

Meta-Analysis Research on the Usage of Technology in Handwriting for Children

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Abstract

Recently, there has been an increased interest in research on the usage of technology in handwriting especially among children across the world but rarely in Malaysia. Therefore, there is a need to research the patterns and research gaps related to the usage of technology in handwriting, especially in preschool children. In this paper, a meta-analysis study was performed on articles related to technology, handwriting and children from the year 2015 until 2020. The main findings from the analysis show that most of the previous studies used stylus pen on tablet compared to other digital tools to assess handwriting performance, and a quantitative research approach using experimental design was used to test the performance. These findings can be used as a reference for researchers in education, especially in the early childhood field to carry out research related to this scope of interests. This paper also provides suggestions for further relevant research in a similar context.

Keywords: *handwriting skills, preschool handwriting, technology handwriting, handwriting application, meta-analysis*

1. Introduction

Learning to write is not as simple as it seems to be. It is a big challenge especially for children because within the writing process, children need to write and integrate their fine motor skills with an object or tool to produce the correct letter at the same time [1]. Before a letter is produced, children start with prewriting skills such as tracing and scribbling [2].

There are three main concepts to hold a writing tool which are thumb placement, fingers on the body of the writing tool and placement of finger's joint. The static type of writing tool's grasp will cause pain and fatigue due to excessive pressure [3]. Therefore, it is crucial for children to use a suitable writing tool to ensure an easy and smooth writing process.

As handwriting is a complex skill for children, it is suggested to combine the traditional way of teaching and training them to write using pencil and paper with technology tool like digital pen on touchscreen [4]. Most preschool teachers do not possess many strategies when teaching handwriting to children, and they only implemented copying and doing exercises repeatedly without any other alternative [5].

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Previous studies regarding the usage of technology in handwriting for children in Malaysia are still limited even though the 7th Shift of Transformation of Malaysia Education Blueprint (2013-2025) targets to utilise technology in education to increase learning quality. Hence, there is a need to identify the pattern and gap that exist in this matter. This research was conducted to answer the following research questions:

- 1) What is the technology used in studies related to the usage of technology in handwriting for children?
- 2) What is the research design used by the researchers to conduct the studies related to the usage of technology in handwriting for children?
- 3) What is the main finding of studies related to the usage of technology in handwriting for children?

2. Materials and Methods

This research used a meta-analysis approach to integrate and analyse the results from previous studies related to the usage of technology in handwriting among children. This study also conducted statistical inference using statistical tools. This approach is considered as the highest level of evidence and can be more grounded compared to depending only on a single previous study's result as this approach combines and systematically reviews all the previous studies that are similar and relevant [6] [7] [8].

To find the relevant studies, a few search engines such as Google Scholar, Google Search, and databases in the university's online library such as Science Direct, Scopus, and SAGE were used to ensure a broader scale of the searching process. To obtain the latest and relevant studies, this research applied limitation on the search engines to only show articles from 2015 to 2021 with the keywords "handwriting skills", "preschool handwriting", "technology in handwriting", and "handwriting application". Two additional search criteria were added to the search engines to ensure more specific studies were selected to be analysed for this study: (i) studies in handwriting and the usage of various tools and application; and (ii) samples involved are among preschoolers and primary year students.

Finally, ten articles that meet the specific criteria were chosen. Table 1 shows the list of articles and some background on the samples used in the study.

Table 1. List of Articles Related to the Usage of Technology in Handwriting for Children

Researchers	Year	Sample Profile	Sample Size	Journal / Proceeding
Nathalie Bonneton-Botte, Sylvain Fleury, Nathalie Girard, Maelys Le Magadou, Anthony Cherbonnier, Mickael Renault et al.	2020	Kindergarten students	233	Computers and Education
Linda Greta Dui, Francesca Lunardini, Cristiano Termine,	2020	3 rd grade and final year	34	JMIR Serious Games

Matteo Matteucci, Natale Adolfo Stucchi, Nunzio Alberto Borghese et al.		kindergarten students			
Jennifer L. Sze & Jane Southcott		Year 6 primary year students	6	6	The Qualitative Report
Carmen Mayer, Stefanie Wallner, Nora Budde- Spengler, Sabrina Braunert, Petra A. Arndt, & Markus Kiefer	2020	Final year kindergarten students		147	Frontiers in Psychology
Christi Butler, Ricardo Pimenta, Jodi Tommerdahl, Chadwick T. Fuchs, & Priscila Caçola	2019	4- to 5-year- old kindergarten students		125	Research in Learning Technology
Miguel Candeias, Maria Gentil A.D. Reis, Joaquim Escola, & Manuel J.C.S. Reis	2019	3- to 6-year- old kindergarten students		44	Heliyon
Wanjoo Park, Georgios Korres, Tania Moonesinghe, & Mohamad Eid	2019	4- to 7-year- old kindergarten students		42	IEEE Transactions on Haptics
Markus Kiefer, Stefanie Schuler, Carmen Mayer, Natalie M. Trumpp, Katrin Hille, & Steffi Sachse	2015	4- and 6-year- old kindergarten students		23	Advances in Cognitive Psychology
Melissa M. Patchan & Cynthia S. Puranik	2015	41- to 65- month-old preschool students		46	Computers and Education
Anne-Marie Mann, Uta Hinrichs, & Aaron Quifley	2015	9- to 10-year- old primary school students		13	The Impact of Pen and Touch Technology on Education

3. Results and Discussions

The findings from this study were divided into three main parts to answer each research question. Part one discusses the type of technology used in each study related to handwriting for children. Part two focuses on the approach, research design, and methodology used in each study. Lastly, part three discusses on the main findings of each study, specifically on technology, handwriting, and children.

3.1 RQ 1: What is the technology used in studies related to the usage of technology in handwriting for children?

Analysis on the studies related to the usage of technology in handwriting for children revealed the use of four types of technology, which are tablet, keyboard, Livescribe pen, and haptic guidance. Table 2 shows the overall findings for the technology used in each study.

Table 2. Types of Technology Used in the Studies

Type of Technology	<i>f</i>	Researchers	Year
Stylus pen on tablet	7	Bonneton-Botte et al.	2020
		Dui et al.	2020
		*Mayer et al.	2020
		Butler et al.	2019
		Candeias et al.	2019
		*Patchan & Puranik	2015
		*Mann, Hinrichs, & Quifley	2015
Finger on tablet	1	Patchan & Puranik	2015
Virtual keyboard on tablet	2	Sze & Southcott	2020
		Mayer et al.	2020
Physical keyboard	1	Kiefer et al.	2015
Livescribe pen	1	Mann, Hinrichs, & Quifley	2015
Haptic Guidance	1	Park et al.	2019

*Studies from Mayer et al. (2020); Patchan & Puranik (2015); and Mann, Hinrichs, & Quifley (2015) used more than one type of technology

Based on the analysis in Table 2, most of the studies used tablet for handwriting among children. Seven studies used stylus pen on tablet and one study used finger on tablet. Virtual keyboard on tablet was used by two studies, while only one study used physical keyboard. Livescribe pen and haptic guidance were each used once. Overall, this finding shows that studies on the usage of tablet especially with a stylus pen and virtual keyboard are becoming more prevalent in handwriting for children.

3.2 RQ 2: What is the research design used by the researchers to conduct the studies related to the usage of technology in handwriting for children?

3.2.1 Approach and research design

After analysing the types of approach and research design used by previous researchers to conduct their studies related to the usage of technology in handwriting for children, it was found that both quantitative and qualitative approaches were used, while experimental and case studies were implemented as the research design. Table 3 shows the overall findings for the approach and research design used in the previous studies.

Table 3. Types of Approach and Research Design used in the Studies

Approach	Research Design	<i>f</i>	Researchers	Year
Quantitative	Experimental	9	Bonneton-Botte et al.	2020

			Dui et al.	2020
			Mayer et al.	2020
			Butler et al.	2019
			Candeias et al.	2019
			Park et al.	2019
			Kiefer et al.	2015
			Patchan & Puranik	2015
			Mann, Hinrichs, & Quifley	2015
Qualitative	Case study	1	Sze & Southcott	2020

Based on the analysis in Table 3, the majority of the studies used a quantitative approach with an experimental research design. Only one study used a qualitative approach with a case study research design. This finding is in line with the statement that experimental design is usually used for research that investigates the influence of treatment on the outcome for two groups [9].

3.2.2 Methodology of data collection

Apart from analysing research design and approach, the methods of data collection in each study were also analysed. Three types of methods were used: test, interview, and video recording. Table 4 shows the methods used by each study.

Table 4. Types of Method used in the Studies for Data Collection

Method	<i>f</i>	Researchers	Year
Test	9	Bonneton-Botte et al.	2020
		Dui et al.	2020
		Mayer et al.	2020
		Butler et al.	2019
		Candeias et al.	2019
		Park et al.	2019
		Kiefer et al.	2015
		Patchan & Puranik	2015
		*Mann, Hinrichs, & Quifley	2015
Interview	2	Sze & Southcott	2020
		Mann, Hinrichs, & Quifley	2015
Video recording	1	Mann, Hinrichs, & Quifley	2015

*Study from Mann, Hinrichs, & Quifley (2015) used more than one method for data collection

The analysis in Table 4 shows that nine previous studies applied testing as their methods, while interview and video recording methods were only implemented by two and one studies, respectively. Only one study used all three methods.

3.3 RQ 3: What is the main finding of studies related to the usage of technology in handwriting for children?

Table 5 summarises the objectives and main findings of each study analysed.

Table 5. Main Findings of the Studies with Research Objective.

Researchers	Year	Research Objective(s)	Main findings
Bonneton- Botte et al.	2020	To assess the impact of implementing a digital notebook application designed for a stylus-oriented tablet in kindergarten classrooms.	Scores from students with high initial performance level was static for both conditions, while medium students showed better result when learning with tablet application compared to learning traditionally. As for low initial performance students, both groups showed improvement. A stylus-oriented tablet app can support handwriting in kindergarten pupils depending on the children's initial graphomotor level [10].
Dui et al.	2020	To investigate if these writing principles hold when writing on a tablet surface. To verify that symbol drawing can anticipate the detection of potential difficulties at the pre literacy stage. To investigate how writing-related skills and principles change with gesture acquisition.	Isochrony, homothety, and speed-accuracy hold when writing on the tablet surface for writing words and drawing symbols. As for detecting potential difficulties at the pre-literacy age, symbol drawing is valid to be used as a screening tool to replace writing words. The principles are present before handwriting acquisition, but handwriting skills also depend on children's age [11].
Sze & Southcott		To investigate student's understanding about the learning of handwriting and keyboarding in schools.	The students always worry of making mistakes while writing and often get tired with physical handwriting compared to using keyboard. Using keyboard also helps with neat writing and avoiding spelling mistakes [12].
Mayer et al.	2020	To test the influence of the writing tool on the acquisition of literacy skills at the letter and	Using pencil on paper resulted in higher performance in letter recognition and visuospatial skills compared to using virtual keyboard. However,

		word level of kindergarten children.	the keyboard group showed the best performance in word writing and reading compared to the stylus pen group. Using stylus pen did not result in any significant difference compared to pencil and keyboard [13].
Butler et al.	2019	To determine the effectiveness of using electronic handwriting applications in addition to the traditional method of teaching handwriting to kindergarten children.	Both experimental and control groups showed improvement in handwriting legibility with significant differences. However, a significant improvement in manual dexterity was only detected in children from the experimental group [14].
Candeias et al.	2019	To develop a system to support the teaching and learning of handwriting skills	Students who used the system showed significant improvement in the development of handwriting skills compared to students who did not use it. Students who had tablet access scored higher than students who did not [15].
Park et al.	2019	To investigate the role of several methods for haptic guidance, namely full haptic guidance, partial haptic guidance, disturbance haptic guidance, and no-haptic guidance toward improving the learning outcomes of handwriting skills acquisition for typical children.	Full haptic guidance is more useful than other methods when practising low complex letter, while for medium complex letter, partial and full haptic guidance produced better outcome. For high complex letter, disturbance haptic guidance gave the best result [16].
Kiefer et al.	2015	To develop an intense training program for preschool children.	No significance difference was observed between handwriting and typing training, but higher word writing accuracy was observed in handwriting training [17].
Patchan & Puranik	2015	To investigate how tablet computers could support the development of	The hypothesis that children wrote more letters using stylus pen compared to pencil was

		preschool children's writing ability.	not supported. However, children who used finger on tablet wrote more letters correctly. There is a small difference between using stylus and finger where using finger is richer in visual, kinaesthetic, and tactile input [18].
Mann, Hinrichs, & Quifley	2015	To investigate digital pen's effect on writing experience.	The majority of the students preferred Livescribe pen compared to other devices as it is easy to control.
		To investigate pen technology support in the writing process.	The writing process is better using Livescribe pen as it is like a normal pencil compared to using stylus pen, as the students trying hard to avoid touching the screen when using the stylus pen. This affects their handwriting quality [19].

The main findings of each study can be categorised into two themes. The first theme is to investigate the impact of using digital tools on the writing process among the students. There were mixed findings on this theme where some of the studies found significant differences when digital tools were used compared to pencil on paper for handwriting [10] [15] [16] [19]. Meanwhile, other studies found no significant differences using technology over traditional or conventional ways for writing process, even though the visual, tactile and accuracy inputs were affected [13] [17] [18]. There were also studies that found the same result when using digital tools or traditional tool, as the writing process is refined the with student's age [11] [14].

The second theme is to investigate student's perceptions when using technology for their handwriting. Students agreed that using digital tools could help them with their anxiousness in the handwriting process, lessen spelling error [12] and ease them to hold and grasp the pen which contributed to having better handwriting quality [19].

Overall, the usage of technology in handwriting does have some effect on the children. This can be seen in most of the studies where digital tools such as Livescribe pen led to better handwriting performance and using keyboard contributed to word writing accuracy. Even though the usage of stylus pen were the least favoured compared to other digital tools in those studies, it is undeniable that it also has advantages. Using pencil on paper and stylus-based tablet both showed better results for post-test, but only the usage of stylus pen improved the children's

manual-dexterity [14]. Children who use stylus pen on a tablet also improved their handwriting skills [15].

However, using the traditional way to write is still relevant for children based on the findings in the previous studies. As writing using pencil on paper has also been proven to give a better result than using digital tools [13], it is suitable to integrate both conventional and digital tools in teaching handwriting for children.

4. Conclusions

In conclusion, the findings from this study provide relevant and concrete information that can be used as references and supporting documents to initiate new research especially in Malaysia, where the research regarding these contexts are still scarce. The usage of technology in handwriting has become a trend nowadays in teaching and learning. Previous research showed mixed results of its advantages and disadvantages especially on the handwriting task, as this study critically analysed and discussed. Future studies should find out how technology can be useful in teaching handwriting for children and develop instruments to assess the overall writing process to enhance the quality of education in children.

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