TABLET COMPUTER ASSISTED COUNTING AND CALCULATING ACTIVITIES FOR KINDERGARTEN CHILDREN

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Abstract

The aim of this study is to explore the impact on kindergarten children’s mathematical competence after the implementation of a software application for counting and calculating with tablet computers. The application consisted of some counting and calculation activities, designed following the background of realistic mathematics education and more specifically that of the learning teaching trajectory for the domain of counting and calculation. Four kindergarten schools of Heraklion participated in the study, which was conducted during spring 2017. The research followed the pre-test and post-test model, using the Early Numeracy Test (ENT), an instrument measuring the early mathematical competence. The test comprises of questions for the concepts of comparison, classification, correspondence, seriation, using counting words, structured counting, resultative counting, and general knowledge of numbers. The results of the study support a positive correlation between children’s early numeracy competence and the integration of tablet computers in teaching and learning numbers.

Keywords: Counting, calculations, numbers, tablet computer, kindergarten.

1 INTRODUCTION

The integration of ICT into primary education has become a high priority for everybody involved in the learning process [1], [2], [3]. A growing body of literature provides increasing evidence of the effectiveness of using computer technologies to facilitate instruction and learning across a variety of school subjects [4], [5], [6], [7], [8]. Particularly, studies have demonstrated that computers have supported the development of the abilities in children's memory, problem-solving, literacy and math [9], [10], [11], [12], [13], [14], [15], [16]. These technologies can therefore play an essential role in achieving the objectives of the first grade curriculum in all sectors and subjects if supported by developmentally appropriate software applications [17], [18], [19], [20] embedded in appropriate educational scenarios [21], [22], [23]. Many early-year practitioners and researchers state that the interactive environment created in a kindergarten by using tablets is stronger in maintaining children's interest towards digital activities, and encourages them to become more closely and effectively involved in digital mathematical activities [24], [25].

Advances in digital technologies and technological gadgets are dramatically altering the tools available to teachers and students, even in preschool education [26]. Although iPads and other similar tablets have not been extensively studied as teaching tools in the early childhood classroom, many educators are enthusiastic about using them; they rave about their versatility, connectivity, mobility, as well as the potential benefits of thousands of educational apps [27], [28]. Usability studies with tablets find that preschool children learn to use the devices quickly, independently, and confidently and explore freely [29]. Also, tablets have three novel features [30] with the potential to make a positive difference in early education: iPads are portable and light-weight, they eliminate the need for separate input devices (such as mouse and keyboard) and they are specifically designed to accommodate a number of apps, many of which have a child friendly intuitive design. Concerning the pedagogical use of tablets in early childhood education, recent studies have concluded that tablets may have the potential to act as a valuable tool for educational use, especially in learning mathematical concepts [31], [32], [33]. The regular use of tablets brings about significant learning gains to young children in areas such as arithmetic, recognition of numbers and formation of digits [34].

Various researches’ results relate the appropriate use of computers with the ability of students to more efficiently understand the different mathematical notions [36], [37], [38]. Also, a vast number of studies show a positive interrelation between the use of computers and the development of mathematical thinking in school [5], [39]. Nonetheless, computer based activities should reflect the theoretical ideas behind them [40], [41], [2].
Following the theoretical framework that blends together kindergarten curriculum in Mathematics and the use of ICT at the kindergarten level, we designed a new model referred to as the Kindergarten Counting Calculating Model (KCCM) which consisted of four levels. The majority of previous studies examined the effects of various teaching methods for mathematics. However, a small number of studies have found in the kindergarten levels of counting and calculating using tablet computers.

Our study was based on the above mentioned international literature; we set out to investigate the following research question:

- The kindergarten students who will be taught mathematical concepts with educational intervention based on KCCM will have a significant improvement of general mathematical thinking in comparison to those taught using the traditional teaching method.
- The kindergarten students who will be taught mathematical concepts with educational intervention based on KCCM will have a significant improvement of counting in comparison to those taught using the traditional teaching method.
- The kindergarten students who will be taught mathematical concepts with educational intervention based on KCCM will have a significant improvement of calculation in comparison to those taught using the traditional teaching method.

2 METHODOLOGY

The present pilot research was conducted in three phases. In the first and third phases, the pre-test and post-test were given to the students respectively. In the second phase, the teaching intervention was performed. The study was carried out during the 2016-17 school year in four public kindergarten schools located in the city of Rethymno on the island of Crete (Greece). It was an experimental research which compared the tablet computer teaching process to traditional teaching based on the kindergarten grade curriculum. The sample included 118 kindergarteners consisting of 55 girls and 63 boys aged four to six years old. There were two groups in the study, one control (n=51) and one experimental (n=67). In the control group there was not a computer available for the students to use. The classes in the experimental group had tablet computers available for daily use by children as part of the teaching procedure. For the uniformity of the survey, instructions were given to the teachers who taught in the experimental or control groups.

2.1 First Phase

In the first phase, the pre-test was given to the classes of the experimental and control groups during the beginning of February 2017 to isolate the effects of the treatment by looking for inherent inequities in the mathematical achievement potential of the two groups. The pre-test was the Early Numeracy Test (ENT) [42].

ENT is based on a developmental view of children’s early numeracy, particularly as defined by Ginsburg and Baroody [42]. It focuses on several aspects of numerical and non-numerical knowledge. The ENT is valid for children in pre-school and early elementary school (ages 4 to 8). The ENT is an individually administered tool that takes about 30 minutes per child. The content domains are the following: 1) Quantity, 2) Comparison, 3) Classification, 4) One-to-One Correspondence, 5) Seriation, 6) Number Words, 7) Counting, and 8) Understanding of Calculating Numbers (Fig. 1, 2). There are a total of 40 items. The first 20 items are based on the logical principles underlying children’s understanding of quantities and relations. The last 20 items focus more explicitly on the use and understanding of whole numbers. Also, one of the purposes for developing the ENT was to provide researchers with a statistical test that was based on current research and theories about mathematical thinking. In particular, ENT’s availability would stimulate the study of mathematical thinking in young children [39].
Due to the young age of the children, the test was given to them individually like an interview. Each task had a grade that was computed from the students’ answers. Scores were computed for each of the individual mathematical tasks of the ENT.

2.2 Second Phase

In the second phase, the control group taught with traditional teaching according to the kindergarten curriculum. Group and individual activities were given to children every day. The experimental group covered the same material at roughly the same time according to the KCCM procedure. The content of the four week syllabus of the KCCM was divided into four levels. All software activities were designed using Flash CS6 Professional Edition and App Inventor application and were presented with tablet computers in the classroom.

The first level started with an activity which a child randomly picks up a number from the floor and starts to count upwards or downwards by pointing to the correct number (Fig. 3a). Also, in another activity the child picks up a number randomly and shows the cardinality of the number with his or her fingers. Finally, a computer activity took place with questions that are solved by counting objects (Fig. 3b).

The second level of the teaching procedure the children are given balls of three different colours and they are asked to separate the balls by colour and count the number of balls in each group. Then we took away a number of balls (e.g. one yellow, two greens etc.) and asked the children to count them and indicate which group has the most or least. Moreover, the kindergarten teacher asks the children to write down the number of balls in each group. The final part of this level involved a tablet based group activity in which the students had to count the players of each team and to identify the team with the most players (Fig. 5).
Figure 3. The child has to count upwards (a), and count the number of balls (b) (1st level).

Figure 4. The child has to count the balls in each group and write it down (2nd level).

Figure 5. The child has to count the basketball players of each team (2nd level).

In the third level of the teaching procedure the kindergarten teacher gives medals to children. Then another child joins the group wearing a metal. The children have to construct the calculation problem with printed cards on the floor (Fig. 6). Finally, a software activity followed with calculation problems (Fig. 7).

Figure 6. The child has to solve the mathematical problem using numbers (2nd level).
In the last level of the teaching process, we do not initially use visual material. The kindergarten teacher orally presents a mathematical problem such as the following (Fig. 8a). There are five players in a basketball team and two of the players were injured. How many players are able to continue playing? Afterwards, there were computer activities where the children had to solve an addition problem without counting objects (Fig. 8b).

2.3 Third Phase

Similarly, during the third and final phase of the study, after the teaching intervention, the same test (ENT) was given to all students in both the experimental and control groups as a post-test at the beginning of April 2017 to measure their improvement on general mathematical ability, counting and calculation.

3 RESULTS

Analysis of the data was carried out using the SPSS (ver. 19) statistical analysis computer program. An independent sample t-test was conducted. The independent variable had two levels: exposure to educational software (experimental group) and no exposure (control group).

The dependent variable was the student's pre-test score for the total mathematical achievement. Levene’s Test for equality of variances was not significant ($F = 0.111, p = 0.739$). The t-test for equality of means was not significant ($t = -0.576, p = 0.565$), indicating no significant differences initially, in the total score of mathematical achievement between the experimental and control groups. Though the control group had a mean score higher than the experimental group, the mean difference in the pre-test scores was -0.807. The results of this test are summarized in Table 1 and Table 2.

In order to determine if the performance of the experimental group for the total mathematical achievement is significant than the control group after the teaching intervention an independent sample t-test was conducted between the post-test values. The independent variable had the same two levels as in the previous test: experimental and control. The dependent variable was the student's
post-test score. Levene's Test for equality of variances was significant (F 4.602, p = 0.034). The t-test for equality of means was significant (t = 9.889, p = 0.001) indicating significant differences in scores between the experimental and control groups, as summarized in Table 3 and Table 4.

Table 1. Group Statistics of the total pre test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>67</td>
<td>16.45</td>
<td>7.743</td>
<td>.946</td>
</tr>
<tr>
<td>Control</td>
<td>51</td>
<td>17.25</td>
<td>7.372</td>
<td>1.032</td>
</tr>
</tbody>
</table>

Table 2. Independent Samples Test of the total pre test.

<table>
<thead>
<tr>
<th>Pre-test</th>
<th>t</th>
<th>df</th>
<th>Mean difference</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-test</td>
<td>-.576</td>
<td>110.300</td>
<td>-0.807</td>
<td>0.565</td>
</tr>
</tbody>
</table>

Table 3. Group Statistics for the total post-test scores.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>67</td>
<td>30.25</td>
<td>7.768</td>
<td>.949</td>
</tr>
<tr>
<td>Control</td>
<td>51</td>
<td>17.04</td>
<td>6.350</td>
<td>.889</td>
</tr>
</tbody>
</table>

Table 4. Independent Samples Test of the total post-test scores.

<table>
<thead>
<tr>
<th>Pre-test</th>
<th>t</th>
<th>df</th>
<th>Mean difference</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-test</td>
<td>9.889</td>
<td>116</td>
<td>13.215</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Similarly, to determine if the performance of experimental group started from the same level as the control group in counting, we conducted an independent sample t-test between the pre-test of the two groups. The dependent variable was the student's pre-test score for counting. Levene's Test for equality of variances was not significant (F = 0.020, p = 0.889). The t-test for equality of means was not significant (t = -0.291, p = 0.772), indicating no significant differences initially, in mathematical achievement for counting between the experimental and control groups. Though the control group had a mean score higher than the experimental group, the mean difference in the pre-test scores was -0.124. The results of this test are summarized in Table 5 and Table 6.

Also, to determine if the performance of control group acted significant than the experimental group in counting, we conducted an independent sample t-test between the post-test of the two groups. Levene's Test for equality of variances was significant (F = 10.369, p = 0.002). The t-test for equality of means was significant (t = 7.002, p = 0.001), indicating significant differences in mathematical achievement for counting between the experimental and control groups. Though the experimental group had a mean score higher than the control group, the mean difference in the test scores was 3.365. The results of this test are summarized in Table 7 and Table 8.

Table 5. Group Statistics of pre-test for counting.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>67</td>
<td>2.209</td>
<td>2.390</td>
<td>.292</td>
</tr>
<tr>
<td>Control</td>
<td>51</td>
<td>2.333</td>
<td>2.233</td>
<td>.312</td>
</tr>
</tbody>
</table>

Table 6. Independent Samples Test of pre-test for counting.

<table>
<thead>
<tr>
<th>Pre-test</th>
<th>t</th>
<th>df</th>
<th>Mean Squares</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-test</td>
<td>-0.291</td>
<td>111,179</td>
<td>-0.124</td>
<td>0.772</td>
</tr>
</tbody>
</table>
Table 7. Group Statistics of post-test for counting.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>67</td>
<td>5.835</td>
<td>2.957</td>
<td>.361</td>
</tr>
<tr>
<td>Control</td>
<td>51</td>
<td>2.470</td>
<td>1.993</td>
<td>.279</td>
</tr>
</tbody>
</table>

Table 8. Independent Samples Test of post-test for counting.

<table>
<thead>
<tr>
<th>Post-test</th>
<th>t</th>
<th>df</th>
<th>Mean Squares</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-test</td>
<td>7.002</td>
<td>116</td>
<td>3.365</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Similarly, to determine if the performance of experimental group started from the same level as the control group in calculating, we conducted an independent sample t-test between the pre-test of the two groups. The dependent variable was the student's pre-test score for calculating. Levene's Test for equality of variances was not significant (F = 1.314, p = 0.254). The t-test for equality of means was not significant (t = -1.324, p = 0.188), indicating no significant differences initially, in mathematical achievement for calculating between the experimental and control groups. Though the experimental group had a mean score higher than the control group, the mean difference in the pre-test scores was -0.325. The results of this test are summarized in Table 5 and Table 6.

Also, to determine if the performance of control group acted significant than the experimental group in calculating, we conducted an independent sample t-test between the post-test of the two groups. Levene's Test for equality of variances was not significant (F = 1.486, p = .225). The t-test for equality of means was significant (t = 7.180, p = 0.001), indicating significant differences, in mathematical achievement for calculating between the experimental and control groups. Though the experimental group had a mean score higher than the control group, the mean difference in the test scores was 1.711. The results of this test are summarized in Table 7 and Table 8.

Results of this study expand the research on the effects of the appropriate software embedded in tablet computers as a tool for mathematical reasoning used alongside with specially designed non-computer activities [8], [3], [23], [33], [16], [28], [15], [29], [35], [37]. Also, the outcomes of the present study helped create a new teaching model using tablet computers and non-computer activities.

Table 9. Group Statistics of pre-test for calculating.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>67</td>
<td>1.60</td>
<td>1.360</td>
<td>.166</td>
</tr>
<tr>
<td>Control</td>
<td>51</td>
<td>1.92</td>
<td>1.262</td>
<td>.177</td>
</tr>
</tbody>
</table>

Table 10. Independent Samples Test of pre-test for calculating.

<table>
<thead>
<tr>
<th>Pre-test</th>
<th>t</th>
<th>df</th>
<th>Mean Squares</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-test</td>
<td>-1.324</td>
<td>116</td>
<td>-0.325</td>
<td>.188</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>67</td>
<td>3.67</td>
<td>1.342</td>
<td>.164</td>
</tr>
<tr>
<td>Control</td>
<td>51</td>
<td>1.96</td>
<td>1.199</td>
<td>.168</td>
</tr>
</tbody>
</table>

Table 12. Independent Samples Test of post-test for calculating.

<table>
<thead>
<tr>
<th>Post-test</th>
<th>t</th>
<th>df</th>
<th>Mean Squares</th>
<th>Sig. (2-tailed)</th>
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<tbody>
<tr>
<td>t-test</td>
<td>7.291</td>
<td>112.965</td>
<td>1.711</td>
<td>0.001</td>
</tr>
</tbody>
</table>
4 CONCLUSIONS

The general purpose of the study was to investigate the impact of instructional intervention using the Kindergarten Counting Calculating Model (KCCM) for the purpose of teaching the mathematical concept of counting and calculating in regards to the mathematical competence of the kindergarten level. In this research, we found that the students who were taught with educational intervention based on KCCM had a significant improvement on their general mathematical achievement in comparison to those taught using the traditional teaching method according to the kindergarten curriculum. Our findings agree with similar researches [12], [38] which implied that ICT helps students to understand mathematical notions more effectively. As a result, the first research question answered positively.

Moreover, we found that the students that taught with the educational intervention based on KCCM had a significant improvement on counting comparing to those taught using the traditional teaching method according to the kindergarten curriculum. Our results overlap with the results of other analogous studies which indicate the positive effects of a computer based-model of teaching math [8], [41], [16], [23], [2]. Therefore, the second research question was confirmed.

In addition, we found that the students that taught with the educational intervention based on KCCM had a significant improvement in calculating comparing to those taught using the traditional teaching method. These results are in agreement with the results of other studies which indicate the positive effects of a computer based-model of teaching math [5], [21], [22], [41], [33]. Therefore, the third research question was confirmed.

The above discussion should be referenced in light of some of the limitations of this study. The first limitation of the study is that the data collected was from the participants residing the city of Rethymno. The second limitation of the study is that the data collected was from a very small sample, because this research was designed as a pilot research. However, as the study was of small scale and context specific, any application of the findings should be done with caution.

Considering the above limitations of this work, the undertaken computer assisted educational procedure based on tablets, which is an ongoing challenge for the reflective teacher to decide how this technology, can be best utilized in kindergarten level.

ACKNOWLEDGEMENTS

This work was supported by the Research Committee of University of Crete (ELKE) http://www.elke.uoc.gr/

REFERENCES


