iPADS AT SCHOOL? A QUANTITATIVE COMPARISON OF ELEMENTARY SCHOOLCHILDREN’S PEN-ON-PAPER VERSUS FINGER-ON-SCREEN DRAWING SKILLS

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ABSTRACT
A growing number of schools are embracing new mobile technologies, such as iPads, with little (or no) prior empirical proof of their usability. We investigated whether iPads, which allow children to write and draw with their fingers without the need of a pen, are relevant devices for drawing activities at elementary school. A within-participants design was used to compare routine drawings produced by 46 elementary schoolchildren with pen on paper (standard condition) and fingertip on screen (iPad condition). Results revealed a significant effect of drawing condition on graphic scores, with lower scores in the iPad condition than in the standard condition. The finding that finger drawings were slightly poorer than pen drawings can be ascribed to the shift from distal to more proximal control of the drawing movements.

The iPad is a touchscreen tablet that was launched by Apple in January 2010, and has since proved extremely popular. This new device combines several features of previously distinct technologies (Buckley, 2010). For example, iPads have all the functionality and connectivity of laptop computers, but are far more...
lightweight, and all the mobility of smartphones, but with a larger, multi-touch flat screen. The iPad’s finger-based interface is intuitive to use, convenient, and can be used to perform a variety of activities, including writing and drawing with the fingertip. A recent survey of the most commonly used devices in educational settings (Pegrum, Oakley, & Faulkner, 2013) revealed that iPads are now a familiar feature in classrooms around the world, regarded as a promising tool for supporting teaching and learning. Accordingly, several projects looking at how iPads are implemented in educational settings have been conducted in the past 3 years (e.g., United States: Bansavich, 2011; Scotland: Burden, Hopkins, Male, Martin, & Traval, 2012; Canada: Crichton, Pegler, & White, 2012; Australia: Jennings, Anderson, Dorset, & Mitchell, 2010, and Oakley, Pergrum, Faulkner, & Stiepe, 2012). These qualitative projects examined students’ and educators’ motivations, perceptions, and attitudes toward the use of iPads in the classroom, via surveys, classroom observations, focus groups, and interviews. As a whole, these projects indicated that the iPad was well received by teachers and students alike, who were convinced that it changed learning for the better. A robust observation was that iPad use seemingly increased students’ levels of motivation and self-efficacy, while it encouraged teachers to explore alternative activities and forms of assessments for learning, especially in elementary school settings. However, beyond the initial burst of motivation and the novelty effect of the iPad technology in the classroom, the longer-term benefits were less clearcut. This uncertainty derives from the very limited amount of quantitative research that has been conducted in this area (partly due to the newness of the technology and its use in educational settings). Two notable exceptions are studies that have tested the impact of iPads on mathematical skills. Carr (2012) carried out a quantitative study in which fifth graders (10-11 years) from two different schools either used iPads during math lessons (experimental group) or did not (control group). Math skills were assessed at pre-test and post-test using standard questionnaires. The effects of iPad use, as measured by changes in the mean difference between the experimental and control groups between pretest and posttest, were not significant. For their part, Haydon et al. (2012) conducted a quantitative study in which high school students with emotional disturbance alternatively used iPads (experimental condition) or worksheets (comparison condition) to complete math problems. Students solved more math problems and in less time in the iPad condition than in the worksheet one. This encouraging finding should nevertheless be viewed with caution, on account of the small number of students (N = 3) involved in the study. To summarize, there is paucity of research confirming the positive impact of iPads in the classroom.

More quantitative research, using a rigorous methodology, is needed to plug this gap in the existing literature, and help teachers make informed decisions about purchasing and using iPads at school in different areas (numeracy, literacy, drawing skills, etc.). Unlike previous studies that have concentrated on math skills, we decided to focus on drawing skills. We designed the present study to test
whether iPads are a useful medium for drawing activities at elementary school. It is important to study the use of tablets in drawing because the iPad’s finger-based interface means that users can draw with the fingertip, thereby obviating the need to handle a pen or a stylus, with all the challenges that can bring. Drawing is a complex skill that develops during childhood and requires the combination of motor, perceptual, and cognitive components (Laszlo & Broderick, 1985). Children have to learn to handle writing/drawing implements, and this is something that many of them find difficult (Connolly & Dagleish, 1989). Previous studies have shown that there is considerable variability in the manner in which children hold pens and pencils (see, for example, Blöte, Zielstra, & Zoetewey, 1987; Braswell, Rosengren, & Pierroutsakos, 2007; Connolly & Dagleish, 1989), and this affects the quality of their graphic production (Braswell et al., 2007; Martlew, 1992). As iPads allow for finger drawing, and are now making inroads into schools, it is worth testing whether their ease of use and immediacy actually improve the quality of drawings produced in an educational context. To that end, we adopted a within-participants design in which we compared drawings of a familiar object produced by elementary schoolchildren with pen on paper (standard condition) and fingertip on screen (iPad condition). Based on the hypothesis that finger drawing on an iPad screen enhances the quality of the resulting production because it bypasses the difficulties involved in handling a pen, we predicted that drawing quality would differ between conditions, with children scoring higher in the iPad condition than in the standard one.

**METHOD**

**Participants**

Forty-six children from kindergarten (5-6 years, \( n = 22 \), mean age = 5 years 7 months, \( SD = 4 \) months, 11 boys) and Grade 2 (7-8 years, \( n = 24 \), mean age = 7 years 6 months, \( SD = 4 \) months, 13 boys) took part in the study. These two different age groups were chosen because they contained children with different levels of drawing practice and formal learning of writing. All the children attended state elementary schools in France. None of them had been diagnosed with a learning disability or a special educational need. According to their teachers, the children had never used an iPad at school prior to the study.

**Materials**

The materials consisted of an Apple iPad Version 1, sheets of white paper, and a black felt-tip pen. The sheets of paper measured the same size as the iPad’s drawing surface (14.5 × 16 cm), and both were presented in a portrait format for the drawing task. The black felt-tip pen was chosen because it produced lines of approximately the same thickness (2 mm) as the electronic black felt-tip pen of the Drawing Pad app.
Procedure

We set up a drawing workshop in a corner of the children’s classroom, with an iPad placed flat on a large table next to a sheet of paper and a pen. Two chairs were put in front of the large table, so that the children could sit either in front of the iPad or in front of the standard drawing material. The children were invited one at a time to come to the drawing workshop and produce “the best drawing of a house you can,” using each medium in turn. A house was selected as the subject of the drawing because it is a very familiar one for children, and is sufficiently straightforward for children as young as 5 years to produce, using their well-established graphic routines (see Picard & Vinter, 2005). In the standard condition, children used their dominant hand to draw with the pen on the paper. In the iPad condition, they drew with the tip of the index finger of their dominant hand. The resulting drawings were saved in electronic files for subsequent analysis. It should be noted that the children were not allowed to use an eraser in either drawing condition. The order in which the house drawings were produced in the iPad and standard conditions was counterbalanced across participants in each age group. The iPad condition was preceded by a short familiarization phase, during which each child was shown how to draw lines (horizontal, vertical, and oblique) and simple geometric shapes (circle, square, triangle, cross) using his/her index finger on the touch screen. This phase, lasting no more than 2 minutes, allowed the children to feel comfortable using the iPad’s drawing app. In each condition, the children were given a maximum of 10 minutes to produce their drawing.

Coding

A total of 92 individual paper and electronic drawings were collected for analysis. The quality of these drawings was assessed on a standardized graphic scale yielding an overall graphic score (Barrouillet, Fayol, &Chevrot, 1994). This scale includes 21 items (see Table 1), each scored 1 point if it is present in the drawing, except for Item 21, which is scored 2 points. A maximum score of 22 points could thus be obtained on the scale. The coding of the drawings was performed by two judges working independently. Interjudge reliability was high (> 98%), and the handful of disagreements that arose (1.08%) were settled by discussion prior to the data analysis. Individual graphic scores on the house-drawing scale were used as the dependent variable.

RESULTS

For both drawing conditions, the data were checked for skewness (standard: $S = -.03$; iPad: $S = -.35$) and kurtosis (standard: $K = .05$; iPad: $K = .28$), which were both within the normal range, and Levene’s test was run, $F(1, 90) = .80, p = .37$, indicating the suitability of using an analysis of variance (ANOVA). A mixed
Table 1. Occurrence (Percentage) of Each Item of Barrouillet et al.’s Scale in Children’s House Drawings as a Function of Drawing Condition

<table>
<thead>
<tr>
<th>Item</th>
<th>Standard</th>
<th>iPad</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Outline (at least 3 rectilinear segments)</td>
<td>98</td>
<td>93</td>
</tr>
<tr>
<td>2- Roof (presence)</td>
<td>100</td>
<td>96</td>
</tr>
<tr>
<td>3- Roof shape * (triangular or trapezoidal)</td>
<td>100</td>
<td>87</td>
</tr>
<tr>
<td>4- Chimney (presence)</td>
<td>37</td>
<td>41</td>
</tr>
<tr>
<td>5- Vertical chimney (perpendicular to roof)</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>6- Door (presence)</td>
<td>93</td>
<td>89</td>
</tr>
<tr>
<td>7- Door handle * (presence)</td>
<td>87</td>
<td>70</td>
</tr>
<tr>
<td>8- Base (closed rectangular shape of outline)</td>
<td>52</td>
<td>61</td>
</tr>
<tr>
<td>9- Path (presence)</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>10- Window (presence of at least one window in the facade)</td>
<td>89</td>
<td>85</td>
</tr>
<tr>
<td>11- Two windows upstairs (the facade has two windows, one on the left, one of the right)</td>
<td>78</td>
<td>70</td>
</tr>
<tr>
<td>12- More than two windows (the facade has more than two windows)</td>
<td>24</td>
<td>20</td>
</tr>
<tr>
<td>13- Window position (none of the sides of the house constitutes one side of a window)</td>
<td>74</td>
<td>65</td>
</tr>
<tr>
<td>14- Window proportions * (height of window is between 1/4 and 1/6 of the height of the facade; idem for width)</td>
<td>78</td>
<td>57</td>
</tr>
<tr>
<td>15- Window alignment * (windows aligned on the same horizontal in the facade)</td>
<td>52</td>
<td>30</td>
</tr>
<tr>
<td>16- Panes (represented as crosses inside windows)</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>17- Shutters * (presence)</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>18- Curtains (presence)</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>19- Attic room (one or more windows drawn in the roof)</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>20- False perspective (two sides drawn, but incorrect perspective)</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>21- Perspective (two sides drawn, correct perspective)</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

QA: What is “idem”? *Items for which there was a significant change in the children’s productions between the standard and iPad drawing conditions (McNemar test).
ANOVA was run on the graphic scores, with drawing condition (2) as a within-participants variable, and sex (2), age group (2), and order (2) as between-participants variables. We set an alpha level of .05 for all statistical analyses.

The ANOVA revealed a significant main effect of drawing condition, $F(1, 38) = 14.35, p = .001, \eta^2_p = .27$, with higher scores in the standard drawing condition ($M = 11.04, SD = 2.49$) than in the iPad one ($M = 9.67, SD = 2.93$). There was no other significant main or interaction effect (all $p$s > .05). A closer look at the data indicated that, out of the 46 children, 27 (59%) scored higher in the standard condition, 14 (30%) achieved similar scores in both conditions, and just 5 (11%) scored higher in the iPad condition. It should be noted that, despite the lower scores in the iPad condition, the children’s graphic scores were generally within the normal range for their age in both conditions.

We decided to take a closer look at the data in order to determine which aspects of the drawings deteriorated when the children drew with their fingers on the iPad. To that end, we examined the occurrence of each item in each of the two drawing conditions (see Table 1), using McNemar tests to look for significant changes between the standard and iPad conditions. Significant changes were found for the following five items: Item 3 (roof shape), $\chi^2(1) = 4.17, p < .05$; Item 7 (door handle), $\chi^2(1) = 4.90, p < .05$; Item 14 (window proportions), $\chi^2(1) = 5.06, p < .05$; Item 15 (window alignment), $\chi^2(1) = 5.06, p < .05$; and Item 17 (shutters), $\chi^2(1) = 5.14, p < .05$. As can be seen in Table 1, all these items were produced less frequently in the iPad condition. The lower graphic scores in the iPad condition were thus due to deterioration in the shape of the roof, the proportions and spatial alignment of the windows, and to the loss of some accessory features (i.e., door handle, window shutters) (see illustration in Figure 1).

**DISCUSSION**

This study was designed to examine the ease of use and immediacy of iPads for drawing in an educational context. We were interested in testing whether iPads constitute a useful medium for drawing activities at elementary school, by virtue of the fact that they allow children to draw with their fingers, thus obviating the need to handle a pen. Contrary to our main hypothesis, we found a slight but significant decrease in graphic scores in the iPad (finger drawing) condition,
Figure 1. House drawings produced in the standard (left) and iPad (right) conditions by a 5-year-old girl. Loss of detail can be observed in the finger drawing (iPad condition).
compared with the standard (paper/pen drawing) condition. The finding that
drawings produced on iPads were inferior to those produced with paper/pen
contrasts with results from studies comparing children’s drawings produced with
tablet computers versus traditional media (e.g., Couse & Chen, 2010; Martin &
Ravenstein, 2006; Martin & Velay, 2012; Matthews & Jessel, 1993; Matthews &
Seow, 2007; Olsen, 1992; Trepanier-Street, Hong, & Bauer, 2001). These studies
either reported a positive impact of technology on drawing quality (Couse & Chen,
2010; Martin & Velay, 2012; Matthews & Seow, 2007; Olsen, 1992; Trepanier-
Street et al., 2001), or else a nonsignificant difference between drawing conditions
(Martin & Ravenstein, 2006; Matthews & Jessel, 1993). It is worth noting,
however, that the children in these studies were provided with a stylus to draw on
the computer, whereas in our study they had to draw with their fingertip on a tablet.

One explanation for the present findings is that despite motor equivalence
(similarity in stroke production across many contexts; see Bernstein, 1967;
Lashley, 1930), there are a number of fundamental differences between drawing
with a pen on a page and drawing with a fingertip on a flat screen, starting with
the muscles that subserve the actions. Whereas pen trajectory is mostly controlled
by distal joints and flexion/extension of the fingers, finger drawing may call for
the involvement of proximal joints (elbow, shoulder) in motor control. The shift
from distal to more proximal control of finger movements may have accounted
for the poorer graphic performance observed in finger drawing. Then again, the
participants in our study had not had any prior practice with iPads at school,
and were not given the opportunity to learn or improve, as they only produced
a single finger drawing on the iPad, and did not receive any feedback. It is,
therefore, possible that our negative findings partly stemmed from insufficient
training in the finger drawing technique.

Future research could focus on learning to draw with tablets in the classroom,
in order to test the effectiveness of iPads versus paper/pen in helping typically
developing children to learn to draw not just simple, but also more complex
objects. This approach could then be extended to children with disabilities or
special educational needs, such as those with Down syndrome. These children
often encounter difficulties in fine motor skills, and are particularly delayed
in their drawing ability (see, for example, Clements & Barrett, 1994; Cox &
Maynard, 1998; Laws & Lawrence, 2001; Tsao & Mellier, 2005). It would be
worthwhile assessing the usability of iPads and the finger drawing technique for
supporting learning to draw in this special population.

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