Freehand drawing activity: A comparison between tablet-finger vs paper&crayon throughout time

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Notice: This is the authors' version of a work accepted for publication in Behaviour &information Technology journal.

Please, cite this document as: MPuerto Paule Ruiz, Miguel Sánchez Santillán & Juan Ramón Pérez-Pérez (2023) Freehand drawing activity: a comparison between tablet-finger vs paper&crayon throughout time, Behaviour & Information Technology, DOI: 10.1080/0144929X.2023.2196578

Abstract

The apps for drawing are present in our children's life. Nevertheless, little is known about the impact of mobile technology on the freehand drawing educational activity. There are few works which are contextualized within short periods of time, with teachers who are not theirs and, in some cases, outside the children's classroom. In this paper, we are focussed on the use of technology on freehand drawing activity. Thus, we have compared the graphics produced by 4- and 5-year-old children with paper&crayon in comparison with those with tablet-finger. Children made the drawings during a planned free-drawing activity, in their ordinary classrooms, with their teachers and during 5 sessions. Assessment of drawings has evidenced tablet feasibility for making graphics. Nevertheless, with the passing of time, quality of graphics (tablet-finger vs paper&crayons), are nearly matched, demonstrating the low impact level technology has on this activity. In addition, if drawings are analysed specifically according to ages, results have shown that both groups have to develop adaptation strategies of visual perceptual skills and fine motor skills for the touch screen in order to obtain the same quality in the drawings made on both support types.

Keywords: e-learning, mobile application, children

1. Introduction

Researches carried out during the last 10 years have shown that more than 70% of 3- to 5-year-old children have access to tablets at home (G. Britain, 2013). Another study, carried out in the United Kingdom with 1028 children (with ages from 3 to 6) has shown that 80 percent of children had access to a touchscreen tablet or smartphone at school or at home (Formby, 2014). Thus, children who are 4 to 5 years old ordinarily use mobile technology in their daily life. They know their parents use it for buying, communicating with friends and family and even for working.

Taking advantage of mobile technology and mobile learning for early childhood (Reeves et al., 2017), during the last years, several apps have been used pursuing the main purpose of improving learning through educational innovation (Aznar et al., 2019). Freehand drawing is one of the most common activities carried out by children in early childhood education by means of which children express their knowledge and thoughts, apart from being the pioneer of formal writing (Couse & Chen, 2010). There are several apps focussed only on the drawing activity, such as Kids Doodle, Peppa's PaintBox or Paint Joy-Color&Draw, with more than 10,000,000 downloads and recent updates. These apps are tools which give children the possibility to carry out graphics with 24 types of magic brushes, drawings on canvas or photographs, animated stickers, pre-designed shapes or 7 types of thicknesses. Besides, children frequently use this type of apps for drawing (Kirkorian et al., 2020) and they are among their favourite ones (Marsh et al., 2015).

Despite being an ordinary activity in the classroom, the existence of several apps and the interest towards smartphones and tablets for research and assessment , little is known about the use of tablets in comparison with using more traditional research tools such as paper and pencil, especially in children (Piatt et al., 2016) during their pre-schematic period (Lowenfeld & Brittain, 1987). The confusing results offered by the few research works available (Lin, 2019) do not give a clear answer to the issue if a new method is likely to yield fundamentally different data from traditional methods and, if so, what might account for any such difference (Piatt et al., 2016).

The only investigations available are mainly focussed on obtaining evidence which confirm (Couse & Chen, 2010; Sakr, 2018) or not (Picard et al., 2014) the tablet feasibility to make drawings during pre-school period. Other studies are focussed on determining if drawing quality depends on the support and the medium used (Kirkorian et al., 2020). And finally, there are some works related with the types of touch which are produced when children are making their graphics (Crescenzi et al., 2014), the necessary skills to make their drawings (Strooband et al., 2020), and the biomechanical limitations that are discovered when drawing (Kirkorian et al., 2020). Most of said investigations are small pilot studies carried out during short time span, and they do not integrate technologies in the classroom activities scheduled for the pre-school level and thus, they do not give a clear answer regarding the practical implications of using the tablet during pre-school stage.

The age period of 4 to 5 years old corresponds to the pre-schematic stage of artistic development (Lowenfeld & Brittain, 1987). Children draw objects from the real world, including the human form. They draw activities taking place around them, and there is a relationship among what they see, think and draw. The requirements for this activity, carried out with paper, are different if it is carried out with the tablet. In the case of the traditional method, children need muscle development, control over their fine motor skills and visual perceptual skills in order to achieve the result pursued. Nevertheless, this activity with the tablet support involves less muscle strength, coordination and dexterity (Mangen et al., 2010). Therefore, it is necessary to carry out a tablet viability study within a real learning environment during some time because requirements are different (Hassler Hallstedt & Ghaderi, 2018) and they involve others skills (Strooband et al., 2020).

1. 1 Research questions

In (Lowenfeld & Brittain, 1987), authors have identified the characteristic features of drawings made by children while drawing with traditional mediums to quantify their quality. In this way, based on children's drawings, Lowenfeld studies aspects such as figure, use of colour or space distribution. Also, in (Lurçat & Lozano, 1982), shape and figure are studied in a parallel way, in such a way that shape is considered within figure. Nevertheless, it is necessary to determine if those features are also present in the drawings made by children while drawing with apps (Yadav et al., 2022). The work suggested in this paper tries to fill in said gap.

Thus, this work offers the following contributions: (a) The comparison between drawings made with paper& crayons vs tablet-finger in children who are 4 and 5 years old during a period of time and (b) Impact analysis of digital technology on drawings made by children within their real learning environment. In order to study such impact, we are going to compare some drawings made with paper&crayons vs tablet-finger with children who are 4 and 5 years old.

Considering the characteristic features of drawings made with traditional means as the point of reference, taking into account that children are digital natives, have access to technology and that they know how to interact with the screen of a tablet**,** we have defined the general style to analyze said impact. General style is a quality measure for the drawing and it includes colour, line thickness, the figure, if it is a schematic or figurative drawing (Lowenfeld & Brittain, 1987; Lurçat & Lozano, 1982) and composition (Golomb, 1987).

To check to what extent we have achieved the expected contribution, we address the following research questions:

1. Is there any variation in the general style between the different supports during a period of time based on the children's age?
2. Is there any variation in the general style between children who are 4 and those who are 5 years old during a period of time based on the support means used?

In our research, we have focused on the pre-schematic stage that covers the 4- and 5-year-old period. We have carried out a detailed study distinguishing between the two different ages due to the maturity differences observed in 4- and 5-year-old children. Cognitive maturity has increased engagement with technology (McBride & Austin, 1986) and older children have more refined motor skills than younger children have. In (Brown, 2012), the author has reported that visual perceptual skills and motor skills were related and that they depend on each other, and many visual perception skills mature at the age of five to six years old (Schneck, Colleen M., 2010). However, it remains unknown how the development of visual perception and fine motor skills through tablet use changes over time (Lin, 2019).

In order to answer these previous questions, by means of a study contextualized in the free drawing activity carried out in a kindergarten school, we have compared the general style of the drawings made by children, using two different supports and means: the tablet-finger and the traditional tools, i.e., paper with crayons. In this sense, we have analyzed the drawings made by 104 children who are 4 to 5 years old during 5 sessions. Additionally, we have carried out interviews with teachers who have told us their perception about the use of technology during the free drawing activity.

The rest of the paper is organized in the following way. The following section details the related work and, in section 3, we define the free drawing activity within the context of our study. The study design, as well as the procedure, analysis and results, are included in section 4. Section 5 includes the discussion. Conclusions and future work are included in section 6.

2. Related work

In general, in childhood education, there is little research about tablet impact on children (Herodotou, 2018). Existing research is mainly focused on late primary years, elementary school and higher education. Nevertheless, there are some studies related with the freehand drawing activity for children who are 4 and 5 years old, which is mentioned below.

The work prepared by (Matthews & Seow, 2007) informed about similar aspect between drawings made by 12 children who are 2 to 7 years old with the stylus interaction on tablets and those traditionally made, i.e., with paper&marks. Nevertheless, it is difficult to generalize results because it gave no specific information about participants or a descriptive analysis supporting the investigation. Previously mentioned deficiencies are covered in the research carried out by (Couse & Chen, 2010). This work studies tablet feasibility for pre-school education. The work includes 41 children who are 3 to 6 years old during two sessions and said children go to a university-based early childhood center that has a room equipped with tablet technologies. They use the tablet as a support and the stylus as interaction medium in order to make their drawings. The authors' conclusion is that the tablet with the stylus is a tool to be used in pre-school education. On the other hand, they recognize that the study follows a descriptive nature and that data are limited because children were from one university-based early childhood program.

The deficiency of carrying out the study within a non-familiar learning environment for the children is solved in (Ackermann, 2014), as the author goes to an early childhood school in which 30 children who are 3 to 5 years old take part in the research. The researcher acts as instructor. The study finds differences between children's digital works and their traditional work. Often, older children spent more time to create their traditional crayon drawings, which in the end featured more detail and visual information. However, in the experimental design of the comparison of drawings carried out with paper & crayons vs tablet, children had access to the stylus and frequently, children used it for a moment and then, they worked with their fingers directly interacting with the tablet. In (Picard et al., 2014), experimental design only includes the interaction of the tablet with the fingers. In this way, the 46 children who were 5 to 8 years old had 10 minutes to make the drawings with a pencil on the paper (standard condition) and fingertip on screen (iPad condition). Researchers said that the drawings made with the pencil and on the paper were better than the drawings made with fingertip on the flat screen. As children had never used the tablets before, they did not have enough training regarding the fingertip drawing technique. Nevertheless, more recent studies like the one made by (Sakr, 2018) with 12 children who were 5 to 6 years old have shown that children were more concentrated when drawing with an app because the app has all the necessary tools concentrated on the screen. Again, this study was carried out with 12 children who were neither in their ordinary classroom nor with their teachers. Besides, time duration is not mentioned in the work.

The study about the influence of the support with the interaction mediums used for drawing is also included in highly recent investigations. Said investigations demonstrate that experience regarding the use of technologies is a factor to be taken into account. Thus, in (Kirkorian et al., 2020), 73 children with ordinary access to a mobile touchscreen device, with ages of 2 to 5, chosen out of an early childhood school and a museum made drawings with three different devices (marker-paper, stylus-tablet, finger-tablet). The study suggests that for young children, the type of medium used has relatively little impact on the quality of drawings that children produce. However, children may prefer drawing on a tablet computer than on paper, and drawing with their finger on a tablet may be the best way to elicit drawings. This preference may be due to the engagement technology creates, partially because of the cognitive maturity older children have (McBride & Austin, 1986).

The previously mentioned studies have given rise to others in which more emphasis is made on the physical nature of the drawing process. This approach has been studied from different points of view:

1. Touch-based interaction. One of the pioneer studies in this same line is the one carried out by (Crescenzi et al., 2014), in which findings indicate both quantitative and qualitative differences in types of touch across these two environments. The work suggests that individual children demonstrate different repertoires of interaction, which may be linked to family practices and familiarity with technologies, such as touchscreen and handheld devices. Additionally, in (Shukri & Howes, 2019) it is wondered if children are able to adapt by themselves to the touchscreen. The study provides that children can adapt well to a touchscreen despite their motor variability and their own limitations and limitations imposed by touch-based devices. Specifically, children adapt drawing strategies to their own motor variability and to the motivational context of action.

2. Fine motors skills (Strooband et al., 2020). In (Gerth et al., 2016) researchers discover that when the task to be carried out requires fine motors skills, children were particularly challenged by the smoother surface of the tablet, because it demanded greater movement control from them. Despite the challenge technology represents, in the study carried out by (Lin, 2019), visual motor skills are less developed in children using the tablet in comparison with children who do not use it. The authors have even declared that frequent use of touchscreen tablets by pre-school children may exert a potentially detrimental effect on the development of their fine motor skills (Lin et al., 2017). On the other hand, (Coutinho et al., 2017) have reported that children with poor visual motor skills showed improvements in visual motor integration skills with interventions using iPad applications or traditional occupational therapy, with similar gains over time between the two interventions.
3. Biomechanical limitations faced when drawing. In (Kirkorian et al., 2020), authors declare that: "drawing with a finger on a touch screen involves different muscle groups and different frictional characteristics than drawing with a crayon or marker on paper". In this way, drawing with one finger may be –if considered motor skills only- simpler than drawing with any other device that requires some strength level in fingers and fine motor skill control. This ability allows that drawing with a finger on a tablet computer may enable children to engage in longer, more continuous marks on the surface (Price et al., 2015). Nevertheless, drawing with a finger may be more exhausting and the result is less detailed drawings (Picard et al., 2014).

Most of the studies mentioned are carried out within an unusual learning environment for children. Researchers act as coaches and teachers are not with children. Results shown are very different as some works show that the tablet is a useful tool for drawing and some others have some doubts about its use for drawing. And finally, it seems that there are neither works focussed on the pre-schematic stage of the child's artistic development nor detailed studies by ages, in which cognitive maturity is an aspect to be taken into account.

3. Our proposal for freehand drawing activity

Freehand drawing is a common activity through which pre-schoolers represent their thoughts and knowledge (Lancaster, 2007; Matthews, 1984). Pre-school teachers regularly promote it in their classes with the aim of promoting children's artistic sensitivity and their creativity. Additionally, drawing and painting are some of the tasks children must carry out during their pre-school education period to improve their development of reading and writing.

In our research, we have developed a freehand drawing activity, which deals with several competences. It is important to mention that in the specific case of Spain[1], in the regulations applicable to early childhood education, competences have not been specifically defined, as only aims are mentioned based on the skills to be dealt with. Basic competences are understood as the implemented capacity of integrating knowledge, skills and attitudes to solve problems and situations in different contexts. In this way, skills are the following ones: a) Cultural and artistic skills. They prepare and share small plastic works. b) Learn to learn skills. There are no pre-stablished rules so each child draws what he or she wants and there are no mistakes.

The purpose of this activity is to foster creativity of both boys and girls during early childhood education, melting traditional teaching methods used in the classroom with the use of the new

[1] Spanish Decree 1630/2006, 29th. December, establishing the minimum syllabus for the second level of Early Childhood Education.

technologies available, specifically, of mobile devices. For this purpose, the following aims are set out: a) to study the impact of new technologies on students, b) to integrate the innovative use of mobile technologies into the activities scheduled for the classes of early childhood education carried out in educational centres. To measure technology impact as well as its use in the classrooms, we have compared the activity with two supports and different means. For the tablet support and the direct interaction of the finger on the screen, we have used Draw&Talk app (Lopez-Ardura, 2014). Draw&Talk is an Android app developed by a multidisciplinary group of stakeholders made up of teachers and experts in Mobile Applications Development. The main purpose of Draw&Talk is that children may have available all the necessary tools on a screen to be able to draw (Figure 1). In this way, it includes a canvas on which the child may draw with his or her finger, and essential drawing tools such as (basic and secondary) colours, and the possibility to choose the line thickness. Besides, it also includes a screen which is prepared for introducing the activity information and a button on the canvas screen which allows saving of the drawing made. All drawings are locally saved on the tablet as .bmp files, in such a way that they may be directly obtained from the tablet for their further processing.

Figure 1. A child making a drawing during the freehand drawing activity

4. Study Design

4.1 Participants

The activity was carried out during the 2018-2019 academic course with the support of a regional Project to which the researchers of this work and the managing team of the educational centre applied. Once the Project was granted to us, the school headmaster informed all the teachers about the performance of the activity. Both the researchers as well as the teachers who were going to be in charge of the activity wrote a document in which we informed about the activity development addressed to 4 and 5-year-old children. We thus required the authorization of their parents/tutors. Only those children who obtained their parent/tutor's authorization took part in this study. Children were divided into control group and experimental group, trying to have the same amount of children of 4 years old and 5 years old in both groups. The sample analyzed in the study corresponds to 104 children who finished the five sessions, and thus, the control group was made up of 61 children (32 were 4 years old and 29, 5 years old) y and the experimental group had 43 children (15 were 4 years old and 28, 5 years old).

In the control group case, children had crayons of different thickness available in several plastic glasses, apart from a sheet of paper A4 (8.3 x 11.7 inches) with a heading specifying the child's identifier, the session and the date. For the experimental group, each child had a tablet of 10 inches with the app of Draw&Talk previously installed by the teachers and which allowed them to draw with their fingers. Before beginning the session, teachers entered the information related with the child's identifier, the session and the date on the app. Children from both groups carried out the freehand drawing activity once a week during 5 sessions and during the hour addressed to this activity in the teachers' timetable. Besides, all the children had had previous experience using the tablet.

4.2 Procedure

Data collection is carried out in different phases which are summarized below:

Phase 1. **Introductory and warming-up session**. Following the recommendations of (Clements & Sarama, 2003), children from the same classroom worked side by side at a child-sized table, each on his or her own tablet. The purpose during this stage is that children feel familiar with the app "Draw&Talk". Teachers teach children, but only on that day, about the basic operation of the drawing tools: selection of colours and line thickness, and finally, the button to save the work. The reason why teachers teach the basic operation on the first day is because "Draw&Talk" is easy to be used and it is not necessary to explain many things. Teachers use peer assistance with phrases such as: "Maria, explain Mario how you have found that colour / made such thin line", etc. Thus, teacher's participation is nearly unnecessary. There is no time limitation within the period assigned for the activity. Each child has spent the time he or she has considered necessary during the period assigned for this phase. In the case of the control group, this phase is not considered because children are already familiar with the freehand drawing activity.

Phase 2: **Free drawing session**. In this stage, children of the experimental group are familiarised with the "Draw&Talk" application. Therefore, it is in this phase when data collection really begins. Thus, teacher introduces the identification data corresponding to the session to both groups. Following the recommendations suggested by (Watts, 2010), teacher says to the children: "draw what you want on a sheet and then, we will save it". Then, children begin drawing and making graphics without the teacher's help. This is an activity to be carried out personally but not alone. It is carried out while being surrounded by companions and interaction among peers is allowed, with comments and suggestions. Children may show their drawings to teachers and to their other companions. There is no time limitation within the time available for the session. Each child spends the time he or she needs. When the child finishes, in the case of the control group, the teacher picks up the sheet of paper; in the case of the experimental group, the child saves the drawing on the tablet (Annex I: Drawings made by the children).

Additionally, there are two more phases during which only the teachers and the research team take part:

Phase 3: **Drawing code**. Once the 5 sessions have finished, the procedure continues with the drawing code phase. For the control group, drawings are directly coded based on the paper and, in the case of the experimental group, we take the drawings from the tablet and they are printed on a sheet of paper to study them in a better way.

Phase 4: **Interview with the teachers**. Teachers were interviewed during 1 hour following a semi-structured interview format. They have direct contact with children when they carry out

the activity and they were used as "proxies" to know their perceptions (Tang & McCorkle, 2002). Specifically, we want to know their perceptions about children's experience while carrying out the activity with both supporting aids and thus, we may be able to know more about the use of the tablet for freehand drawing. Teachers analyse the drawings made on paper and with the tablet, giving us their points of view about the tablet potential as a technological device to be used for classes.

4.3 Codification of graphics produced

By means of children's representations, we studied characteristic features in the pre-schematic stage (Lowenfeld & Brittain, 1987; Lurçat & Lozano, 1982). These features allow the definition and codification of the general style variable with which we may solve our research questions. General style refers to the drawing quality and its possible values are: 0, 1, 2, 3, 4 and 5. In order to obtain the general style, we consider the colour, thickness, figure if it is an schematic or figurative drawing and the compositional development of the drawing (Golomb, 1987). In Table 1 below, we have mentioned these factors as well as their code. If we sum up all of them, the general style value is obtained. In addition, in Annex 1, we have included examples of codified graphics for children who are 4 and 5 years old, for a better understanding.

Table 1: Factors and their coding

Aspects to be evaluated	Elements	Coding
Colours	One colour	0
	More than one colour	1
Thickness	One thickness	0
	More than one stroke thickness	1
Figure	Intentional but unrecognizable scribble	0
	Recognizable figure	1
Drawing	Schematic drawing. Like a tadpole, for example: head with two lines that may be arms or legs	0
	Figurative drawing. It may be identified what it is represented in most of the drawing.	1
Composition	If children distribute their figures and forms across the page and establish any order among them.	1 or 0

Two independent teachers with experience codified the drawings. Cohen's Kappa was .85, indicating substantial agreement between both teachers. In case of coding disagreement, they talked about it until they reach an agreement; otherwise, the more experienced teacher's code was used.

4.3 Data analysis

The analysis –carried out with the SPSS v24 and an alpha level of .05 for all statistical tests- was focused on giving an answer to the two research questions introduced in this study.

In order to reply to the first research question, the two-way mixed ANOVA procedure was suggested, using the general style as dependent variable, the supporting device (tablet-finger vs

paper&crayon) as between-subject factor and time (5 sessions) as within-subjects factor. The study of the simple main effects of time and of the supporting device in the general style variable was carried out following the ANOVA procedure with Bonferroni Post Hoc Test. These analyses were separately implemented, both for children who were 4 years old as well as for those who were 5 years old.

In the case of the second research question, the previous process was repeated, using the two-may mixed ANOVA procedure, and the general style was the dependent variable, the age (4 years old vs 5 years old), the between-subject factor and the time (5 sessions) the within-subjects factor. The simple main effects of time and age in the general style variable were carried out using the ANOVA procedure with Bonferroni Post Hoc Test. These analyses were separately carried out both for the control group as well as for the experimental group.

To analyse the importance of the effect, we have followed the criterion suggested by Cohen (Cohen, 1988) which establishes that: $\eta^2_p = 0.01$ is a small effect size, $\eta^2_p = 0.059$ is a medium effect size and $\eta^2_p = 0.138$ is a large effect size. A supporting assistant in this research has transcribed the interviews. Additionally, we have analysed the interviews with teachers using qualitative methods (Bogdan & Biklen, 2006). The authors have independently worked with the transcription of the interviews, following the thematic analysis (Maguire & Delahunt, 2017), to find out evidence addressing the main purpose of our research. Besides, the authors have carried out a member check with the teachers to confirm the interpretation and discussion of results in order to obtain study credibility (Golafshani, 2003).

4. 4 Results

We have included below the results obtained after the statistical analysis carried out for each research question. The descriptive statistics of general style variable for each session, categorized by support and age, are shown in Table 2. In addition, in Table 3, the most relevant results for drawing composition are included. In our study, this variable allows us to analyze the visual perceptual skill. Finally, we have shown the results obtained from the analysis of the interviews.

Table 2: Descriptive Statistics

	Tablet			Paper		
General style	Total (N = 43)	4 years (N = 15)	5 years (N = 28)	Total (N = 61)	4 years (N = 32)	5 years (N = 29)
Session1	0.72 ± 1.05	0.47 ± 0.75	0.86 ± 1.18	1.39 ± 1.42	0.47 ± 0.95	2.41 ± 1.12
Session2	1.21 ± 1.54	0.47 ± 0.92	1.60 ± 1.66	1.21 ± 1.25	0.69 ± .097	1.79 ± 1.29
Session3	1.35 ± 1.54	0.20 ± 0.41	1.96 ± 1.57	1.79 ± 1.42	0.94 ± 0.98	2.72 ± 1.22
Session4	1.86 ± 1.53	1.27 ± 1.22	2.18 ± 1.61	1.71 ± 1.48	1.03 ± 1.15	2.45 ± 1.45
Session5	2.37 ± 1.57	1.40 ± 0.91	2.89 ± 1.62	1.75 ± 1.26	1.03 ± 0.86	2.55 ± 1.15

Note: The values shown are expressed as mean ± standard deviation.

RQ1. Is there any variation in the general style between the different supports during a period of time based on age?

First of all, it was studied the variation of the general style mark for a period of time in 4-year-old children both on the paper as well as on the tablet. Two-way mixed ANOVA showed that the Mauchly test violated the sphericity assumption $\chi^2(9) = 20.08$, $p = .018$, $W = 0.63$. Considering that all the approximations have the same power and implementing the Huynh-Feldt correction ($\epsilon = 0.91$), it was found out that there are statistically significant differences in the general style during a period of time according to the type of support used $F(3.63, 163.14) = 2.52$; $p = .048$; $\eta^2_p = 0.053$; small effect size, as it seemed to be shown in Figure 2. Afterwards, it was analysed the simple main effects of time on the general style mark for each support. In the case of the paper as support, there was no statistically significant effect of time on the general style mark. In the case of the tablet as support, there was a statistically significant effect of time on the general style mark, $F(4, 56) = 5.22$; $p = .001$; $\eta^2_p = 0.27$; large effect size. The general style mark was, statistically, significantly higher in session 5 than in session 3. Finally, the simple main effects of the support on the general style mark in each session were analysed. And it was discovered that there was a statistically significant difference in the general style mark between the supports in session 3, $F(1, 45) = 7.75$; $p = .008$; $\eta^2_p = 0.15$; large effect size. In this session, the general style mark was statistically significantly higher for paper than for the tablet. Considering the results obtained, and based on Figure 2, it may be concluded that differences found are due to the low mark obtained in session 3 for the tablet support. In all the other cases, the general style mark along that period of time had no variation neither depending on time nor on the support used.

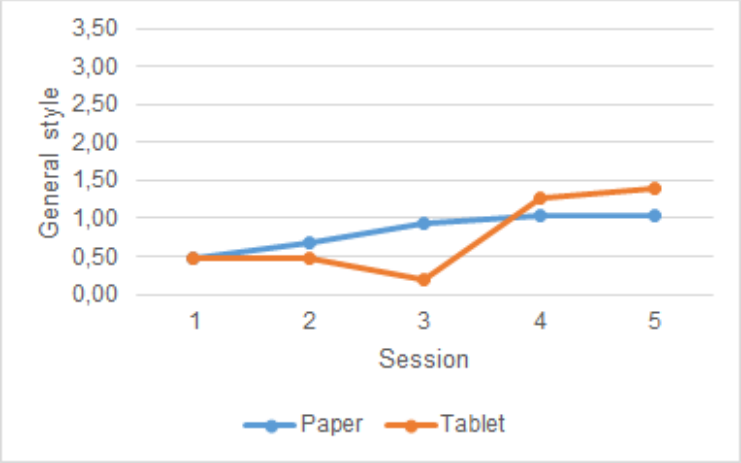

Figure 2. General style mark during the sessions for both supports in the group of 4-year-old children.

Repeating the previous process but now for 5-year-old children, the two-way mixed ANOVA test revealed that there are statistically significant differences in the general style during the period depending on the support used $F(4, 220) = 5.91$; $p < .001$; $\eta^2_p = 0.097$; medium effect size, as it seemed to be shown in Figure 3. Then, the simple main effects of time on the general style mark for each support were analyzed. In the case of the paper being the support, there was a statistically significant effect of time on the general style mark, $F(4, 112) = 3.66$; $p = .008$; $\eta^2_p = 0.12$; medium effect size. General style mark was, statistically, significantly higher in the comparative session 3 vs session 2, and it was an expected result based on Figure 3, as in session 2 the lowest mark was obtained in the general style. In the case of the tablet as support, there was a statistically significant effect of time on the general style mark, $F(4, 108) = 10.56$; $p = .001$; $\eta^2_p = 0.28$; large effect size. The general style mark was statistically significantly higher in the following comparisons: session 5 vs: session 3, session 2 and session 1; session 4 vs session 1; and session 3 vs session 1. Thus, 5-year-old children using the tablet as support improve their marks in the general style about every two sessions, except in the case of the comparison of session 2 vs session 4. Finally, the simple main effects of the support on the general style mark for each session were analyzed, where it was concluded that there was a statistically significant difference on the general style mark between the supports in session 1 [$F(1, 55) = 26.20$; $p < .001$; $\eta^2_p = 0.32$; large effect size] and session 3 [$F(1, 55) = 4.16$; $p = .046$; $\eta^2_p = 0.07$; small effect size]. In session 1, general style mark was statistically significantly higher on paper than on the tablet. In session 3, general style mark was, statistically, significantly higher on paper than on the tablet.

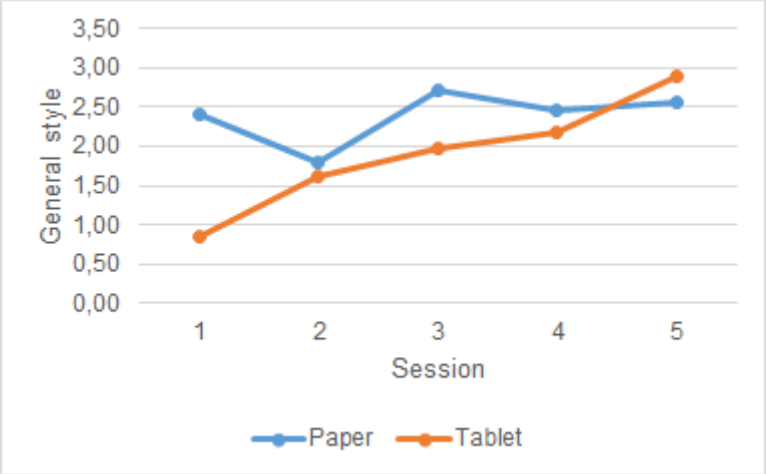

Figure 3. General style mark during the sessions for both supports in the group of five-year-old children.

RQ2. Is there any variation in the general style between children who are 4 years old and those who are 5 years old during a period of time based on the support?

To answer this research question, firstly, paper was used as support and crayons were used as medium. The hypothesis was that 5-year-old children would have better marks in the general style than 4-year-old children. Based on the two-way ANOVA test, there was no statistically significant interaction between the age and the time for the general style mark $F(4, 236) = 1.90$; $p = .111$; $\eta^2_p = 0.031$; small effect size. The main effect of age showed that there was a statistically

significant difference in the general style mark between the ages $F(1, 59) = 64.43$, $p < .001$, $\eta^2_p = 0.52$; large effect size, as it seemed to be shown in Figure 4. In all the pairwise comparisons, general style mark of 5-year-old children were, statistically, significantly higher ($p < .001$) than those of the four year-old children, with large effect sizes ($\eta^2_p > 0.20$).

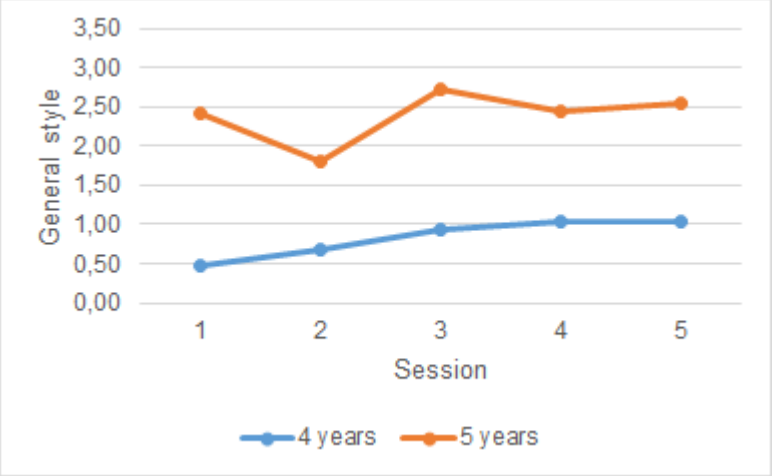

Figure 4. General style mark during the sessions for both ages using paper as support.

In the case of the tablet support, the two-way ANOVA test found no statistically significant interaction between the age and the time in the general style mark $F(4, 164) = 2.76$; $p = .073$; $\eta^2_p = 0.051$; small effect size. The main effect of the age showed that there was a statistically significant difference in the general style mark between the ages $F(1, 41) = 15.54$, $p < .001$, $\eta^2_p = 0.275$; large effect size. In comparison, regarding the paper support, the effect size is nearly half of the other and, as it seems to be shown in Figure 5, not all the comparisons will be statistically significant. In fact, general style mark was statistically significantly higher in comparisons: session 2 ($M = 1.14$, $SE = 0.47$ points; $p = .018$; $\eta^2_p = 0.13$; medium effect size), session 3 ($M = 1.76$, $SE = 0.42$ points; $p < .001$; $\eta^2_p = 0.31$; large effect size), session 5 ($M = 1.49$, $SE = 0.45$ points; $p = .002$; $\eta^2_p = 0.21$; large effect size).

This last analysis disclosed that children who were 4 and 5 years old had the same average marks in the general style in session 1 using the tablet. In fact, for the first session, if we compare the general style of 5-year-old children using the tablet and that of 4-year-old children using paper no statistically significant differences were found ($p = .163$). This means that, in the first session, the only ones who had higher marks in the general style than the others are the 5-year-old children who use paper.

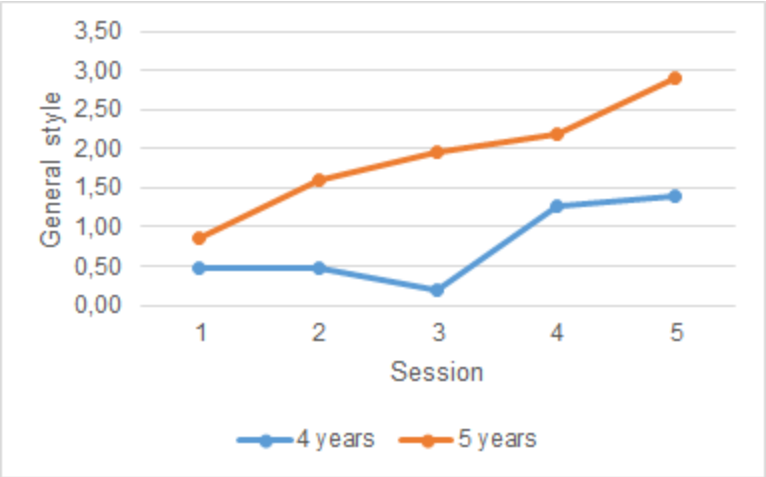

Figure 5. General style mark during the sessions for both ages using the tablet as support.

Table 3: Visual Perceptual Skills Summary

Paper (4-year-old group vs 5-year-old group)	session 1 ($M_{four\text{-}years}$ = 0.09, SE = 0.05 points) vs ($M_{five\text{-}years}$ = 0.52, SE = 0.09 points)
	session 3 ($M_{four\text{-}years}$ = 0.06, SE = 0.04 points) vs ($M_{five\text{-}years}$ = 0.45, SE = 0.09 points)
	session 5 ($M_{four\text{-}years}$ = 0.06, SE = 0.04 points) vs ($M_{five\text{-}years}$ = 0.52, SE = 0.09 points)
Tablet (5-year-old group vs 4-year-old group)	session 5 ($M_{five\text{-}years}$ = 0.61, SE = 0.09 points) vs ($M_{four\text{-}years}$ = 0.07, SE = 0.06 points)
Tablet (5-year-old group)	session 1 (M = 0.07, SE = 0.05 points) session 2 (M = 0.21, SE = 0.08 points) session 3 (M = 0.25, SE= 0.08 points) session 5 (M = 0.61, SE= 0.09 points)

<u>Findings taken from teachers' interviews</u>

During the interviews, teachers give qualitative descriptions about what children like most or even dislike about the activity and if, at any time, they have felt influenced by the supporting aid used. Teachers have told us the following:

"Children like the freehand drawing activity because it is creative, and it allows them to express their thoughts. Besides, they are surprised when they see their drawings on the tablet and it is highly important for them to show their drawings to their companions and to me (the teacher)".

With reference to what they like most or what they dislike, teachers relate their likes with the available materials children have for the activity. As traditional tool, they use paper and crayon, but with the tablet, children draw directly using their fingers. This digital interaction offers the following advantage:

"The tablet offers a direct way, with no intermediate elements such as a pencil or crayon, which may disturb or disappoint them on a specific moment, without taking into account their ability

at the time of using the pencil or crayon, pursuing only the purpose of realising if they may draw with their finger directly on the tablet".

Teachers think that "Draw&Talk" is well designed for the purpose it pursues:

"Children draw using the necessary tools. They have completely understood the app very quickly. They have both the elements and enough space to be able to draw freely".

With reference to the use of the tablet in the classroom as the only supporting tool for the activity, both teachers comment that it must be complemented with the traditional tool:

"Drawings made with the tablet do not replace those made with the paper and crayons. Both supports should be complementary. For example, this is a proposal thought for younger children: a direct way from their hands to the tablet, with no intermediate process, without taking into account if they are more or less skillful with the most traditional instruments of writing, with the interest of realizing that their fingers leave some tracks on the tablet surface."

5. Interpretation and Discussion

Results obtained seem to show that drawings made with the tablet are similar to those made on paper, both in the case of 4-year-old children as well as in the case of 5-year-old children. However, we are going to analyse in detail and discuss the results obtained for each of the research questions made.

RQ1. Is there any variation in the general style between the different supports during a period of time based on age?

In the case of the 4-year-old children, significant differences cause a slight effect and the only existing difference is due to the low mark obtained in session 3 by the children who used the tablet. Therefore, drawing quality for both supports is similar, and there is no clear improvement in any of them. This result is similar to the one obtained in (Kirkorian et al., 2020), but in our case, it is generalized during a period of time.

Significant differences between both supports may be observed in section 3, with a comparatively lower score for the tablet and which gives rise to a turning point in the use of said mobile device. This result may be explained by the low level of technology engagement observed in this age group. This lack of engagement may be because cognitive maturity increases engagement with technology (McBride & Austin, 1986) and, perhaps, these children have not reached the necessary cognitive maturity because they are still going through the stage of developing visual and motor skills which are highly necessary for their daily activities (Strooband et al., 2020).

Another reason for this result is that drawing with the traditional method requires some fine motor skills and muscle development which are not necessary when using the tablet (Lin, 2019). This difference of requirements gives 4- year-old children the possibility to use the tablet easily (Piatt et al., 2016), as they directly interact with their finger on the tablet surface and with no need of intermediate elements. Besides, children may adapt themselves to a touchscreen despite their motor variability and their own limitations and limitations imposed by touch-based devices (Shukri & Howes, 2019), thus allowing results of drawing quality to be similar in both supports during a period of time.

Nevertheless, despite the similar scores obtained during a period of time and the easiness of using the tablet when drawing, it must be taken into account the visual perceptual skills and motor skills to be developed by this age group and which depend one on the other, as informed by Brown in 2012 (Brown, 2012). Thus, we have analyzed drawing composition as, in our study, it is the variable that it is most related with visual perceptual skill. Result has shown that there are no significant differences in this variable between both supports. This means that, during a period of time, the 4-year-old group finishes adapting their motor variability to the touchscreen (Shukri & Howes, 2019) to obtain the same quality as the drawings made on paper, but the tablet does not improve any of the fine skills children need for their daily activities, such as getting dressed or eating.

In the case of the 5-year-old group and during a period of time, there are significant differences between both supports, though paper has more impact than the tablet but with a medium effect. Thus, drawing quality is very similar. Nevertheless, quality development on the tablet is different from that on paper. Specifically, on the tablet, there are significant differences with great effect while on paper, though such significant differences exist, they are less intensity. The reason for this result is that this age group has cognitive maturity (Schneck, 2010) which fosters engagement with technology (McBride & Austin, 1986). And such maturity level is just checked with the composition variable, which shows that there are no significant differences between the tablet and the paper. At that age, children may have their visual perceptual skills and motor skills already developed (Schneck, Colleen M., 2010), which may imply that drawing quality does not completely depend on skills or adaptations they have to develop to carry out drawing on both supports. Nevertheless, a detailed analysis focused on each session really shows dependency between quality and adaptations to be carried out with the tablet. Thus, there are significant differences between drawing quality in session 1 and in session 3 and, in both sessions, it was better on paper than on the tablet. This result shows that, in fact, in this age group, some adaptation of their motor variability to touchscreen should be carried out (Shukri & Howes, 2019) during a period of time in order to obtain similar quality than the one of the drawings made on paper.

In the case of the 4-year-old children, the only existing difference is due to the low mark obtained in session 3 by the children who used the tablet. Besides, this circumstance is also observed in the 5-year-old children when using paper for session 2. The fact that this occurs with both ages, in different sessions, which are not the first and /or the last one, has suggested us that it takes place on a specific moment which is related, perhaps, with children's motivation, interest or tiredness. From our point of view, this is an obvious result as children are not always enthusiastic. Perhaps, in the case of the 4-year-old children, it is also because it takes them more time to get used to a different medium. The interactions they use to carry out at the time of drawing are most of the tap type followed, but in a smaller number, by straight and circular strokes (Crescenzi et al., 2014; Price et al., 2015). Drawing with your fingers may be more tiresome (Picard et al., 2014). Apart from tiredness, as it was commented by (Shukri & Howes, 2019), it seems that children adapt their drawing strategy to the tablet and their fingers, improving their drawings in the last sessions.

Therefore, we can declare that there is no mark variation in the quality of the drawings, taking into account the age, between both supports, within the period of time established in this study. Our results agree with those included in the work made by Picard et al., 2014, carried out during a shorter period of time. Nevertheless, interviews with teachers have evidenced the advantage of using fingers directly to make drawings in the group with younger children (4 years old),

without any need of intermediate elements on which some strength is to be exercised. Despite this advantage, our study suggests that the support has a minimum impact on the quality of the drawings made by children who are 4 and 5 years old during a free-drawing activity carried out within their ordinary learning environment during a period of time

RQ2. Is there any variation in the general style between children who are 4 years old and those who are 5 years old, during a period of time, based on the support used?

Based on the results, we may assure that there is a variation in the quality of drawings considering children who are 4 years old and those who are 5 years old, depending on the support. This result is obvious, as 5-year-old children are more cognitive mature than 4-year-old children. The 5-year-old group has their visual perceptual skills and motor skills already developed (Schneck, Colleen M., 2010), which explains the fact that drawing quality is higher on paper if compared with that of the 4-year-old group. Besides, that same maturity level is fostering engagement with technology (McBride & Austin, 1986), which explains better scores on the tablet for the 5-year-old group.

We consider it is important to study and analyse that such mark variation is nearly twice on paper ($\eta^2_p = 0.52$) than on the tablet ($\eta^2_p = 0.275$). This result may be due to the fact that children are familiar with the paper-and-pencil tasks and to the development of visual perceptual skills and motor skills. In the case of the paper, the composition variable clearly shows significant differences in the visual perceptual skills between both groups, and it is considerably greater in the 5-year-old group during the three-session period (Table 3). Nevertheless, there are no significant differences for the tablet. This means that children in both groups show no difference regarding the visual perceptual skill; some differences may only be observed in the last session, when children in the 5-year-old group overcome those in the 4-year-old group.
In order to achieve the expected drawing quality in each group, children are adapting their motor variability to the touchscreen (Shukri & Howes, 2019), but at a different pace. Thus, 4-year-old children are stable regarding composition, which means that the tablet is not fostering the development of their skills. Nevertheless, it may not be asserted that the frequent use of touchscreen tablets by pre-school children may exert a potentially detrimental effect on the development of their fine motor skills, as it is commented in (Lin et al., 2017). On the other hand, the 5-year-old group with the tablet, thanks to their maturity level, shows significant differences in the composition during a period of time (Table 3). This implies certain development of the visual perceptual skill. It is obvious that cognitive maturity of 5-year-old children allows them to adapt easily to the use of the tablet. Besides, it is plausible to assume that younger children in the tablet group require more visual perceptual skills in order to achieve such adaptation.

In the first session, 5-year-old children who use the tablet have similar results regarding quality of their drawings if compared with those obtained by 4-year-old children. This low score may be explained by the comments made by Gerth et al. (Gerth et al., 2016) who observed that 5-year-old children draw more quickly with their fingers on the tablet than with the pen /stylus due to low level of friction on the surface. Besides, as it was commented by (Price et al., 2015) speed increase may lead to some reduction of attention and concentration and, thus, a lower level of drawing capacity. This drawing speed may be increased in the first session, because the use of technology supplies interest, motivation and change if compared with traditional tools (Couse & Chen, 2010). Once this first session has finished, mark separation in the general style between both ages has an important effect that clearly shows that the drawings made by 5-year-old children have better quality than those made by 4-year-old children. Besides, this same effect is observed on paper as, in this case, the effect size is also important.

Finally, based on our results, it seems that for 5-year-old children, the tablet may be a support for making their drawings. Besides, teachers confirm their interest because children like this activity. Obviously, with the tablet, children may save their drawing and show it to their companions with autonomy in the following session. This is not the case when they draw on paper, as they have to ask the teacher to give them the drawing made during the previous sessions.

6. Conclusions

Technology impact on children during their pre-schematic stage for free-drawing activity during some period of time, has not been considerably studied. Most of the investigations dealing with children's drawings have been carried out during short periods of time, in a different physical place than the one where they study and the instructors are not their ordinary teachers. These circumstances make these studies –though giving relevant findings – to be taken into account but with care and, therefore, it is necessary to carry out more studies. In our work, children carry out their drawings within a longer period of time, in their ordinary learning environment and with their teachers.

The case study based on free-drawing activity gives us the possibility to compare two supports with their corresponding mediums to really know if the use of technology exerts any impact on the quality of drawings made by 4 and 5-year-old children. For this purpose, we have carried out a comparative study of tablet-finger vs paper&crayons during 5 sessions.

The tablet is a feasible tool for the free-drawing activity for the 4- and 5-year old groups. However, for the 4-year-old group, quality of their drawings is similar to that of the papel&crayon and tablet-finger activities. Our study shows that for these children, the tablet may be a suitable support to make drawings because drawings made using the traditional tools require some fine motor skills and some muscle development that are not necessary when using the tablet. They interact directly with their finger on the tablet surface and it is not necessary to have intermediate elements. This encourages children to draw without paying attention to the necessary skills for drawing which, in some cases, may discourage them to make a drawing. On the other hand, this age group needs to develop fine motor skills which are encouraged with the papel&crayon but not with the tablet. Specifically, when drawing with the tablet, children in the 4-year-old group adapt their motor variability to the touchscreen to achieve the same drawing quality as with the paper. In the 5-year-old group, drawing quality is similar for both supports. In the case of the tablet, it is observed that maturity level of this group improves their engagement with technology. Besides, this group may have their visual perceptual skills and motor skills already developed, which suggests that drawing quality does not completely depend on the skills or adaptations they have to develop to make the drawings on both supports.

Comparison by ages shows that 5-year-old children are better than 4-year-old children both regarding tablet-finger as well as paper&crayon. This result is evident due to the maturity level 5-year-old children have if compared with the 4-year-old children which encourages their engagement with technology. Besides, results of effect sizes - considerable for both groups, but which is twice on the paper than on the tablet - suggest that children are more accustomed to paper-and-pencil tasks and that development of visual perceptual skills and motor skills in both supports is different. Effectively, with paper, children in the 5-year-old group have higher visual perceptual skills than those in the 4-year-old group. On the other hand, when using the tablet, this difference of visual perceptual skills is not observed between both groups. It is evident that children in both groups are developing adaptation strategies to draw with the tablet, but 5-year-

old children, due to their maturity level, adapt easily than 4-year-old children, who need more skills to achieve such adaptation.

This research has practical consequences that must be taken into account at the time of including the tablet in the pre-school syllabus. The tablet is a feasible tool for making drawings at the pre-school educational level, but in the case of the youngest children, it may cause that some skills, which are necessary for maturity, are not encouraged. It is really a useful tool when children do not want to draw because they have not developed some skills yet as they directly draw on the screen with their finger and with no intermediate elements. Another advantage of the tablet, if compared with the paper, is that children may easily show their drawings made during previous sessions to their companions and to the teacher because they are on the tablet and they may quickly look for them. Therefore, from our point of view, drawing with the tablet should be a complement to drawing with traditional elements.

Work limitations and future studies

This study has some limitations that may give rise to several future research lines. Thus, this result may be applied to other educational environments, with more children, to other cultures and to other activities, which may give us the possibility to accurately establish the impact of mobile technology on pre-school education. Apart from that, additional studies would be necessary using other supports and mediums such as tablet-stylus or paper-finger. Besides, as there are differences regarding the skills used when drawing with a tablet and drawing on a paper, it would be necessary to know more if task evaluation is going to be different according to the support used. Other future studies that may be carried out are related with the assessment of students' fine motor skills using validated tools prior to the beginning of the intervention in order to obtain a more-elaborated profile. These approaches would allow us to go ahead with the design of a generalized evaluation framework for tasks carried out with a mobile device.

Acknowledgements

This work has been partially funded by the Department of Science, Innovation and Universities: project RTI2018- 099235-B-I00. We have also received funds from the Principality of Asturias, through its Science, Technology and Innovation Plan (FC-GRUPIN-IDI/2018/000199) and University of Oviedo (GR-2011-0040). We thank the teachers and caregivers of the educational institutions for their support.

References

Ackermann, S. (2014). Digital Finger Painting: A Qualitative Exploration of the Tablet Computer and its Artistic Implications in an Early Childhood Setting [University of Missouri-St. Louis]. https://irl.umsl.edu/dissertation/201

Aznar, I., Cáceres, M. P., Trujillo, J. M., & Romero, J. M. (2019). Mobile learning y tecnologías móviles emergentes en Educación Infantil: Percepciones de los maestros en formación. Revista Espacios, 40(05). https://revistaespacios.com/a19v40n05/19400514.html

Bogdan, R., & Biklen, S. K. (2006). Qualitative Research for Education: An Introduction to Theories and Methods, Fifth Edition (5th edition). Pearson.

Brown, T. (2012). Are Motor-free Visual Perception Skill Constructs Predictive of Visual-motor Integration Skill Constructs? Hong Kong Journal of Occupational Therapy, 22(2), 48–59. https://doi.org/10.1016/j.hkjot.2012.06.003

Clements, D., & Sarama, J. (2003). Young Children and Technology: What Does the Research Say? Young Children, 58(6), 34–40.

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed). L. Erlbaum Associates.

Couse, L. J., & Chen, D. W. (2010). A Tablet Computer for Young Children? Exploring its Viability for Early Childhood Education. Journal of Research on Technology in Education, 43(1), 75–96. https://doi.org/10.1080/15391523.2010.10782562

Coutinho, F., Bosisio, M.-E., Brown, E., Rishikof, S., Skaf, E., Zhang, X., Perlman, C., Kelly, S., Freedin, E., & Dahan-Oliel, N. (2017). Effectiveness of iPad apps on visual-motor skills among children with special needs between 4y0m-7y11m. Disability and Rehabilitation. Assistive Technology, 12(4), 402–410. https://doi.org/10.1080/17483107.2016.1185648

Crescenzi, L., Jewitt, C., & Price, S. (2014). The role of touch in preschool children's learning using iPad versus paper interaction. Australian Journal of Language & Literacy, 37, 86–95.

Formby, S. (2014). Parents' Perspectives: Children's Use of Technology in the Early Years. National Literacy Trust.

G. Britain. (2013). Children and parents: Media use and attitudes report. Ofcom. https://www.ofcom.org.uk/research-and-data/media-literacy-research/childrens/children-and-parents-media-use-and-attitudes-report-2021

Gerth, S., Klassert, A., Dolk, T., Fliesser, M., Fischer, M. H., Nottbusch, G., & Festman, J. (2016). Is Handwriting Performance Affected by the Writing Surface? Comparing Preschoolers', Second Graders', and Adults' Writing Performance on a Tablet vs. Paper. Frontiers in Psychology, 7. https://www.frontiersin.org/article/10.3389/fpsyg.2016.01308

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. The Qualitative Report, 8(4), 597–607.

Golomb, C. (1987). The development of compositional strategies in children's drawings. Visual Arts Research, 42–52.

Hassler Hallstedt, M., & Ghaderi, A. (2018). Tablets instead of paper-based tests for young children? Comparability between paper and tablet versions of the mathematical Heidelberger Rechen Test 1-4. Educational Assessment, 23, 195–210. https://doi.org/10.1080/10627197.2018.1488587

Herodotou, C. (2018). Young children and tablets: A systematic review of effects on learning and development. Journal of Computer Assisted Learning, 34(1), 1–9. https://doi.org/10.1111/jcal.12220

Kirkorian, H. L., Travers, B. G., Jiang, M. J., Choi, K., Rosengren, K. S., Pavalko, P., & Tolkin, E. (2020). Drawing Across Media: A Cross-Sectional Experiment on Preschoolers' Drawings Produced Using Traditional Versus Electronic Mediums. Developmental Psychology, 56(1), 28–39. https://doi.org/10.1037/dev0000825

Lancaster, L. (2007). Representing the ways of the world: How children under three start to use syntax in graphic signs. Journal of Early Childhood Literacy, 7(2), 123–154. https://doi.org/10.1177/1468798407079284

Lin, L.-Y. (2019). Differences between preschool children using tablets and non-tablets in visual perception and fine motor skills. Hong Kong Journal of Occupational Therapy: HKJOT, 32(2), 118–126. https://doi.org/10.1177/1569186119888698

Lin, L.-Y., Cherng, R.-J., & Chen, Y.-J. (2017). Effect of Touch Screen Tablet Use on Fine Motor Development of Young Children. Physical & Occupational Therapy in Pediatrics, 37(5), 457–467. https://doi.org/10.1080/01942638.2016.1255290

Lopez-Ardura, C. (2014). Hablo & Dibujo—Aplicaciones en Google Play. https://play.google.com/store/apps/details?id=es.uniovi.pulso.drawandtalk&hl=es

Lowenfeld, V., & Brittain, W. L. (1987). Creative and Mental Growth (8th ed.). Prentice-Hall.

Lurçat, L., & Lozano, J. V. (1982). Pintar, dibujar, escribir, pensar: El grafismo en el preescolar. Cincel.

Maguire, M., & Delahunt, B. (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. All Ireland Journal of Higher Education, 9(3).

Mangen, A., Velay, J.-L., Mangen, A., & Velay, J.-L. (2010). Digitizing Literacy: Reflections on the Haptics of Writing. In Advances in Haptics. IntechOpen. https://doi.org/10.5772/8710

Marsh, J., Plowman, L., Yamada-Rice, D., Bishop, J., Lahmar, J., Scott, F., Davenport, A., Davis, S., French, K., & Piras, M. (2015). Exploring Play and Creativity in Pre-schooler's use of apps: Final Project Report.

Matthews, J. (1984). Children drawing: Are young children really scribbling? Early Child Development and Care, 18(1–2), 1–39. https://doi.org/10.1080/0300443840180101

Matthews, J., & Seow, P. (2007). Electronic paint: Understanding children's representation through their interactions with digital paint. International Journal of Art & Design Education, 26(3), 251–263. https://doi.org/10.1111/j.1476-8070.2007.00536.x

McBride, K. M., & Austin, A. M. (1986). Computer affect of preschool children and perceived affect of their parents, teachers, and peers. The Journal of Genetic Psychology: Research and Theory on Human Development, 147(4), 497–506. https://doi.org/10.1080/00221325.1986.9914525

Piatt, C., Coret, M., Choi, M., Volden, J., & Bisanz, J. (2016). Comparing Children's Performance on and Preference for a Number-Line Estimation Task: Tablet Versus Paper and Pencil. Journal of Psychoeducational Assessment, 34(3), 244–255. https://doi.org/10.1177/0734282915594746

Picard, D., Martin, P., & Tsao, R. (2014). iPads at school? A quantitative comparison of elementary schoolchildren's pen-on-paper versus finger-on-screen drawing skills. Journal of Educational Computing Research, 50(2), 203–212.

Price, S., Jewitt, C., & Crescenzi, L. (2015). The role of iPads in pre-school children's mark making development. Computers & Education, 87, 131–141. https://doi.org/10.1016/j.compedu.2015.04.003

Reeves, J. L., Gunter, G. A., & Lacey, C. (2017). Mobile learning in pre-kindergarten: Using student feedback to inform practice. J. Educ. Technol. Soc., 20(1), 37–44.

Sakr, M. (2018). Multimodal participation frameworks during young children's collaborative drawing on paper and on the iPad. Thinking Skills and Creativity, 29, 1–11. https://doi.org/10.1016/j.tsc.2018.05.004

Schneck, Colleen M. (2010). A frame of reference for visual perception. In P. Kramer & J. Hinojosa (Eds.), Frames of Reference for Pediatric Occupational Therapy (3rd edition). Lippincott Williams & Wilkins.

Shukri, S. R. M., & Howes, A. (2019). Children adapt drawing actions to their own motor variability and to the motivational context of action. International Journal of Human-Computer Studies, 130, 152–165.

Strooband, K. F. B., Rosnay, M. de, Okely, A. D., & Veldman, S. L. C. (2020). Systematic Review and Meta-Analyses: Motor Skill Interventions to Improve Fine Motor Development in Children Aged Birth to 6 Years. Journal of Developmental and Behavioral Pediatrics: JDBP, 41(4), 319–331. https://doi.org/10.1097/DBP.0000000000000779

Tang, S. T., & McCorkle, R. (2002). Use of Family Proxies in Quality of Life Research for Cancer Patients at the End of Life: A Literature Review. Cancer Investigation, 20(7–8), 1086–1104. https://doi.org/10.1081/CNV-120005928

Watts, R. (2010). Responding to children's drawings. Education 3-13, 38(2), 137–153. https://doi.org/10.1080/03004270903107877

Yadav, S., Chakraborty, P., & Mittal, P. (2022). Designing Drawing Apps for Children: Artistic and Technological Factors. International Journal of Human–Computer Interaction, 38(2), 103–117. https://doi.org/10.1080/10447318.2021.1926113

Annex I: Drawings made by children

Drawing 1.Age: 4 years old. Mark: 5

Drawing 2. Age: 4 years old. Mark: 0

Drawing 3. Age: 4 years old. Mark: 3

Drawing 4. Age: 5 years old. Mark: 1

Drawing 5 Age: 5 years old. Mark: 3

Drawing 6. Age: 5 years old. Mark: 5