The Distributional Effects of the 'Digital School' Project

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Abstract

In the last decade, one laptop per child projects were implemented in many countries. Such projects are usually intended to improve quality of instruction (although specific goals may differ between projects). Logically, follow-up investigations should determine how pupil competencies were influenced, as measured by standardized testing. This paper presents such an investigation, conducted within the ex-post evaluation study of the 'Digital School' project implemented in Poland in academic year 2012/2013. A unique trait of this study as compared with other similar work is the rare conjunction of three features. Firstly, use of a randomized project design to construct a valid control group, secondly, focus on the impact of the 'Digital School' on test score distribution, beyond the usual comparison of means and thirdly, using final exam results from two years, 2013 and 2014, allowing inquiry on how the effects of the intervention change over time. Owing to these aspects of the study design, conclusions could be drawn about likely benefits to some low-scoring pupils, although effects seemed to be short term.

1. Introduction

In recent years the impact of information and communications technology (ICT) on student achievement has drawn much attention from researchers. A synthesis of meta-analyses published in 2011 [1] summarizes findings from over one thousand studies in this field and suggests that computer technologies have on average positive effects. There is also some evidence that ICT may have a more positive impact on low and middle ability students than on high ability students [2]. Nonetheless, some meta-analyses, e.g. [3], reported an effect size not significantly different from zero. Moreover, some analyses of Programme for International Student Assessment (PISA) results suggest that intensive ICT use at school is negatively correlated with student outcomes or an inverted U-shaped relationship between these two factors [4]-[7].

Despite this warning evidence, it is a common belief among policy makers that more intensive use of ICT for educational purposes may help equip learners with the ICT skills required by the labor market, reduce the digital divide and improve quality of instruction [8], [9]. As a result, in the last decade 1:1 initiatives (also called one laptop per child projects), providing every student and teacher with a portable computer and Internet access, were launched in many countries all over the world [9], [10].

Some 1:1 projects were followed by investigation of their impact on student achievement. In an early synthesis, Penuel stated that some studies reported positive effects on technology literacy and writing skills, but evidence of effects on the latter is less strong, since no studies used a pre-test/post-test design [11]. In some recent research, adopting a more advanced quasi-experimental or experimental approach, no impact was observed in 1:1 projects on test scores in math and language [12], [13]. Moreover, recent studies on initiatives providing students with home computers revealed no significant effects [14], [15] or an adverse impact on school grades [16].

This work is intended to deliver more evidence on the impact of 1:1 projects on student outcomes, focusing on the 'Digital School' project implemented in Poland.

2. The 'Digital School' project

The 'Digital School' was a Polish government pilot study involving 399 primary schools, conducted in academic year 2012/2013. It might be regarded as a 1:1 project, but it was designed as a comprehensive public intervention. Schools were financed for the purchase of ICT equipment, including laptops or tablets for teachers and pupils, interactive whiteboards, visualizers, routers and other devices. Teachers were intended to use the equipment provided for teaching all (or almost all) subjects. Teacher training was provided in the framework of interschool networks for co-operation between teachers. The project also included development of educational e-resources, such as e-textbooks, a research component and an evaluation study.

More than 3,500 schools applied to join the project. The schools which finally participated in the project were selected on a random basis.
The theory behind the public intervention was that ICT helps create more interesting classes for pupils and is a useful tool for teaching and learning, which can be used to introduce more individualization, group work and student engagement techniques. Generally, ICT was perceived as a means to improve the quality of education. For this reason, results, as clearly emerges from project indicators, were also expected in improved basic student skills in reading, writing, mathematics, social and creative competences. Given such logic for the intervention, it is plausible to interpret student exam scores to measure project effectiveness.
The Educational Research Institute was responsible for an evaluation of the project. The evaluation study was co-financed by the European Social Fund and involved both questionnaire survey administered to all schools participating in the 'Digital School' and extensive desk research. In this paper, the focus is exclusively to discover if and how participation in the 'Digital School' influenced final exam results.

3. Data and methodology

3.1 The data set

Databases containing exam results for individual pupils were used. The exam was an external and compulsory exam taken by all pupils at the end of primary school, in the 6th grade. The results of three exams were included: in April 2012 (from before the project began), in April 2013 (3 to 5 months after the ICT equipment was delivered), and in April 2014 (15 to 17 months after the delivery). The 2012 exam served as pre-test and the other two exams served as post-tests. It is necessary to notice that the three exams were not taken by the same pupils, but rather by sixth graders in that particular academic year.
The exam is divided into five parts: reading, using information sources, writing, reasoning and applying knowledge. Each section was analyzed separately. The question of reliability and validity of the final exam as a psychometric test lies beyond the scope of this paper.
The analyses presented in this paper were conducted on raw scores. Further analyses of IRT-scaled scores are omitted for the sake of clarity.

3.2 Construction of the control group

As previously mentioned, selection to the project was random, which is a particularly fortunate condition for project evaluation, because random selection does not generate selection bias. Without selection bias, the difference in outcome between participants and unsuccessful applicants may be regarded as an unbiased estimator of the true impact of the project on the participants ([17], [18], [19]). The real conditions for assessing the impact of the 'Digital School' project were, however, more complicated. There was an array of factors threatening the validity of conclusions drawn from analyses which called for adjustments in the evaluation design (not described here for lack of space). Some schools were excluded from the analysis and the population of pupils from remaining schools was weighted, so as to construct a valid control group and assure the internal and external validity of the study.
The final number of schools and pupils that were included in the analysis is shown in Table 1. Due to the problems described above, 7-11% of participating schools were left out of the analysis.

Table 1. Size of the treatment and control group

	Schools			Pupils		
Year	2012	2013	2014	2012	2013	2014
Treatment	368	357	367	13492	12731	12985
Control	2858	2746	2832	111084	104406	107223

3.3 Significance tests

Monte Carlo permutation tests were used to determine significance of the observed differences between the treatment and control group (i.e., whether the conclusion that the project intervention affected the score distribution could be legitimately drawn or the differences could be purely chance). They were based on 10,000 repetitions of the same simulation. The first step in the simulation procedure was random assignment of a 'pseudo-participating' label to 399 applying and eligible schools. The actual project rules for school selection were followed to construct 'pseudo-treatment' and 'pseudo-control' groups. For each simulation and each exam section, the maximum distance (in terms of absolute values) between the 'pseudo-treatment' and 'pseudo-control' cumulative distribution of exam scores was calculated. After 10,000 repetitions a set of 10,000 simulated maximum distances was produced. The test statistic was the absolute value for the maximum distance between the exam score cumulative distribution in the actual treatment group and the actual control group. The difference between the two distributions was regarded as significant at the 0.05 level if the test statistic had a value higher than 95% of the simulated maximum distances.

4. Results

The analysis presented in this paper regarded the comparison of cumulative exam score distributions between the treatment and control group. What is sought here is impact of the project on the score distribution rather than on particular pupils (a subtle and tricky, yet important distinction [18]). The cumulative distributions for the 'reading' exam section are plotted in Fig. 1. As for the 2012 exam, the line representing the treatment group is almost indistinguishable from that representing control. This visual evidence is confirmed by the Monte Carlo permutation test which did not detect significant differences between the two groups. This confirms that the control group was well constructed and a good match for the treatment group. The two lines also overlap completely in the 2013 and 2014 exam plots. Again, statistical tests show no significant differences. It allows the conclusion that the exam results were unaffected by the 'Digital School' project.

The same pattern holds for the 'using information sources' and 'writing' sections – no effects were observed. The results for the 'applying knowledge' section are similar, even if the lines seem to diverge further at some points. For 'reasoning', the cumulative distributions for the treatment and control group are the same for the 2012 and 2014 exams, but diverge for the 2013 exam, since in the treatment group there were fewer pupils who scored less than 4 points (Fig. 1). The maximum distance between the cumulative distributions occurred at the score of 2 points and amounts to 0.02 (0.28 vs. 0.26). Visually, the difference appears to be very small, but the statistical test indicate that the p-value is 0.05, which corresponds to the threshold of statistical significance. The Monte Carlo permutation test relies on random procedures and a closer examination showed that the calculated p-value randomly falls slightly below or slightly above the threshold. This puts into question the statistical significance of the difference, but still the low p-value suggests that the project helped some pupils who in the absence of treatments would have obtained low scores (i.e. scores in the lowest quartile) in 'reasoning'. The effect was no longer noted in the 2014 exam results, so it was weak and ephemeral.

5. Conclusions

Only one likely effect of the 'Digital School' project was discovered – the results suggest that some pupils obtained better scores in the 2013 'reasoning' section of the exam owing to the intervention. This section contains mathematical and logic tasks, so technology use might have improved skills in this area. The effect was weak and only benefitted some low-scoring pupils.

The effect was only visible in the 2013 exam results (3 to 5 months after the ICT equipment was delivered) and no more in 2014. Perhaps we deal with a novelty effect, that is to say, ICT equipment made classes more attractive to pupils (as confirmed by the questionnaire survey) because it was something new and unusual, but this effect vanished once they became more familiar with the new technology. The hypothesis that ICT integration acted through increased interest and involvement of pupils may explain why the observed distributional effects were ephemeral and restricted to low-scoring pupils.

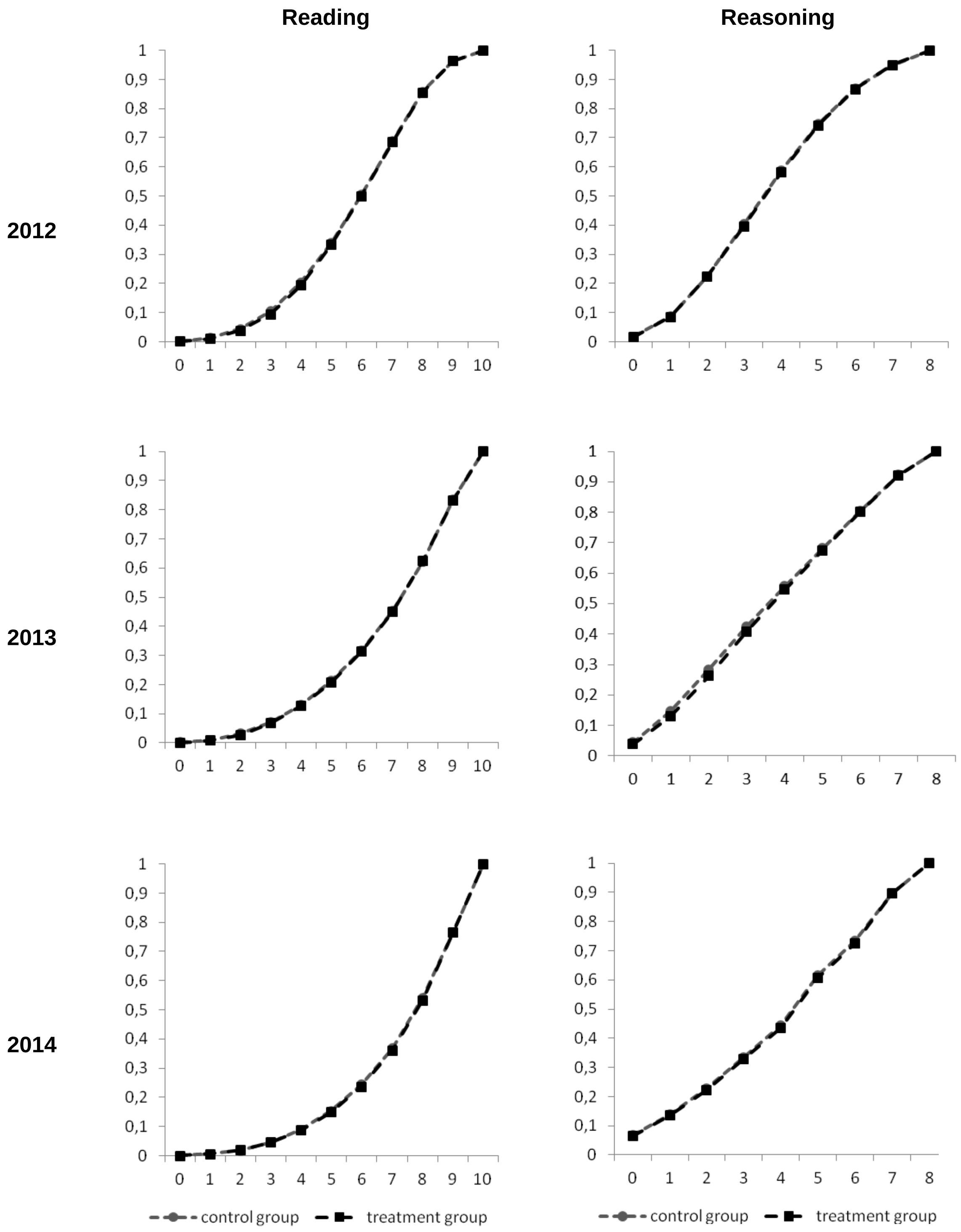

Fig. 1. Cumulative exam score distributions

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