Computers & Education 96 (2016) 1–14

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

The impact of integrating ICT with teaching: Evidence from a randomized controlled trial in rural schools in China

Yu Bai [a, b], Di Mo [c, d, *], Linxiu Zhang [a], Matthew Boswell [c], Scott Rozelle [c]

[a] Center for Chinese Agricultural Policy, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, No. 11-A Datun Road, Chaoyang District, Beijing 100101, PR China
[b] University of Chinese Academy of Sciences, PR China
[c] Stanford University, USA
[d] University of Leuven, Belgium

ARTICLE INFO

Article history:
Received 1 August 2015
Received in revised form 26 January 2016
Accepted 11 February 2016
Available online 13 February 2016

Keywords:
ICT in education
Computer assisted learning
Computer assisted instruction
English learning
Randomized controlled trial

ABSTRACT

Recent attention has been placed on whether integrating Information Communication Technology (hereafter, ICT) into education can effectively improve learning outcomes. However, the empirical evidence of the impact of programmes that adopt ICT in schooling is mixed. Theory suggests it may be due to differences in whether or not the ICT programmes are integrated into a teaching programme of a class. Unfortunately, few empirical studies compare the relative effectiveness of programmes that integrate ICT into teaching with the ones that do not. In order to understand the most effective way to design new programmes that attempt to utilize ICT to improve English learning, we conducted a clustered randomized controlled trial (RCT) with some schools receiving ICT that was integrated into the teaching programme of the class; with some schools that received ICT without having it integrated into the teaching programme; and with other schools being used as controls. The RCT involved 6304 fifth grade students studying English in 127 rural schools in rural China. Our results indicate that when the programme is integrated into the teaching programme of a class it is effective in improving student test scores relative to the control schools. No programme impact, however, is found when the ICT programme is not integrated into the teaching program. We also find that when ICT programmes are integrated into teaching, the programmes work similarly for students that have either high or low initial (or baseline) levels of English competency. When ICT programmes are not integrated with teaching, they only raise the educational performance of English students who were performing better during the baseline.

1. Introduction

Integrating Information and Communication Technology (ICT) into the classroom is a promising approach to help disadvantaged students across the world (Bakar, Inal, & Cagiltay, 2006; Ebner & Holzinger, 2007; Pal, Pawar, Brewer, & Toyama, 2006; Banerjee, Cole, Duflo, & Linden, 2007; Lai, Luo, Zhang, Huang, & Rozelle, 2011; Mo, Zhang, Luo, et al., 2014). Policymakers in developed and developing countries have tested various methods to use ICT for innovation and improvement

* Corresponding author.
E-mail address: dimo@stanford.edu (D. Mo).

http://dx.doi.org/10.1016/j.compedu.2016.02.005
0360-1315/

of poor performance students (Sweet & Meates, 2004). In many parts of the world, large investments have been made to integrate ICT into education systems in order to support remedial learning (Butcher, 2011; Zhang, Zhang, Zhao, & Wu, 2014). For instance, Turkey spends 11.7% of its education budget on ICT (Hismanoglu, 2012). China's government has established a plan to increase the investment in ICT in education, with special attention given to remote rural areas (MOE, 2012, 2012, 2014). According to this plan, a computer classroom is to be set up in every rural primary school during *the 12th Five-Year Plan* (2011–2015—MOE, 2012).

Despite the increasing use of ICT for helping disadvantaged students in schools, researchers have found large heterogeneity in the impact of ICT programmes on student academic achievement. Previous studies in both developed and developing countries have shown inconsistent evidence of the educational benefits of using ICT in schools (e.g. Banerjee et al., 2007; Barrow, Markman, & Rouse, 2008; Almekhlafi, 2006; Olibie, 2010; Lai et al., 2012, 2013; Mo, Zhang, Wang, et al., 2014; Angrist & Lavy, 2002; Rouse & Krueger, 2004; Hlas & Vuksanovich, 2007; Dynarshki et al., 2007; Chien, 2011). For example, Banerjee et al. (2007) showed that a Computer Assisted Learning (CAL) programme significantly helped students increase math scores. Additionally, these increases were sustained when students' educational performance was measured one year after the programme concluded. He, Linden, and MacLeod (2008) and Mo, Zhang, Wang, et al. (2014) have also found positive impacts of ICT programmes in developing countries. In contrast, Angrist and Lavy (2002) came to fundamentally different conclusions, finding that when ICT was used inside the classrooms of Israeli elementary schools, it led to negative, but insignificant, impacts on 8th grade students. Similarly, Rouse and Krueger (2004) demonstrated that an ICT programme in US schools had no significant effect on student reading.

While there are many factors that may have contributed to the heterogeneity of the outcomes, one potential reason for the observed differences in ICT programmes may be that some integrated ICT into teaching (henceforth, *computer assisted instruction* or *CAI*) while others did not. In the rest of the paper we call programmes that do not integrate ICT into teaching *computer assisted learning* or *CAL* programmes.

Whether or not ICT should be integrated into the teaching programmes of instructors is an ongoing debate in the literature (Bingimlas, 2009; Granger, Morbey, Lotherington, Owston, & Wideman, 2002; Mumtaz, 2000; Stockwell, 2007; Tondeur, Valcke, & Van Braak, 2008). On the one hand, many scholars believe that CAI is an effective way to utilize ICT in schools. Researchers have argued that ICT's value in education is that it provides the means to make teaching more efficient and interesting (Hughes, 2005). However, it is believed ICT, while potentially effective, cannot replace the role of teachers in providing timely feedback to their students (Dina & Ciornei, 2013; Hismanoglu, 2013). Therefore, it is not only desirable, but also necessary for ICT to be integrated into the teaching process.

In contrast, there are also proponents of using CAL approaches to education in schools. The main benefit of a successful CAL programmes (if they are indeed successful) is that they can replace teachers and still help students to learn. CAL programmes can also be rolled out in an inexpensive manner due to limited human resource requirements. In this way, CAL programmes are not constrained by factors such as the quality of teaching or teacher effort. Rahimi and Yadollahi (2011) suggest that one of the main issues associated with adopting and integrating ICT into teaching curricular is that teachers may act in a way that undermines the effectiveness of ICT. Teachers may simply choose to use ICT materials without matching the materials to the learning levels of students. If teachers do not expend enough effort to incorporate ICT into their teaching, student performance could potentially be harmed.

Another important point made by the literature is that the effectiveness of different ICT programmes may depend in part on the learning level of students at baseline. For example, Huang et al. (2014) show that the effectiveness of ICT programmes can depend on the initial learning level of students. According to Krashen (1982), calibrating the additional amount of new learning material relative to the student's current level of knowledge is a crucial step to better learning. In other words, the provision of new learning material is most effective when it is provided at a level just beyond the student's current level of competence. As a result, ICT-based instruction needs to be readily comprehensible to students for there to be effective learning (Hatch, 1978; Long, 1996). Such a theory implies that students should at least have a minimum level of knowledge of the subject before ICT can benefit them. In other words, ICT is not a technology that can be effectively used by a student to learn a subject that is totally new to him/her.

In addition, the type of teacher implementing an ICT programme may play a role in determining the programmes' effectiveness. Burston (1996), Jones (2001) and Yang and Huang (2008) show that implementing an ICT programme may increase teachers' workload, since they need to make efforts to prepare for and organize the new programme. Therefore, a teacher's workload at baseline could affect the effectiveness of an ICT programme. If a teacher has a heavy workload, he/she may not be willing to carefully or fully implement an ICT programme, while a teacher with a lighter workload would be more inclined to implement the program. However, researchers have also suggested that if an ICT programme is effective in helping student learn and complements regular teaching, it may require less marginal effort from the teachers to improve student performance (Lam, 2000; Nomass, 2013). In other words, the overall teacher effort may decrease if the ICT programme can help improve student performance, thus improving overall efficiency of teaching. As a result, determining which type of ICT programmes works in a particular context may depend on the nature of the teacher and how well the ICT programme complements teaching practices.

If this theory is true, then we may be able to create a testable hypothesis: the effectiveness of ICT programmes depends on both the nature of students and the engagement of teachers. Under this hypothesis, when an individual student is performing poorly we would expect that CAI programmes would be more effective than CAL programs. Because CAI is rolled out as part of a teaching program, an instructor could help poorer performing students catch up with the subject so that they may better