DIGITAL LIFE, MATHEMATICAL SKILLS AND COGNITIVE PROCESSES

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ABSTRACT

A consistent part of the literature shows the significant role of digital experience in digital natives' cognitive processes. The main goal of the current study was to investigate the impact of digital learning on the improvement of mathematical skills and on some change in cognitive processes in 166 primary school children from schools located in different parts of Italy. Participants were divided in two group: one group experienced the study of math mainly through digital tools, the other spent more time on pencil-and-paper trainings. All our participants were assessed with a battery of tests measuring numerical and cognitive abilities. Our results suggest the positive effect of a different type of training for the empowerment of visuo-spatial and numerical abilities. Specifically, effects of a digital experience are particularly evident in some specific numerical areas, such us accuracy, speed, semantic and syntactic numerical knowledge. Also, participants with greater experience of digital trainings score higher on spatial orientation.

KEYWORDS

Digital Learning, Mathematics, Educational Technology, School, Cognitive Processes

1. INTRODUCTION

Cognitive flexibility, problem solving, speed of processing, spatial orientation and visuo-spatial abilities are abilities that have an impact on maths proficiency. Therefore, these are also crucial factors to succeed in nowadays'society (Moffitt, et al., 2011). In Italy, where this study has been carried on, OCSE data show that high-proficiency math students are the 9.9% of the students' population compared to the 12.6% of the European sample (PISA – OCSE, 2012). What these data tell us about? We think they show how much Italy falls behind other EU countries in terms of digital education in school contexts. Indeed, we rank 25 out of 28 in terms of connectivity and human capital (PNSD, Ministero dell'Istruzione e della Ricerca, 2015). However, ICT is a fact we cannot neglect nowadays; it becomes extremely important for Italy to regain positions in the digital world scenario and to strengthen research in the field of digital learning and education. It is within these boundaries that this study takes place. Our starting point in this work is the assumption that computer-based interventions can contribute to increase math skills (Agus, Mascia, Fastame, Melis, Pilloni and Penna, 2015; Mascia, Agus, Fastame & Addis, 2016). Indeed, ICT allows teachers to make up learning materials that are more familiar to children than the old-fashioned paper and pencil. A crucial example comes from the study of Zhang et al., where two-year old toddlers were able to use iPads with little direction from adults (Zhang, Trussel, Gallegos, Asam, 2015). Another plus of digital education is that digital devices offer personalized learning strategies (token economy, chunking, scaffolding) for children with special needs, and they guarantee an easy way to manage and analyze data coming from the interventions that are put into practice (Wayman, 2005; Papadakis, Kalogiannakis & Zaranis, 2016). Thus, because of the wide presence of digital tools in our life, and their potential implications on learning, we consider of extreme importance a further and deepen investigation of the phenomenon, focusing on the digital tools that allow the best user experience. For example, the opportunity to give immediate feedback to individual learners, especially if they have learning disabilities, seems to be the only way this population can improve their math performances. Also, the individual usage allows learners to work on math problems at their own pace, which can be

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particularly useful for struggling students who need more time to solve a problem (Baker, Gersten, & Lee, 2002; Hassler, B., Major, L., Hennessy, S.2015). Unfortunately, the actualization of these practices is barely feasible in Italy today, where the percentage of digital devices per student is one out of eight (PNSD, Miur, 2015).

2. METHOD

One of the main concerns about digital education is that it can impact negatively on cognitive variables that are crucial for the child's development and learning (Li & Ma, 2010; Livingstone, 2011; Highfield & Goodwin, 2013). However, studies comparing digital and analogical education do not display a similar outcome (Falloon, 2013; Berge & Muilenburg, 2013). Hence, persuaded that personalization of the educational could decrease anxiety while learning and could offer many advantages to school curricula, we conducted our research in primary school – where the basic and essential skills are tackled – and we tested our sample on two different cognitive measures: visuo-spatial abilities and spatial relations. Furthermore, numerical skills have been measured to analyze the learning outcomes of the intervention. The results fall within a wider research about the use of digital tools in learning founded by Acer for Education and led by CNIS and Impara Digitale.

3. PARTICIPANTS, MATERIALS AND PROCEDURE

One hundred and sixty six 8-year-old children took part into this research study. All of them have been recruited through previous contact with primary schools all over Italy. Therefore, the sample is equally distributed over the whole Nation. Participants were for the 47.9% female. Participation to the research was voluntary and no economic compensation has been offered to families or schools. Sampling was random and non-probabilistic. However, before the participation to the study, each family had to fill in a consent form where the nature of the research and data treatment was explained. Standardized tests have been administered to children to measure numeracy skills, visuo-spatial abilities, and fluid intelligence. Interviews to the teachers allowed us to divide the sample in "digitalized children", namely those who learned mathematics mainly through apps, softwares and digital tools, and "non-digitalized children", those who mainly had an analogical approach to the subject. The participants were divided into two experimental groups that followed two type of trainings, in computerised and pencil-and-paper formats, for 12 weekly sessions. In order to assess respectively abilities, at pre and post-test, our participants compiled a battery of standardised tests: to measure numeracy skills, we administered the ACMT 6-11 battery of tests (Cornoldi, Lucangeli, & Bellina, 2012), for visuo-spatial abilities we used Thurstone's PMA test (Thurstone & Thurstone, 1962) and for fluid intelligence Ravens' Coloured Progressive Matrices (cfr. Ed. It. Belacchi, Scalisi, Cannoni, et al., 2008; Brouwers, Van de Vijer & Van Hemert, 2009).

4. FINDINGS

The mean and standard deviations for AC-MT (Written calculation, Accuracy, Speed, Semantic and Syntactic numerical knowledge), PMA and CPM scales were examined. A Manova and a correlation analysis have been applied. Our results show that students with a greater experience in digitalized version of mathematical trainings have better results in some of the mentioned mathematical areas. The multivariate tests were significant for the covariates (Wilks' lambda [6, 159] = .897, p=.000). Then univariate tests indicated a significant effect of 'greater experience in digital trainings' in terms of Accuracy ($F(1, 164) = 10.453$, $MSE = 455{,}949$ $p=.011$, partial $\eta p2= .060$), Speed ($F(1, 164) = 13.626$, $MSE = 43926{,}343$ $p = .000$, partial $\eta p2= .070$), Semantic and Syntactic numerical knowledge ($F(1, 164) = 11.433$, $MSE = 106{,}98$ $p = .001$, partial $\eta p2= .065$) and spatial orientation ($F(1, 164) = 6.587$, $MSE = 113.339$ $p = .011$, partial $\eta p2= .032$).

The correlation study (Table 1) confirms the relationship between the cognitive variables analyzed in this study and mathematical abilities.

Table 1. Correlation analysis

			1	2	3	4	5	
Spatial orientation	r	1	1					
	Sig. (2-tailed)							
Written operations	r	2	,189*	1				
	Sig. (2-tailed)		,011					
Numerical Knowledge	r	3	,130	,377**	1			
	Sig. (2-tailed)		,090	,000				
Accuracy	r	4	-,203**	-,483**	-,552**	1		
	Sig. (2-tailed)		,007	,000	,000			
Speed	r	5	-,132	-,488**	-,486**	,720**	1	
	Sig. (2-tailed)		,084	,000	,000	,000		
Fluid intelligence	r	6	,403**	,200**	,378**	-,379**	-,289**	1
	Sig. (2-tailed)		,000	,008	,000	,000	,000	

5. CONCLUSION

We can now conclude that the use of digital tools in learning numerical and mathematical skills has had a positive impact on primary school children in their third year of study. First, the use of the digital version of mathematical trainings is more effective than the paper-and-pencil mathematical in some specific areas, in particular, in terms of interaction and in terms of spatial orientation.

Therefore, we can conclude that our findings are consistent with those by previous researches (Brouwers, Van de Vijer & Van Hemert, 2009; Burns, Kanive, De Grande, 2012; Zaranis, Kalogiannakis & Papadakis, 2013) and that the use of digital intervention supports the development of numerical knowledge in children (Pitchford, 2015), especially when it comes to improve some specific cognitive processes, such as the spatial orientation. In our sample, no differences were found in fluid intelligence. To conclude, we think that a tailored and personalized digital education has a crucial role in the effectiveness of learning.

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