	8.56	2, 200	<0.001	0.079
	Group	34.70	1, 200	<0.001	0.148
	Grade	17.81	2, 200	<0.001	0.151
Narrative writing					
Total number of words	Group*Grade	2.25	2, 194	0.108	0.023
	Group	30.33	1, 194	<0.001	0.135
	Grade	1.04	2, 194	0.355	0.011
Description quality	Group*Grade	0.66	2, 198	0.514	0.007
	Group	86.30	1, 198	<0.001	0.304
	Grade	1.37	2, 198	0.255	0.014
Temporal/causal relations	Group*Grade	0.86	2, 198	0.424	0.009
	Group	10.99	1, 198	0.001	0.053
	Grade	0.17	2, 198	0.841	0.002

grade separately, with all *p*s < 0.05. On the number of spelling errors, these differences between groups were only significant in Grades 4 and 6 with *p*s < 0.05, but not in Grade 5, $p = 0.08$. In sum, because the experimental group had followed the touch-typing course and the control group had not, it can be concluded that the touch-typing course had an effect not only on typing skills but also on spelling and narrative-writing skills.

4 | DISCUSSION

The aim of the present study was to investigate the effect of a touch-typing intervention on typing, spelling, and narrative-writing skills in elementary school students. The experimental group received a complete professional touch-typing course, and the control group did not receive this course. It can be concluded that typing skills (e.g., number of keystrokes) are positively correlated with students' spelling and narrative-writing skills on the computer. These results are in line with studies that found relations between typing skills and spelling (Masterson & Apel, 2006; Ouellette & Tims, 2014) and between typing skills and narrative writing (Alves et al., 2008; Goldberg et al., 2003).

Furthermore, the improvement in typing skills in the experimental group was larger than in the control group. The experimental group outperformed the control group at posttest and accomplished to type at a level that is higher than required for a "Professional typing level" (ECDL, 2018). Thus, it can be concluded that the touch-typing course in the present study was effective in training the students in Grades 4 to 6 to gain a professional touch-typing level. This is in accordance with previous research (Christensen, 2004; Freeman et al., 2005; Rogers & Case-Smith, 2002; Stevenson & Just, 2014). An important question is, however, whether similar progress in touch-typing skills can be gained in younger students, because it has been found that elementary teachers' belief that the ideal time would be between Grades 1 and 4 (Poole & Preciado, 2016). Only one study has investigated this in Grade 2 students and reported progress on "written communication skills" (Chwirka et al., 2002). Results of the present study showed a decline in performance (e.g., slower, more errors, and less quality of narrative-writing text) from Grades 6 to 4, and therefore, it is likely that children in grades lower that 4 will show even less performance, but the question remains to what extent their progress in typing, spelling, and narrative-writing skills on the computer will be improved by a touch-typing course.

The improved typing skills also had a positive effect on spelling ability. The decline in spelling errors on the spelling dictation task was larger in the experimental group than in the control group. This can be explained by Berninger and Winn (2006) in which the ability to spell correctly is seen as a low-level transcription skill that is relying on working-memory resources during the process of typing or writing a text. It could be argued that when typing is automatized, the demand on working-memory resources is reduced and the cognitive load is lower, which could result in better attention to spelling rules (Connelly et al., 2007; Johansson et al., 2010; Ouellette & Tims, 2014). However, it is important to notice that all children (in both the experimental and the control groups) were instructed to pay

attention to spelling rules while typing the text. It is likely that more spelling errors will occur when this is not the case. However, it is unknown how this will affect the differences in spelling errors between the two groups.

Last, improving the students' typing skills positively influenced the students' narrative-writing skills. Students in the experimental group showed a larger improvement than those in the control group on the quality of the typewritten narratives, for example, on the length of the text, the description of the comic pictures, and the use of temporal and causal relations in the text. These results are in line with Christensen (2004) who also found that children who followed a typing-skill program improved more than control children did on the quality of a typewritten text. This improvement was seen on several measures, and some of them are comparable with the ones that were used in our study, for example, "logical organization and structuring of ideas" and "comprehensiveness and elaboration of ideas in relation to the topic." Furthermore, the typing-skill program in Christensen (2004) was partly comparable with the touch-type training used in the present study in such a way that progression through the program was criterion based, indicating that children were stimulated to practice sufficiently to be able to go to the next level in the program. However, it is unknown which typing method was taught in Christensen's (2004), that is, the touch-typing, the visually guided typing strategy, or another method.

Overall, it can be concluded that a touch-typing intervention as executed in our study can result not only in better touch-typing skills but also in less spelling errors and a better text quality in a narrative-writing task on the computer. Important aspects of the touch-typing training in the present study are worth noticing: It was teacher directed, it contained 15 training sessions of 1.5 hr each and 20 min of practice every day, and there was the opportunity for students to attend extra training sessions when falling behind. Freeman et al. (2005) also reported on the basis of a review of the literature that a total of 25 to 30 hr of appropriate instruction and opportunities for ongoing practice are critical elements. It is questionable whether the effect of this course would have been the same when the students had not been stimulated and motivated to practice at home and when no extra lessons were given to students who fell behind. We think it is worth investigating whether an intervention that meets these criteria can become an evidence-based intervention to improve not only typing skills but also spelling and narrative-writing skills on the computer.

4.1 | Limitations and future research

Despite the positive results found in our study, a few limitations should be noted and taken into account in future research. First, it may be that the students in the experimental group were trained not only in touch-typing but also in language-related skills. This assumption is based on the fact that the intensive training of several months contained a variety of word games on the computer and exercises in typing all sorts of texts. This may have influenced their language development positively. Furthermore, research has indicated that in regular Dutch classroom situations, little attention is paid to narrative writing (Van Gelderen, 2010). It is possible that children in the control group only had a narrative-writing assignment once or twice a month. Attending the typing course, therefore, may have improved not only the students' typing skills but also their language skills. In future research, the activities of the control group should also be monitored closely. Furthermore, the influence of specific parts of the intervention could be investigated by conducting experiments in which specific elements of the intervention are manipulated and children are matched on relevant skills.

Second, the supposed mechanism that better touch-typing decreases the cognitive load on the working-memory resources was not tested in the present study. It was only used as a hypothetical explanation. We reasoned that mechanisms that are important during the multidimensional process of learning to handwrite (Berninger & Winn, 2006) could also be applied to the process of learning to write by touch-typing. However, this hypothesis still needs to be tested in both adults and children. For example, research focusing on the cognitive processes underlying text production, such as planning, verbalizing, and revising, is needed (Van Waes, Leijten, & Quinlan, 2010). At the same time, the role of executive functions like working memory, short-term memory, inhibition, and attention is important to consider in detail. A promising and useful technique might be keystroke logging. The main rationale behind keystroke logging is that writing fluency and flow reveal traces of the underlying cognitive processes (Leijten & Van Waes, 2013). Keystroke logging programs record the typing behaviour of the writer, allowing the researcher to replay and analyse the dynamics of the writing process, such as transcription fluency, pausing, and revisions (Van Koss Torkildsen et al., 2016). This technique can be used in research on creative writing, spelling, and the first and second language writing in children with and without writing or learning difficulties. Furthermore, this technique can be combined with eye-tracking devices enabling researchers to characterize reading activities during the writing and typing process by providing information on, for example, pausing and revision behaviour, to make well-founded inferences about the role of executive functions (Leijten & Van Waes, 2013).

Third, the design of the present study could be improved by considering bias in sample selection and tasks. For instance, tasks were not counterbalanced, and therefore, pretest and posttest measures may not have been comparable in terms of difficulty. Also, even though there was a strict protocol to evaluate the narrative-writing task and consensus between raters was large, no interrater reliability was measured. Furthermore, the task that we used for narrative-writing skill on the computer focused on rather specific characteristics of the text (e.g., number of words, description quality, and temporal/causal relations). It is unknown to what extent this task is extrapolatable to other tasks, also given the finding of Beers and Nagy (2009) that the relationships between syntactic complexity and text quality were found to be dependent both on the genre of the text and on the measure of syntactic complexity used. Another limitation concerns the recruitment of participants; all parents were asked whether their child was allowed to follow the touch-typing course. Some parents refused, and their children were placed in the control group. However, the reasons for these refusals are unknown. Because parents had to pay for the course, financial reasons are likely, and this could imply that control students have a less

fortunate economic background. On the other hand, it is also possible that the parents who did not give permission, thought that their children already had sufficient typing skills. To overcome this problem, a longitudinal multiple baseline across individuals design is needed. In this design, two experimental groups receive intervention at different time points. This manipulation is considered to be a viable and ethical alternative to the withdrawal of treatment approach that was used in the present study. Finally, little was known about possible diagnoses like dyslexia and attention deficit hyperactivity disorder. Therefore, in future research, factors such as economic background, language skills, reading level, and (learning) disorders should be controlled.

4.2 | Practical implications

Elementary school students increasingly do their learning and testing assignments on the computer. If children are not able to touch-type while carrying out those tasks, the computer may be more of a hindrance than an effective tool (Connelly et al., 2007). In the present study, students' typing skills are related to their spelling and narrative-writing skills. Learning how to touch-type requires a major time investment for this skill to be automatized. However, based on the results of the present study, this appears to be worth the effort because it can also improve spelling and narrative-writing skills proficiency on the computer. Moreover, it appears to be justified to pay more attention to the development of typing skills in elementary education.

The results of this study cannot simply be generalized to situations in educational practice. For example, a time limit was set during the typing tasks and the narrative-writing task in the present study, whereas in educational practice children often have less strict time restrictions for finishing a task. Furthermore, word-processing programs have spelling-check options, and when students use these options while typing, they produce better spelling but also have less practice in applying the spelling rule actively themselves.

The touch-type course in the present study can probably not be generalized to all touch-typing methods that are available nowadays. Our course was conducted at a certified educational institute that made use of intense supervision, homework schedules, and catch-up training sessions when students fell behind. This intense supervision may have played an important role in the development of automaticity in typing. In this sense, Lewis, Hearn, and Zilbert (1991) argued that typing skills could only be fully automatized by following a prolonged and intensive typing course. Their academic students took a 6-week typing course but eventually fell back into their old habit, that is, visually guided typing. However, the study of Lewis et al. (1991) was published 20 years ago, and since then, the situation in the educational school system has changed. Nowadays, implementation of digital tools in educational settings is growing, and the possibilities to practice touch-typing are ample for most children in elementary school in Western societies (Wollscheid et al., 2016). Further investigation is needed to find out what the effects of a touch-typing course are in the long run.

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How to cite this article: van Weerdenburg M, Tesselhof M, van der Meijden H. Touch-typing for better spelling and narrative-writing skills on the computer. *J Comput Assist Learn*. 2018;1–10. https://doi.org/10.1111/jcal.12323