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An analysis of the relationship between information and communication technology (ICT) and scientific literacy in Canada and Australia

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ABSTRACT

Despite the lack of substantial evidence for improvement in the quality of teaching and learning with information and communication technology (ICT), governmental organizations have pushed ICT as a means of providing broad-scale training to meet the demand for a skilled workforce, centred upon a hypothesized ICT–scientific literacy relationship. To better understand this possible association, this study used data from the 2006 administration of the Programme for International Student Assessment (PISA 2006) to determine the extent to which scientific literacy is predicted by a host of ICT-related variables, after adjusting for student demographic characteristics. The findings suggest that, once demographic characteristics have been accounted for, students with prior experience with ICT, who browse the Internet more frequently, and who are confident with basic ICT tasks earned higher scientific literacy scores. Gender differences existed with respect to types of productivity and entertainment software used; this difference may be attributed to personal choice and initiative to learn ICT. Furthermore, the way in which students are using computers in schools, towards attaining learning outcomes, may have a stronger effect on scientific literacy than how often computers are accessed.

1. Introduction

Information and communication technology (ICT)[2] literacy and science skills have been perceived by governments as important factors for economic growth and development in the 21st century, and investment for training and equipment has increased for these fields. In the past quarter-century, this heightened attention has been given to science education in response to the growing shift towards knowledge-based economies, which require a supply of workers well-prepared in the sciences to ensure continued innovation and development. ICT literacy refers to "[the use of] digital technology, communications tools, and/or networks to access, manage, integrate, evaluate and create information in order to function in a knowledge society" (Educational Testing Service, 2002, p. 16).

A shift has also taken place with regards to the use of ICT in science education. The first applications, in the late 1960s, focused on cognitive benefits to the learner (e.g., the transmission of predefined content knowledge); today, the goals of science education found in modern curricula centre on inquiry-based learning where developments in ICT have been most beneficial (Linn, 2003; Osborne & Hennessy, 2003). As a result, schools have included the use ICT in their educational programs, to help students learn effectively. The emergence of Internet technologies, for example, has prompted the Australian and New Zealand governments to collaboratively fund projects aimed at developing a body of high-quality curriculum content for their schools, distributed online (Schibeci et al., 2008).

Currently, research on the impact of ICT on teaching and learning has been inconclusive (Reynolds, Treharne, & Tripp, 2003). One reason is the lack of agreement as to what should be measured, or even whether or not it can be measured, to quantify success; there is no systematic methodology in place at institutions that have adopted ICT (Reynard, 2009). Analyzing data from PISA 2006, an

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1 Tel.: +1 613 533 6000x77298; fax: +1 613 533 2556.
2 Abbreviations used in this article: exploratory factor analysis (EFA); economic, social, and cultural status (ESCS); hierarchical linear modeling (HLM); intraclass correlation (ICC); information and communication technology (ICT); Organisation for Economic Co-operation and Development (OECD); Programme for International Student Assessment (PISA); socioeconomic status (SES); Trends in Mathematics and Science Study (TIMSS).

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assessment that measures how well 15-year-old students approaching the end of formal schooling are prepared to meet the challenges of today's knowledge, differences in accessibility to and use of ICT that exist at the student level (e.g., socioeconomic status, gender, computer experience) and at the school level (e.g., computer and Internet availability) may partially explain ICT's effects on academic achievement.

1.1. Conceptual framework

The variables measured in PISA 2006 may have connections to previous research on access and usage of ICT by students, both at home and at school. In the past, sociodemographic factors largely influenced how frequently a student used ICT, since computer ownership was dependent on a family's ability to afford one. This issue has become less important in recent years as a result of the continuing decline in the price of a computer relative to the average household income. As a result, computer ownership has increased, and studies have suggested that *digital divide*, defined as the gap between individuals and households at different socioeconomic levels with regards to opportunities to access ICT and use the Internet (Looker & Thiessen, 2003), should be considered as the extent to which "[individuals] can access, adapt and create knowledge and those who cannot" (Gorski, 2005). Therefore, other factors in addition to sociodemographic characteristics are coming increasingly into play, namely, frequency and location of access to ICT and computing experience and skills.

1.1.1. Frequency and location of access to ICT

One factor that may be linked to SES is frequency of access to ICT, and where it is accessed. Students who do not have access to ICT at home become dependent on schools and public places for ICT-related activities (Zhao, Lu, Huang, & Wang, 2010), and thus have fewer opportunities to access ICT. For example, Ravitz, Mergendoller, and Rush (2002) analyzed the software capability of students in Grades 8 and 11. While they found a positive relationship between software capability and achievement (i.e., test score gains), they found a stronger association between home computer use and computing proficiencies than with school computer use.

In Canada and Australia, access to ICT and Internet connectivity at schools is nearly universal (OECD, 2005). Since access at school may be restricted by demand from other students, the nature of access needs to be considered (Ainley, Enger, & Searle, 2008). This access is also provided to students with the intention of providing ICT-based learning opportunities, to a greater extent than for personal uses. Interestingly, in PISA 2003, OECD (2005) found that access to a computer at home had the largest impact on mathematics literacy (the major domain for PISA 2003). Therefore, computer accessibility was included as a predictor in the current study.

1.1.2. Computing experience and skills

Students' prior experience using ICT may affect how frequently and how confidently they use computers. Their level of experience may be determined by earlier exposure to ICT, perhaps from a home computer. The lack of computer use at home may thus be a greater barrier than the lack of access at school, as out-of-school computer experiences are strongly related to students' attitudes towards ICT (Moos & Azevedo, 2009). More importantly, the way in which students use ICT for educational purposes may relate to achievement. With a large variety of software and Internet applications accessible to students, some may be more beneficial to learning, while others may require more skill (Plumm, 2008). However, high-level ICT tasks (requiring more computer knowledge or skill)—which may potentially be beneficial to achievement in science and technology-related subjects—are, not surprisingly, less frequently used than routine computer or Internet tasks, and approached with more difficulty by students (Ainley et al., 2008). Since PISA does not measure computing skill, students' self-rated confidence with different types of ICT was used as a proxy for computing skills in the current study.

Although OECD (2005) cautions that "associating computer access and usage with performance cannot provide evidence of computers on learning, since the PISA data do not demonstrate causation" (p. 53), it does raise issues for further investigation. With universal connectivity to ICT in Canada and Australia, especially in schools, an analysis of achievement based on software use and confidence with ICT would provide conclusions to support or refute this conclusion.

Investments in ICT resources by school jurisdictions have also increased the availability to computers for students, which, in turn, may influence how often computers are used in schools for learning purposes. However, Pelgrum (2001) states that "indicators of infrastructure tend to be obsolete by the time they are published" (p. 167). Moreover, the availability of electronic instructional tools for the science curriculum (e.g., software, websites, applets) is continually on the rise; therefore, a periodical examination of ICT use for learning may offer an operational indication of the extent to which educational practitioners can view ICT as a useful tool (Pelgrum & Plomp, 2002). In light of the rapid uptake of ICT in education, the purpose of this study was to determine the extent to which ICT-related student- and school-level variables are associated with scientific literacy in Australia and Canada in the presence of student- and school-level demographic variables.

1.2. Rationale for country selection

Canada and Australia were selected in this study because they share a number of economic, social, and cultural factors. These factors include the reliance on natural resource exports to maintain standards of living, a strong immigrant population to sustain their economies, large proportions of the population residing in urbanized areas, and similar levels of socioeconomic status (Corbett & Willms, 2002). These national demographics guide decisions made by their respective federal governments, including the purposes of their education systems, and the types of learning resources provided to schools. In addition, relative to other participating countries, the two countries scored significantly above the PISA 2006 mean of 500 on scientific literacy (Canada, 534; Australia, 527). While the two countries are appropriate for examining ICT with respect to achievement because of their similar resources, they differ in allocation of resources across schools. According to the TIMSS 1994 and 1999 data, Australia had low levels of between-school resource inequality (including computer hardware and software), while Canada was a nation with average levels of inequality (Baker & LeTendre, 2005). These differences in inequality may have an effect on science achievement and the ways schools are resourced to achieve academic success, if a connection between ICT resources and achievement exists. Furthermore, similarities between ICT and science (e.g., cognitive processes and curricular outcomes) indicate the possibilities inherent in promoting the integration of ICT in science education.