How the ICT development level and usage influence student achievement in reading, mathematics, and science

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ABSTRACT

The main purpose of this study is to investigate how national ICT development level and individual ICT usage will influence achievements in reading, mathematics, and science for 4th and 8th grade school students. Large-scale international databases, including TIMSS 2011, PIRLS 2011, and PISA 2012, were employed in the current study. Hierarchical linear models (HLM) were applied to examine both country- and individual-level variables. According to the findings of this study, the national ICT development level is a significant positive predictor for individual academic performance in all three subjects for both 4th grade and 8th grade students, while the national economic development level was controlled for. Such finding indicates a similar trend of the ICT influences for both groups, although there exists a difference in terms of the extent of the relationships. In addition, individual-level ICT use is a significant predictor, even if students' gender and socioeconomic status are controlled for; however, its influence is mixed across different student groups and subjects depending on the ICT usage type.

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1. Introduction

In the context of information societies, ICT has been perceived as one of the most important tools in changing education, based on the contemporary information society needs (Blackwell, Lauricella, & Wartella, 2014; U.S. Department of Education, 2010). Therefore, many countries have implemented ICT-related policies and invested considerable resources in ICT infrastructures in schools (Witte & Rogge, 2014). The integration of ICT in teaching and learning is aimed at improving students' 'twenty-first century skills' (Anderson, 2008; Kim, Kil, & Shin, 2014) and achieving major international goals such as EFA (Education for ALL) and the WSIS goals (World Summit of Information Society) (WSIS, 2003). Moreover, the application of ICT in education might be helpful for increasing opportunities for learning and reducing the gap between socioeconomic factors and education system outcomes (Shank & Cotton, 2014). It is also believed that integrating ICT with education would create talented teacher communities where professionals can share their best practices and success stories and thus improve the quality of education (Cox, 2008).

However, the planned application of ICT in education is determined to a large extent by national ICT development, in that national ICT policies and plans provide the principle means for ICT to contribute significantly to a society's sustainable development (FAIDP, 2010). Moreover, national ICT development can also be a driver for educational reforms through the introduction of new teaching and learning practices, facilitating the restructuring of the education system (Kozma, 2002). Although the importance of a highly developed national ICT level for overall education quality has been recognized by governments, few studies have addressed whether the national ICT level will influence student learning outcomes. As a review of the literature shows, a large number of studies focused on the impact of ICT on students' achievements and individual skills (Carrasco & Torrecilla, 2012; McMahon, Yeo, & Williams, 2011). However, most of these studies investigated the usages of ICT in the classroom or at home, rather than considering ICT as an environmental factor at the national level. This study draws on large-scale data, combining survey responses from students with rich administrative data from international authorities to identify whether the national ICT level and individual ICT usage matter for student learning outcomes. The purpose of this research is to

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present evidence about the relationship of both ICT development (national level) and ICT usage (individual level) with achievement in reading, mathematics, and science for 4th and 8th grade students by exploring three international large-scale student assessment projects: the Trends in International Mathematics and Science Study (TIMSS 2011), the Progress in International Reading Literacy Study (PIRLS 2011), and the Programme for International Student Assessment (PISA 2012).

2. Background

2.1. The National ICT Level and Education Development

Information and communication technologies (ICT) are defined as a "diverse set of technological tools and resources used to communicate and to create, disseminate, store, and manage information" (Blurton, 1999). A broad definition of ICT includes computers, the Internet, telephones, personal digital assistants (PDAs) and mobile phones, television, radio and audio-visual equipment. Taking into account the importance of ICT for social development, several initiatives exist for measuring and monitoring ICT level (IADB, 2010; ITU, 2010; UIS, 2009). The International Telecommunication Union (ITU) is the United Nations' specialised agency for information and communication technologies. In 2006, the ITU was asked to develop a single index, called the ICT Development Index (IDI), to measure the extent of a country's ICT level (ITU, 2010). The overall national ICT level has the inherent power of promoting the modernisation of society, including the education system.

As more and more educators and policymakers have begun to value the potential benefits of ICT in the revolution of the modern education system, more and more advanced ICT equipment has been introduced and invested into schools and classrooms. In 2009, the UNESCO Institute for Statistics (UIS) introduced a three-level model of ICT integration in education (UIS, 2009). It consists of three levels (see Fig. 1):

1) **Readiness.** The readiness of the infrastructure, society, and the education system to undertake ICT activities in the education system. The main criteria are access to and use of basic ICT infrastructure, ICT-trained teachers, ICT support staff, radio and television instruction, educational software, email and other "simple" educational technologies.
2) **Intensity.** The intensity of the use of ICT and the extent to which ICT activities in education (such as distance education and mobile learning) are carried out by the government and business. The main criteria are ICT-enhanced content development and innovative pedagogy management, new ICT vocational skills development, the expansion of ICT-related fields of studies, distance education, virtual and open universities, virtual high schools, virtual laboratories and online simulations, digital libraries, and Internet-enabled self-learning.
3) **Impact.** The outcomes and impacts of ICT on business activities and economic growth in countries with a relatively high level of ICT in education. The main criteria are the availability of ICT for lifelong learning, ICT and student achievements, tracer studies on ICT-skilled students in the labour market, the relationship between ICT in education and economic productivity, webcasting, podcasting, and videoconferencing.

According to the three-level model, the development of the overall national ICT level will help in achieving not only national developmental goals but also major international goals set by the WSIS (WSIS Plan of Action, WSIS, 2003), MDGs (Millennium Development Goals), and the EFA (Education for All), which are related to the use of ICT in education for expanding teaching and learning opportunities, for improving educational achievements, for promoting educational reformation, for achieving education equality and equity (Kozma, 2002;
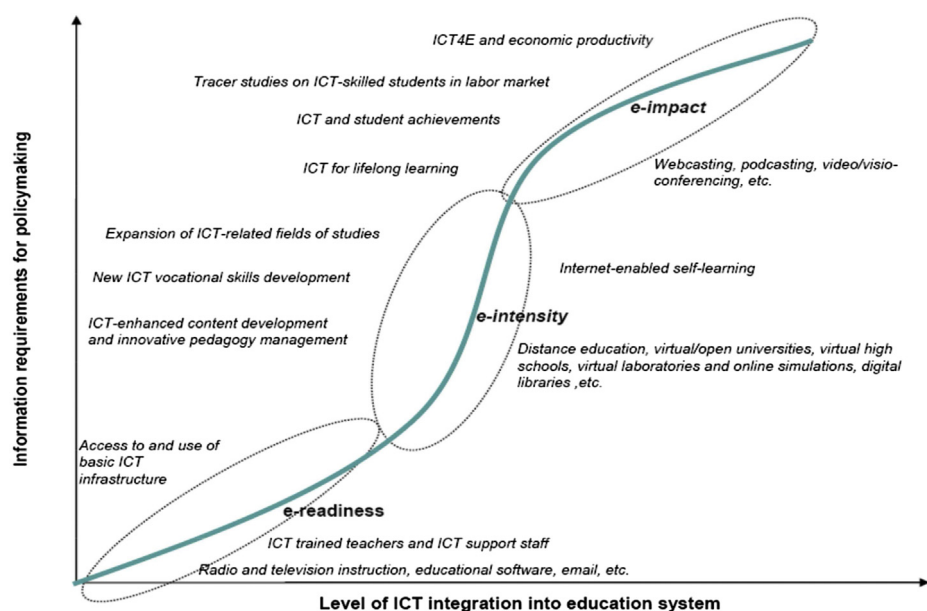

Fig. 1. Information needs for different types of ICT in education over time.
Source: UIS (2009).