Preschool Children Handwriting Evaluation on Paper-Based and Tablet-Based Settings

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Abstract— **Learning to write could be a difficult task for preschool children as they need to acquire better perceptual-motor ability during the development of their writing skills. This paper describes selected results based on the study of Arabic word writing practices with a group of 5 and 6 years old children (non-native Arabic speakers). Children were invited to participate in a guided-writing practice activity both in paper-based and tablet-based settings. For paper based setting, children used pencil and paper sheet. In tablet setting, children were asked to use finger and stylus. Children's performances were recorded and observed for data analysis purposes. The findings are used to suggest guidelines for improving the use of tablet for writing practice by young children.**

Keywords-component; Arabic writing practice; preschool children; handwriting guided practice; tablet-based; stylus

I. INTRODUCTION

Arabic language is the language of the Holy Quran which is read by more than 1.6 billion Muslims all over the world every day and is spoken by millions of people as their primary and secondary language especially in Muslim countries [1, 2]. In order to be able to read the Quran, understanding Arabic languages is necessary. Arabic scripts are composed by logographic characters. Most of the children who learn this script as their second language experienced difficulties in memorizing the letter names due to the linguistic factor as they are sometimes distinctively different from the native language [3].

Currently, many teachers are still adapting conventional ways of teaching the children by using paper, pencil and books to learn the Arabic character at school [4]. Thus, with the development of the tablet technology in the market, it is likely to become an interesting learning tool for preschool children, due to their features which are more flexible, lighter and easier to be engaged. Besides, it also allows children to become more independent and asking less instructions from the adults once they have gained familiarity with the tablet setting [7]. However, up until now the study on preschool children's Arabic writing skill is relatively new and research is still going on to improve it.

The focus of the research is to explore the possibility of the use of tablet computer technology as learning and teaching aid for the practice of writing Arabic letters. We aim to investigate the suitability of using finger and stylus as the writing input modalities for Arabic handwriting practice on tablet computer among preschool children. The empirical study was conducted by observing the performance of the preschool children using a guided-writing practice activity using finger and stylus. The paper is structured in 4 sections. Section 1 provides the literature review, Section 2 presents the empirical study, Section 3 reports the results and finally the discussion and conclusion are presented in Section 4.

II. LITERATURE REVIEW

A. Children's Handwriting

Writing skill is one of the conventional literacy skills needed in order to achieve a good level in language literacy. Before children formally learn to write at school, they start to draw unreadable lines, which are referred to as scribbles [8]. Scribbles show distinctive purposes which are only understood by the child as a way to convey their thoughts [9]. In general, writing skill is actively developed throughout a child aged between 3 to 5 years old. During this period, they begin to learn the capital letters, small letters, directionalities, and spaces between words. As writing skill requires advanced perceptual-motor ability, children may have difficulties to be really good at it. There are five areas that need to be addressed in handwriting difficulties: (a) readabilities of the written text; (b) neatness of handwriting; (c) sufficient pressure while writing on material; (d) feeling ease; and (e) writing speed [10, 11, 12]. Children who have these difficulties may have less motivation levels due to the lack of efficiency in performing school tasks [13].

There are several works related to handwriting for young children, especially in primary school. These studies focused on various writing systems including Arabic, English, and Chinese. In a previous research which investigated the importance of repeated writing exercises in helping children to recall letters, the children's capability in recognizing letter improved via repeated writing exercise compared to just only tracing, reading or visually scanning the letters [14]. This is particularly important when a child learns two or more writing systems that are very distinct from each other. In another study, the result has shown that handwriting practice also helped young children to improve their letter recognition better than typing the letter using

the keyboard [15].Another previous study which focused on the use of pen input together with the desktop pc as the screen display and the graphic tablet as the writing area has shown that separation between the writing area and the screen display has caused confusion among children as they were distracted to focus to both the screen and at the writing area [16]. Some of the children were tended to look only at the writing area and some of them were only focused on the screen display and sometimes they did not noticed that the pen had exceeded the writing area. Hence, it is recommended to have the screen display and the writing area at the same place as humans tend to naturally look at the place where they are writing.

B. Arabic Letters

Arabic is distinctly different from many other writing systems because it is written from right to left, in a cursive style and includes 28 basic letters starting with 'ا' (pronounced as *Aleef*) and ending with 'ي' (pronounced as *Yaa'*) and the directionality of the Arabic alphabets are from the right to the left (Figure 1). Arabic letters also have a total of 30 phonemes. The standard Arabic letters have substantially different shapes depending on whether it will be connecting with a preceding and or a succeeding letter, thus all primary letters have conditional forms and they may exhibit four different forms which are the initial, medial, final or isolated (Figure 2). These forms occasionally give confusion to new learners especially for children [17, 18].

ث	ت	ب	ا
د	خ	ح	ج
س	ز	ر	ذ
ط	ض	ص	ش
ف	غ	ع	ظ
م	ل	ك	ق
ي	و	ه	ن

Figure 1. Twenty-eight of Arabic letters in isolate form

Contextual form			
Final	**Medial**	**Initial**	**Isolated**
ع	ع	جـ	ع
ـف	ـفـ	فـ	ف
ـك	ـكـ	كـ	ك
ـم	ـمـ	مـ	م

Figure 2. Example of Arabic letter in different forms

Arabic letters are based on the *abjad* system where each letters stands for a consonant. Therefore the reader is required to place a vowel sound which is appropriate to the context. In contrast, the English alphabet is based on the *Latin* alphabet system where letters have both consonants and vowels that help the reader to read and understand words in an easier context. This language

consists of two types of orthography forms which are shallow and transparent or opaque. Shallow orthography occurred when there is the usage of diacritical mark in a word, while transparent or opaque appeared when diacritical mark is not used. For children, reading materials usually have diacritical marks, however, for high-level reading materials such as newspapers and university scientific material usually will not be used diacritical marks [19]. However, several studies have been conducted on Arabic graphic letters and agreed that it is indeed difficult for Arabic readers, especially the children [1].This problem does not occur in English writing as the letters' form maintain in any position. However, English letters have uppercase and lowercase letters which does not occur in Arabic letters.

III. METHODOLOGY

A. Participant and design

A group of twenty-four preschool children aged 5 and 6 years old (mean = 65 months, SD = 6.17 months) of mixed gender (11 girls and 13 boys) were voluntarily recruited to participate in the study, and they learnt Arabic as their second language. The participants enrolled in Sri Ayesha Islamic School, Selangor, Malaysia with the background of middle-class of socioeconomic status. On the day of the study, 2 boys refused to participate. Thus, the participants consisted of 11 girls and 11 boys.

Prior to the study, the consent forms were distributed to the parents or guardians to obtain permission regarding the participation of their children as well as for data collection purposes. The background surveys were distributed to the parents which contains questions about the demographic information, child background of the Arabic language capabilities and the child computer usage including the type of devices they usually used at home [20, 21]. Informal interviews were carried out with the teachers and the children. During the interview, teachers were asked about the information of the children's Arabic language competency, the primary language and the computer usage in the kindergarten. Teachers were also asked to provide advices on the best way to approach the children based on their knowledge and experiences. During the interview session with the children, they were asked about their experiences with both types of activities.

Figure 3. Experiment setting equipped with two cameras

The sessions were divided into two parts: (a) Session 1: Pretest – children were required to read a set of selected Arabic words; and (b) Session 2: Writing activity – children were required to perform their writing activity in both paper-based and tablet-based settings. All sessions were recorded using two digital cameras (Figure 3).

B. Material

In the pretest session, 37 Arabic words (contains 28 Arabic letters in all possible positions) were selected from the Iqra' book which currently used by the teacher at schools to teach the children to learn basic words of Arabic language. The list of words was presented on an A5 sized paper which equivalent to original size of Iqra' book (Figure 4).

Figure 4.   A set of 37 selected Arabic words

In the paper-based writing activity session, dotted pictures *(guided practice)* of Arabic words were presented on a 10.5cm x 6cm white paper (Figure 5a). The same sized of dotted pictures also presented in the tablet-based setting. The Samsung Note 10.1 with 1280 x 800 screen resolution was used as the interaction device. A stylus or known as "S pen" was used as an input modality which works similarly to a pencil in the conventional writing (Figure 5b).
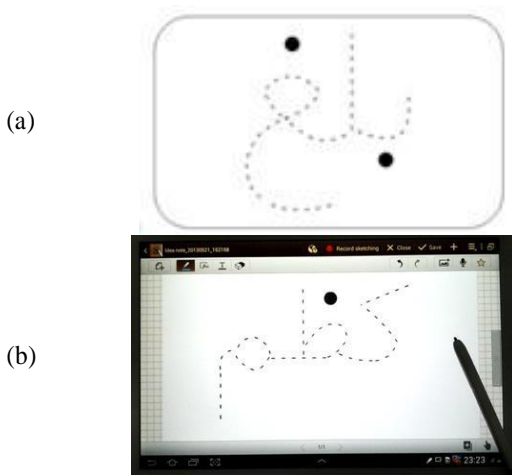
(a)

(b)

Figure 5.   Tablet application for pretest: Dotted-pictures of Arabic in:
(a) paper-based setting; (b) tablet-based setting

C. Procedure

The study was based on a within-subject design. All children were invited to involve in the pretest and the writing activity session (paper-based and tablet-based settings). The play sessions were conducted during a school time in a private room at the second floor of the school premises. The experimenter accompanied each of the participants from their classrooms to the study location. The children were familiar with the experimenter as she spent a few days with the children before the study was conducted. At the beginning of each activity, a brief instruction was given to each participant.

1) Pretest session: During the pretest session, each participant was asked to pronounce a list of 37 Arabic words (with the combination of 28 Arabic letters) for about 5 minutes andassistance was only given if needed. Any mistakes and answers given by the experimenter were marked as unidentified letters. At the end of the pretest session, the children were also invited to interact with a simple application on the tablet for about 3 to 5 minutes in order to get familiar with the device as some of them had never used it before. The application allowed the children to click on the sound button located on the top right corner which provided the correct letter name of a word shown on the screen (Figure 6).

Figure 6.   Tablet application for pretest

2) Writing activity session: In the paper-based setting, children were provided with a pencil to trace the dotted-pictures of Arabic words. In the tablet setting, the children were asked to trace the dotted-pictures of the Arabic words on the tablet twice: (a) using their finger (Figure 7a); and (b) with a stylus (Figure 7b). There were no hints provided, such as arrows, numbers or directions included in the dotted-pictures. The duration for the writing activity were about 5 minutes for each child and the children were asked to trace the dotted-pictures in two attempts (one word per attempt) for each condition.After completing the writing activity, each child was interviewed and answered the given questionnaires relating to their experiences of writing on both settings. The children's behaviour while performing the writing activity were recorded by using two digital cameras. The writing activities on the tablet were also captured by using the embedded recording systemavailable on the tablet.
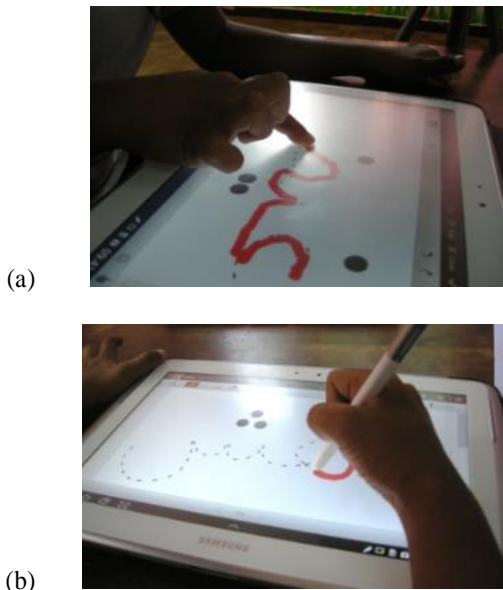
Figure 7. Example of input modality (a) finger; (b) stylus

At the end of the session, children were asked to rate their experience using the Smileyometer scale (Figure 8) [22]. Each child was given a small gift as a token of appreciation.

Figure 8. Smileyometer used in user experience interviews

IV. ANALYSIS

Videos from both cameras were combined, transcribed and analysed. The analysis focused on the stroke production error. The errors were captured and grouped into 4 categories (Figure 9): (a) broken stroke – a continuous stroke as a separated stroke; (b) concatenated stroke – extra stroke but attached to the correct stroke; (c) missing stroke – absent stoke which included the I'jam (diacritics stroke) that consists of one or more dots that functions as the distinguisher of the letter sounds and it may be located above or below the letter; (d) extra stroke - additional stroke(s) which is not part of the abjad [23].
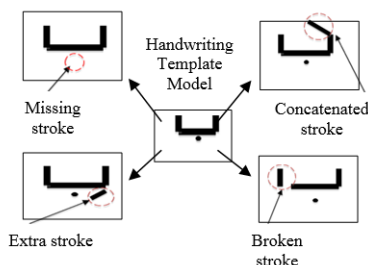

Figure 9. Examples of the stroke production errors

The data analysis also captured the user experience during the session such as the difficulties faced by the children while writing using finger and stylus. The writing data from paper sheet and tablet were evaluated manually by researcher.

V. RESULT

All of the children except the two boys who refused to participate in the study and completed both pretest and writing activity sessions.

A. *Pretest session*

The duration of pretest sessions lasted an average of 180 seconds. A total of 13 children pronounced the 28 Arabic letters incorrectly especially the last three letters due to the tendency of the children to read the letter based on the rhythm of the abjad song known as 'Aleef Baa Ta' (children's popular first song to learn Arabic abjad in Malaysia). The song consists of a ligature ' لا ' (pronounced as *Lam-Aleef*) which is a combination of two letters which are ' ل ' (pronounced as Lam) and ' ا ' (pronounced as *Aleef*). The song also includes another diacritic sign ' ء ' (pronounced as *Hamzah*). Therefore, the song ends up with 30 Arabic letters. The session also evinced a total of 6 children who read the letters from the left to the right which inversed with the directionality of the Arabic reading. In the tablet reading activity, the majority of the children like to press the sound button in order to listen to the letter's name.

B. *Writing activity session*

On average, the evaluation time to write during the first attempt on the paper-based setting was 25 seconds per word, the tablet-based with a stylus was 30 seconds and the tablet-based with a finger was 19 seconds. Whilst, the evaluation time for the second attempt in the paper-based setting lasted an average of 18 seconds per word in the paper-based setting, 30 seconds in the tablet-based with a stylus and 20 seconds in the tablet with finger setting. The majority of the children tended to create stroke production errors during the writing activity session. Frequencies and percentages for all four categories are reported in Table 1.

TABLE I.   STROKE PRODUCTION ERRORS

	1ˢᵗ Attempt		2ⁿᵈ Attempt	
Paper-based	Frequency	Percent	Frequency	Percent
Broken	16	26 %	6	10%
Concatenated	3	5 %	10	17%
Missing	42	67 %	42	73%
Extra	1	2 %	-	-
Total	**64**	**100 %**	**58**	**100%**
Tablet (Stylus)				
Broken	9	18 %	9	17%
Concatenated	7	14 %	3	6%
Missing	33	64 %	41	77%
Extra	2	4 %	-	-
Total	**51**	**100 %**	**53**	**100%**
Tablet (Finger)				
Broken	4	9 %	10	21%
Concatenated	5	12 %	5	10%
Missing	33	77 %	33	69%
Extra	1	2 %	-	-
Total	**43**	**100 %**	**48**	**100%**

From the observation, most children did not write the diacritics symbol of the Arabic words and contributed to high

evidence of *missing stroke* errors were captured in both attempts in all settings. *Broken stroke* errors were highest in the paper-based writing condition compared to writing using stylus or finger during the first attempt. On the other hand, the percentage of broken stroke's error was decreasing at the second attempt whereby it was almost constant using stylus but increased up to 21% of error by using a finger. The number of concatenated errors increased to 10 errors for the paper-based writing due to less concentration whilst performing the task and there was low evidence of extra stroke errors which was observed in all settings.

In the paper-based setting, seven children completed the task in excessive speed. Moreover, a boy enjoyed singing while performing the writing task and showed less concentration. It was also observed that ten children (six girls and four boys) were tended to produce lines that exceeded the dotted-line, which then they tried to fix the mistakes by adding a new line that finally formed other errors such as concatenated stroke errors. This also happened in the tablet settings. It was possible that these four children (a girl and three boys) were also possible to have small knowledge of Arabic letters combinations which contributed to broken stroke error in paper settings as they tended to leave a space between the letters.

In the tablet setting, children experienced some difficulties in drawing the stroke because the tablet failed to capture the written stroke. Four pieces of evidence were obtained from writing practice using the stylus (two girls and one boy aged 5; and one boy aged 6) and another three were captured when using a finger (two boys aged 5 and one boy aged 6 years old). An additional issue faced by children in the study is the jaggedness of their writing. Fifteen children (two girls and five boys aged 5 years old; and six boys and two girls aged 6 years old)show high level of jaggedness when using their finger as the input modal (Figure 10). However, none of them showed high level of jaggedness when using a stylus in writing the *abjad*. However, it is best to note that thirteen of them (two girls and five boys aged 5; three girls and three boys aged 6 years old) have moderate levels of jaggedness when using the stylus (Figure 11).While writing on the tablet, children tended to lean their forearm or other fingers on the screen which caused the screen to suddenly pinch-out or enlarge the size of the dotted-picture. Three children (one girl and one boy aged 5; and one girl aged 6) experienced difficulties because of the size of the dotted-picture suddenly changed.

A total of eight children (four children using the stylus and four children using a finger) experienced the picture moved from the original location to the upper or to the lower side of the screen. A few cases evinced two children (a girl and a boy) using the stylus and a boy using a finger accidentally touched the taskbar and caused the icons to suddenly pop-up on the lower side of screen. For error handling, two children (one girl and one boy) tried to use the end of the stylus as an eraser to erase their errors. The rest of the children prefer to make one or more strokes to correct their mistakes. Overall, nineteen girls

and eleven boys preferred to use the stylus as the input modality.
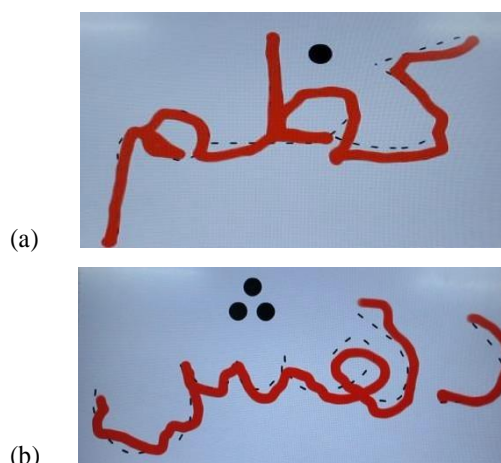

(a)

(b)

Figure 10. Example of high jaggednesswhen using finger in tablet setting
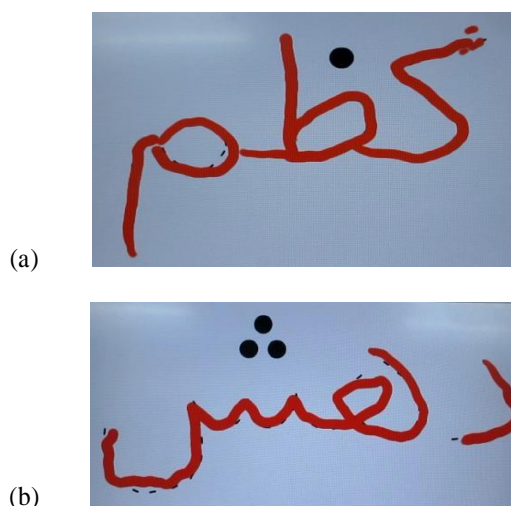

(a)

(b)

Figure 11. Example of moderate jaggedness when using stylus in tablet setting

In all settings, children were tended to neglect the diacritics symbols as the dots were already darkened; hence the children thought they did not have to write on the dots. The study also observed that the children who actually have the directionality knowledge prior to the study still committed the errors because there is no barrier or indicators that prohibit them.

VI. DISCUSSION

Based on the results, a few issues need to be considered when using a stylus and a finger as input modalities for Arabic Handwriting practice.

A. Stroke Production Error

The percentage of the stroke production errors was high especially for missing stroke error. This is due the template of the words image. The templates already bold the diacritic symbol which was mistaken by the children as not need to be traced. However, children reduced the concatenated errors

during their second attempts in the tablet setting (both when using their finger and the stylus). The result has shown that the children become more concentrated on their writing in tablet setting as they were not familiar with the environment. This stroke production error should be reduced to the minimum as the children should learn to write correctly in order to increase the letter recognition rate. Hence, supervision should be added to the application which will warn any mistakes made by the children.

B. Writing Speed

The average time taken by the children to complete each word was much longer when using the stylus. This case has shown that the children were tended to be more careful and detailed when writing using a stylus than using their finger. This is probably due to the nature of the stylus which is similar to a pencil as they were more familiar and comfortable with. However, there were some children who take quite a long time to complete the written word with their finger due to some kind of friction as well as the problems from the device. These children also take a long time because they were confused when writing Arabic words with no proper sequence. While, the time taken by the children to complete a word was much faster when using their finger as they were not required to hold any weight (stylus) on their hand when writing which allow them to move their arms more freely and also were not required to focus on handling the stylus. However, it had resulted in high evidence of serious errors on written words.

C. Jaggedness

This study evinced jaggedness errors due to friction. Jaggedness occurs most commonly when the children used their finger to write. The jaggedness also happened not because of the generality of children's fingers, but due to the failure of the child to anticipate the proper pressure needed to write on the tablet surface. The problem increases by the size of the children's fingertip and also the amount of forces the child use to write. However, by the time they were practice more, they will be able to adapt with the situation and capable to estimate the total pressure needed in order to write properly and produce less friction. An example of this behaviour reported as the following. The result of the participant's writing as shown in Figure 10a.

Researcher:	Okay, you can write now. Follow the dots.
Andy	(Start to trace the dot with his finger). (Suddenly the screen pinched in) (Startled)
Researcher:	Opss... (Fixed problem). Okay...
Andy	(Continue tracing. His finger shaking until finished writing).
Researcher:	Okay, great.

D. Modality Preference

In the interview session, nineteen girls and eleven boys preferred to use the stylus as the input modality. This might be due to the similarity between a stylus and a pencil. Another reason of the preference was also caused by difficulties they encountered while writing such as friction and the moving pictures.

VII. CONCLUSION

This study suggest the importance of guidance and instruction given to young children toward writing in correct directionality. However, the most problematic issue is the *i'jām* (*phonetic symbol*). The phonetic symbol is important for letter sound differentiation which was ignored by majority of the children ($N=21$). To maximize the success of the phonetic symbol awareness: (a) children need to be reminded with the existence and the importance of the phonetic symbol; (b) writing application designed for Arabic handwriting should include the signals that may alert the children if they missed to write the symbols. Children also faced the friction problem as they wrote using their finger on tablet. This condition made the shape of the stroke became very jittering which affected the quality of the letter appearance and also reduced the visual learning. This problem can be reduced by: (a) reducing the writing speed; (b) writing using the stylus to decrease the tip area of input modality. Even though the performance was better when using the stylus, some of the children were unable to estimate the correct pressure to apply on the tablet screen. Parents and teachers should always assist these children and help to explain if the pressure was too intense or not enough to produce line on the tablet. An alert system can also be provided in the future to alert the children if they are giving too much or less pressure while conducting their writing practice.

The study also highlighted several difficulties which may benefit to future study: (a) children easily become bored or tired whilst pronounced 37 words. The words list can be reduced or chunked into several parts; (b) some children had never used stylus before. They need to have a little practice before the data collection session; (c) researcher need to talk to the children after every session about their experience regarding the difficulties they encounter while writing; (d) the template for the diacritic marks should be left without bold.

Overall, the setting for handwriting practice in the tablet needs to consider the way children naturally behave. Children should be reminded not to lean their forearm or other fingers on the writing surface whilst interacting with the tablet. Using the end of stylus as an eraser is an interesting way of thinking children had shown. Based on the lessons learned in the study, our research has now concentrated on the new design of an application to make the children engage and improve their writing experience on the tablet. For the future, the monitoring technology can be used to monitor the children during writing exercises. This will help children learn by their own with less supervision of teachers and parents. This technology should be complemented by friendly interactive feature that may increases the motivation of the child.

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