UNDERSTANDING CHILEAN STUDENTS’ DIGITAL SKILLS

MAGDALENA CLARO TAGLE

Thesis submitted to the Office of Research and Graduate Studies in partial fulfillment of the requirements for the Degree of Doctor in Engineering Sciences.

Advisor:

MIGUEL NUSSBAUM VOEHL

Santiago, Chile, September 2014
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MAGDALENA CLARO TAGLE

Members of the Committee:

MIGUEL NUSSBAUM VOEHL
JOSÉ JOAQUÍN BRUNNER
RICARDO PAREDES
ÁLVARO SALINAS
KENTARO TOYAMA
JORGE VASQUEZ

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Santiago, Chile, September 2014
To Maximiliano, Amalia, Joaquin and Julia, the loves of my life.

To my parents, for their example, love and support.
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UNDERSTANDING CHILEAN STUDENTS’ DIGITAL SKILLS

Thesis submitted to the Office of Research and Graduate Studies in partial fulfillment of the requirements for the Degree of Doctor in Engineering Sciences by

MAGDALENA CLARO TAGLE

ABSTRACT

Digital literacy is essential if new generations are to become fully integrated and participate in an increasingly technology-rich society. Although this is part of international academic and policy debate, the issue has scarcely been studied in Chile. This thesis aims to contribute to the understanding of digital literacy among students in Chile, a country which has invested more than 20 years in its ICT for education policy. While this policy has provided schools with equipment, Internet access and teacher training, as well as technical and pedagogical support, there have been no specific learning objectives for developing students’ digital skills.

The studies that shape this thesis look to analyze this topic in five ways. The first is by defining the skills that should be assessed among 10th grade students. This is achieved by looking at definitions by other countries, the Chilean curriculum framework, and research evidence regarding the skills required for solving information and communication problems in digital context. The second is by applying a Rasch Model to examine the performance of 10th grade students on a digital skills test piloted in 2009.
To do so, regression analysis is used to study the relationship of these results with student-level factors relating to ICT and socio-demographics. The third is by employing a Two-parameter Logistic Model (2PL) to investigate which types of tasks best differentiate performance of 10th grade students on a national digital skills test. This test, the ICT SIMCE, was first administered in 2011. The fourth is by using a Hierarchical Linear Model to study the relationship between the performance of 10th grade students on the 2011 ICT SIMCE and their performance on the 2005 and 2009 Language and Mathematics SIMCE tests. The final way is by conducting a Multivariate Linear Regression analysis to compare the marginal effect of economic, social and cultural status on results on 10th grade national standardized tests. This is done by comparing the effect on the 2011 ICT SIMCE with the effect on the 2009 Language and Mathematics SIMCE tests.

As well as offering a wider perspective on digital skills than traditionally considered by the Chilean curriculum, this thesis also provides significant evidence regarding digital skills among students in Chile. The results of these studies reveal five main findings:

1) There is little development of digital skills among students in Chile.

2) The results are positively correlated with socioeconomic group, ICT access at home, frequency of ICT use at home, and confidence in performing simple ICT tasks.

3) The types of questions that best differentiate between proficiency levels on the 2011 ICT SIMCE are those that require criteria or knowledge to be applied when solving problems related to basic digital culture and processing information in a digital environment.

4) Previous performance on language test is a stronger predictor than previous performance on a mathematics test of student performance on the digital skills test.

5) The marginal effect of Economic, Social and Cultural Status as a whole on students' digital skills is equal to the effect on mathematics and greater than the effect on language.
Keywords: Digital literacy, digital skills assessment, determinants of digital literacy, traditional literacies on digital literacy, Chilean students’ digital skills.

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Members of the Committee:
Miguel Nussbaum
José Joaquín Brunner
Ricardo Paredes
Alvaro Salinas
Kentaro Toyama
Jorge Vásquez

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LAS HABILIDADES DIGITALES DE LOS ESTUDIANTES CHILENOS

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RESUMEN

La integración y participación plena de las nuevas generaciones a una sociedad crecientemente tecnologizada, demanda prepararlas en la alfabetización digital. A pesar de ser un tema de debate académico y de políticas públicas a nivel internacional, aún ha sido poco estudiado en Chile. Esta tesis busca contribuir a la comprensión de la alfabetización digital de los estudiantes chilenos, luego de más de 20 años de inversión pública en una política de tecnologías en educación que ha entregado equipamiento a los colegios, acceso a Internet, capacitación a profesores y apoyo técnico y pedagógico, pero sin objetivos de aprendizaje específicos para el desarrollo de estas habilidades.

Los estudios que configuran la presente tesis buscan analizar este tema de cinco maneras. Primero, por medio de definir las habilidades que debieran ser medidas en estudiantes de 2° Medio, considerando las definiciones de otros países, el marco curricular chileno y la evidencia de la investigación relacionada con las habilidades que se necesitan para resolver problemas digitales. Segundo, a través de aplicar un Modelo Rasch para examinar el desempeño de estudiantes de 2° Medio en una prueba piloto de medición de habilidades digitales implementada el año 2009, y de usar un análisis de regresión para estudiar la relación de estos resultados con factores vinculados con las
Tecnologías de la Información y Comunicación (TIC) y con las características sociodemográficas de los estudiantes. Tercero, por medio de emplear un Modelo Logístico de Dos Parámetros (2PL) para investigar qué tipos de tareas mejor discriminan el desempeño de los estudiantes en una prueba nacional de habilidades digitales implementada por primera vez el año 2011 (SIMCE TIC). Cuarto, a través de usar un Modelo Lineal Jerárquico para estudiar la relación entre el desempeño de estudiantes de 2º Medio en el SIMCE TIC 2011 y su desempeño previo en SIMCE Language y SIMCE Matemáticas los años 2005 y 2009. Y finalmente, por medio de aplicar un análisis de Regresión Lineal Multivariado para comparar el efecto marginal del estatus social, económico y cultural de los estudiantes de 2º Medio en su resultado en la prueba nacional de habilidades digitales SIMCE TIC 2011 con el efecto en sus resultados en las pruebas nacionales de SIMCE Lenguaje y SIMCE Matemáticas el año 2009.

Junto con ofrecer una perspectiva más amplia a las habilidades digitales a como han sido tradicionalmente concebidas en el currículum chileno, esta tesis entrega evidencia significativa sobre las habilidades digitales de los estudiantes chilenos. Los principales hallazgos son los siguientes:

1) Hay un bajo nivel de desarrollo de habilidades digitales en los estudiantes chilenos.
2) Los resultados están positivamente relacionados con el grupo socioeconómico, el acceso a las TIC en el hogar, la frecuencia de uso de las TIC en el hogar, y la confianza para realizar tareas TIC simples.
3) El tipo de ítemes que mejor discriminan entre diferentes niveles de dominio en el SIMCE TIC 2011 son aquellos que demandan aplicar criterios o conocimientos para resolver problemas relacionados con una cultura digital básica y de procesamiento de información en ambiente digital.
4) El desempeño previo de los estudiantes en lenguaje es más relevante que su desempeño previo en matemáticas en sus resultados en la prueba nacional de habilidades digitales.
5) Finalmente, el efecto marginal del Estatus Económico, Social y Cultural de los estudiantes en las habilidades digitales de los estudiantes es igual al efecto en matemáticas y mayor al efecto en lenguaje.

**Palabras claves:** Alfabetización digital, medición de habilidades digitales, determinantes de la alfabetización digital, alfabetizaciones clásicas en alfabetización digital, habilidades digitales de los estudiantes chilenos.

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Miembros del comité:
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José Joaquín Brunner
Ricardo Paredes
Álvaro Salinas
Kentaro Toyama
Jorge Vásquez

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1. INTRODUCTION

1.1 Chilean ICT policy and its effects on teaching practices and student learning

For more than two decades, the Chilean Ministry of Education has developed a policy for integrating ICT in schools. The policy’s goal has been to improve the equity and quality of the education system by building a national network to support the learning and development of ICT skills in schools (Rusten et al., 1999; Hepp, 2003; Hinostroza et al. 2008; Sánchez & Salinas, 2008; Toro, 2010; Blignaut et al., 2010). Since 1993, Enlaces, the initiative created to implement this policy, has equipped schools with computers, local networks, educational resources, productivity software, free or subsidized Internet access, as well as technical and pedagogical support in association with 24 universities across the Country (Donoso, 2010; Sánchez & Salinas, 2008). In 2007, Chilean policy defined a specific plan called “Technology for a quality education” based on four strategies: (a) a plan for the use of ICT; (b) the reduction of the digital divide, through the provision of ICT and the development of a management plan for ICT infrastructure; (c) the development of digital skills among students and teachers; and (d) the provision of digital education resources that can be used to deliver the curriculum (Blignaut et al., 2010). Thanks to Enlaces, by 2012 80% of students from state-subsidized schools had Internet access, and the Country reached a national average of 9 students per computer in schools (Mineduc, 2013).

In recent years, a central concern for studies in Chile has been examining the effects of these policies. These studies have analyzed how these resources are being used in teaching practices and their impact on student learning. With regards to the use of ICT, Chilean evidence is consistent with international studies that show that the frequency of use in teaching and learning activities is relatively low. They also show that ICT are mainly used to support traditional education practices
In fact, the data collected in a national study in 2009 of all subsidized schools and a sample of private schools showed that ICT are not frequently used in the teaching and learning process in Chilean classrooms. Even more, when they are used this is done to support previous teaching practices instead of promoting innovation or change (Hinostroza et al., 2010). This problem was also analyzed in the context of this doctoral project in a study that aimed to understand how a strategy of Mobile Computer Labs (MCL) had been integrated into 3rd and 4th grade teaching and learning practices in 1,591 state schools in Chile. In particular, the study aimed to identify the most important factors related to MCL integration in these practices a year after its implementation. The findings obtained by conducting a survey and performing classroom observations showed that, although the schools were willing to use this resource, they were used only sporadically. They also showed that the use of ICT was predominantly for searching for information and drilling and practicing contents related to mathematics and language, as well as for motivating students. Furthermore, the classroom observations did not reveal any innovative teaching strategies in terms of using this new technology. The study showed that among the main reasons for this traditional and sporadic use of the MCL was a lack of targeted teacher training and planning time, as well as insufficient technical and pedagogical support during the integration phase (See Claro et al., 2013 in Appendix 1). In addition to this, a complementary study combining quantitative and qualitative data was conducted. This study analyzed teachers’ and principals’ views of the process of integrating MCL in their schools. The results showed that part of the problem were the diverging views of the conditions that are required in a school in order to learn how to use the new resources, as well as who should be responsible. Another interesting finding was that schools did not have a clear plan about what to do with this new resource, nor how to solve the problems encountered during its use (See paper submitted by Claro et al., 2013 in Appendix 2).
In terms of the impact of ICT on student learning, national and international research has failed to provide any sound evidence to suggest it has a positive or negative effect. On the contrary, evidence is either inconsistent or does not allow general conclusions to be drawn. Research is either specific to the countries or groups under study, or developed under very specific conditions, such as pilot projects or case studies. In addition to this, there are very few experimental studies that provide solid empirical evidence relating to causality between ICT and academic performance. Evidence tends to show that the relation between ICT and learning is non-linear and complex (Balanksat et al., 2006; Kozma, 2006; Ungerleider & Burns, 2003; McFarlane et al., 2000; Cuban & Kirkpatrick, 1998).

Part of the problem is that the question in itself is problematic as it is difficult to refer to ICT in general. Although all ICT involve the manipulation and communication of information in a digital format, the applications, functions and characteristics are very diverse. Furthermore, as ICT can be considered as both instruments and media, they can be used in many different ways. As McFarlane et al. (2000) stated, “The problem is analogous to that of asking whether books are having an impact on learning: books are a medium for transmitting information, they cover a vast range of content, structure and genres, they can be used in an infinite variety of ways. It is therefore extraordinarily difficult to make generalized statements about their impact on learning.” (p.9)

However, ICT are more than just a medium for transmitting information; they have changed the way contemporary societies are organized. These societies are characterized by moving from an economy based on raw materials and workforce to one based on information and global capital; from a culture based on time and space to the virtualization of culture; and by the development of horizontal interactive communication networks (Castells, 2000), among others. The relevance of these characteristics in terms of the way in which societies function today is related to the emergence of ICT. This is because ICT do not require members to be physically present and facilitate both the access to and sharing of information and
knowledge (Anderson, 2008). Consequently, ICT can be considered as more than just a medium or resource with which to improve subject-based learning; it can also be considered as the foundation of a new type of social organization. As this is where economic, political, social and cultural life takes place, it also leads to new trends in the way people work, do business, communicate, participate and spend their leisure time. At the same time, ICT provide people with opportunities to access, use, share, and create information and knowledge much more significantly than in previous decades (Anderson, 2008).

These new trends related to the emergence of ICT have significant implications for education as they demand certain types of skills as more important than others. As well as the more traditional literacies of reading, writing and mathematics, an increasingly technology-rich world also requires individuals to be ICT or digitally literate (Buckingham, 2003). This means that they should have the cognitive and practical skills needed to use digital technologies and fully participate in society (Hague & Williamson, 2009). Knowing which these skills are and how they should be measured and developed in education is a matter of open debate and research (Anderson, 2008; Griffen et al., 2012). This thesis aims to contribute to this debate in four ways.

The first is by proposing a definition of digital skills for the Chilean context and analyzing the performance by 10th grade students on the first instrument designed to measure these skills in the Chilean education system. This instrument later became a national standardized test, the 2011 ICT SIMCE. The second is by analyzing which types of tasks best discriminate student performance on a national digital skills test (2011 ICT SIMCE). The third is by studying the relationship between student performance on the 2011 ICT SIMCE and their previous performance on the national language and mathematics SIMCE tests. The fourth way is by comparing the role played by a student’s economic, social and cultural status (ESCS) in their performance on the digital skills test versus their
performance on the language and mathematics tests. The first study aims to define and analyze students’ digital skills, as well as examining the factors relating to ICT and socio-demographics that might explain these results. The second study aims to understand the intrinsic characteristics of the national digital skills test (2011 ICT SIMCE) by studying the tasks that best discriminate students’ digital skills. The last two studies aim to contribute to the understanding of whether digital literacy is different from the more traditional literacies of language and mathematics, as measured by national standardized tests. Together, the four studies aim to contribute to the understanding of what it means to be digitally literate and which factors best explain the digital skills of students in Chile.

1.2 Theoretical Background

In this section, the main concepts and research behind this thesis will be presented.

1.2.1 Digital literacy as a new form of literacy

The concept of digital literacy first emerged in the 1980s, referring to the notion of computer or ICT literacy and the need to master or operate new technologies and their programs (Norman, 1984; Levine, 1986). These computational skills have been taught as an independent subject in education systems and there are several examples of instruments to measure them. These include the ECDL in Europe and ICDL for all other countries, as well as the ICT Skills test in Australia. Later, a broader concept of ICT literacy emerged, transcending technical ICT skills. This concept partly materialized under the framework of twenty-first century skills, supported by evidence that labor markets valued not only technical abilities but also higher order cognitive skills, especially when using new technologies (Binkley et al., 2012). In the education sector, this has meant a growing demand for highly qualified workers that not only possess a solid foundation in traditional literacy skills (reading, writing and mathematics), but also the ability to solve non-routine problems and handle the type of complex information frequently present in digital contexts (Levy & Murnane, 2007).
Furthermore, the concept of digital literacy has been part of academic and policy debate regarding the changing features of literacy in our culture (see Voogt, 2013; Jenkins, 2006; Mossberger, 2003; Warschauer, 1999; Tyner, 1998; Beynon, 1993). There are three aspects or dimensions of digital literacy described in this debate:

1) Operating ICT: refers to ‘tool literacies’ (Tyner, 1998) or ‘basic ICT skills’ (OECD, 2010) which imply having the necessary skills to be able to use, operate and solve problems related to technology, e.g. word processors, spreadsheets, navigation tools and software (Fraillon & Ainley, 2010; MCEETYA, 2008; Mossberger et al., 2003).

2) Working with Information: refers to the cognitive skills required to deal with the large amount of information on the Internet, such as searching, accessing, evaluating and organizing information, as well as producing and communicating information to solve problems (Fraillon & Ainley, 2010; OECD, 2010; Mossberger et al., 2003). As Manuel Castells (2001) suggests, most information is on the Internet and therefore what is really needed is the ability to decide what we want to find, how to obtain it, how to process it and how to use it in the task that motivated the search in the first place (p.325).

3) Understanding digital technologies: refers to critical thinking about the role (opportunities and challenges) of technology and media in real world problems (Hague & Williamson, 2009; Binkley et al., 2012). It is about knowing when and why digital technologies are appropriate and helpful to the task at hand and when they are not (Hague & Payton, 2010). Kathleen Tyner (1998) refers to this aspect as ‘literacies of representations’, which relate to the knowledge of how to take advantage of the possibilities provided by different forms of representation, such as ICT. More critical perspectives stress the importance of treating technology as a ‘text’ and understanding that no texts are neutral. As Beynon (1993) suggests,
“Once created it can float free of its author, take on a life of its own and obscure the origins of its production. This is as true of computers as it is of literary texts.” (p. 19). Consequently, the 'skills' required to 'read' technology are essential attributes of the well-educated or literate person (Mackay, 1992; Middlehurst & Beynon, 1991). As Manuel Castells (2001) states, the Internet is not just a technology; it is the technological instrument and the form of organization that distributes the power of information, the generation of knowledge and the capacity to connect to a network in any sphere of human activity (p.337).

In synthesis, the concept of digital literacy has shifted from a more technical and restricted orientation based on the mastery of digital applications towards a broader perspective. This new perspective includes using these tools critically to solve cognitive problems on a daily basis and to participate in all areas of contemporary social life. More specifically, digital literacy considers computational skills (i.e. operational, functional skills), information and communication skills (i.e. cognitive processes related to critical and creative use of information, such as searching for and evaluating information, exchanging information and developing new ideas in a digital environment), and new understandings related to the effects of these technologies in contemporary life (i.e. understanding that social organization has changed as a consequence of ICT, providing new ethical and social dilemmas).

1.2.2 Relevance of teaching digital literacy

Considering the discussion presented above, the ability to use ICT and work with information may be considered “the indispensable grammar of modern life” (Wills, 1999). However, it may also be considered an important capability for learning (Hague & Payton, 2010:11). Both concepts refer to digital literacy as being a strategic matter for new generations. The first concept refers to preparing students for full participation in society, while the second refers to developing their capacity
for lifelong learning. On the one hand, this allows students to successfully search for and select relevant information, as well as facilitating access to subject knowledge in different formats (e.g. text, videos and images). On the other hand, it may also affect what students know about school subjects and the skills they will need to independently develop subject knowledge (Hague & Payton, 2010).

However, little is known about how children, teenagers and adults become skilled in solving information and communication problems in the digital environment. There is a tendency to assume that these abilities develop spontaneously and therefore these skills receive little attention from education systems. However, research has shown that it is unlikely that new generations will develop these skills without adult guidance (Brand-Gruwel et al., 2005; Brand-Gruwel et al., 2009; Walraven et al., 2008; Duijkers, Gulikers-Dinjens, and Boshuizen, 2001; Hirsch, 1999; Fuentes and Sánchez, 2000). Furthermore, teachers are increasingly reporting that young students are not as competent or skilled as they might seem. In fact, research on information problem solving shows that while students may have the ability to find information using digital technology, they have difficulties defining information problems, specifying proper search queries and evaluating the information they find (Walraven et al., 2008; Brand-Gruwel et al., 2009; Van Deursen and Van Diepen, 2013).

The first study of this thesis is motivated by the relevance of digital literacy and the problems found among teachers and students when working with information in schools. This study aims to define these skills among 10th grade students (15 years old) in Chile. It also looks to analyze the factors relating to ICT and socio-demographics that explain student performance on a pilot test developed to measure these skills in 2009.

1.2.3 The Chilean national digital skills test (2011 ICT SIMCE)
Measuring digital skills in education systems is relatively new and only a few countries have started to do this on a national level. Based on the pilot test, a national digital skills test was developed in Chile called the ICT SIMCE. The ICT SIMCE was first administered in 2011 and measured three dimensions of problem solving in a digital context: Information, Communication, and Ethics and Social Impact (Enlaces, 2011). In total, there were 12 skills measured within these three dimensions. Firstly, the Information dimension assessed two kinds of skills: information as a source (defining the information needed, searching for, selecting, evaluating and organizing information) and information as a product (integrating, analyzing and representing information as well as generating new information). Secondly, the Communication dimension assessed the student’s ability to transmit information by selecting appropriate digital media for different contexts. Finally, the Ethics and Social Impact dimension assessed the students’ skills in recognizing and reflecting on ethical dilemmas related to the use of new technologies in their personal lives, the lives of others, and on society as a whole. The test was administered using software that simulated a virtual environment where students had to perform several tasks related to the topic of ‘the environment’ (Enlaces, 2011).

The test aimed to measure the students’ ability to solve information and communication problems. For example, students were presented with a task where they needed to develop a campaign to protect animals in danger of extinction. They did so by preparing a presentation to quantify and explain the phenomenon, as well as highlighting the consequences of human actions. In order to do this, they were asked to define the information needed, search online, select valid and reliable information, summarize, reorganize, analyze and represent information. Finally, they were required to produce the presentation using the proper tools.

An important question regarding the digital skills of students in Chile as defined and measured by this test is which items on the test best define the requirements of
a student in order to be functional in a digital environment. Consequently, the third study of this thesis aims to understand which types of tasks best differentiate between performances by 10th grade students in Chile on the 2011 ICT SIMCE.

1.2.4 Relationship between digital literacy and literacy in language and mathematics

Another important question is about the effect of previously acquired language and mathematics skills on student performance on the 2011 ICT SIMCE. The relationship between digital literacy and traditional literacies has mostly been studied in the context of the so-called New Literacies Theory (Leu et al., 2005). This research has mostly focused on the relationship between reading comprehension of digital versus printed texts. The reason for this approach is related to new online factors, such as new text formats, reading objectives and ways to interact with information. This in turn may require new literacy skills in the digital world (Schmar-Dobler, 2003). According to Sutherland-Smith (2002), online texts require non-linear, non-sequential and non-hierarchical cognitive strategies and visual literacy to understand multimedia components. Some tasks carried out online may require the same skills as traditional comprehension, simply applied in a different learning context. However, other tasks, such as using online search tools, hyperlinks and collaborative work online will require new skills or new literacies (Coiro, 2003).

Coiro (2011) studied the relationship between print and online reading skills among 118 students in a North-Eastern school district of the United States. He concluded that reading comprehension skills for printed texts may inform, but do not complete our understanding of online texts. This study found that online reading comprehension is not identical to reading comprehension of printed texts and may even require new skills that are unique to digital contexts. However, it still requires similar and more complex versions of the skills and strategies
traditionally defined for print reading. These skills would be related to the reading comprehension skills needed to locate, evaluate, summarize and communicate information online. Elsewhere, Schmar-Dobler (2003) used observations and interviews with teenagers in the United States to propose that online and print reading comprehension share similar strategies, although they are different in the areas of monitoring and restoring comprehension, as well as asking questions to guide searches and navigation. In order to understand an online text, strategies such as skimming and scanning are needed to deal with large volumes of information, as well as having an explicit question in mind to guide the search. Finally, the reader must understand Internet features (e.g. downloads) in order to search for and access information.

Finally, the PISA ERA test, administered by the Organization for Economic Cooperation and Development (OECD) in 2009, measured the digital skills of students from 16 OECD countries, as well as three non-OECD nations (OECD, 2011). The findings from this study suggested that, although digital and print reading both belong to the same construct and many of the abilities required for the two formats are similar, digital reading requires the reader to incorporate new strategies. For example, information gathering requires fast reading skills, such as skimming and scanning, for large volumes of material whose credibility must be evaluated on the spot. It also suggests that critical thought is more relevant for digital literacy than for print reading (Halpern, 2008; Shetzer and Warschauer, 2000). In fact, an analysis of the PISA ERA 2009 results found that this test and the print PISA reading exam (administered in the same year) were strongly correlated (equivalent to a correlation of 0.83). However, this relationship was not perfect and the results did indicate some differences between the two formats. Furthermore, some countries showed strong disparity between the average results on the two tests (OECD, 2011).
The specific relationship between print and digital mathematics has been explored less. Nevertheless, the research highlights two main findings. The first is that visual-spatial representations are used extensively in mathematics and that spatial ability is highly correlated with success in mathematics education (Stravidou & Kakana, 2008; Bull et al., 2008; Shah & Hoeffer, 2002; Reukhala, 2001; Hegarty & Kozhevnikov, 1999; Flannery & Watson, 1991; Tartre, 1990; Eliot & Smith, 1983; Guay & McDaniel, 1977). The second is that visual-spatial representations, or so-called *graphicacy*, are playing an increasingly important role in digital environments (Stern et al., 2003; Mayer, 2009; Leu et al., 2004). For example, a relationship has been found between visual-spatial capacity and hypertext reading, specifically regarding the role of visual-spatial capacity in keeping track of link structures during navigation (Rouet et al., 2012).

The 2011 ICT SIMCE measured a set of skills that are relevant for effective performance in the digital realm. Many of these are related to the skills measured by the Language and Mathematics SIMCE tests. This is especially true of problems where the use and production of information requires skills in the area of reading comprehension, or when representing data in tables or charts requires an understanding of numerical information. In this sense, tasks carried out in digital contexts draw directly from skills required when working with printed texts. Therefore, the third study of this thesis aims to examine the relationship between student performance on the 2011 ICT SIMCE and their performance on the 2005 and 2009 Language and Mathematics SIMCE tests. More specifically, the aim is to understand this relationship longitudinally; i.e., the effect of previously acquired language and mathematics skills on student performance on a digital skills test. This is done by using panel data with three measurements within a 6 year timeframe. The time component is particularly relevant as research has shown that it acts as a form of capital that can be translated into academic success over the years, at least in the case of language (Crook, 1997; De Graaf, 2000; Sullivan, 2001).
Pierre Bourdieu & Passeron referred to this phenomenon as ‘linguistic capital’. They described it as something that was gradually acquired by spending time with family members and in educational environments, as well as the unique opportunities provided to each individual. The aim is therefore to understand if language and mathematics skills acquired in the first and second cycles of primary education are an important predictor of future student performance in the digital environment.

1.2.5 The role of a student’s Economic, Social and Cultural Status in digital literacy

Finally, to understand digital literacy in the field of education, it is also important to examine the role played by a student’s economic, social and cultural status (ESCS). Research on the differences in student learning outcomes has strongly focused on the role played by this variable. The impulse for this research came partly from two important projects: the Coleman Report in the USA (Coleman et al., 1966) and the Plowden Report in Great Britain (Peaker, 1971). Broadly, these reports concluded that the family context was more important than school-level factors in determining student achievement at school. Initially, the family context was restricted to economic and social status (measured by income, education, and occupation of the parents). However, the definition has become more complex over time, as research has found evidence that factors such as educational resources at home and family social and cultural capital have an independent influence on student educational outcomes (Sullivan, 2001; Buchmann, 2002; Sirin, 2005). Studies in various areas of performance, particularly in mathematics and language, consistently demonstrate the relevance of these factors in determining the difference in performance by students (Bradley and Corwyn, 2002; Sirin, 2005; Schulz, 2005; Dahl and Lochner, 2005; Starkey and Klein, 2008; Sirin, 2005; Perry and McConney, 2013; OECD, 2013).
As Manuel Castells (2001) argues, even though research is scarce in these topics, it is foreseeable that in a context where the capacity to process information on and using the Internet is crucial, children from disadvantaged families may be left behind. This is because their classmates may have a larger capacity to process information thanks to their exposure to a richer cultural environment. For students in similar intellectual and emotional conditions, differences in terms of learning capacity are related to the cultural and educational level of the family (p.326).

It is this problem that provides the impetus for the fourth study of this thesis. This study aims to understand whether ESCS has the same effect on student performance on digital skills tests as it does on performance on language and mathematics tests. In other words, the question is whether student performance in the digital realm is more or less equitable than performance in the more classical domains of language and mathematics.

1.3 Research Hypotheses

The research hypotheses of this thesis are the following:

1) It is possible to define and measure the digital skills of 10th grade students (15 years old) in Chile by developing a performance-based digital test that simulates ICT applications and items that emulate real-life schoolwork tasks.

2) Chilean students’ performance on the pilot digital skills test is associated with factors relating to ICT and socio-demographics.

3) There are items (tasks) on the national Chilean digital skills test (2011 ICT SIMCE) that better discriminate students’ digital skills than others.

5) Economic, Social and Cultural Status (ESCS) is more strongly related to student performance on national language and mathematics tests (2009 Language and Mathematics SIMCE) than on the national digital skills test (2011 ICT SIMCE).

1.4 Research Questions

In relation to the hypotheses detailed above, the research reported in this thesis has been driven by the following research questions:

1) Which digital skills should Chilean students master in 10th grade (age 15)?

2) How do 10th grade students in Chile perform on the pilot test developed to measure their digital skills and what factors relating to ICT and socio-demographics best explain their performance?

3) Which types of items (tasks) best discriminate performance by 10th grade students in Chile on a digital skills test?

4) What is the relationship between the performance by 10th grade students in Chile on the national digital skills test (2011 ICT SIMCE) with their previous performance on national language and mathematics tests (2005 and 2009 Language and Mathematics SIMCE tests)?

5) What is the marginal effect of a 10th grade Chilean student’s economic, social and cultural status on their performance on the national digital skills test (ICT
versus their performance on the national language and mathematics tests (2009 Language and Mathematics SIMCE)?

1.5 Objectives
The specific research objectives proposed in this thesis are the following:

1) Define the skills to be measured by considering definitions by other countries, the Chilean curriculum framework and research evidence regarding the skills required for digital activities and participate in the development of the pilot performance-based digital skills test for 10th grade students (15 years old).

2) Analyze 10th grade students’ performance on the pilot digital skills test by applying a Rasch Model to the test results and study the factors relating to ICT and socio-demographics that might explain this performance by using regression analysis.

3) Study which types of tasks best discriminate digital skills among 10th grade students in Chile using results from the 2011 ICT SIMCE and applying a Two-parameter Logistic Model analysis (2PL).

4) Study the relationship between 10th grade students’ performance on the national digital skills test (2011 ICT SIMCE) and their previous performance on the 2005 and 2009 Language and Mathematics SIMCE tests by applying a Hierarchical Linear Model.

5) Compare and analyze the marginal effect of economic, social and cultural status on the results of a single group of Chilean students on the national digital skills test (2011 ICT SIMCE) and the 2009 Language and Mathematics SIMCE by applying multivariate linear regression analysis.
1.6 Results

The research for this thesis produced several results, listed below:

1) A proposal of the digital skills for 10th grade students (15 years old) to be measured by the educational system in Chile.

2) Most 10th grade students in Chile were not proficient in solving information and communication problems in a digital environment. More students were able to solve tasks related to the use of information as consumers than as producers, which requires higher levels of cognitive complexity.

3) Performance by 10th grade students in Chile on the pilot digital skills test was indeed associated with factors relating to ICT and socio-demographics. More specifically, they were positively associated with socioeconomic group, ICT access and frequency of use at home, as well as confidence in performing simple ICT tasks. Gender and ICT use at school were not relevant factors.

4) Some items on the Chilean national digital skills test were indeed better at determining 10th grade students’ digital ability than others. Tasks related to applying criteria or knowledge in order to solve problems relating to basic digital culture and processing information in a digital environment were better at discriminating between different levels of digital proficiency.

5) Previous performance in language and mathematics were indeed both important in explaining the performance by 10th grade students in solving information and communication problems in a digital environment.

6) Previous performance in language was indeed more important in explaining performance by 10th grade student on the national digital skills test.
7) The relevance of performance in language at the end of the first cycle of primary education (4th grade) in performance by 10th grade student on the national digital skills test suggests that linguistic capital is important in the digital realm.

8) The marginal effect of factors related to economic, social and cultural status as a whole on students' digital skills was equal to the effect on mathematics and greater than the effect on language. These findings challenge the belief that the Internet would reduce economic, social and cultural inequalities in new generations. Instead, they reveal that the gap among Chilean students tends to perpetuate or widen when comparing performance in mathematics and language with performance in the digital domain.

1.7 Research Limitations

The research presented in this thesis had some limitations regarding the test instruments and scope of the results.

As it was the first version of the digital skills test, the pilot test had some limitations. The most relevant were, firstly, that the test was too long (two and a half hours), which may have influenced students’ responses towards the end of the test. Secondly, although the test aimed to measure student performance in digital environments, because of the complexity of measuring student performance when collaborating with others, the items only asked students to report about their attitudes and opinions regarding collaboration. Thirdly, the pilot test was unbalanced between items that demanded linguistic, numerical, spatial and social abilities, favoring items that required linguistic abilities. Fourthly, the students’ characterization questionnaire did not include variables to measure the students’ cultural capital (e.g. parents’ level of education, number of books at home, among other indicators) and only included the students’ socioeconomic status (family possessions). Finally, the test did not separately register the students’ ICT
functional skills, limiting the analysis and the ability to report on these skills independently.

Although I participated as an advisor in the development process for the pilot and national digital tests, final decisions rested with the Ministry of Education. Therefore, only some of the limitations identified in the analysis of the pilot test were considered when making improvements to the national version (ICT SIMCE). Among the most important improvements were reducing the test to one and a half hours, eliminating the items for measuring collaboration, and balancing the distribution of items between linguistic, numerical and spatial skills. Social skills were not included on the ICT SIMCE test. Unfortunately, the national test again failed to register functional or operational skills separately, limiting the possibility to analyze these skills independently from information and communication skills.

Even though the three national tests analyzed in this thesis were developed considering international frameworks in the areas of language, mathematics and digital skills (ACE, 2014; Mineduc, 2011), the final format of the three tests are specific to the Chilean educational context. Therefore, to check the scope of the findings of this thesis, it would be necessary to perform international studies and analyze these relationships across different countries. In this sense, the International Computer and Information Literacy Study (ICILS) in which Chile participated represent an excellent opportunity. An international report of this study will be released at the end of this year, with the database following in 2015.

Finally, the quantitative approach adopted by this thesis allowed studying general relationships between student performance on the digital skills tests and related factors to be studied. Nevertheless, to understand some of these findings in more depth, this quantitative approach should be complemented with qualitative studies. Qualitative studies could provide descriptive data related to teacher and student
digital skills and attitudes. Examples of this could include teacher and student activities and motivations when working with digital information, how teachers support and guide students in their work with digital information, as well as strategies to promote digital skills in schools, among others.

1.8 Thesis Outline

This thesis is structured in three self-contained chapters, each of them being a paper submitted or published in a refereed journal. One of the papers has been published as the time of this writing. The listing of the subsequent chapters of this thesis is as follows:

Chapter 2: Assessment of 21st Century ICT Skills in Chile: Test Design and Results from High School Level Students. Claro, M., Preiss, D., San Martín, E., Jara, I., Hinostroza, J.E., Valenzuela, S., Cortes, F. & Nussbaum, M. Computers & Education, 59 (2012) 1042–1053. This chapter reports on the definition of digital skills for the Chilean context and analyzes the ICT-related and socio-demographic factors that explain students’ performance in the first instrument built to measure these skills in the Chilean education system that later became a national test (SIMCE ICT).

Chapter 3: Understanding digital ability: A test items discrimination analysis of a national digital skills test and a longitudinal study on the relationship between digital ability and language and mathematics performance. San Martin, E., Claro, M., Cabello, T., Preiss, D. & Nussbaum, M. Computers & Education, under review. This chapter reports two studies: the first one that analyses which types of tasks best discriminate 10th grade Chilean students’ digital performance as measured in SIMCE ICT, and the second one, that studies the relationship between students’ performance in the national digital skills test (SIMCE ICT) and their performance in language and mathematics national tests (SIMCE Language and SIMCE Mathematics, respectively).

Chapter 4: Comparing marginal effects of Chilean students' economic, social and cultural status on digital versus reading and mathematics performance. Claro, M., San
Martin, E., Cabello, T., & Nussbaum, M. Computers & Education, under review. This chapter reports on the study that compares the role-played by students’ economic, social and cultural (ESCS) in their performance in the digital skills test and their performance in language and mathematics national tests.

1.9 Thesis Structure

This thesis is structured around the research objectives mentioned above. The structure of this thesis is summarized in Table 1-1: Summary table detailing the hypotheses, questions, objectives, papers and results presented in this thesis. shows the connection between the hypotheses, research questions, objectives, papers and results. Next, the relationship between the documents and results are analyzed.

Table 1-1: Summary table detailing the hypotheses, questions, objectives, papers and results presented in this thesis.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>It is possible to define and measure the digital skills of 10th grade students (15 years old) in Chile by developing a performance-based digital test that simulates ICT applications and items that emulate real-life schoolwork tasks.</td>
</tr>
<tr>
<td>H2</td>
<td>Chilean students’ performance on the pilot digital skills test is associated with factors relating to ICT and socio-demographics.</td>
</tr>
<tr>
<td>H3</td>
<td>There are items (tasks) on the national Chilean digital skills test (2011 ICT SIMCE) that better discriminate students’ digital skills than others.</td>
</tr>
<tr>
<td>H4</td>
<td>Chilean students’ performance on the national digital skills test (2011 ICT SIMCE) is more strongly related to their previous performance on national language tests (2005 and 2009 Language SIMCE) than on national mathematics tests (2005 and 2009 Mathematics SIMCE).</td>
</tr>
<tr>
<td>H5</td>
<td>Economic, Social and Cultural Status (ESCS) is more strongly related to student performance on national language and mathematics tests (2009 Language and Mathematics SIMCE) than on the national digital skills test (2011 ICT SIMCE).</td>
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</tbody>
</table>
### Research Questions

<table>
<thead>
<tr>
<th>Q1</th>
<th>Which digital skills should Chilean students master in 10th grade (age 15)?</th>
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<tbody>
<tr>
<td>Q2</td>
<td>How do 10th grade students in Chile perform on the pilot test developed to measure their digital skills and what factors relating to ICT and socio-demographics best explain their performance? and what ICT-related and socio-demographic factors explain their performance?</td>
</tr>
<tr>
<td>Q3</td>
<td>Which types of items (tasks) best discriminate performance by 10th grade students in Chile on a digital skills test?</td>
</tr>
<tr>
<td>Q4</td>
<td>What is the relationship between the performance by 10th grade students in Chile on the national digital skills test (2011 ICT SIMCE) with their previous performance on national language and mathematics tests (2005 and 2009 Language and Mathematics SIMCE tests)?</td>
</tr>
<tr>
<td>Q5</td>
<td>What is the marginal effect of a 10th grade Chilean student’s economic, social and cultural status on their performance on the national digital skills test (ICT SIMCE 2011) versus their performance on the national language and mathematics tests (2009 Language and Mathematics SIMCE)?</td>
</tr>
</tbody>
</table>

### Objectives

<table>
<thead>
<tr>
<th>O1</th>
<th>Define the skills to be measured by considering other country’s definitions, Chilean curriculum framework and research evidence about the skills required for digital activities and participate in the elaboration of the pilot performance-based digital skills test for 10th grade (15-year-old) students.</th>
</tr>
</thead>
<tbody>
<tr>
<td>O2</td>
<td>Analyze 10th grade students’ performance on the pilot digital skills test by applying a Rasch Model to the test results and study the factors relating to ICT and socio-demographics that might explain this performance by using regression analysis.</td>
</tr>
<tr>
<td>O3</td>
<td>Study which types of tasks best discriminate digital skills among 10th grade students in Chile using results from the 2011 ICT SIMCE and applying a Two-parameter Logistic Model analysis (2PL).</td>
</tr>
<tr>
<td>O4</td>
<td>Study the relationship between 10th grade students’ performance on the national digital skills test (2011 ICT SIMCE) and their previous performance on the 2005</td>
</tr>
</tbody>
</table>
and 2009 Language and Mathematics SIMCE tests by applying a Hierarchical Linear Model.

O5 Compare and analyze the marginal effect of economic, social and cultural status on the results of a single group of Chilean students on the national digital skills test (2011 ICT SIMCE) and the 2009 Language and Mathematics SIMCE by applying multivariate linear regression analysis.

Papers

P1 Assessment of 21st Century ICT Skills in Chile: Test Design and Results from High School Level Students.

P2 Understanding digital ability: A test items discrimination analysis of a national digital skills test and a longitudinal study on the relationship between digital ability and language and mathematics performance.

P3 Comparing marginal effects of Chilean students' economic, social and cultural status on digital versus reading and mathematics performance.

Results

R1 A proposal of the digital skills for 10th grade students (15 years old) to be measured by the educational system in Chile.

R2 Most 10th grade students in Chile were not proficient in solving information and communication problems in a digital environment. More students were able to solve tasks related to the use of information as consumers than as producers, which requires higher levels of cognitive complexity.

R3 Performance by 10th grade students in Chile on the pilot digital skills test was indeed associated with factors relating to ICT and socio-demographics. More specifically, they were positively associated with socioeconomic group, ICT access and frequency of use at home, as well as confidence in performing simple ICT tasks. Gender and ICT use at school were not relevant factors.

R4 Some items on the Chilean national digital skills test were indeed better at determining 10th grade students’ digital ability than others. Tasks related to applying criteria or knowledge in order to solve problems relating to basic digital culture and processing information in a digital environment were better at
| R5  | Previous performance in language and mathematics were indeed both important in explaining the performance by 10th grade students in solving information and communication problems in a digital environment. |
| R6  | Previous performance in language was indeed more important in explaining performance by 10th grade student on the national digital skills test. |
| R7  | The relevance of performance in language at the end of the first cycle of primary education (4th grade) in performance by 10th grade student on the national digital skills test suggests that linguistic capital is important in the digital realm. |
| R8  | The marginal effect of factors related to economic, social and cultural status as a whole on students' digital skills was equal to the effect on mathematics and greater than the effect on language. These findings challenge the belief that the Internet would reduce economic, social and cultural inequalities in new generations. Instead, they reveal that the gap among Chilean students tends to perpetuate or widen when comparing performance in mathematics and language with performance in the digital domain. |

Figure 1-1 Summary diagram presenting the relationship between the hypotheses, questions, objectives, papers and results presented in this thesis presents the connection among the hypotheses, research questions, objectives, papers and obtained results.
In relation to hypothesis H1, i.e., “It is possible to define and measure the digital skills of 10th grade students (15 years old) in Chile by developing a performance-based digital test that simulates ICT applications and items that emulate real-life schoolwork tasks.” and the related research question Q1 and objective O1, paper P1 presents a definition of the skills to be measured in the Chilean educational system by considering other national definitions, Chilean curriculum framework and research evidence about the skills required for digital activities (result R1). Regarding hypothesis H2, i.e., “Chilean students’ performance in the pilot digital skills test is associated to ICT-related (access and use) and socio-demographic factors”, and the linked research question Q2 and research objective O1, paper P1 also presents first, an analysis of 10th grade (15-year-
old) students performance in the pilot digital skills test by applying a Rasch Model to the test results and finds that most students were not proficient in solving information and communication problems in digital environment (result R2). Second, paper P1 also presents the study of the ICT-related and socio-demographic factors that may explain this performance by applying a regression analysis and finds that factors positively associated with test results were socioeconomic group, ICT access and frequency of use at home and confidence in performing simple ICT tasks (result R3).

With respect to hypothesis H3, i.e., “There are items (tasks) on the national Chilean digital skills test (2011 ICT SIMCE) that better discriminate students’ digital skills than others” and the linked research question Q4 and research objective O4, paper P2 presents the analysis of the types of test items that best discriminate students’ digital ability by applying a 2PL model and finds that those related to applying criteria or knowledge to solve problems related to basic digital culture and information processing in digital environment present the highest discrimination parameters (result R4). In relation to H4, i.e., “Chilean students’ performance on the national digital skills test (2011 ICT SIMCE) is more strongly related to their previous performance on national language tests (2005 and 2009 Language SIMCE) than on national mathematics tests (2005 and 2009 Mathematics SIMCE).” and the linked research question Q4 and research objective O4, paper P2 also describes the study of the relationship between 10th grade Chilean students’ performance in the national digital skills test (SIMCE ICT) with their previous performance in the SIMCE Language and SIMCE Mathematics tests at the end of the first and second cycles of primary education, by applying a Hierarchic Linear Model analysis. The paper present three relevant results R5, R6 and R7 that show an important relationship between students’ language and mathematics performance, particularly language performance, with students’ digital skills performance test.

Finally, in relation to hypothesis H5, i.e., “Economic, Social and Cultural Status (ESCS) is more strongly related to student performance on national language and mathematics tests (2009 Language and Mathematics SIMCE) than on the national digital skills test
(2011 ICT SIMCE)” and the related research question Q5 and research objective O5, paper P3 presents a study that compares and analyzes the marginal effect of social, economic and cultural status in the results of one same group of Chilean students in the national digital performance test (SIMCE ICT) and in SIMCE Language and SIMCE Mathematics national tests by applying a multivariate linear regression analysis. The paper presents an important result R8 that denies the hypothesis and shows that economic, social and cultural inequality in the digital skills test results is equal than mathematics and greater than language.
2 ASSESSMENT OF 21ST CENTURY ICT SKILLS IN CHILE: TEST DESIGN AND RESULTS FROM HIGH SCHOOL LEVEL STUDENTS.

2.1 Abstract

This paper describes a study that evaluates fifteen-year-old (10th grade) Chilean students Information and Communication Technology (ICT) skills. The paper presents an operational definition of ICT skills, an instrument measuring these skills as well as the students’ results in the test. The definition of ICT skills used considers Chile’s curricular framework, functional and cognitive skills. Specifically, ICT skills were defined as the capacity to solve problems of information, communication and knowledge in digital environments. A performance-based assessment was designed in a virtual environment to measure these skills. The analysis of the results showed that, the majority of students were able to solve tasks related to the use of information as consumers, this is, approximately three quarters of the students were able to search for information and half of them were also able to organize and manage digital information. Additionally, they show that very few students were able to succeed in tasks related to the use of information as producers, this is, only one third of the students were able to develop their own ideas in a digital environment and less than one fifth were able to refine digital information and create a representation in a digital environment. Socio-economic group, access, daily use and confidence in doing ICT related activities were all positively associated with higher scores, showing the need to implement strategies to compensate this inequality, possibly by explicitly defining these aims in the national curriculum.

2.2 Introduction

During the last two decades the Chilean Ministry of Education has developed a policy called Enlaces (Links) to implement Information and Communication Technologies (ICT, hereafter) at schools. The policy’s goal has been to improve the equity and quality of the education system by building a national network to support learning and develop ICT skills in schools (Rusten et al, 1999; Hepp, 2003; Hinostroza et al. 2008; Sánchez &
Salinas, 2008; Toro, 2010; Blignaut et.al., 2010). Since 1993 Enlaces has equipped schools with computers, local networks, educational resources, productivity software, free or subsidized Internet access, as well as provided technical and pedagogical support in partnership with 24 universities from across the country (Donoso, 2010; Sánchez & Salinas, 2008). Starting from 2007, the Chilean policy defined a specific plan named “Technologies for quality education” that considers four strategies: (a) an ICT-Use Plan, where each school defines some commitments regarding the use of ICT in areas such as teaching, learning and management; (b) the reduction of the digital gap, that consists in the provision of ICT infrastructure ad the development of an ICT infrastructure management plan; (c) the development of digital competencies and skills in students and teachers; and (d) the provision of digital educational resources that can be used to deliver the curriculum (Blignaut et.al., 2010). Thanks to Enlaces, by 2010 90% of students going to publicly financed schools had access to computers, 60% of schools had Internet access, 110.000 teachers had been trained to use computers as a part of their instruction process, and the country reached a national average of 9,8 students per computer in schools (Donoso, 2010).

In this paper we describe a study implemented during 2009 with the goal of analysing the effects of Enlaces’ policy in the development of Chilean students’ ICT skills. Since 1998 for secondary education and 2008 for primary education, these skills have been officially integrated to the curriculum in Chile as a cross-disciplinary set of aims to be accomplished within traditional subject areas, with an emphasis on computer literacy or ICT functional skills -that is, students’ mastery of ICT applications. Notwithstanding this focus on functional skills, this study adheres to a broader notion of ICT literacy that goes beyond technical skills and considers students higher-order cognitive skills in an ICT context. In so doing the study is aligned with the notion advanced during the last decade that the impact ICT have on human abilities should be related to the broad spectrum of abilities needed in contemporary society.
As noted by Preiss and Sternberg (2006), the malleable nature of information technology has challenged the development of static definitions of computer literacy or related constructs. To illustrate, during the 80s Norman (1984) stated that there was no straightforward notion of what computer literacy involves and proposed four levels of computer literacy: first, understanding the general principles and concepts of computation; second, understanding how to use computers; third, understanding how to program computers and, four, understanding the science of computation. According to him, the average person would only need to manage the first two levels while the other two would probably be a specific domain of expertise. He was right. During the 90s, researchers realized that a full understanding of the impact of ICT on human skills involved going beyond specific user-level technical skills. Thus, the term “computer literacy” was used to draw attention to the fact that paper-related skills such as writing and reading were not enough to be a ‘productive citizen’ in the information society (Reinking, 1998; Tuman, 1992). In fact, to define who is computer-literate is more difficult than to define who is literate because there are no paradigmatic skills, such as reading and writing, in the arena of computers. Next, a broader concept of ICT literacy that transcends technical ICT skills was brought into attention. This concept emerges from the 21st century skills frameworks, and it is supported by evidence showing that labour markets do not value technical skills per-se but higher-order cognitive abilities, especially in the context of ICT use. For the educational sector, the demand for high skilled workers placed by the economic sector, triggers the need to develop a high quality workforce that not only possesses a strong foundation in traditional literacy skills (reading, writing and mathematics) but is also able to solve non-routine problems and deal with complex information often presented in digital environments (Levy & Murnane, 2007).

An important part of the contemporary debate addresses the current and future role of ICT in the school curriculum. As noted, initial efforts focused in defining a set of ICT skills associated to mastering technology. This approach -often called Computer literacy, ICT Literacy or ICT Functional Skills- defined skills related to the use of ICT
applications, and have considered that these technologies are a complement of traditional numeracy and literacy skills. These computer skills are frequently taught as a separate subject and there are several examples of instruments to measure them, such as ECDL in Europe, Australian ICT Skills, and UNESCO Bangkok. Yet, some countries and international efforts have claimed that if we are to understand the role of ICT in human development we need to go beyond the functional definition of ICT skills as mastering ICT applications and to adopt a wider definition that considers the use of these tools within the context of everyday complex cognitive problem solving (Fraillon & Ainley, 2010; MCEETYA 2008, OECD, 2010a). For example, the OECD Programme for the International Assessment of Adult Competencies (PIAAC), claims that adults should have the skills and competencies to solve problems and accomplish complex tasks in technology-rich environments. This means considering ‘(...) not just basic proficiency but also higher-order skills necessary to work out an information need, evaluate information critically and use information to solve problems’ (OECD, 2010a: 7).

In summary, the initial approach to the definition of ICT skills is shifting from a restricted functional orientation towards a wider orientation that considers ICT skills relevant for productive participation in all areas of contemporary social life. Therefore, ICT literacy relies on, and brings together, computer literacy skills (i.e., functional technical abilities) and information and communication literacy skills (i.e. higher-order thinking processes related to critical and creative use of information, such as searching and evaluating information, exchanging information or developing ideas in a digital context).

This study is interested in assessing ICT literacy in the broader context posed by the 21st century framework. Thus, we define ICT literacy as the capacity to solve problems of information, communication and knowledge in digital environments. This definition has the following characteristics:
1) The mastery of ICT applications (i.e. functional ICT skills) is a condition to solve cognitive tasks in a digital environment. Without the technical skills to use ICT applications, students cannot solve cognitive tasks in digital environments.

2) The skills are not technology-driven, as they do not refer to the use of any particular software, but to the problem solving of information, communication and knowledge tasks in an ICT context.

3) The higher-order thinking processes included are supported and contained by general ICT applications.

4) The skills are related to cognitive processes favoring students’ continuous learning and, therefore, are those relevant to learning contexts in the knowledge society.

The two last characteristics rest in two important ideas related to the meaning of learning in digital contexts. The first idea is that an effective use of ICT in learning activities enhances the development of higher-order thinking skills. Research shows that computers can be used as “mental tools” for the development of higher-order thinking skills. These tools include applications such as databases, spreadsheets, modeling tools, instruments for the creation of hypermedia and Web 2.0 participation platforms. All these tools allow students to represent what they have learned using different representation formats and engaging their higher-order thinking abilities, such as evaluation, analysis, synthesis, design, problem-solving and decision-making (Balanksat et.al, 2006; Bers, 2010; Kim et al. 2009; Lajoie, 2005; Kirriemur & McFarlane, 2004; Spence & Feng, 2010; Preiss & Sternberg, 2006). The second idea is that as students apply higher-order thinking skills in digital environments, they are also more capable of making informed decisions about how, why, and when to use digital resources to support their learning process, which in turn constitutes one of the grounds for enabling more effective learning and participation in contemporary society (Hague & Williamson, 2009).

Three main questions guided this study:
1) Which are the ICT Skills for Learning that Chilean students should master at the age of 15?

2) How do 15-year-old Chilean students perform in the test developed to measure these skills?

3) What is the relationship between ICT-related and socio-demographic factors to 15-year old Chilean students’ performance in the test?

This paper is organized as follows. Next we present the set of ICT Skills for Learning for Chilean Students as well as the main characteristics of the instrument designed to measure these skills. In the results section, we report on the psychometric characteristics of the test, including a factorial analysis of the underlying structure of it, and analyze if the test actually measured something different from a classical IQ test. Also, the results section presents the performance of the students in the tests as well as Chilean students’ characteristics in terms of ICT access and use; students’ performance in the test using a Rasch model and regression models. Finally, in concluding we discuss the implications of the main results and findings.

2.3 ICT Skills for Learning for Chilean Students

In this section we present the set of ICT Skills for Learning for Chilean Students defined as part of this study and describe the criteria used to select the dimensions, sub-dimensions and skills included. The set of ICT Skills for Learning for Chilean Students was elaborated and adapted based on three types of sources:

1) Other national evaluations: The iSkills-ETS from the USA, Key Stage 3 ICT from the United Kingdom, and ICT Literacy from Australia (MCEETYA, 2008, 2005).

2) The Chilean curricular framework, specifically, the curriculum’s cross-disciplinary aims (Mineduc, 2009): These aims relate to students general education and, because of their nature, cross all disciplinary sectors of the
school curriculum. They are comprehensive in character and oriented to personal development, as well as to students’ moral and social conduct.

3) Research evidence providing empirical support about the skills and competencies being developed by young students as a consequence of the use of ICT inside and outside school, looking for empirical support for skills and associated abilities. At the same time, evidence regarding the level of access and use of technology among Chilean students was considered (Enlaces, 2005; Garcia, Nussbaum & Preiss, 2011; Injuv, 2007; IGD, 2009).

The Set of ICT Skills for Learning was framed within three dimensions, with two sub-dimensions each, as follows:

1) Information Fluency. The information explosion led by ICT demands new abilities to search, select, evaluate, and organize information in digital environments (Catts and Lau, 2008). But in a knowledge society it is not enough to be able to process and organize information: it is also necessary to transform information in order to create new knowledge or to use ICT fluency/skill in sourcing for information for new ideas. Research shows that varied ICT applications make up a particularly appropriate environment to develop higher-order abilities necessary to work with information and knowledge such as organization skills, critical analysis, problem-solving and creativity (Cox, 2003; Bers, 2010; Kim et al., 2009; Balanksat et.al., 2006; Kirriemuir & McFarlane, 2004; Sefton-Green, 2003; Spence, 2010; Rosas et.al. 2002). Thus, this dimension considered two sub-dimensions:

   a. ICT fluency /skill in sourcing for information; which includes the abilities to search, select, evaluate, organize and manage digital information;
b. ICT skills in processing information, that considers the abilities to analyse, refine, and represent information, generate new information and develop own ideas.

2) Effective Communication. Communication and collaboration play an important role in the preparation of students to be not only learners, but also members of a larger community with voice and a sense that they can make a contribution. Therefore, the skills included in this dimension should be seen as social skills, where the ability to interact and contribute within a group or community is as important as using the skill for personal expression (Hague & Williamson, 2009; Jenkins et al., 2006). Research in this field suggests that the varied applications of ICT strengthen and increase the possibilities of communication and reinforce the development of skills of coordination and collaboration between peers (Dede, 2006; Dieterle, 2009; Kirriemuir & McFarlane, 2004; Squire, 2003; Zurita & Nussbaum, 2004). In addition, ICT are used in many ways with communication ends, such as writing e-mails and participating in chats (OECD, 2011). This dimension is divided in two sub-dimensions:

a. ICT skills in effective communication; that considers the ability to transmit information to others, ensuring that the meanings are communicated effectively by taking into account media and recipient.

b. ICT skills in collaboration and virtual interactions; that includes the ability to interact in virtual networks and to use ICT to exchange information, negotiate agreements, and make decisions with peers within mutual respect for ideas.

3) Ethics and Social Impact Dimension. ICT deliver information and tools to young people that allow them to think about their responsibilities towards other people and their place in a digital world. The ICT skills included would contribute to the general ethical formation (or citizenship) of students through
the specific ethical dilemmas posed by ICT in a knowledge society. Additionally, there is an emerging concern in the international community regarding the safety use of Internet (digital safety), including not only children’s access to inadequate digital contents or services on the Internet or other digital medias such as mobile phones, but also the access to children that unwanted individuals gained through these media (Gasser et.al. 2010). As with the previous dimensions, two ethical sub-dimensions were defined:

a. Ability to evaluate ICT responsible use, which considers the ability to decide about the legal, ethical and cultural limits (boundaries) of personal and social responsible use of ICT, by understanding potential risks (at personal, social and technical levels) that are to be found in the Internet.

b. Ability to evaluate ICT social impact; that includes the ability to understand, analyze and evaluate the impact of ICT in social, economic and cultural contexts.

2.4 Methods and Instruments

2.4.1 Sample

The test was applied between October and November of 2009 to a sample of 15 years old students attending private and state subsidized schools with different educational modalities (oriented to further university studies or to technical profession) and located in the three regions with the highest population, located in the center of the country. To ensure representation, they were selected using a stratified probabilistic sample design so that the samples were proportionate to the stratified populations. As Table 2-1: Final sample of schools and students shows, the final sample was composed of 1.185 students; the sizes of the sampling error ensure that the sample of students under study is representative of the geographical locations where the sample was selected.
Table 2-1: Final sample of schools and students

<table>
<thead>
<tr>
<th>Region</th>
<th>Nº of Schools</th>
<th>Nº of Students</th>
<th>Sampling Error (95% confidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metropolitana</td>
<td>63</td>
<td>755</td>
<td>+3.6%</td>
</tr>
<tr>
<td>Valparaíso</td>
<td>19</td>
<td>195</td>
<td>+7.0%</td>
</tr>
<tr>
<td>Bio-Bío</td>
<td>23</td>
<td>235</td>
<td>+6.4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School Administration</th>
<th>Nº of Schools</th>
<th>Nº of Students</th>
<th>Sampling Error (95% confidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal</td>
<td>37</td>
<td>395</td>
<td>+4.9%</td>
</tr>
<tr>
<td>Private subsidized</td>
<td>58</td>
<td>679</td>
<td>+3.8%</td>
</tr>
<tr>
<td>Private</td>
<td>10</td>
<td>111</td>
<td>+9.3%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Educational Modality</th>
<th>Nº of Schools</th>
<th>Nº of Students</th>
<th>Sampling Error (95% confidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humanistic-Scientific</td>
<td>54</td>
<td>589</td>
<td>+4.0%</td>
</tr>
<tr>
<td>Technical Profession</td>
<td>25</td>
<td>304</td>
<td>+5.6%</td>
</tr>
<tr>
<td>Mixed</td>
<td>26</td>
<td>292</td>
<td>+5.7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School Size</th>
<th>Nº of Schools</th>
<th>Nº of Students</th>
<th>Sampling Error (95% confidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 49 15y students</td>
<td>18</td>
<td>184</td>
<td>+7.2%</td>
</tr>
<tr>
<td>50 to 103 students</td>
<td>23</td>
<td>237</td>
<td>+6.4%</td>
</tr>
<tr>
<td>104 to 223 15y students</td>
<td>38</td>
<td>445</td>
<td>+4.6%</td>
</tr>
<tr>
<td>224 and more</td>
<td>26</td>
<td>319</td>
<td>+5.5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>Nº of Schools</th>
<th>Nº of Students</th>
<th>Sampling Error (95% confidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td>101</td>
<td>594</td>
<td>+4.0%</td>
</tr>
<tr>
<td>Boys</td>
<td>97</td>
<td>591</td>
<td>+4.0%</td>
</tr>
<tr>
<td>Total</td>
<td>105</td>
<td>1.185</td>
<td>+2.8%</td>
</tr>
</tbody>
</table>

2.4.2 Instruments and procedure

Since performance-based assessments are generally built of tasks that require students to perform an activity or construct a response (Linn, 1993), for this study the performance-based assessment test (i.e. the ICT Skills for Learning Test; hereafter, ICTSfL test) was designed as a virtual environment mirroring the actual environment where these skills are used. Therefore, a piece of software was developed that simulated ICT applications and the tasks designed emulated real-life schoolwork situations. More specifically, the software presented, in a closed environment, the applications most commonly used in
schools - that is, a virtual desk, an e-mail administrator, an Internet browser, a text processor, a spreadsheet and a program for presentations. Additionally, a chat window was incorporated where a virtual conversation among three young classmates was simulated. During the flow of this conversation, the student was assigned with different tasks to perform using the tools available in the simulated environment.

The test was organized around three big tasks related to each of the dimensions defined: Information, Communication, and Ethics and Social Impact. In order to ensure the flow of the activities between tasks, a general script (story) was defined using a common theme (ecology) and in each task, the student was faced with different situations, which were designed to test his or her ICT for Learning skills. In the first task, related to the Information dimension, the student was asked to do different activities in order to participate in a campaign for the protection of species near extinction; in the second task, related to Communication dimension, the student was asked to prepare a working document about global warming; and in the third task, related to Ethics and Social Impact dimension, the students had to recognize risky behaviors in virtual environments and analyze the impact of Internet in different dimensions of life. Since it is a topic widely discussed and debated in contemporary society we decided for global warming as a topic to motivate students to express an opinion and engage in exchanging ideas about a social issue. Good effective communication on global warming involved capitalizing on scientific evidence presented in graphs, text and images; analyzing and putting this evidence in context by considering other sources of information; and discussing its implications with their virtual classmates. It also involved being able to communicate their conclusions to specific audiences by for example posting their ideas in a forum. Although the assessment simulated a collaboration virtual environment where students worked and discussed with their virtual classmates, constrained by the limitations of a large-scale standardized assessment actual collaboration skills could only be evaluated at a declarative level.
Additionally, while the student was undertaking these tasks, other requirements emerged, associated to different ICT for learning skills: for example, dealing with a virus or interacting with others to handle some issue that emerged from school work in other areas. Figure 2-1 represents an example of one of the tasks in the test, in which students had to make a graph in a spreadsheet about the major causes of species in extinction. This application, specially designed for the test software, contained the typical tools to develop a graph from numeric data in spreadsheet software. In the task of the example, one of the virtual classmates sent a spreadsheet file to the student through the chat application. In this spreadsheet there was a table that contained a list of major causes of species’ extinction, and the percentage attributed to each one of them that the student had to analyze. This was one of the tasks designed to measure the skill “Refine and represent digital information”.

![Figure 2-1: Example of a task in the ICTSfL test](image)

Although the majority of the test items included in each task were designed as multiple-choice questions, most of them required the student to use some of the tools of the simulated environment prior to select the alternative (for example, reviewing e-mails received to decide which was most suitable to the task or reading Web pages to indicate which were the most appropriate for searching information about a particular topic, etc.).
The test also included open questions in which the student had to produce something: for example, post an idea in a forum, review or edit a graph or text document, send e-mails, etc. Items based on open questions were included in all sub-dimensions, except ICT fluency/skill in sourcing for information, where the emphasis was placed in students’ activities as ‘consumers’ of information. The number and type of items were assigned considering representation by sub-dimension, skills defined in each sub-dimension and extension of the test overall. The last sub-dimension had only one item because there was only one skill to cover and had a deliberative orientation, so it was measured through a relatively extensive 4 minutes open question. The main characteristics of the test are summarized in a table in Appendix 3.

Also, as part of the application of the test, a students’ characterization questionnaire was administered in order to collect data about students’ features in terms of sociodemographic variables, ICT access and use, and self-perception of ICT skills to analyze possible relations between Chilean students’ ICTsFL skills and their individual and contextual factors. More specifically, it explored for example, how students learned to use ICT and how capable they felt with different ICT tasks, such as write a letter using a word processor, sending an email, organizing files and folders in the computer, designing slideshows, etc.

**2.4.3 Psychometric properties of the ICT Skills for Learning Test**

Next, we report the psychometric properties of the ICTsFL test, namely its factorial structure, test reliability and a summary of its classical test theory (CTT) properties (Crocker & Algina, 2006). This analysis is relevant taking into account that the ICTsFL test is a new instrument. Furthermore, we provide empirical evidence that shows that the ICTsFL test measured something different from a classical standardized test measuring verbal and numerical abilities.
2.4.3.1 Factorial structure and reliability

The dimensions Information and Communication in the ICTSfL test were initially composed of 48 items: 42 were dichotomous items and 6 were open items. The open items were corrected through rubrics and subsequently dichotomized. Taking into account that the ICTSfL test was designed from a theoretical framework of ICT skills, a confirmatory factor analysis was performed in order to establish whether the items composing the test actually measured the constructs developed according to the theoretical framework. Two findings were provided by the confirmatory factor analysis:

1) The items composing the Ethics and Social Impact dimension appeared as a distinct factor from the group of items of the Information and Communication dimensions.
2) The items corresponding to the Information and Communication dimensions did not reproduce the expected factorial structure (did not result in two factors, but in only one factor composed by all Information and Communication items).

This finding lead to perform an exploratory factor analysis of the items related to the Information and Communication dimensions. The polychoric correlation matrix was obtained and subsequently an exploratory factor analysis was conducted. The first factor explained 39% of the variance, whereas the remaining 11 factors explained between 8 and 5 % each. It is important to mention that each of these 11 factors grouped at most three items and, therefore, it becomes very difficult to provide a theoretical interpretation of them. Thus, the dimensions Information and Communication were considered empirically uni-dimensional. Under this assumption (Bechger et al., 2003), the reliability of the test was equal to 0.833. Thus, considering that the items of Information and Communication were grouped in one dimension, separate from the Ethics and Social Impact dimension, for conceptual clarity we decided to focus further analysis and discussion in this first dimension. The theoretical meaning of this dimension is explored below through a Rasch model.
2.4.4 Classical Test Theory (CTT) properties

The CTT properties of an item which are typically reported are the empirical difficulty of the item (i.e., the proportion of examinees who correctly answers the item); the proportion of examinees who omitted to answer the item; and the item-test correlation (i.e., the correlation between the correct alternative of the item and the total score and the correlation between each incorrect alternative of the item and the total score). Item-test correlation captures the effectiveness of an item in discriminating among “good” and “poor” examinees and, therefore, is a rough index of the item discriminating power (Lord & Novick, 2008). From the original 48 items, 40 were retained. The criteria to eliminate items were the following: (1) if the item discriminating power was positive for both the correct alternative of the item and at least one incorrect alternative; (2) if the percentage of omission was higher than 20% for the examinees in the 27% highest-scoring group. The reliability of the reduced test was 0.825. The reliability of the reduced test was 0.825, whereas the initial reliability was 0.833. This shows that the reduced test is still measuring the same dimension as the original test. Table 2-2 shows the distribution of the empirical difficulty of the retained items; each interval of difficulties contains the right-limit, but not its left-limit. Thus, most of the items had difficulties between 30% and 60%.

Table 2-2: Items difficulties

<table>
<thead>
<tr>
<th>Range of Difficulty</th>
<th>Number of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%-10%</td>
<td>1</td>
</tr>
<tr>
<td>10%-20%</td>
<td>1</td>
</tr>
<tr>
<td>20%-30%</td>
<td>8</td>
</tr>
<tr>
<td>30%-40%</td>
<td>10</td>
</tr>
<tr>
<td>40%-50%</td>
<td>12</td>
</tr>
<tr>
<td>50%-60%</td>
<td>6</td>
</tr>
<tr>
<td>60%-70%</td>
<td>1</td>
</tr>
<tr>
<td>70%-80%</td>
<td>1</td>
</tr>
<tr>
<td>80%-90%</td>
<td>0</td>
</tr>
</tbody>
</table>
The item discriminating power indexes of the 40 retained items were between 0.11 and 0.52: 30 items had correlations greater or equal to 0.30, which shows that the ICTSfL was a discriminative instrument.

### 2.4.5 ICTSfL test and classic cognitive abilities

Together with the psychometric properties of the test, a relevant question was whether it actually measured something different from classical cognitive abilities (i.e., verbal and numerical abilities). This hypothesis makes sense, considering that in every item of the ICTSfL-test, a classic ability was required in order to solve the task correctly (higher-order thinking skills are used in a certain classical cognitive domain). In fact, 7 items required a verbal-conceptual ability to be solved; 5 items required a verbal-reading comprehension ability to be solved; 8 items required a verbal development of ideas ability to be solved; and 4 items required a numerical ability to be solved. The correlations between the total score and the sub-scores (namely, the number of correct answers to the items composing each classical ability) were high (verbal-conceptual (0.69), verbal-reading comprehension (0, 72), verbal-development of ideas (0,71) and numerical (0, 62)) but not extremely high (namely, greater than 0.85). This shows that the ICTSfL-test requires this type of abilities, but not exclusively measures them. In fact, as it was described above, the test demanded ICT functional abilities. More specifically, 21 items demanded what could be called Simple ICT abilities (perform tasks that demanded ICT use as a ‘consumer’; such as open and save a document or visit a web page), and 4 items demanded what could be called complex ICT abilities (perform tasks that required using ICT as a ‘producer’; such as creating a representation). The correlation between the test score and the Complex ICT abilities was moderate (0.57), but the correlation with Simple ICT abilities was very high (0.91). This, along with the previous reported correlation, suggests that the test measured a combination of higher-order thinking skills, classical cognitive skills and ICT functional skills.
2.5 Students’ results

In this section, due to space constraints, we describe and analyze the most important results obtained from the students’ characterization questionnaire and the application of the ICTSfL test to the sample of Chilean 15-year old students. This section is organized in three parts: in the first part (4.1) we characterize Chilean students’ access and use of ICT at home and at school. In the second part (4.2), we describe students’ performance following a Rasch model of analysis. And in the third part (4.3), after applying a factorial analysis, we explore which covariates could be related to differences in students’ results in the test.

For the following analysis, two indexes were built:

1) The socioeconomic-group (SEG, hereafter) index was built through a Principal Component Analysis on the following available information: number of cellular phones at students’ the home; number of TVs at students’ home; number of showers at students’ home; and number of personal computers at students’ home. Once the index was obtained, students were classified into five groups using a K-means procedure: low SEG, low-middle SEG, middle SEG, middle-high SEG and high SEG. The indicator performed well in the sense that the higher the index, the higher the economic goods at the student's home. Thus, 7% of the students were classified into the low SEG; 19% at the middle-low SEG; 43% at the middle SEG; 21% at the middle-high SEG; and 10% at the high SEG.

2) Similarly, the confidence in doing ICT tasks index was constructed through a Principal Component Analysis using questions related to confidence in ICT use for different activities. Thereafter the students were classified with respect to this indicator using a K-means procedure. From this analysis emerged two factors: Confidence in doing Simple ICT Tasks, which includes produce a letter using a
word processor (for example: Word), send a document to a classmate by email (for example a home work or a project), take pictures and show them on the computer and save digital documents in folders or sub-folders in the computer); and Confidence in doing Complex ICT Tasks, which includes use a spreadsheet to work on a budget or maintain a list of classmates or friends (for example: Excel), share ideas, knowledge and experiences with other friends or classmates in a discussion group/forum; buy or sell on the Internet; and install a software on a computer.

2.5.1 Students’ Access and Use of ICT

In order to have a closer look at what can be expected in terms of the role played by home and school based ICT use, as well as students’ family and personal characteristics, we will analyze the most interesting data emerged from the students’ characterization questionnaire. For each question about how often students used computers in different locations or for different purposes, there were five possible responses, but the answers were grouped in to three categories:

1. Frequent use: “Almost every day” or “A few times each week”
2. Moderate use: “Between once a week and once a month”
3. Rare or no use: “Less than once a month” or “Never”

This decision was based on both a Principal Component Analysis and a K-means classification procedure. In fact, each question was analyzed through a Principal Component Analysis procedure, obtaining the corresponding scores for each individual. Thereafter, a K-means procedure was applied to these scores: five initial classes (corresponding to the answers categories) were defined, but the K-means procedure converged at three classes. This type of conclusions was also verified through descriptive analysis of the individual PCA-scores.
2.5.1.1 Students’ Access to ICT

In terms of access, three quarters of students evaluated declared to know how to use a computer and the majority (63%) reported to have access to at least one computer at home. Although access at school is still relevant for lower SEGs, we cannot say the same for learning and use of ICT in schools. First, students were asked where did they learn to use computers and the majority (57%) reported that they learned by themselves, one fifth with family members (21%) and only 10% in schools. Second, in terms of frequency of use by location, less than half the percentage of students that reported using computers frequently at home, did so at school (53% and 19%, respectively). Third, it is worrying to notice that frequent use at school is similarly low for all SEGs, whereas students from higher SEGs tend to use computers more frequently at home. This means that students that don’t have access to computers at home are not being adequately compensated at school in terms of frequency of use (Figure 2-2 and Figure 2-3).

Figure 2-2: Percentage of students by frequency of use at school and SEG

Note: Lowest SEG is I and highest SEG is V

Figure 2-3: Percentage of students by frequency of use at home and SEG
2.5.1.2 Students’ types of ICT use

In terms of general ICT types of use, similar percentages of students (between 40% and 50%) reported to use computers frequently for communication, entertainment and school related activities. In terms of ICT related activities at school, students were asked how frequently they did four types of activities: (1) related with collaboration, (2) related with communication, (3) related with developing ideas and (4) related with working with information. Only one fifth of the students reported doing communication activities frequently and a slightly higher percentage reported developing ideas frequently. Similarly, 40% of students reported collaborating and close to 50% reported working with information.

2.5.2 Students’ confidence doing different activities with ICT
Students were also consulted about how confident they felt doing different activities with ICT. Around half of the students reported feeling very confident doing simple activities related to school context, such as look up for information on the Internet or write projects and home works on the computer, while less than one quarter of students reported feeling very confident doing more complex activities such as installing a software or using a spreadsheet program to work on a budget or keep a list of classmates.

In synthesis, the data regarding Chilean 15-year old students access and use of ICT shows that although schools are still important in terms of access to computers for lower SEGs, with regard to frequency and type of use, they do not seem to be playing a significant role.

### 2.5.3 Students’ performance in the ICTSfL test

The objective in this part is to describe Chilean students’ performance in the ICTSfL test. First, we will present the results in terms of students’ scores, and second, they are presented showing what students’ demonstrated they could actually do in the test.

With respect to students’ scores, each student obtained a score from the total number of correct responses. The mean score was equal to 15.8 points, with a standard deviation equal to 6.7; the median was equal to 16 points, the maximum score was equal to 33 points over 40, and the minimum was 0 points. 43.9% of the students obtained a score not greater than the mean, whereas the 0.1% of the students obtained the maximum score.

Figure 2-4 shows the density Kernel estimation of the scores (Silverman, 1986), with a distribution slightly skewed to the left.
However, a relevant problem is to provide an interpretation or substantive meaning to students’ scores, that is, categorize into different levels of proficiency with respect to a particular criterion or set of criteria. The categories are most often dichotomous, such as classifying masters/does not master an item, but they can also be polytomous, such as grading the performance on an exam. Numerous methods, typically called standard setting procedures, have been proposed on how standards can be set to obtain a mastery classification of the respondents of the test (Livingston & Zieky, 1982; Cizek & Bunch, 2006). Most standard setting methods rely on a continuum view of mastery (Meskauskas, 1976), where mastering a trait or educational objective is conceived as a gradual process. This perspective can be combined with the framework of item response theory (IRT) models, notably with the Rasch model (Janssen et al., 2000). The Rasch model was fitted using the procedure proposed by Del Pino et al. (2008). Figure 2-5 summarizes the simultaneous representation of items difficulties and students’ abilities. The abscise corresponds to the common scale of ability and item difficulties. The percentage of students whose general ability to solve information, communication and knowledge tasks is between the difficulties of specific items are reported; thus, for instance, 29.8% of students have a higher ability than the difficulty of the item dealing with “develop own ideas in digital environment” and lower than the difficulty of the
item dealing with “refine and represent digital information”. We say that these students master the item “develop own ideas in digital environment”, but do not master the item “refine and represent digital information”. This simultaneous representation also includes an accumulative aspect. Thus, for instance, the 9.8% of students who master the item “analyze digital information”, also master all the items with lower difficulties.

Figure 2-5: Simultaneous representation of items difficulties and students’ abilities

The Rasch model showed that:
- 72.7% of students can search digital information (e.g. adequately use general and specific search engines).
- 50.9% of the students not only are able to search and select digital information, but also can organize and manage digital information (e.g. search for files and arrange folders in the computer).
- 44.9% of the students not only master the previous two tasks, but are also able to transmit information effectively, this is, select the most adequate media (e.g. blog, social network, email, etc.) and information to communicate something in a digital
environment and can also collaborate and interact in virtual networks (e.g. solve a problem in virtual interaction with others).

- 39.6% of the students not only master the three previous tasks, but are also able to evaluate digital information using a specific criteria related to it’s quality (e.g. authorship, relevance, edition) and also can analyze digital information (e.g. integrate and compare information presented in a digital representation).

- 29.8% of the students not only master the five previous tasks, but are also able to develop their own ideas in a digital environment (e.g. publish a post or write an email adequate in content).

- 17.4% of the students not only master the seven previous tasks, but also are able to refine digital information and create a representation in a digital environment (e.g. synthesize, interpret and represent information using worksheet tools and functions).

- 27.3% of the students do not master any of the previous eight tasks.

Let us mention that the difficulty of the item search digital information corresponds to an observed score of 11 correct answers, whereas the difficulty of the item refine digital information and create a representation corresponds to 22 correct answers. It should be emphasized that the 40 items of the ICTSfL test measure the ability to solve information, communication and knowledge tasks in a digital environment represented on a continuum. Thus, the previous interpretation corresponds to a holistic view of student performance on the test, so the observed score should not be interpreted in relation with the specific items correctly answered by a student, but taking into account the common scale ability-difficulty (San Martin et al., 2009).

Finally, the tasks resulted empirically ordered from lower to higher levels of difficulty. Chilean students seem to be more able as consumers than as producers of information. In fact, approximately three quarters are able to search for information and half of them were also able to organize and manage digital information, while only one third of the students are able to develop their own ideas in a digital environment and less than one fifth can refine digital information and create a representation in a digital environment.
2.5.4 Students’ characteristics and test results

Next, we explore how the variability of students’ scores could be explained by their characteristics in terms of SEG, gender, access and frequency of ICT use at school and at home, and confidence in doing ICT tasks.

A regression analysis showed that access, SEG, frequency of ICT use at home and Confidence in doing ICT Simple Tasks were statistically significant predictors of students’ scores. Gender and ICT use at school were not. In terms of access, a t-test (with equal variances) was performed. The difference in their mean-scores in the test between students that have a PC at home and students’ that do not have one although low, is statistically significant (t-value=-4.80; d.f.=927; p-value < 0.0001). The same conclusion is obtained after performing a t-test with unequal variances (t-value=-5.05; d.f.=290.07; p-value < 0.0001). As to SEG, we found that as students’ SEG increases, their average test scores increase. Students’ in the middle, middle-low and low SEGs do not obtain statistically significant different mean scores (15.9; 14.98; and 14.68, respectively) as well as students’ from middle-high and high SEGs (18.04 and 19.24, respectively). In other words, students are divided in two performance SEGs, only.

With regard to frequency of use, a positive relationship was found between home use and students’ mean scores in the test. The frequency of use at home, together with SEG explains 8.76% of the variation in test results. As in other studies such as PISA (OECD, 2010), here ICT use at home turned to explain more test results than ICT use at school, once controlled by SEG.

Finally, among all, the factor Confidence in Simple ICT Tasks explains the highest percentage of variability in test scores (19.9%). When the SEG is added as an explanatory variable, both explain 21.6% of the variability of test scores, and the relationship with test scores also showed to be positive.
Summarizing, the analysis of students’ characteristics shows that access, SEG, frequency of ICT use at home and confidence in simple ICT tasks are positively related with ICTSfL test scores.

### 2.6 Discussion and conclusions

The first question in this study regarding the ICT Skills for Learning Chilean students should master at the age of 15, was answered by revising other country’s examples, Chilean national curriculum and research evidence related to the development of skills in digital environments. The list of skills should therefore be understood as a proposal, for further discussion and revision according to the results in the test, new evidence and national and international discussions in this area.

As to the second question, related to how 15-year-old Chilean students performed in the test, the results showed that in average they were able to solve somewhat less than half the tasks in the test. In terms of skills, on the one hand it was found that the majority of students were able to solve tasks related to the use of information as consumers, this is, approximately three quarters of the students were able to search for information and half of them were also able to organize and manage digital information, On the other hand, very few students were able to succeed in tasks related to the use of information as producers, this is, only one third of the students were able to develop their own ideas in a digital environment and less than one fifth were able to refine digital information and create a representation in a digital environment.

These results are difficult to assess based on the ICT related education strategies developed in Chile. In fact, in its more than 15 years of implementation, the Chilean National Center for Technology and Education (Enlaces) has supported schools providing equipment, facilitating access to the Internet, training teachers, and providing support and advice through a university network all along the country. As mentioned in the introduction of this paper, ICT related aims were integrated into the curriculum with
a functional focus as a cross-disciplinary set of aims related to traditional disciplinary subject objectives. Therefore, ICT were available as a resource in a computer lab where teachers could freely go to reinforce their classroom work, but not necessarily with specific learning objectives related to the development of ICT for Learning Skills as defined in this study. Hence, for good or worst, there is no explicit strategy that can be examined to explain students’ (good or bad) ICTsL results.

In addition, as ICT availability has increased in homes, the role of schools in terms of access to ICT has been decreasing, to the level that only 10% of students in this study reported learning to use computers at school. Even more, frequency of use at school resulted low for all SEGs and much lower than its use at home, implying that ICT related activities at school could have a relatively lower impact in individual differences in learning since there are not, in fact, much differences in effective use of computers at school. These results are consistent with the international evidence showing a low, inexistent or negative relation between ICT use at school and students’ academic performance (Spezia, 2010; Tamim et.al, 2011).

Based on these findings, we suggest that to expect Chilean students to develop ICT related skills relevant for learning, education plans (i.e. national curriculum) should be designed to increase ICT use in schools with pedagogical orientations that encourage deliberative and creative use.

In relation to the third question of this study, this is, the factors explaining test results, classical factors emerged as the most important: SEG, access, daily use and confidence in doing ICT related activities, all of which were positively associated with higher scores. In future research it will be important to explore deeper into these and possibly other factors to help explain ICT skills for learning as defined in this study, such as the specific role of basic cognitive skills, the critical level of students’ frequency of use and experience with digital culture to develop these skills; or the particular ICT uses and pedagogical practices that foster these skills.
These questions are even more relevant if we consider that the results in the test show that these new capabilities tend to reproduce the differences observed in other school performance evaluations in Chile, many of them showing high levels of inequality associated to students’ SEG. This is worrying by itself, but even more if one considers that solving problems in digital contexts demands together with higher-order cognitive and ICT literacy skills, a certain level of verbal and mathematical abilities. An effective use of the Internet or of certain ICT applications such as word processor or spreadsheets, require some reading, writing and numeric skills. Therefore it can be hypothesized that students that already have weak abilities in these classical domains, will not be able to recover or catch up in the digital domain, summing up in their case two limitations (lack of classical and ICT skills) to manage adequately in today’s world. In consequence, schools in Chile should compensate for differences of access and use at home, which seems not to be happening considering the low frequency of school use in all SEGs.

In fact, as shows the data presented in section 4.1, it is highly probable that Chilean youngsters are showing a certain level of development of ICTsL as a consequence of informal out of school use of ICT, particularly in the case of students belonging to higher SEGs. However, considering their social and economic importance, they should be worked intentionally with all students. Moreover, this becomes a key matter when research shows that a ‘second digital divide’ is emerging. In fact, OECD’s report on the effect of ICT in learning (OECD, 2010b) found that although the first digital divide (the difference in access to ICT) is disappearing among OECD countries, a second digital divide is emerging. This divide is related to young people’s capabilities to take advantage of computers, which depends on their capital or context characteristics, a combination of their economic, cultural and social capital. The results of the OECD study showed that computer use could make a difference in students’ school performance if they have the necessary competencies, abilities and attitudes. If they are not present, it doesn’t matter how intensive computer use, their benefits will be lost. Consequently, it is crucial that schools equally prepare students in skills that enable them to use ICT in a deliberative way and that educational policies develop actions to reduce this new gap in the learning of students.
In concluding it is worth noting that there are some limitations of the study. Although the test worked well and presented good psychometric properties, some lessons were learned for future applications. The theoretical definition of skills was extensive and resulted in a test that students’ found too long (two hours and thirty minutes) when consulted in the pilot test. The test had a higher number of items that demanded verbal abilities than numerical and social abilities. Considering that the interest is in these three cognitive skills, a better balance should be considered. Constrained by the characteristics of a large-scale standardized test, collaboration skills were only evaluated at a declarative level, limiting the possibility to draw conclusion regarding students’ actual skills. The test did not register separately students’ ICT functional skills, which limited the analysis and the ability to report independently about these skills. And the students’ characterization questionnaire did not register information about students’ families’ cultural capital (e.g. parents’ level of education, number of books at home, among other indicators), which has been found to be more important than social and economic capital in explaining the influence of home in students’ school performance (Yang, 2003, Yang & Gustaffson, 2004; Carrasco, 2008). These issues should be addressed when new versions of this test are implemented in the future.
3 UNDERSTANDING DIGITAL ABILITY: A TEST ITEMS DISCRIMINATION ANALYSIS OF A NATIONAL DIGITAL SKILLS TEST AND A LONGITUDINAL STUDY ON THE RELATIONSHIP BETWEEN DIGITAL ABILITY AND LANGUAGE AND MATHEMATICS PERFORMANCE

3.1 Abstract

An increasingly technology-rich world requires developing digital literacy, in addition to the traditional reading, writing and mathematics literacies. This research contributes to the understanding of students’ digital skills, first by analyzing the types of tasks that best discriminate 10th grade Chilean students’ digital ability in a national digital skills test and second, by analyzing the relationship between students’ performance in the national digital skills test with their previous performance in national language and mathematics tests when they finished the first and second cycles of primary education (i.e., when they reached 8th and 4th grades, respectively). For the first study, a discrimination analysis of the items of a Chilean national digital skills test was performed and results showed that basic digital culture and information processing tasks better discriminate between different levels of digital ability. For the second study, a Hierarchical Lineal Model was adjusted using a representative sample of 10th grade Chilean students selected to assure no correlation between school effects and the explanatory factors. Results showed that, after subtracting the contribution of schools from the scores of the national digital skills test and controlling for students’ social, economic and cultural status, language ability in 8th grade had the greatest marginal effect, followed by language ability in 4th grade. Mathematics ability in 8th grade had a lower marginal effect than language in 8th and 4th grade, and mathematics ability in 4th grade was not significant. These findings show that developing students’ digital skills requires, on the one hand, reinforcing their language and mathematics skills, and specially language in their early years of schooling, and, on the other, specific digital abilities related to basic digital culture and information processing in digital environments.
3.2 Introduction

Information and Communication Technologies (ICT) play a core role in important features of contemporary society such as an economy based in information and global capital, the virtualization of culture and the development of horizontal interactive communication networks (Castells, 1996; 2004). These technologies do not require members to be physically present and facilitate access and sharing of information motivating a networked social structure that changes the way people do business, communicate, participate, work and spend their leisure time (Castells, 2004). This social structure has significant implications for education, as it emphasizes the need to prepare new generations in skills that are different from those best suited to an industrial society (Anderson, 2008). The so-called 21st century skills frameworks state that educational systems need to develop a high quality workforce that not only possesses a strong foundation in traditional literacy skills (reading, writing and mathematics) but is also able to solve non-routine problems and deal with complex information often presented in digital environments (Anderson, 2008; Claro et.al., 2012; Griffin, 2012). More specifically, an increasingly technology-rich world, requires together with traditional literacies that individuals be ICT or digitally literate (Buckingham, 2003) meaning by this that they should have the necessary cognitive and practical skills related to working with information and communication in digital environment for their full participation in society (Anderson, 2008; Hague & Williamson, 2009).

What does it mean to be digitally literate and how should digital skills be measured and developed within the educational context is a matter of debate (Anderson, 2008; Griffin et.al., 2012; Hague & Williamson, 2009). The concept of digital literacy has been analysed in relation to the changing features of literacy in our culture (see Beynon, 1993; Hague & Williamson, 2009; Jenkins, 2006; Mossberger, 2003; Reinking, 1998; Tuman, 1992; Tyner, 1998; Voogt, 2013; Warschauer, 1999). The concept has shifted from a more technical and restricted orientation based on the mastery of digital applications towards a broader perspective that includes using these tools critically to solve cognitive problems on a daily basis and to participate in all areas of social life (Claro et.al. 2012).
More specifically, definitions of digital literacy include computational skills (i.e., operational functional skills), information and communication skills (i.e. cognitive processes related to processing of information, such as searching and evaluating information, representing information, exchanging information and developing new ideas in a digital environment), and new understandings related to the effects of these technologies in contemporary life (i.e., understanding that social organization has changed as a consequence of ICT, motivating new ethical and social dilemmas) (Ainley et.al., 2013; Anderson, 2008; Claro et. al, 2012; Ferrari, 2013; Griffin et.al., 2012; Mossberger et.al. 2003; Voogt, 2013).

Little is known in relation to how youngsters become skilled in solving information and communication problems in the digital environment. From an educational perspective there are several issues that are important to answer this question. One important question is how does digital literacy relate to the more traditional print literacies or academic subjects taught in educational systems, such as language and mathematics. The relationship between traditional print literacies and digital literacy has been studied in the context of the so-called New Literacies Theory (Coiro et.al., 2008; Leu et al., 2004; Leu et.al., 2009), mostly through examining the relationship between reading comprehension of digital versus print texts. The starting point for this approach is related to new online factors, such as new text formats, reading objectives and ways to interact with information, which could require new skills in the digital world (Schmar-Dobler, 2003). According to Sutherland-Smith (2002), online texts require non-linear, non-sequential and non-hierarchical cognitive strategies and visual literacy to understand multimedia components. Coiro (2003) argues that although some tasks carried out online may require the same skills such as traditional comprehension merely applied in a different learning context, other tasks, such as using online search tools, hyperlinks and collaborative work online will require new skills or literacies. In a similar fashion, the PISA ERA test’s framework, administered by the Organization for Economic Cooperation and Development (OECD) in 2009, proposed that although digital and print reading belong to the same construct and many of the abilities required for the two
formats are similar, digital reading requires the reader to incorporate new strategies (OECD, 2011). For example, information gathering requires fast reading skills, such as skimming and scanning, through large volumes of material whose credibility must be evaluated on the spot. Consistent with these definitions research in this area is starting to show that online reading comprehension is not isomorphic with offline reading comprehension (Afflerbach & Cho, 2008; Coiro & Dobler, 2007; Coiro, 2007; Coiro, 2011; Leu et al., 2005; Leu et al., 2007) and that students perform differently in both contexts (Halpern, 2008; Mangen et al., 2012; Leu et al., 2009; Shetzer & Warschauer, 2000). In fact, an analysis of the PISA ERA 2009 results showed that this test and the print PISA reading exam (administered in the same year) were strongly correlated (equivalent to 0.83 correlation), although this relationship was not perfect suggesting some differences between the two formats. Moreover, some countries showed strong disparity between the average results of the two tests (OECD, 2011).

The specific relationship between print and digital mathematics has been less explored. Nevertheless, research shows, first, that visual-spatial representations are used extensively in mathematics and spatial ability is highly correlated with success in mathematics education (Bull et al., 2008; Eliot & Smith, 1983; Flannery & Watson, 1991; Guay & McDaniel, 1977; Hegarty & Kozhevnikov, 1999; Reukhala, 2001; Shah & Hoeffner, 2002; Stravidou & Kakana, 2008; Tartre, 1990). Second, that visual-spatial representations or so-called graphicy is playing an increasing role in digital environments (Leu et al., 2004; Mayer, 2009; Stern et al., 2003). For example, a relationship between visuo-spatial capacity and hypertext reading has been found, specifically regarding the role of visuo-spatial capacity in keeping track of link structures during navigation (Rouet et al., 2012) and information seeking skills (Downing et al., 2005).

Considering the definitions of digital skills and the theoretical and empirical relationships between digital literacy and print language and mathematics literacies described above, this research aims to contribute to the understanding of digital literacy
by performing two studies. The first study aims to analyze a Chilean digital skills test in terms of the tasks (or items) that best discriminate students’ ability and therefore best define what do students need to be functional in digital environments. That is, bearing in mind the digital skills defined and selected as relevant to be measured in Chilean 10th grade students, the first question of this study is:

1. Which types of tasks best discriminate Chilean 10th grade students’ performance in the digital skills test?

The second study analyses the relationship between 10th grade Chilean students’ performance in the national digital skills test with their performance in national language and mathematics tests. More specifically, our interest is to understand this relationship longitudinally; that is, the effect of previously acquired language and mathematics ability in students’ digital performance by using panel data with three measurements along a 6 years time frame. The time component is relevant as at least in the case of language research has shown that it acts as a form of capital that can be translated into academic success through the years (Crook, 1997; De Graaf, 2000; Sullivan, 2001). Pierre Bourdieu & Passeron referred to this phenomenon as ‘linguistic capital’, which he described as something that was gradually acquired through spending time with family members, in educational environments and the unique opportunities of each person. As expressed by Bourdieu and Passeron, language is not simply an instrument of communication: it also provides, together with a richer or poorer vocabulary, a more or less complex system of categories, so that the capacity to decipher and manipulate complex structures, whether logical or aesthetic, depends partly on the complexity of the language transmitted by the family (Bourdieu & Passeron, 1977:73). Therefore our interest is to understand if language and mathematics abilities acquired in the first and second cycles of primary education are important to understand students’ performance in the digital environment later.

In summary, the second study aims to answer the following three research questions:
2. Is Chilean 10th grade students’ performance in a national digital skills test related with their previous performance at the end of primary education in both national language and mathematics tests?

3. Is Chilean 10th grade students’ performance in a national digital skills test more strongly related to their previous performance in the national language test or in the national mathematics test?

4. Does Chilean 10th grade students’ performance in the national language and mathematics tests at the end of the first cycle of primary education still have a relationship with students’ performance in the national digital skills test?

By answering these four questions, this study aims to contribute to understanding Chilean students’ digital skills in two ways: one that is intrinsic to the digital skills test (by analyzing the types of tasks that best discriminate students’ digital ability) and the other that is extrinsic (by relating digital skills with other literacies). Through these analyses, this study also aims to provide evidence that can be relevant in the design of educational strategies to develop students’ digital skills.

3.3 Methodology

3.3.1 Discrimination analysis of SIMCE ICT test items

For the first study and first question of this paper, related to which types of tasks best discriminate Chilean students’ digital performance as measured in SIMCE ICT, an analysis of the test items (40 dichotomous items) was performed (this test is described in section 3). This analysis was based in Item Response Theory estimating a two-parameter model (2PL) (De Boeck & Wilson, 2004), which estimates the probability of answering correctly an item depending on the students’ ability (latent trait), item difficulty
(inflexion point in the ability scale in which a student has a 50% chance of answering correctly) and item discrimination (importance of items or how well an item discriminates between students with different levels of ability). 20% of the items that had a greater discrimination parameter were analyzed, assuming that these are the kind of tasks that better differentiate students by ability level.

### 3.3.2 Nested Data Structure and Hierarchical Linear Models (HLM)

For the second study regarding the relationship between the national digital skills test and language and mathematics ability, we analyze national data related to Chilean students’ performance in three national tests: a national sample digital skills test called SIMCE ICT, a national censal language test called SIMCE Language and a national censal mathematics test called SIMCE Mathematics. This was possible because students measured with the SIMCE ICT test in 2011, when they were in 10th grade, were also evaluated in 2005 and 2009 when they were ending the first half (fourth grade) and second half (eighth grade) of primary education with SIMCE Mathematics and SIMCE Language.

In order to define this relationship, the school contribution was discounted from the SIMCE ICT scores. To do so, it was necessary to operationalize the school effect on these scores and choose a statistical approximation that matches this operationalization. Students tested with the SIMCE ICT were grouped into specific schools and this nested data structure allowed for the operationalization of the school effect using a Hierarchical Linear Model (HLM), which is in widespread use for educational quantitative research (Goldstein, 2001; Snijders & Bosker, 1999). By using this type of model, the SIMCE ICT scores can effectively be explained by both a set of factors at the individual and a random effect, representing the school effect (Goldstein, 2001).
It is important to discuss the substantive adequacy of HLM models, as the interpretation of results is entirely based on this. HLM models consider three main elements or conditions (Goldstein, 2001):

1) Schools are complex institutions with a series of internal dynamics and practices that contribute to SIMCE ICT scores. In HLM models, these dynamics and practices are represented with a component that is not directly observable, but that has an effect on SIMCE ICT scores, as it explains the correlation between these scores, and at the same time cannot be explained by co-variables or factors. Thus, common belonging to a school is defined by an observable feature: the correlation between SIMCE ICT scores.

2) Independency between the school effect and the idiosyncratic error (the part of the SIMCE ICT score that is not explained by the covariates, neither by the school effect).

3) Factors or co-variables presented in the model must not be correlated with the school effect, neither with the idiosyncratic error. This allows researchers to establish selection criteria to inset variables to the model by knowing that they can only consider explanatory factors that are out of the control of the school. When this happens, the factor is said to be exogenous with respect to the school effect (Manzi, San Martín & Van Bellehem, 2014).

### 3.3.3 Sample used

A sample was selected in order to assure no correlation between school effect and the explanatory factors SIMCE Language and SIMCE Mathematics, measured two and six years before. From an initial approach, scores in Mathematics and Language are correlated with the school effect because this effect is one of its explanatory components (endogeneity problem). However, with further analysis, the data allows us to distinguish two different scenarios:
Students that took the SIMCE 2009 at the end of the eighth year of primary school and continued in the same school for the first two years of secondary education, at which point they took the SIMCE ICT.

Students that took the SIMCE 2009 at the end of the eighth year of primary school and then changed schools and were enrolled for their first two years of secondary school in a different institution than at the end of 2009.

In the first situation, SIMCE Language and SIMCE Mathematics scores contain part of the school effect (which at least covers the last year of primary school, as well as the first two years of secondary), which means that these scores are correlated with the school effect. On the contrary, in the second scenario, the school effect (which covers that first two years of secondary education) is not correlated with SIMCE Language and SIMCE Mathematics scores, because these measurements were taken when the students attended a different school.

In the sample of students that participated on SIMCE 2009 and 2011 tests, 56% of students were forced to enroll at a different school to attend secondary education once graduated from primary schooling, due to the Chilean school structure where many schools have only primary or secondary education. By only including in the sample students that were forced to change schools because their school finished at primary school, we are excluding students that changed schools because of other reasons like, for example, poor performance.

The students taking the SIMCE ICT were selected using a stratified sample (Enlaces, 2011). In this way, each student in the sample had a final weight assigned in order to have adequate representation of the universe of Chilean students. For further details, see OECD (2009, chapters 3 and 15). Because we were working with a sub-sample of the initial sample, these final weights were recalculated, following the procedure described
in Enlaces (2011, section 2.2). To check descriptive analyses of distribution were made comparing performance of students who changed school and students who continued in the same school. Results indicated similar performance between both groups in language, mathematics and digital skills.

The initial sample consisted in 7540 students who took SIMCE test in 2009 when they were in 8th grade and also were part of the sample that took SIMCE ICT in 2011. Nevertheless the final sub-sample used in this study consisted of 2295 students that attended 128 schools and met the following conditions: (a) were enrolled in public or subsidized schools in 2011; (b) changed schools at the end of primary education in 2009, after SIMCE Language and SIMCE Mathematics testing because their school did not offer secondary education (c) enrolled in schools that had only secondary education (d) enrolled in schools with a minimum of 10 students per school that took SIMCE ICT in 2011. These four conditions were met by 32% of the students from the initial sample.

It is worth mentioning that in order to use the complete sample we explored two other methods. First, we tried to control the endogeneity problem by looking for instrumental variables. These variables are explanatory factors of the endogenous variables which in turn are, on the one hand, uncorrelated with the school effect and, on the other hand, satisfy the condition that once we control by the school effect and the endogenous variables, those exogenous factors have no impact on students’ SIMCE ICT scores (Manzi, San Martin & Van Bellegem, 2014). But although conceptually feasible, it was not possible to find those instrumental variables (the SIMCE surveys are unfortunately not conceived to collect instrumental variables in the sense above-explained). Second, we conducted an analysis through the use of a proxy variable for the school effect during those two years. A percentile of the mean scores of language and mathematics for schools in 2009 and 2011 was calculated. The difference of this percentile between schools in both years was correlated with the estimated school effect from an HLM model. Nevertheless, the correlation was too low (0.15) to consider the use of this
variable. Since none of these methods were viable, we decided for the method described above.

3.3.4 Instruments and covariates

All the instruments used in the analysis are part of the National Evaluation System for learning results led by the Ministry of Education of Chile (SIMCE tests). SIMCE ICT measured students’ digital skills and was applied in 2011 to a sample of 10th grade students. SIMCE Language and SIMCE Mathematics tests measure students’ achievement of these subjects in the national curriculum. The results used were from 2009, when these tests were administered to the same group of students when they were in 8th grade and that were later evaluated in the SIMCE ICT in 2011. In order to gather contextual information, these tests are applied with a characterization questionnaire for students and parents/tutors. Information about students Economic, Social and Cultural Status (ESCS) described below was obtained from these questionnaires and was included in the model as a covariate in order to control for possible differences attributable to ESCS (Section 2.4.2).

a) SIMCE ICT

The SIMCE ICT test was first evaluated in 2011 and measured three dimensions of the ability to solve problems in a digital context: Information, Communication and Ethics and Social Impact (Enlaces, 2011). In total, there were 12 skills measured along the different dimensions. First, the Information dimension evaluated two kinds of skills: information as a source (define the information needed, search, select, evaluate and organize information) and information as a product (integrate, analyze and represent information as well as generate new information). Second, the Communication dimension evaluated the capacity of the student to transmit information by selecting appropriate digital media considering different contexts. Finally, the Ethics and Social Impact dimension evaluated the student skills in recognizing and reflecting about ethical
dilemmas related to the use of new technologies in their personal lives, the lives of others, and on overall society. The test was administered on a computer software that simulated a virtual environment where students had to perform several tasks that were related with the environment (Enlaces, 2011).

The test aims to measure the ability to solve information and communication problems. For example, students are presented with a task where students need to build a campaign to protect animals in danger of extinction preparing a presentation to quantify and explain the phenomenon and highlight the consequences of human actions. In order to do this, they are asked to define the information needed, search online selecting valid and reliable information, summarize, reorganize, analyze and represent information. Finally, they are required to produce the presentation using the proper tools.

In the sub-sample of this study SIMCE ICT scores were available for 2295 students, with scores ranging from 130 to 365 and a mean of 236.

b) Description of Explanatory Factors Used in the HLM Model

As discussed before, the HLM model was fitted using SIMCE ICT 2011 test described in section 2.1, as dependent variable.

In 2009, the SIMCE Mathematics and Language tests were taken by 239,745 Chilean pupils, representing 92.5% of the national total enrolled at this level (MINEDUC, 2010) and in 2005, these tests were taken by 259,852 Chilean pupils, representing 96% of the national total enrolled at this level (MINEDUC, 2005).

Student level independent variables or explanatory factors were the following:

- **SIMCE Language 4th grade (2005):** This variable was included in the model, as the interest was to learn if students’ language skills and knowledge as acquired at the end of the first part of primary education (4th grade) still had an effect in their performance in the SIMCE ICT test taken in 10th grade in secondary education.
This test evaluated reading comprehension and text production. Reading comprehension encompassed two levels of comprehension – global (determine purpose or objective of a text) and local (identify explicit information and understand its meaning). It included literary texts and non-literary examples. Text production, on the other hand, required students to draft a response to a given prompt (for example, a narration) using the content provided in accordance with orthographic rules (MINEDUC, 2005). In the sub-sample data was available for 1924 students with scores ranging from 122 to 365 and a mean of 253.

- *SIMCE Mathematics 4th grade (2005)*: This variable was included, as the interest was to learn if students’ mathematics skills and knowledge as acquired at the end of the first part of primary education (4th grade) still had an effect in their performance in the SIMCE ICT test taken in secondary education (10th grade). This test evaluated three areas: numbers, arithmetic operations, and shapes and space. Problem solving was evaluated in an integrated manner for each area. Both real-life and symbolic situations were included (MINEDUC, 2005). In the sub-sample data was available for 1926 students with scores ranging from 96 to 364 and a mean of 243.

- *SIMCE Language 8th grade (2009)*: This variable was included in the model, as the interest was to learn if students’ language skills and knowledge as acquired at the end of the second part of primary education (8th grade) had an effect in their performance in the SIMCE ICT test taken in secondary education (10th grade). This test measured reading comprehension in, basically, three types of skills: extract information, make inferences or interpretations and reflect on the content and format of a text. Also, the ability to recognize the relation between verbal information and images was measured. Texts were included complete or in fragments and had both real and imaginary contents. Literary and non-literary texts and examples were included. Also, non-literary texts such as charts, tables or illustrations were considered (MINEDUC, 2010). In the sub-sample data was available for 2231 students with scores ranging from 110 to 378 and a mean of 241.
- **SIMCE Mathematics 8th grade (2009):** This variable was included, as the interest was to learn if students’ mathematics skills and knowledge as acquired at the end of the second part of primary education (8th grade) had an effect in their performance in the SIMCE ICT test taken in secondary education (10th grade). Four areas were measured: numbers, geometry, algebra, and data and probability. Just as in SIMCE 2005, students had to show their knowledge and solve problems related to relevant mathematical concepts in each of these areas (MINEDUC, 2010). In the sub-sample data was available for 2224 students with scores ranging from 140 to 398 and a mean of 246.

- **Economic, Social and Cultural Status Index (hereon ESCS):** this index considered five variables with information obtained through the SIMCE ICT characterization questionnaire. The variables were those typically used in international education evaluations: highest educational level of parents, highest occupational status of parents, household income, home educational resources, and cultural possessions at home (OECD, 2012). The index construction based on PISA methodology (OECD, 2012) consists on factor scores for the first component of a Principal Component Analysis. The eigenvalue for the first component was 2.13 and explained a 43% of the variance. Missing values (1.001 observations) for this index were imputed using a regression imputation of socioeconomic variables (household income, educational level of student’s father, educational level of student’s mother and number of possessions at home) obtained from SIMCE 2009 characterization questionnaires. The R2 of this regression over ESCS index was 0.66. In the sub-sample, after the regression imputation, data was available for 1876 students with values ranging from 0 to 1 and a mean of 0.33. Considering extensive evidence that shows the importance of these variables in explaining students’ academic performance (Sirin, 2005; Sullivan, 2001), it was included as a control variable in the model.

### 3.4 Results
3.4.1 Item discrimination analysis results

For the first study, the 2PL model estimation of SIMCE ICT items was performed and the descriptive statistics of the discrimination and difficulty parameters are presented in (see Table 3-1) From the total items, the 20% with higher discrimination parameters were analyzed. The results of the discrimination analysis of the items showed that it was possible to identify two types of tasks with higher discrimination parameters in the test. The first type can be characterized as basic digital culture tasks and the second type as information processing tasks (see Table 3-1). The first ones were in general easy tasks with a low difficulty parameter (below zero) that involved two types of items: first items that ask students’ to demonstrate basic operation skills, such as using the trash folder, and second, items that demand students to show self-care skills in the digital environment, such as being able to choose a safe password or understanding the risks of getting together with someone you met online. The second ones were in general difficult tasks with a high difficulty parameter (over zero) that involved processing information and generating an information product, such as summarizing, representing and analyzing information. Both kinds of tasks could be accounting for two types of important digital skills: basic general digital culture skills that allow to thrive in the digital environment (operation and self-care skills) and higher order cognitive skills associated to information processing in the digital realm. Although they are different in terms of cognitive complexity (the second type being more complex than the first), they both require applying certain criteria or knowledge to solve specific problems in the digital environment. It is also important to emphasize that, regardless the difficulty parameter, these items discriminate between students, meaning that they are useful items that discriminate between students with different digital skills ability.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.D</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discrimination parameter</td>
<td>0.871</td>
<td>0.330</td>
<td>0.334</td>
<td>1.692</td>
</tr>
<tr>
<td>Difficulty parameter</td>
<td>0.089</td>
<td>1.265</td>
<td>-2.956</td>
<td>2.548</td>
</tr>
</tbody>
</table>
### Table 3-1: Description of 20% of SIMCE ICT items with highest discrimination parameter

<table>
<thead>
<tr>
<th>Item N°</th>
<th>Discrimination parameter</th>
<th>Difficulty parameter</th>
<th>Mean probability of correct answer</th>
<th>Dimension</th>
<th>Item description</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>1.692</td>
<td>1.099</td>
<td>0.135</td>
<td>Information as a product</td>
<td>Extract and integrate information from a data table or graph and write a paragraph.</td>
</tr>
<tr>
<td>34</td>
<td>1.543</td>
<td>-1.586</td>
<td>0.920</td>
<td>Self-care</td>
<td>From different alternatives, choose the safest password.</td>
</tr>
<tr>
<td>13</td>
<td>1.461</td>
<td>-0.560</td>
<td>0.694</td>
<td>Operational skills</td>
<td>Retrieve files from the trash folder.</td>
</tr>
<tr>
<td>25</td>
<td>1.421</td>
<td>0.001</td>
<td>0.500</td>
<td>Information as a product</td>
<td>Select and represent information taking in consideration a specific context.</td>
</tr>
<tr>
<td>27</td>
<td>1.326</td>
<td>0.989</td>
<td>0.212</td>
<td>Information as a product</td>
<td>Create a slide with conclusions obtained from a certain task.</td>
</tr>
<tr>
<td>17</td>
<td>1.186</td>
<td>0.920</td>
<td>0.251</td>
<td>Operational skills</td>
<td>Open email, attach a file and send email.</td>
</tr>
<tr>
<td>23</td>
<td>1.164</td>
<td>2.208</td>
<td>0.071</td>
<td>Information as a product</td>
<td>Represent information. From a text, create a table that summarizes the information.</td>
</tr>
<tr>
<td>36</td>
<td>1.092</td>
<td>-1.508</td>
<td>0.838</td>
<td>Self-care</td>
<td>Understand risks of Internet. Choose the most appropriate course of action if someone you met online suggests meeting in person.</td>
</tr>
</tbody>
</table>

**3.4.2 HLM model results**

For the second study, an HLM model was fitted using xtmixed from STATA 12 (see Table 3-2). All variables were standardized using z-score in order to obtain comparable marginal effects.
Results of the model show first, that regarding individual marginal effects (effect of each covariate on SIMCE ICT, controlling for all other covariates), both SIMCE 8th grade scores and ESCS have a positive and statistically significant relation with SIMCE ICT. Comparing each effect, it is possible to observe that language has a much greater marginal effect than mathematics and ESCS (0.28, 0.16, and 0.12 respectively). Also, it is interesting that the difference between the marginal effect of language and ESCS is much greater than between mathematics and ESCS, emphasizing the importance of language on SIMCE ICT performance, once controlling for the other covariates.

Regarding SIMCE 4th grade, language has a positive and important marginal effect (0.22) while mathematics has a non-statistically significant marginal effect. Also, it is interesting to notice that language performance in 4th grade has a stronger effect than mathematics taken in 8th grade showing that language as acquired at the end of the first part of primary education transcends after 6 years.

It must be emphasized that these effects correspond to individual contribution to SIMCE ICT after taking away the contribution of the school to SIMCE ICT scores, which is feasible given the exogenous nature of these individual effects with respect to the school effect. Regarding the variance explained by the model, all the individual covariates together explain a 42% of initial within-school variability, that is, SIMCE ICT scores variability between students in a school.

The intra-class correlation of 0.12 shows that 12% of the total variance, after controlling for the covariates, is explained by between schools differences (not individually). In other words, it refers to the portion of the variance that is explained by the contribution of the school in SIMCE ICT, after controlling for the covariates or exogenous factors (SIMCE Language, Mathematics and ESCS Index).
In synthesis, these results show first, a greater importance of language than mathematics ability as acquired at the end of primary education in explaining students’ performance in SIMCE ICT. And second, they show that language ability as acquired at the end of the first cycle of primary education continue to affect SIMCE ICT performance, while mathematics loses its’ influence. Mathematics ability is relevant as acquired at the end of the second, but not the first cycle of primary education.

<table>
<thead>
<tr>
<th>Table 3-2: HLM Model over SIMCE ICT standardized scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null Model</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Intercept</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
| SIMCE Language 8th grade (2009) | 0.277 | **
|            | (0.047) ** |
| SIMCE Mathematics 8th grade (2009) | 0.161 | **
|            | (0.036) ** |
| SIMCE Language 4th grade (2005) | 0.222 | **
|            | (0.040) ** |
| SIMCE Mathematics 4th grade (2005) | 0.047 | **
|            | (0.038) ** |
| ESCS       | 0.119    |         |
|            | (0.032) ** |
| Within-school variance | 0.778 | 0.452 |
| Between-school variance | 0.200 | 0.061 |
| Intraclass correlation | 0.239 | 0.120 |
| % of between-school variance explained | 69.33% | |
| % of within-school variance explained | 41.93% | |
| % of total variance explained | 47.55% | |
| AIC        | 6035.29  | 3267.73 |
| N          | 2295     | 1528    |
3.5 Discussion and conclusions

This study aimed to contribute to the understanding of Chilean 10th grade students’ digital skills in two ways: first, by analyzing the types of tasks that best discriminate students’ digital ability, and second, by relating students’ digital skills with their previous language and mathematics performance. For the first study, an item discrimination analysis was conducted to see which items best discriminate between students with different digital ability as defined in the Chilean digital skills test. For the second study, the question was about language and mathematics ability as previously acquired at the end of the first and second cycles of primary education. To do this, a Hierarchical Lineal Model was adjusted using a representative sample of students selected to assure no correlation between school effect and the explanatory factors.

In relation to the first research question (concerning the first study), related to the types of tasks that best discriminated students’ performance in the digital skills test, results showed that the most informative tasks of the digital skills test, were those that demanded students to demonstrate their ability in solving problems of two types: A first type that demanded students to solve basic operation problems (e.g. use the trash folder) and apply basic criteria to self-care problems in digital environments (e.g. choose a safe password). And a second type that asked students to solve information problems (e.g. represent numerical information in graphical format, which assumes that students not only understand numerical information, but also know how to summarize and represent data using spreadsheet tools). Consequently, according to these results, tasks related to applying criteria or knowledge to solve problems related to basic digital culture and information processing in digital environment, were the most sensible to discriminate between different levels of digitally proficiency. In contrast, those tasks that asked students to answer stating their previous knowledge related to ‘desirable behaviors’ had the lowest discrimination strength.
Regarding the second research question (concerning the second study), about the relationship between Chilean secondary students’ performance in the national digital skills test with their performance in the national language and mathematics tests, results showed that after subtracting the contribution of schools to the digital skills test scores and controlling for students’ economic, social and cultural status (ESCS), language and mathematics previous performance were both important in explaining students’ results in the national digital skills test. One way to quantify the scope of the effect of language and mathematics is to state that students’ performance in these academic areas together with students’ ESCS, explain 42% of digital skills test individual variability. This relationship can be understood by considering that the Chilean national digital skills test measures a set of skills that are relevant for effective performance in the digital realm, and many of these are related to skills and knowledge measured in the SIMCE Language and SIMCE Mathematics. This is especially true for problems involving the use and production of information require skills in the area of reading comprehension, or when representing data in tables or charts require understanding numerical information. In this sense, tasks carried out in digital contexts do not exist in a vacuum. Rather, they are tasks that draw directly from skills required when working with linguistic or mathematical print texts.

Complementary to the previous finding, it should be noticed that there was still a residual variance of 58% that could not be explained by students’ previous print language and mathematics ability, nor their ESCS. This result is consistent with other studies comparing specifically students’ language performance in print and digital environments, which show that although their results are positively correlated, they are not the same (OECD, 2011; Coiro, 2011; Leu et.al., 2005) and provides evidence for the idea that the Chilean digital skills test is not simply another SIMCE Language or SIMCE Mathematics test in a digital format. Although this issue requires further study, a hypothesis is that part of the residual variance may be explained by abilities required specifically in digital environments that are therefore intrinsic to the digital skills test.
Results related to the first research question of this study discussed above, provides some evidence related to which are these intrinsic skills.

In relation to the third research question (related to the second study), whether Chilean secondary students’ performance in the national digital skills test was more strongly related to their performance in the national language test or in the national mathematics test as measured at the end of primary education (8th grade), results showed that language had the greatest relationship with digital performance, compared to mathematics performance and students’ ESCS. The relative stronger relationship of the digital skills test with language performance can be partly explained by the characteristics of the test. Although items were built balancing language and mathematics knowledge, the features of the test aimed to emulate real world problems related to the use of information in the Internet, which is heavily based in language.

As to the fourth research question (regarding the second study,) that asked whether Chilean secondary students’ performance in the national digital skills test was still related to their performance in the national language and mathematics tests as measured at the end of the first part of primary education (4th grade), results showed that language had a positive and important marginal effect, similar to that of 8th grade (0,27 versus 0,22), while mathematics had a non-statistically significant marginal effect. This finding is particularly interesting, as it may be indicating the relevance of ‘linguistic capital’ (Bourdieu & Passeron, 1977) for the digital skills measured in the Chilean test and is consistent with research that shows that language is a form of capital that can be translated into academic success (Crook, 1997; De Graaf, 2000; Sullivan, 2001).

In summary, it can be concluded that digital skills, as defined and measured in the Chilean digital skills test (SIMCE ICT), are strongly related to the traditional school literacies of language and mathematics, and specially language starting from students’ early school years. Results also provide some grounds to believe that strategies and abilities intrinsic to the digital context partly explain student performance in the digital
test and therefore should be taught directly to students and integrated as learning objectives in school subjects across the curriculum.

A limitation of this study was that although the three national tests were built considering international frameworks in the areas of language, mathematics and digital skills (ACE, 2014; Mineduc, 2011), the final forms of the three tests were specific to the Chilean educational context. Therefore to check the scope of the findings it would be necessary to perform more international studies in the lines of PISA ERA (OECD, 2012) in order to compare results between countries. Also, the data used in the second study has an underlying trade-off between endogeneity bias and selection bias. The decision was to control the first one by assuming the risk of selection bias, considering the impossibility to find 'good' instrumental variables in the available data. Another limitation was that the three tests were one-dimensional, and therefore it was not possible to study the relationship of specific mathematics or language sub-skills with specific digital sub-skills. Future research should consider analyzing more specific relations, such as visual-spatial skills and digital representation. Finally, in addition to understanding what explains digital performance, future research should consider studying pedagogical strategies that can directly develop students’ digital skills in schools.
4 COMPARING MARGINAL EFFECTS OF CHILEAN STUDENTS’ ECONOMIC, SOCIAL AND CULTURAL STATUS ON DIGITAL VERSUS READING AND MATHEMATICS PERFORMANCE

4.1 Abstract

This paper provides evidence that helps understand the digital divide in education. It does so by comparing the effect of economic, social and cultural status (ESCS) on the digital skills of Chilean students compared with mathematics and language. This comparison is made using national standardized tests. The marginal effect of a group of variables measuring student ESCS was compared both as a whole and separately using multivariate linear regression analysis. The results show that the marginal effect of ESCS as a whole on students’ digital skills was equal to the effect on mathematics and greater than the effect on language. Furthermore, the results show that the parents’ level of education was the most relevant factor of ESCS for explaining student performance on the digital test, more so than for mathematics and language. These findings challenge the belief that the Internet would reduce economic, social and cultural inequalities in new generations. Instead, they reveal that the gap among Chilean students tends to perpetuate or widen when comparing performance in mathematics and language with performance in the digital domain. At the same time, by comparing national test results, this paper offers empirical evidence for the existence of a second digital divide in the field of education, a concept which is widely discussed at a theoretical level but with little empirical support to date.

4.2 Introduction

For some, access to the Internet represents the promise of a more democratic and equitable society; for others it is a potential source of cultural and social inequality, giving rise to the so-called digital divide (Castells, 2001; DiMaggio et al., 2004; van Dijk, 2006; Selwyn & Facer, 2007; Warschauer, 2012). In this context, the adoption of Information and Communication Technologies (ICT) by educational systems has been
partly inspired by a social rationale that sees schools as levelling access to the opportunities provided by ICT and digital literacy. As several authors have reported, the concept of the digital divide was initially defined in dichotomous terms as the distance between those that have access to ICT and those that do not (Selwyn, 2004; Di Maggio et al., 2004; Van Dijk, 2006; Hargittai, 2008). To reduce this gap, schools have been equipped with computers and the Internet. In some countries, such as Uruguay, Peru and Haiti, One-to-One programs have been implemented to provide children from low-income families with access to a personal computer (Näslund-Hadley, E. et al., 2009; Severin & Capota, 2011). However, evidence today shows that as quantitative access increases and levels-out, qualitative disparities appear in the way in which technology is used. These disparities are not only financial, but also cognitive, social, and cultural, leading to the concept of a ‘second digital divide’ (OECD, 2010). This concept represents a more refined approach that shows that the benefits of using ICT depend not only on access, but also on the conditions of the individual and their ability to take advantage of the opportunities provided (Selwyn, 2004; van Dijk, 2006; Selwyn & Facer, 2007; Hargittai, 2008; OECD, 2010). In this sense, the concept of digital divide goes from being one-dimensional to multidimensional. It also accounts for factors that are extrinsic and extrinsic to technology, such as individual skills or digital literacy (Ferro et. al., 2010).

An important question in the field of education is how the second digital divide relates to other differences in student learning. Research on the differences in student learning outcomes has strongly focused on the role played by the student’s economic, social and cultural status. The impetus for this research was partly provided by two important projects: the Coleman Report in the USA (Coleman et al., 1966) and the Plowden Report in Great Britain (Peaker, 1971). In broad terms, these reports concluded that the family context was more important than school-level factors in determining student achievement. Initially, the family context was restricted to economic and social status (measured by income, and the parents’ education and occupation). However, this definition has become more complex over time. This is because research has found
evidence to suggest that factors such as educational resources at home, as well as the family’s social and cultural capital also influence student’s educational outcomes (Sullivan, 2007; Buchmann, 2002; Sirin, 2005). Studies of performance in various subjects, particularly in mathematics and language, consistently show the relevance of these factors in explaining differences between students (Bradley Corwyn, 2002; Schulz, 2005; Dahl and Lochner, 2005; Starkey & Klein, 2008; Sirin, 2005; Perry & McConney, 2013; OECD, 2013).

Research into the role of economic, social and cultural status in explaining the digital divide among students has mostly been centered on how it affects student use of ICT (Peter & Valkenburg; 2006, Hargittai, 2010; Van Deursen & Van Dijk, 2014). So far, little research has been focused on student performance in a digital context, partly due to the difficulty of defining and measuring ICT or digital skills (Litt, 2013). Initially the concept of digital literacy referred to computer literacy, i.e. the ability to operate computers and their different programs (Norman, 1984). Subsequently, a broader concept appeared, transcending technical ICT skills and including skills linked to the capacity to solve information and communication problems in a digital environment. For example, searching, assessing, summarizing, analyzing, representing, or creating information; as well as sharing and collaborating with others (Fraillon, 2012; Author et. al., 2012; Ferrari, 2013; Fraillon et al. 2013). The most reliable way to measure these skills is to use standardized tests in closed computational environments. However, due to the high cost involved in their design, measurements tend to rely on self-reporting by those being assessed (van Dijk, 2006). Nevertheless, there are some studies that measure individual Internet skills (Hargittai, 2002; Van Deursen & Van Dijk, 2009; Van Deursen & Van Diepen, 2013) and digital reading skills (OECD, 2012). Furthermore, some countries such as Australia (ACARA, 2012) and Chile (Enlaces, 2011) have developed performance tests that are taken nationally and cover a range of objectives. Likewise, under the auspices of the IEA (International Association for the Evaluation of the Educational Assessment) the International Computer and Information Literacy Study (ICILS), an international evaluation, has been carried out with the participation of 21
countries (Fraillon et al., 2013). In general, the results of digital skills tests tend to show that, as within other fields of performance, family background measured using economic, social and cultural variables is a strong predictor of digital skills (Hargittai, 2010; Van Deursen & Van Dijk, 2010; Gui & Argentin, 2011; Author et al. 2012; Litt, 2013; Hatlevic et al., 2014).

In summary, academic research and discussion shows that the digital divide is more complex than simply the *haves* vs. the *have nots*. In the field of education, research is increasingly focused on the differences between students in terms of their digital skills. Furthermore, there is plenty of research on the importance of economic, social and cultural status to student performance in mathematics and language. Additionally, there is increasing evidence of this also being the case for digital skills. Nevertheless, there have been few studies as to whether the performance gap explained by student ESCS differs for print and digital tests in language or mathematics. One such study is PISA 2009. This study featured a print and digital reading test, and compared the effects of student attitudes and family background on both assessments. The results showed a very similar relationship between socio-economic background and student performance on both the print and digital tests (OECD, 2011:140). These types of studies are important for understanding whether there is anything new or different about the gap in student performance in the digital domain when compared with more traditional academic domains, such as print tests in language and mathematics. Consequently, the purpose of this study is to compare the effect of economic, social and cultural status in three performance domains —mathematics, language, and digital skills— in order to answer two questions:

1. Is the marginal effect of ESCS on students’ digital skills equal to, greater than or less than the marginal effects on students’ performance in language and mathematics?

2. Which factors of ESCS best explain student performance in the digital domain?
To do this, we will compare the effect of ESCS on student performance by a single group of Chilean students on a national standardized test in digital skills (sample test) against their performance on national standardized tests in mathematics and language (census tests).

4.3 Methodology

To answer the research questions, we will analyze the marginal effect of ESCS on the results of a group of Chilean students on three standardized tests. These tests are the Mathematics SIMCE, the Language SIMCE and the ICT or digital skills SIMCE. As will be described in more detail in section 4.3.3, the ICT SIMCE measures students’ digital skills. ESCS was measured using five variables that are typically used in international studies on education: parents’ highest level of education, parents’ highest occupational status, household income, educational resources at home, and cultural possessions at home (OECD, 2012).

The sample used in this study is presented in section 4.3.1. The variables that comprise student ESCS, as well as the dependent variables, i.e. the national SIMCE tests, are described below in Section 4.3.2 and 4.3.3, respectively (Table 4-1).

4.3.1 Sample

Chile is an OECD member Country since 2010. Disposable household income in Chile is about 60% of the OECD average. The Country also has the highest level of income inequality and the 4th highest level of relative poverty in the OECD area (OECD, 2014a). Chile spent 6.9% of its GDP on educational institutions in 2011, above the OECD average of 6.1%, but has the highest share of private expenditure on all levels of education with 40% of education expenditure coming from private sources (OECD, 2014b). In terms of educational results, in PISA 2012 Chile scored higher than any other
Latin-American country but significantly below de OECD average. In terms of equity, Chile is one of the countries where the socioeconomic factors explain a greater percentage of the PISA results variance, way above the OECD average (OECD, 2013).

The SIMCE tests analyzed in this study were sat by the same group of students at two different moments in time: the Mathematics SIMCE and Language SIMCE in 2009, when the students were in 8th Grade; and the ICT SIMCE in 2011, when they were in 10th Grade. The Mathematics SIMCE and Language SIMCE were taken by 239,745 students; i.e. 92.5% of 8th Grade students in the country. The ICT SIMCE, on the other hand was taken two years later by a sample of 9,462 students; i.e. 3.8% of the students who were in 8th grade in 2009. The decision to apply this test only to a sample of the student population was made by the Ministry of Education because of cost effective reasons.

The sample used in this study corresponded to students that sat all three SIMCE tests (7,153) and for whom the necessary information on their ESCS was available, as reported by the student (4,489) and by the parent or tutor (7,391). This information was gathered using characterization questionnaires that were administered at the same time as the ICT SIMCE test in 2011. Considering the above conditions, the final sample consisted of 2,933 students. In order to ensure national representation, weightings by type of school administration and region were used in all estimations.

4.3.2 ESCS covariates

The variables for measuring student ESCS were selected based on the information gathered in the characterization questionnaires administered together with the SIMCE tests. All ESCS variables, except for household income, are the variables used in the PISA socioeconomic index and were constructed using the PISA methodology (OECD, 2012: 280-287). Of the variables included in these questionnaires (parents’ education, parents’ occupation, household income, goods and services available at home) the ones
selected were those that were considered more stable over time, i.e. those that had less chance of changing over a two-year period. Considering these criteria, goods and services available at home were not included. Table 4-1: Description of ESCS variables describes the ESCS variables that were used.

**Table 4-1: Description of ESCS variables**

<table>
<thead>
<tr>
<th>ESCS Variable</th>
<th>Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest educational level of parents</td>
<td>SIMCE ICT 2011 Parents or Tutors Questionnaire</td>
<td>Maximum including Mother and Father’s years of schooling. Index based on PISA (OECD, 2012).</td>
</tr>
<tr>
<td>Highest occupational status of parents</td>
<td>SIMCE ICT 2011 Parents or Tutors Questionnaire</td>
<td>Maximum occupational level of Mother or Father Occupations recoded into four International Standard Classification of Occupations (ISCO) skill levels (ILO, 2012). Index based on PISA (OECD, 2012).</td>
</tr>
<tr>
<td>Household Income</td>
<td>SIMCE ICT 2011 Parents or Tutors Questionnaire</td>
<td>13 income segments from lower to higher</td>
</tr>
</tbody>
</table>
| Home educational resources           | SIMCE ICT 2011 Student Questionnaire        | Index based on PISA (OECD, 2012), constructed with one-parameter Item Response Theory (IRT) scaling methodology for dichotomous items, that measures the possession of:  
A desk for studying
A place for studying
A computer that can be used for schoolwork
Educational software
Internet connection (this is not part of the original PISA (OECD, 2012) index, however, it is included due to increasing evidence of Internet use as a source of information for schoolwork (OECD, 2011; Author et al., 2012; Hinostroza et al., 2014). |
| Cultural possessions                 | SIMCE ICT 2011 Student Questionnaire        | Index based on PISA (OECD, 2012), constructed with one-parameter IRT scaling methodology for dichotomous items, that measures the possession of:  
Classical literature books
Poetry books
Works of art |
| ESCS Index                           | SIMCE ICT 2011 Student and Parents or Tutors Questionnaire | Index constructed with a Principal Component Analysis considering the five ESCS variables presented above:  
Highest educational level of parents
Highest occupational status of parents
Household Income
Home educational resources
Cultural possessions |

It should also be mentioned that indices for Educational Resources at Home and Cultural Possessions are complex and were constructed using Item Response Theory, following the PISA methodology (OECD, 2012). Therefore, these indices were verified to see if
the scores defining Educational Resources at Home and Cultural Possessions were monotonically related to the items used to construct each index. For the data under analysis, this was the case. In other words, as the Educational Resources at Home or Cultural Possessions indices increased, the amount of goods related to each index also increased.

### 4.3.3 National assessments used in the study

The SIMCE is a national system for assessing learning outcomes administered by the Chilean Ministry of Education. The system has been in place since 1988 (first version). The Mathematics SIMCE and Language SIMCE evaluate student achievement on the national curriculum and are administered once a year to all students enrolled in the grade levels under evaluation (MINEDUC, 2010). The ICT SIMCE evaluates students’ digital skills and was applied to a sample of students in Secondary Education for the first time in 2011 and for a second time in 2013. A characterization questionnaire is also administered to students and their parents or tutors, with both types of assessment. The Ministry of Education ensures that the use of the results is strictly confidential and for academic purposes only.

The Language SIMCE for 8th Grade students in 2009 measured reading comprehension skills, especially extracting information, making inferences or interpretations and reflecting on the content and format of a text. Questions asked students to extract information located in different sections of a text, such as a footnote, or to make inferences and interpretations, such as inferring how a character might feel. It also asked participants to determine the relationship between images and verbal information. These skills were evaluated using questions related to different types of texts, both literary (e.g. stories, poems and plays) as well as non-literary (e.g. news articles, instructions, opinion pieces and posters). Non-literary texts generally included complementary elements such as tables, charts, boxes, footnotes or illustrations. The texts were either complete or excerpts, and referred to both real and imaginary situations (MINEDUC, 2010). The
Mathematics SIMCE for 8th Grade students in 2009 evaluated four areas: numbers, geometry, algebra and data, and probability. Students had to demonstrate their knowledge by solving problems related to relevant mathematical concepts in each of these areas (MINEDUC, 2010).

The ICT SIMCE in 2011 measured the students’ ability to solve information and communication problems, as well as ethical dilemmas in a digital context (Enlaces, 2011). The assessment was administered on a computer, using specific software that simulated a virtual environment (with chat, files, desktop, programs, tools and an instruction window). Here, students were asked to perform tasks related to a cross-curricular topic, “the environment”. It measured 12 skills involving three dimensions: Information, Communication, and Ethics and Social Impact. The Information dimension evaluated skills related to the use and production of information. More specifically, Use of Information (information as a source) evaluated the students’ ability to determine the information that was needed, search, select, evaluate and organize information. Production of Information (information as a product) evaluated the students’ ability to integrate, analyze and present information as well as to generate new information. The Communication dimension evaluated the students’ ability to transmit information by selecting the appropriate digital media based on a given context. The Ethics and Social Impact dimension evaluated the students’ ability to recognize and reflect upon the ethical dilemmas generated by the use of new technologies in their personal lives and the lives of others, as well as their impact on society as a whole (Enlaces, 2011).

A generic example of the type of task included in the test is the following: students are presented with a statement that says “In order to build a campaign together with your friends to protect animals in danger of extinction, prepare a presentation to quantify and explain this phenomenon, highlighting the consequences of human actions”. Students were then asked to:

1. Determine the information that was needed
2. Search online and select valid and reliable information
3. Summarize and reorganize information
4. Analyze and represent information
5. Decide on the most appropriate method for presenting the information (text, charts, diagrams, photos, video, etc.)
6. Produce the presentation considering message and audience.

As the example shows, the test transcends the functional management of technology and requires students to solve information and communication problems. Although mastery of ICT applications is required, higher-order cognitive skills are also very important, such as the ability to analyze, synthesize and represent information.

4.3.4 Analytical approach

One possible approach for analyzing the relationship between ESCS and the different SIMCE test scores is to conduct separate analyses of the association between ESCS and each SIMCE test. However, this approach assumes that SIMCE scores are uncorrelated, which is not the case. A simple correlation analysis showed that the correlations between the students’ performance on the tests are 0.65 between Language and Mathematics; 0.57 between ICT and Language; and 0.6 between ICT and Mathematics. It is therefore necessary to fit a model that takes into account the correlation between the scores of each pupil. Multivariate linear models or Seemingly Unrelated Regressions (SUR) (Zellner, 1962) are therefore the most appropriate statistical tool.

SUR models are specified in the following way: for each pupil, the dependent variable corresponds to a 3-dimensional vector (the scores on the ICT, Language and Mathematics SIMCE tests). The explanatory factors are the same, but the vector of marginal effects, or linear regression coefficients, is specific to each coordinate of the dependent variable. Thus, it is possible to estimate the marginal effect of each explanatory factor on the ICT SIMCE test, as well as on the Language and Mathematics
SIMCE tests. Finally, the residuals for each equation are assumed to be correlated, which is a consequence of the empirical correlation between the three test scores.

Two advantages of fitting SUR models should be highlighted:

1) It is possible to compare the marginal effects of the explanatory variables on, for instance, the ICT SIMCE with the marginal effects on the Language SIMCE. This comparison should be made using a hypothesis test.

2) It is possible to estimate the correlations between the three SIMCE test scores after controlling for the explanatory factors (the socio-economic and socio-cultural factors). When those correlations are not zero, we can say that correlations between the three SIMCE test scores are due to individual characteristics (those of the pupils), and not to the explanatory factors.

Using SUR or Multivariate linear models, two analyses were performed in order to answer the studies research questions:

1. In order to answer the first research question, related to the marginal effect of ESCS as a whole, a multivariate regression analysis was conducted using an ESCS index and the three SIMCE tests. The ESCS index was created using a principal component analysis of the five ESCS variables: parents’ highest level of education, parents’ highest occupational status, household income, educational resources at home and cultural possessions. The first component explained 56% of the variance.

2. In order to answer the second research question, related to the specific variables of ESCS that explain student performance on the ICT SIMCE, a multivariate regression analysis was conducted using the five ESCS covariates and the three SIMCE tests.
The analyses were performed using *manova* and *mvreg* commands, along with the test post-estimation command in STATA 12.

### 4.4 Descriptive analysis

Table 4-2 presents descriptive statistics for the model variables. It is worth noting that in order to achieve comparability between the marginal effects and facilitate interpretation of the model in terms of standard deviations, all ESCS covariates were standardized using a z-score.

The selected set of ESCS variables to be included in the model seeks to address different aspects of student ESCS. All correlations between the five ESCS variables are significant and positive (Table 4-3). However, correlations range from 0.21 to 0.72, which shows that none of the variables fully explain any of the others and that different aspects of student ESCS are being measured. It was therefore relevant to include all of the selected variables in the model. Furthermore, the correlations between the ESCS index and the variables that were used to create it were very high, which validates the construction of the index.

Likewise, it can be observed how the three SIMCE tests are positively correlated to the ESCS index, as well as to all of the ESCS variables. This indicates a positive association between a higher ESCS and student performance. The ESCS index is most closely correlated to the ICT SIMCE (0.49), then to Mathematics (0.45) and finally to Language (0.43). More specifically, three out of the five ESCS variables are most closely correlated to the ICT SIMCE (parents’ highest level of education, parents’ highest occupational status and educational resources at home). This suggests that the effect of ESCS is greater on students’ digital skills than on the other two subjects. Nevertheless, these correlations do not account for the association between the three SIMCE tests. Therefore, multivariate regressions need to be used.
Table 4-2 Descriptive statistics of dependent and covariate variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMCE Reading 2009</td>
<td>2933</td>
<td>253.49</td>
<td>47.66</td>
<td>111.84</td>
<td>378.08</td>
</tr>
<tr>
<td>SIMCE Mathematics 2009</td>
<td>2933</td>
<td>261.43</td>
<td>52.71</td>
<td>140.43</td>
<td>402.42</td>
</tr>
<tr>
<td>SIMCE ICT 2011</td>
<td>2933</td>
<td>256.06</td>
<td>47.55</td>
<td>107</td>
<td>384</td>
</tr>
<tr>
<td>Highest educational level of parents</td>
<td>2933</td>
<td>-0.13</td>
<td>0.97</td>
<td>-3.60</td>
<td>2.58</td>
</tr>
<tr>
<td>Highest occupational status of parents</td>
<td>2933</td>
<td>-0.13</td>
<td>0.90</td>
<td>-1.09</td>
<td>1.61</td>
</tr>
<tr>
<td>Household income</td>
<td>2933</td>
<td>-0.17</td>
<td>0.87</td>
<td>-1.14</td>
<td>2.41</td>
</tr>
<tr>
<td>Home educational resources</td>
<td>2933</td>
<td>-0.13</td>
<td>1.01</td>
<td>-2.03</td>
<td>1.63</td>
</tr>
<tr>
<td>Cultural possessions</td>
<td>2933</td>
<td>-0.14</td>
<td>1.00</td>
<td>-1.62</td>
<td>1.24</td>
</tr>
<tr>
<td>ESCS index</td>
<td>2933</td>
<td>-0.18</td>
<td>0.91</td>
<td>-2.40</td>
<td>2.43</td>
</tr>
</tbody>
</table>

All ESCS covariates and ESCS index were standardized using z-score.

Table 4-3: Matrix of correlations among variables

<table>
<thead>
<tr>
<th>Highest educational level of parents</th>
<th>Highest occupational status of parents</th>
<th>Household income</th>
<th>Home educational resources</th>
<th>Cultural possessions</th>
<th>SIMCE Reading 2009</th>
<th>SIMCE Mathematics 2009</th>
<th>SIMCE ICT 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest occupational status of parents</td>
<td>0.72</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household income</td>
<td>0.60</td>
<td>0.64</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home educational resources</td>
<td>0.45</td>
<td>0.40</td>
<td>0.43</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultural possessions</td>
<td>0.21</td>
<td>0.22</td>
<td>0.30</td>
<td>0.33</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIMCE Reading 2009</td>
<td>0.35</td>
<td>0.35</td>
<td>0.34</td>
<td>0.29</td>
<td>0.29</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>SIMCE Mathematics 2009</td>
<td>0.35</td>
<td>0.34</td>
<td>0.42</td>
<td>0.34</td>
<td>0.23</td>
<td>0.65</td>
<td>1</td>
</tr>
<tr>
<td>SIMCE ICT 2011</td>
<td>0.45</td>
<td>0.38</td>
<td>0.39</td>
<td>0.35</td>
<td>0.22</td>
<td>0.57</td>
<td>0.60</td>
</tr>
<tr>
<td>ESCS index</td>
<td>0.84</td>
<td>0.85</td>
<td>0.83</td>
<td>0.68</td>
<td>0.46</td>
<td>0.43</td>
<td>0.45</td>
</tr>
</tbody>
</table>

All correlation coefficients have a p-value <0.001
All ESCS covariates and ESCS index were standardized using z-score.

It is important to highlight that based on prior research which distinguished between operational, formal, information and strategic skills van Dijk, 2006; Van Deursen and Van Dijk, 2010; Van Deursen et al., 2012), we also explored whether it is possible to identify the probability of correctly answering operational questions vs. information and communication questions. Operational questions are those which require students to carry out tasks relating to the use of a computer, such as following instructions to edit
and format a text. Information and communication questions are those that require students to perform tasks involving searching for, selecting, evaluating, understanding, analyzing and presenting information. We also looked at whether ESCS had different effects on these skills. However, a factor analysis using a polychoric correlation matrix (Holgado–Tello et al., 2010) on all test items showed that it was not possible to differentiate between sub-dimensions on the ICT SIMCE test. There was therefore no point in continuing with this analysis.

4.5 Results

4.5.1 ESCS Index

Table 4-4 shows the multivariate model results of the three SIMCE tests (components of the dependent variable) with the ESCS index. Residual correlations were 0.57 between Mathematics and Language; 0.45 between Language and ICT; and 0.49 between Mathematics and ICT. The Breusch-Pagan test of independence was statistically significant with a p-value<0.001. In other words, after controlling for the ESCS index, the tests are not independent. The pertinence of adjusting the multivariate regression models is therefore confirmed.

Table 4-4: SIMCE test multivariate model with ESCS index

<table>
<thead>
<tr>
<th></th>
<th>SIMCE ICT 2011</th>
<th>SIMCE Mathematics 2009</th>
<th>SIMCE Reading 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>SE</td>
<td>B</td>
<td>SE</td>
</tr>
<tr>
<td>ESCS Index</td>
<td>13.842</td>
<td>(30.15)**</td>
<td>14.288</td>
</tr>
<tr>
<td>Constant</td>
<td>256.06</td>
<td>(333.73)**</td>
<td>261.428</td>
</tr>
<tr>
<td>Wilks’ Lambda</td>
<td></td>
<td>0.71**</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>2933</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Second, as can also be observed in Table 4-4, the model has an adequate fit (Wilks’ Lambda of 0.71, with a p<0.01). A hypothesis testing procedure was performed in order to compare the marginal effect of the ESCS index on the three SIMCE tests, and learn
whether the differences reported by the model are statistically significant or not. The results, presented in Table 4-5, show that the ESCS index has a statistically greater marginal effect on the ICT SIMCE than on the Language SIMCE. However, the difference between the effect on the ICT SIMCE and on the Mathematics SIMCE is not statistically significant. It can therefore be concluded that the association between ESCS as a whole and the ICT SIMCE is greater than or equal to the other SIMCE tests.

Table 4-5: Hypotheses tests of differences among marginal effects of ESCS Index

<table>
<thead>
<tr>
<th>Tests</th>
<th>Test F (1, 2931)</th>
<th>p-value</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT - Reading</td>
<td>9.61</td>
<td>0.0019</td>
<td>Reject null hypothesis. Marginal effect is greater in ICT.</td>
</tr>
<tr>
<td>ICT - Mathematics</td>
<td>0.8</td>
<td>0.37</td>
<td>No statistically significant difference.</td>
</tr>
</tbody>
</table>

4.5.2 ESCS variables

Table 4-6 shows the multivariate model results of the three SIMCE tests (components of the dependent variable), using the five ESCS variables as covariates. Residual correlations were 0.57 between Mathematics and Language; 0.46 between Language and ICT; and 0.5 between Mathematics and ICT. The Breusch-Pagan test of independence was statistically significant with a p-value<0.001. In other words, after controlling for the ESCS covariates, the tests are not independent. The pertinence of adjusting the multivariate regression models is therefore confirmed.

Table 4-6: SIMCE test multivariate model with ESCS variables

<table>
<thead>
<tr>
<th></th>
<th>SIMCE ICT 2011</th>
<th>SIMCE Mathematics 2009</th>
<th>SIMCE Reading 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE</td>
<td>B</td>
</tr>
<tr>
<td>Highest educational level of parents</td>
<td>13.960 (1.201)**</td>
<td>4.369 (1.358)**</td>
<td>6.849 (1.243)**</td>
</tr>
<tr>
<td>Household income</td>
<td>6.548 (1.227)**</td>
<td>15.302 (1.387)**</td>
<td>5.262 (1.271)**</td>
</tr>
<tr>
<td>Highest occupational status of parents.</td>
<td>1.436 (1.333)</td>
<td>2.799 (1.507)</td>
<td>5.907 (1.380)**</td>
</tr>
<tr>
<td>Home educational resources</td>
<td>6.133 (0.896)**</td>
<td>7.583 (1.012)**</td>
<td>4.159 (0.927)**</td>
</tr>
</tbody>
</table>
As can be observed, the model has an adequate fit (Wilks’ Lambda of 0.67, with a p<0.01). As with the multivariate model using the ESCS index presented in section 4.1, there are differences between the marginal effects of each ESCS factor on the three SIMCE tests (Table 4-6). A hypothesis testing procedure was therefore used to test whether or not these differences are statistically equal (Table 4-7). The hypothesis test results comparing the marginal effects of ESCS variables over Mathematics and Language SIMCE tests (or between them) are presented in the Appendix.

Table 4-7: Hypotheses tests of differences among marginal effects of the ESCS factors between SIMCE ICT and other SIMCE tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>Tests</th>
<th>Test F (1, 2927)</th>
<th>p-value</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest educational level of parents</td>
<td>Reading - ICT</td>
<td>31.26</td>
<td>0.000</td>
<td>Reject null hypothesis. Marginal effect is greater in ICT.</td>
</tr>
<tr>
<td></td>
<td>Mathematics - ICT</td>
<td>55.18</td>
<td>0.000</td>
<td>Reject null hypothesis. Marginal effect is greater in ICT.</td>
</tr>
<tr>
<td>Household income</td>
<td>Reading - ICT</td>
<td>0.98</td>
<td>0.323</td>
<td>No statistically significant difference</td>
</tr>
<tr>
<td></td>
<td>Mathematics - ICT</td>
<td>44.01</td>
<td>0.000</td>
<td>Reject null hypothesis. Marginal effect is greater in Mathematics.</td>
</tr>
<tr>
<td>Home educational resources</td>
<td>Reading - ICT</td>
<td>4.33</td>
<td>0.038</td>
<td>Reject null hypothesis. Marginal effect is greater in ICT.</td>
</tr>
<tr>
<td></td>
<td>Mathematics - ICT</td>
<td>2.27</td>
<td>0.132</td>
<td>No statistically significant difference.</td>
</tr>
<tr>
<td>Cultural possessions</td>
<td>Reading - ICT</td>
<td>29.90</td>
<td>0.000</td>
<td>Reject null hypothesis. Marginal effect is greater in Reading.</td>
</tr>
<tr>
<td></td>
<td>Mathematics - ICT</td>
<td>0.64</td>
<td>0.425</td>
<td>No statistically significant difference.</td>
</tr>
</tbody>
</table>
The results (Table 4-7) show that after controlling for the remaining covariates, the parents’ level of education is more strongly associated to the ICT SIMCE than to the Language and Mathematics SIMCE.

With regards to household income, the hypothesis test showed that its marginal effect is significantly different between ICT and Mathematics and not between ICT and Language (Table 4-7). The conclusion can therefore be made that household income is less associated to the Digital or ICT SIMCE than to Mathematics SIMCE, and that its association with ICT and Language is not different.

The parents’ occupational status does not have a statistically significant marginal effect on the ICT SIMCE neither on the Mathematics SIMCE (Table 4-6). For this reason, no hypothesis test was performed. It could therefore be suggested that, after controlling for the remaining covariates, the parents’ occupational status does not add any new significant information on explaining ICT SIMCE results, and it is only relevant in explaining performance on the Language SIMCE.

There is a statistically significant difference in the marginal effect of educational resources at home on student performance between the ICT SIMCE and Language SIMCE. However, this is not the case for the ICT and Mathematics SIMCE (Table 4-7). It could therefore be suggested that having educational resources at home is more closely correlated to performance in the ICT test than in the language test. There is also a statistically significant difference in the effect of having cultural possessions at home on student performance between the ICT SIMCE and Language SIMCE. However, this is not the case for the Mathematics and ICT SIMCE. It could therefore be suggested that, after controlling for the remaining covariates, cultural possessions at home have less of an effect on student performance in ICT than in Language.

Finally, in relation to the ESCS variables that specifically have the strongest marginal effect on the ICT SIMCE, after controlling for the remaining covariates, the parents’
highest level of education is the most relevant variable (Table 4-8). The marginal effect between educational resources at home, household income and cultural possessions at home show no statistically significant difference. The parents’ highest occupational status has no significant marginal effect.

Table 4-8: Hypotheses tests for differences among marginal effects on SIMCE ICT

<table>
<thead>
<tr>
<th>Tests</th>
<th>Test F (1, 2927)</th>
<th>p-value</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education – Household income</td>
<td>15.46</td>
<td>0.000</td>
<td>Reject null hypothesis. Highest educational level of parents has a greater marginal effect.</td>
</tr>
<tr>
<td>Education - Home educational resources</td>
<td>22.89</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Education - Cultural possessions</td>
<td>51.46</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Household income – Home educational resources</td>
<td>0.06</td>
<td>0.799</td>
<td>No statistically significant difference.</td>
</tr>
<tr>
<td>Household income - Cultural possessions</td>
<td>3.48</td>
<td>0.062</td>
<td>No statistically significant difference.</td>
</tr>
<tr>
<td>Home educational resources - Cultural possessions</td>
<td>3.55</td>
<td>0.059</td>
<td>No statistically significant difference.</td>
</tr>
</tbody>
</table>

4.6 Discussion and conclusions

This article presents empirical evidence that helps understand the second digital divide in education. This is done by comparing the effect of economic, social and cultural status (ESCS) on the performance by Chilean students on a digital skills test with their performance on standardized language and mathematics tests. The marginal effect of a group of variables measuring student ESCS as a whole and separately were compared using multivariate linear regression analysis.

First, we found that variables of ESCS that are commonly measured to explain results on standardized tests (Schulz, 2005; Sirin, 2005; OECD, 2010) are relevant when explaining performance on the Chilean national standardized ICT or digital test.

Second, the ESCS index was equally relevant in explaining performance on the digital skills and mathematics test, while less relevant on the language test (see Table 4-5). This finding is particularly important since it provides evidence contrary to the belief that the
digital environment, especially the Internet, would have the potential to provide equal opportunities and reduce ESCS differences among new generations of students. On the contrary, it indicates that the gap based on ESCS tends to perpetuate or even widen when moving from the areas of language and mathematics to the digital domain. These results provide empirical evidence for the idea put forward by some authors that being effective in solving problems involving information and communication is more demanding in a digital context (Castells, 2001; Di Maggio et.al, 2004; Hargittai, 2008; Warschauer, 2012). The results also support the so-called Amplification Theory, which claims that instead of leveling the playing field, technologies tend to amplify existing inequalities (Toyama, 2011).

In addition, there were two interesting findings in relation to the ESCS factors that best explain Chilean students’ performance on the ICT or digital test. The first is that achievement on the ICT test was best explained by the parents’ highest level of education (Table 8). The second is that the parents’ level of education was more strongly associated with the ICT test than with the other two tests (Table 4-7). These results are interesting since previous studies have shown that the parents’ education is the most stable indicator of ESCS in the sense that it is established when the student is young and tends to persist over time. Income, occupation, or education and cultural possessions, on the other hand, may change more over the 12 years of the student’s schooling (Sirin, 2005). Research also shows that the parents’ education is significantly associated with and generally the best predictor of their children’s intellectual outcomes (Mercy & Steelman, 1982). This is even the case after controlling for other indicators of socioeconomic status such as income (Duncan & Brooks-Gunn, 1997; Dubow et. al., 2009). It also has long-term effects on outcomes for middle adulthood, such as education and occupation (Dubow et. al., 2009). The fact that one of the strongest and most stable indicators of ESCS has a more significant effect on student performance in a digital context adds further support to the concern that performance differences may be widening in the digital domain in Chile. This in turn presents educational policymakers with the challenge to develop students’ digital literacy skills starting from an early age.
To further understand the marginal effect of each of the ESCS variables in students’ performance in each of the domains, qualitative studies should be performed. In addition, these findings pose the question of whether existing attitudes, practices and strategies normally associated with high ESCS families can explain the relevance of ECSC in digital context. For example, previous research shows that parents engaging in more and richer conversations with their children, reading to them more and providing more teaching experiences are characteristic of high ESCS families (Shonkoff & Phillips 2000; Hoff-Ginsberg Tardif, 1995; Bradley & Corwyn, 2002). Alternatively, these families could be developing new strategies to deal with the demands of the digital world. This also calls for future qualitative research in order to have a more in-depth understanding of how specific ESCS-related characteristics may be affecting student performance in a digital context.

In summary, the results of this study indicate that the effect of ESCS on Chilean students’ performance on a digital test tends to be equal to or greater than the effect on other, more traditional tests. This therefore offers empirical evidence to suggest that instead of being more equal, the digital world tends to perpetuate and even widen the gap that is evident in other skills. In this sense, it also highlights the importance of public policy in education. In addition to being concerned about providing access and promoting the use of technology in schools, policies should also work on strategies to develop digital skills related to working critically and creatively with information in digital environments. As research is starting to show, these skills do not develop spontaneously in students as a result of having access to and using ICT. In fact, for example, research on information-problem solving shows that while students may have the ability to find information using digital technology, they have difficulty in defining information problems, specifying proper search queries and evaluating the information that they find (Walraven et al., 2008; Brand-Gruwel et al., 2009; Van Deursen & Van Diepen, 2013). Consequently, as in other performance areas, information problem-solving requires formal education activities if it is to be properly developed as a skill.
Finally, there were some limitations to this study. First, the digital test had very few items that only involved computer operation tasks without also involving information and communication tasks. In fact, analysis of the psychometric characteristics of the test indicated a strong correlation between the probability of correctly answering the information items and the operational items. Although this responds to the test construct that sought to measure the ability to jointly solve information, communication, and technical tasks, it also represents a limitation since it does not allow these two types of skills to be differentiated for comparison and deeper analysis. It would therefore be recommendable to give separate scores to technical tasks when designing digital skills tests in the future. This would allow for important hypotheses to be tested, such as whether technical skills are more even among students than information or communication skills. It would also provide educational policymakers with evidence of which skills to support more intensively in formal schooling. Second, the results are only representative of the Chilean student population and therefore future work should consider performing international studies to compare the effect of ESCS on student performance in these three performance areas across different countries.
The importance of having a digitally literate population forms part of international academic and policy debate. However, it has been scarcely studied in Chile. This thesis aimed to contribute to the understanding of digital literacy among students in Chile, following more than 20 years of public investment in an ICT for education policy. Although this policy has provided schools with equipment, Internet access, and teacher training, as well as technical and pedagogical support, there have been no specific learning objectives related to the development of these skills.

The studies that shape this thesis aimed to analyze this topic in four ways. The first was by proposing a definition of digital skills for the Chilean context. The second was by analyzing student performance on the first test designed to measure these skills in the Chilean education system, which later became a national test (ICT SIMCE). The third was by examining the items (tasks) that best discriminate performance by 10th grade students in Chile on the digital skills test (2011 ICT SIMCE). The fourth was by studying the relationship between student performance on the national digital skills test (2011 ICT SIMCE) and their previous performance on national language and mathematics tests (2005 and 2009 Language and Mathematics SIMCE). The fifth and final way was by comparing the effect of a student’s economic, social and cultural status (ESCS) on their performance on the digital skills test (2011 ICT SIMCE) and on their performance on the national language and mathematics tests (2009 Language and Mathematics SIMCE).

Firstly, with respect to the definition of a set of digital skills for Chilean students (Objective 1 of this thesis), a review of the status of these skills in the Chilean curriculum showed that they had been officially integrated into the curriculum in Chile (since 1998 for secondary education and 2008 for primary education). This was done as a set of cross-disciplinary aims to be accomplished within traditional subject areas. These skills placed particular emphasis on computer literacy or ICT functional skills,
i.e., the students’ mastery of ICT applications. Nevertheless, a review of international research and policies showed that a broader notion of ICT literacy has emerged. This notion considers not only technical skills, but also the engagement of higher-order cognitive processes in solving information and communication problems in a digital context. Digital literacy is therefore becoming a strategic matter in the education of new generations. This was the perspective adopted when proposing a set of digital skills called ICT Skills for Learning and that was to be evaluated in the Chilean educational system (see Chapter 2).

Secondly, the analysis of results by 10th grade students (15 years old) in Chile on a pilot test designed to evaluate their level of digital skills showed in general that there was little development of these skills among Chilean students. This was particularly the case for skills that were related to producing information. Furthermore, these skills were related to ICT access and daily use at home, as well as confidence in performing simple ICT tasks. However, they were not related to school use, showing that schools have not played a significant role in developing these skills. This can partly be explained by the fact that these skills have not been the focus of the learning objectives established by educational policy in Chile. It can also be explained by the fact that Chilean teachers have not been properly prepared to develop these skills among their students (see Chapter 2).

Thirdly, to understand the types of skills that are measured by the 2011 ICT SIMCE test, an analysis was performed of the types of tasks that best discriminate student performance on the test (Objective 3 of this thesis). The results showed that the most informative tasks on the test were those that required students to demonstrate their ability in applying criteria or knowledge to solve problems related to basic digital culture and processing information in a digital environment. In contrast, those tasks that asked students to answer by stating their previous knowledge related to ‘desirable behaviors’ were the worst at discriminating student performance. This shows the importance of being able to solve digital problems on the test (see Chapter 3).
Fourthly, another objective of this thesis was to understand the relationship between the performance by 10th grade students in Chile on the national digital skills test (2011 ICT SIMCE) and their previous performance on the national language and mathematics tests (2005 and 2009 Language and Mathematics SIMCE). This was so to better understand the factors that explain the digital skills of students in Chile and determine whether these skills are different from other skills such as language and mathematics as measured in the national tests (Objective 4 of this thesis). The results showed that after removing the contribution of schools from ICT SIMCE scores, the effect of language and mathematics skills and the students’ economic, social and cultural status; explain 42% of individual variability on the ICT SIMCE. Furthermore, the results also showed that achievement in language by the end of the first and second cycles of primary education had the greatest marginal effect on performance on the ICT SIMCE. This was followed by achievement in mathematics by the end of the second cycle of primary education (8th grade). This relationship can be understood by considering that the ICT SIMCE measures a set of skills that are relevant for effective performance in the digital realm, and that many of these are related to the skills measured in the Language and Mathematics SIMCE tests. This is especially the case for problems where the use and production of information requires skills in the area of reading comprehension, or when representing data in tables or charts requires an understanding of numerical information. In this sense, tasks carried out in digital contexts do not exist in isolation. Rather, they are tasks that draw directly from skills required when working with linguistic or numerical printed texts. At the same time, although language and mathematical abilities were important in solving tasks on the ICT SIMCE, the results show that these were not the only skills required. There was still a 58% residual variance that must be explained. One hypothesis is that this residual variance can be attributed to specific digital skills, which demand cognitive strategies and processes that are different from those needed for printed environments. Finally, the results regarding the relationship between the ICT SIMCE and achievement in language and mathematics by the end of the first cycle of primary education (4th grade) showed that language had a positive and significant marginal effect, similar to
that of the 2009 SIMCE (8th grade). Meanwhile mathematics had a non-statistically significant marginal effect. This finding is particularly interesting and may indicate the relevance of linguistic capital (Bourdieu & Passeron, 1977) in solving information and communication problems in a digital environment (see Chapter 3).

Finally, research has revealed the importance of a student’s economic, social and cultural status in their academic performance. The final objective of this thesis was therefore to compare and analyze the marginal effect of economic, social and cultural status on the results of the group of Chilean students that sat the national digital performance test (ICT SIMCE 2011) and the 2009 Language and Mathematics SIMCE tests (Objective 4 of this thesis). This question is also relevant for understanding digital skills. For some, access to the world wide web has represented the promise of a more democratic and equal society, while for others it has represented a new source of potential cultural and social inequality. This has given rise to the so-called digital divide (see Castells, 2001; DiMaggio et al., 2004; van Dijk, 2006; Selwyn and Facer, 2007; Warschauer, 2012). The results of this study indicate that the role of economic, social and cultural status is equal to mathematics and greater than language in the domain of digital performance. Consequently, instead of being more equal, the digital realm would tend to perpetuate and even widen differences that already exist in other performance areas (see Chapter 4).

In synthesis, the results from the studies that shape this thesis provide important evidence relating to the level of development of digital skills among 10th grade students in Chile. They also provide evidence of the factors that explain students’ performance and offer a wider perspective of digital skills than is traditionally considered by the Chilean curriculum. The low level of development of these skills among Chilean students, as well as the increased relevance of economic, social and cultural status in explaining student test results in the digital domain, highlight the importance of public policy in this area of learning. Public policy should not only be concerned about providing access to and promoting the use of technology in schools. It must also focus
on strategies for developing digital skills in terms of working critically and creatively with information in a digital environment. As research evidence is showing, these skills do not develop spontaneously in students just by having access to and operating ICT (Walraven et al., 2008; Brand-Gruwel et al., 2009; Van Deursen and Van Diepen, 2013). Consequently, as in other performance domains, solving problems regarding information and communication in a digital environment requires the development of formal education policy and pedagogical activities.

Furthermore, the results highlight the relevance of mathematics and specially language skills in student performance within the digital realm. This shows that the development of digital skills in new generations, on the on hand, require reinforcing traditional literacies (language and mathematics) and specially language starting from students’ early school years. On the other hand, results also provide some grounds to believe that strategies and aptitudes specific to the digital context should be taught directly to students and integrated as learning objectives in school subjects across the curriculum. Although new subject programs published in 2012 and 2013 include some digital skills more explicitly (especially in the case Language), they are still in an early stage of definition (see for example, MINEDUC, 2012a, 2012b, 2012c, 2013). Therefore, it is important to advance from a generic inclusion of digital skills to a much more specific inclusion. This would illustrate teachers about the learning objectives that they should achieve with their students, as well as, guide their own competencies development and pedagogical practices in order to achieve these objectives. For this to happen, the Ministry of Education should grade, specify and exemplify these skills across subjects and include them in the instruments that mobilize the school system. These instruments include the school curriculum, teacher standards, teacher training and assessments.

Finally, to further the understanding of students’ digital skills, the ICT SIMCE test should be continuously revised and improved, taking into consideration international discussion and recent developments. In this effort, future research should include qualitative studies about teacher and student activities related to working with
information, as well as cognitive studies related to the development of these skills in the different stages of child development.

Appendix

Table 9: Hypotheses test results on differences of ESCS index marginal effects between SIMCE Reading and SIMCE Mathematics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Tests</th>
<th>Test F (1, 2931)</th>
<th>p-value</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESCS index</td>
<td>Mathematics - Reading</td>
<td>17.58</td>
<td>0.000</td>
<td>Reject null hypothesis. Marginal effect is greater in Mathematics.</td>
</tr>
</tbody>
</table>

Table 10: Hypotheses test results on differences of ESCS factors marginal effects between SIMCE Reading and SIMCE Mathematics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test F (1, 2927)</th>
<th>p-value</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest educational level of parents</td>
<td>4.18</td>
<td>0.041</td>
<td>Reject null hypothesis. Marginal effect is greater in Reading.</td>
</tr>
<tr>
<td>Household income</td>
<td>65.55</td>
<td>0.000</td>
<td>Reject null hypothesis. Marginal effect is greater in Mathematics.</td>
</tr>
<tr>
<td>Home educational resources</td>
<td>14.31</td>
<td>0.001</td>
<td>Reject null hypothesis. Marginal effect is greater in Mathematics.</td>
</tr>
<tr>
<td>Cultural possessions</td>
<td>23.84</td>
<td>0.000</td>
<td>Reject null hypothesis. Marginal effect is greater in Reading.</td>
</tr>
</tbody>
</table>

Table 11: Hypotheses tests for differences among marginal effects on SIMCE Mathematics

<table>
<thead>
<tr>
<th>Tests</th>
<th>Test F (1, 2927)</th>
<th>p-value</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education - Household income</td>
<td>26.32</td>
<td>0.000</td>
<td>Reject null hypothesis. Household income has a greater marginal effect.</td>
</tr>
<tr>
<td>Education - Home educational resources</td>
<td>3.02</td>
<td>0.082</td>
<td>No statistically significant difference.</td>
</tr>
<tr>
<td>Education - Cultural possessions</td>
<td>0.00</td>
<td>0.969</td>
<td></td>
</tr>
<tr>
<td>Household income – Home</td>
<td>17.55</td>
<td>0.000</td>
<td>Reject null hypothesis.</td>
</tr>
<tr>
<td>Tests</td>
<td>Test F (1, 2927)</td>
<td>p-value</td>
<td>Conclusion</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------------</td>
<td>---------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>Education - Household income</td>
<td>0.66</td>
<td>0.412</td>
<td>No statistically significant difference.</td>
</tr>
<tr>
<td>Education - Home educational resources</td>
<td>2.52</td>
<td>0.112</td>
<td></td>
</tr>
<tr>
<td>Education - Cultural possessions</td>
<td>1.03</td>
<td>0.315</td>
<td></td>
</tr>
<tr>
<td>Education – Occupation</td>
<td>0.17</td>
<td>0.681</td>
<td></td>
</tr>
<tr>
<td>Household income – Home educational resources</td>
<td>0.43</td>
<td>0.514</td>
<td></td>
</tr>
<tr>
<td>Household income - Cultural possessions</td>
<td>3.6</td>
<td>0.057</td>
<td>No statistically significant difference.</td>
</tr>
<tr>
<td>Household income – Occupation</td>
<td>0.09</td>
<td>0.768</td>
<td></td>
</tr>
<tr>
<td>Occupation - Home educational resources</td>
<td>1.07</td>
<td>0.301</td>
<td></td>
</tr>
<tr>
<td>Occupation - Cultural possessions</td>
<td>2.29</td>
<td>0.131</td>
<td></td>
</tr>
<tr>
<td>Home educational resources - Cultural possessions</td>
<td>9.12</td>
<td>0.025</td>
<td>Reject null hypothesis. CULPTOS has a greater marginal effect.</td>
</tr>
</tbody>
</table>

Table 12: Hypotheses tests for differences among marginal effects on SIMCE Reading


Comisión para el Desarrollo y Uso del Sistema de Medición de la Calidad de la Educación. (2003). Evaluación de Aprendizajes para una Educación de Calidad. Recuperado en marzo de www.simce.cl


RAND Reading Study Group. (2002). Reading for understanding: Toward an R&D program in reading comprehension. Santa Monica, CA: RAND.


APPENDICES
APPENDIX 1: INTRODUCING 1 TO 1 IN THE CLASSROOM: A LARGE-SCALE EXPERIENCE IN CHILE

Magdalena Claro, Miguel Nussbaum, Ximena López, Anita Díaz


Abstract

This paper presents the results of a study that sought to understand how a strategy of Mobile Computer Labs (MCL) has been integrated into 3rd and 4th grade teaching-learning practices in 1,591 state schools in Chile. In particular, the study aims to identify the most important factors related to MCL integration into these practices a year after its implementation. The findings obtained by applying a survey and performing classroom observations show that, although the schools are willing to use this resource, it has been used sporadically for searching information and drilling and practicing contents related to Mathematics and Language, in addition to motivating students. Furthermore, the classroom observations do not reveal any innovative teaching strategies, related to the use of this new technology. The study shows that amongst the main reasons for this traditional and sporadic use of the MCL are a lack of targeted teacher training and preparation time, and insufficient technical and pedagogical support during the phases of implementation and integration to the pedagogical practices.

Keywords: ICT in the classroom, One-to-one initiatives, Teaching practices with ICT, ICT strategy evaluation, Teacher support

Introduction

The Chilean ICT in education policy (Enlaces) started in 1993 and has equipped schools with computers, local networks, educational resources, productivity software, free or
subsidized Internet access, as well as providing technical and pedagogical support in partnership with 24 universities from across the country. Computers have been placed in special rooms called Computer Labs and, since 2007 classrooms have been equipped with a multimedia package that includes a personal computer, audio equipment and a projector. By the year 2010 90% of students going to publicly financed schools had access to computers, 60% of schools had Internet access, 110.000 teachers (there are around 180.000 teachers working today in the system) had been trained to use computers as a part of their instruction process, and the Country reached a national average of 9,8 students per computer in schools (Donoso, 2010; Hepp. Et.al., 2004; Sánchez & Salinas, 2008).

For the past few years, the primary concern in Chile has been investigating the effects of these policies. In particular, studies have looked at how these new resources are being used and whether or not there has been any impact on student learning. In Chile, the evidence is consistent with other international studies and reports which show that the frequency of ICT use in teaching and learning activities in schools is relatively low (Cuban, 2001; Hinostroza, et.al., 2005; Plomp & Voogt., 2009; OECD, 2010) and that they are mostly used to support “traditional” teaching practices (i.e. instruction based lessons) (Plomp & Voogt, 2009; Trucano, 2005; Balanksat et. Al., 2006). In fact, data collected through a 2009 national survey of all state-subsidized schools and a sample of private schools showed that ICT is not frequently used in teaching and learning in the classroom. When used, it is to support teacher’s current practices instead of changing or revolutionizing them (Hinostroza et. Al., 2010).

In terms of the impact on student learning, international and national research has not been able to provide conclusive statements about their positive or negative effects. On the contrary, findings are most often inconsistent between studies or difficult to generalize. These studies are commonly country-specific or developed under particular conditions; such is the case with pilot projects or case studies. Additionally, there are very few experimental studies that allow for empirically sound conclusions related to
causality between ICT and student performance (Balanksat et al., 2006; Kozma, 2006; Ungerleider & Burns, 2003; McFarlane et al., 2000; Cuban & Kirkpatrick, 1998). Where evidence seems to converge is in indicating a non-linear and complex relationship between ICT and learning.

The lack of impact of ICT in schools has been explained in different ways by educational researchers and experts. One such explanation is related to the inability of technologies and technological school settings to adapt to real educational needs (Means, 2000; Watson, 2001). As previously mentioned, in Chile ICT resources are found mainly in computer labs, which implies that activities built around these technologies change the natural context of classroom teaching and tend to focus on the purely technological aspects. In this sense, the technologies “(...) are not truly integrated into the classroom teaching dynamic, which may limit their impact on teaching styles traditionally used in schools” (Nussbaum et al., 2009, p. 295). As Watson (2001) argues, having to book a timetabled fixed resource and moving the class to a separate room for a limited time does not allow for open-ended exploratory work, which the technology could facilitate. Software is increasingly seen as having the potential to support and enhance curriculum initiatives based on a conceptual understanding and the development of process skills. Nevertheless, hardware’s physical location and management threaten this potential benefit. Consequently, from this point of view, as technologies adapt to real educational needs, ICT should tend be used more appropriately and achieve the desired learning results (Means, 2000).

Among the technologies available, interactive whiteboards and laptops, provided on a one-to-one (1:1) basis, have been introduced in the classroom. With regard to laptops it is argued that ubiquitous or 1:1 computing environments may enhance learning. This is because they can provide all students and teachers with continuous access to digital teaching resources within the same classroom dynamics, something that computer labs outside the classroom do not allow for (Bonifaz & Zucher, 2004). Furthermore, 1:1 models of ICT use in education are promoted with the idea that they can provide
personalized and student-centered experiences to students within schools and beyond (Severin & Capota, 2011). For example, the One Laptop per Child (OLPC) initiative promised to transform education for world disadvantaged students by giving them the means to teach themselves and each other (Kenneth et.al., 2009). The OLPC project was strongly shaped by the visions of the founder of the Massachusetts Institute of Technology (MIT) Media Lab, Nicholas Negroponte and Seymour Papert’s constructionist learning theory. From Paperts’ perspective students learning depends on constructing ideas and individual laptop computers can be essential for carrying out such construction in today’s world. Through the OLPC program, Negroponte, Papert and others have sought to develop and distribute a low-cost “children’s machine” that could empower youth to learn without, or in spite of, their schools and teachers (Warschauer & Ames, 2010; Kenneth, 2009).

However, recent studies do not show clear evidence regarding the benefits of 1:1 models of computer use in schools and homes (Warschauer & Ames, 2010). In Latin America and the Caribbean, the Inter-American Development Bank (IDB) recently published a study that concluded that there are still uncertainties relating to the impact of 1:1 programs and that further evaluation is needed (Chong, 2011). The evidence collected in this study and others, so far indicates that programs that overlook teacher training and the development of specific software may yield very low returns (Chong, 2011; Karsenti & Collin, 2011; Severin & Capota, 2011). Additionally, evidence related to projects that give students the opportunity to take their computers home is not positive, especially when it comes to poor students. In fact, Chong et. Al (2011) found that children with weak adult supervision at home may not spend their time using computers for homework and studying, and therefore this may have no positive impact in their educational achievement. Some studies have even found that access to computers at home may have a negative impact on academic achievement (Vigdor & Ladd, 2010; Malamud & Pop-Eleches, 2011).
In summary, studies that look at ICT use in schools in Chile and around the world show that there is still some way to go before we really understand how to naturally integrate technologies into the teaching and learning process in the classroom and, subsequently, impact learning. Although significant efforts have been made to use technologies that can adapt to natural teaching conditions in the classroom, the benefits are still not clear.

In 2009, Enlaces launched a Mobile Computer Labs (MCL) strategy with the main purpose of developing the capacity of third grade students to read, write and perform basic mathematical operations through the integration of computer equipment. This equipment allows 1:1 learning strategies to be developed. This strategy consisted in providing 1,591 state primary schools with a cabinet of netbooks, one netbook for each student in each third grade classroom and one for the teacher with software that allows them to control and communicate with the class. The cabinet makes possible to move the computers between classrooms, as well as offer storage, security and a means for charging the batteries. It also provides integrated wireless networking technology that allows communication between computers and classroom collaboration (Mineduc, 2009). The strategy also includes a web page that provides information about the project, as well as digital educational resources in Mathematics and Language to support class lessons.

In this context, the main purpose of this study was to evaluate how Chilean schools implemented and used the MCL in the classroom and whether this new strategy had any effect in teaching practices. More specifically, our interest was to study how this new strategy of providing 1:1 technology in the classroom had been integrated into the teaching and learning process of Chilean third grade classrooms. More specifically, our purpose was to identify the most important variables associated with key dimensions in the process of implementation and integration of MCLs in schools and classrooms during its first year of implementation. The research questions were driven by the work of Zhao et al. (2002) who identified three key domains that should be considered when trying to understand the processes involved in implementing new technologies:
1. The innovator that uses the technology, in this case, the teacher.
2. The innovation or project to be developed with the technology, in this case, the pedagogical use of the MCL.
3. The context in which the innovation takes place (i.e. technology infrastructure, human infrastructure and organization culture), in this case the school.

In this study we aimed to identify and analyze the different factors related to these three processes that explain a higher or lower level of integration of the MCL in third grade Chilean classroom teaching practices. Consequently, the research questions were:

- In what way and to what extent are teachers using this technology in their teaching practices?
- What have been the aids/facilitators and barriers for integrating these technologies into teaching practices?
- Which factors associated with human, technological and contextual school conditions are more closely related to the integration of MCL into teaching practices?

**Methodology**

**Instruments**

A quantitative method was used based on the design and application of a self-administered questionnaire completed by the participating schools. The questionnaire was built taking into consideration the main elements of the MCL strategy, as well as the
results of interviews with representatives from the Ministry of Education and other school figures ( principals and teachers) from participating institutions.

The questionnaire comprised 147 items, organized in four sections or dimensions: (1) personal characteristics of the respondent; (2) teaching and ICT in the school; (3) use and organization of the MCL; and (4) MCL Project. The first dimension asked about the role of the respondent at the school (i.e. teacher, school director, ICT coordinator), his/her age and ICT access and use at home. Dimensions two and three were related to the organizational conditions found after a literature review, i.e. the context for integrating the MCL in the school and the classroom, such as time for teacher preparation (Jones, 2004, Cox et.al. 2004), technical and pedagogical support (Kirkland & Sutch, 2009; Law et.al., 2008; Trucano, 2005), the school directors’ support and leadership (Law et.al., 2008) and schools’ ICT plans and strategies (Kozma, 2003). Finally, the fourth dimension asked about the expectations, evaluation and future perspectives related to the MCL project at the school. The questionnaire presented different types of questions: 53 multiple-choice questions, 11 multiple answer questions, 82 4-point Likert scale questions and one open-ended question. Originally the items did not belong to predefined scales. In the data analysis phase, scales were created to facilitate analysis and interpretation of data (see Data Analysis section). The design of the questionnaire considered that it could be answered online in approximately 30 minutes.

Sample design and data collection

The study’s sampling frame comprised the 1,591 schools that participated in the MCL project. Stratified random sampling was applied, using the criteria of Region (Chile’s first-order administrative division) and ‘rurality’ to form the required strata. A probabilistic sampling of schools was then applied to each stratum in order to maintain the proportion of schools in each stratum and guarantee the representativeness of the sample. The sample size was calculated using a 95% confidence interval and 5% margin
of error. For each of the selected schools, two ‘replacement’ schools were also chosen randomly. These schools would be successively incorporated in case the original school failed to answer the survey.

A total of 565 schools were contacted in three successive calls. An email with the URL to access the survey was sent to each school. Only one representative from the school could answer the survey (teacher, Principal, Head of Curriculum and Instruction or Head of ICT). This representative had to be someone who had participated in the MCL project. A total of 242 valid survey responses were gathered for analysis. The follow-up after the third call revealed that 70% of non-responses were due to causes not related to the project (e.g., a nationwide student strike).

Unit non-response was treated by post-stratification weighting based on the known information about the population frame (region and rurality) (Holt & Elliot, 1991). Weighting is the most widely used strategy for handling unit non-response in order to reduce non-response bias (Armoogum & Madre, 1998; Little & Vartivarian, 2004), especially in cases where non-response is not related to the phenomena under study. Weighting coefficients were calculated by dividing the expected number of respondents by the actual number of respondents in each stratum. Table 1 shows the details of the composition of the sample and the weighting coefficients.

Table 1
Sample Characteristics

<table>
<thead>
<tr>
<th>Region</th>
<th>Expected Sample Size</th>
<th>Achieved Sample Size</th>
<th>Weighting Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urban</td>
<td>Rural</td>
<td>Total</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>
Data analysis

Three types of analysis were carried out:

a. The data were analyzed using descriptive statistics for each item (analysis of frequency and percentages). Chi-square values were estimated in order to study the possible differences between sub-groups (e.g. differences due to the role in the school; rurality of the school).

b. Given the large quantity of items and sub-items in the questionnaire, new variables (scales) were created using an Optimal Scaling procedure (Greenacre, 2007). Scales were created following two criteria: theoretical coherence of the items and an internal consistency of the scale (Cronbach’s alfa) above 0.7. A total of 57 items were grouped in 10 different scales. After quantification, different quantitative analyses were done (e.g. averages, correlations, t-tests and ANOVA) on the aggregated variables.

c. Finally, a Binary Logistic Regression analysis was carried out to establish the factors associated with a successful implementation of the project. For the Ministry of Education, investing in the MCL project and implementing the national strategy was worthwhile if the technological resources were frequently used to support learning of
third graders, and if the technology was being used to promote diversity and innovation in teaching practices. The frequency of use of the MCL in schools and the pedagogic diversity of use of the MCL were therefore the two scales chosen as dependent variables. The scale for frequency of use was constructed based on the 6 items that captured information about how much the MCL was used in different subjects. The scale for diversity of use was constructed based on the 8 items that referred to the frequency of use of the MCL in different pedagogical activities. Schools were assigned to two groups (higher/lower frequency of use and higher/lower diversity of use) according to the values attained in each scale. So as to find the optimum number of predictive factors for each of the dependent variables (i.e. find the model with the lowest possible number of variables and maximum predictive capacity), it was decided to carry out a logistic regression analysis with a sequential extraction method based on likelihood (Forward Stepwise Likelihood Ratio).

Results

Characteristics of the survey respondents

A large number (44.4%) of those who answered the survey were the Head of ICT at their school (Table 2).

<table>
<thead>
<tr>
<th>Position</th>
<th>Frequency (N)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>38</td>
<td>15.8</td>
</tr>
<tr>
<td>Head of Curriculum and Instruction</td>
<td>40</td>
<td>16.6</td>
</tr>
<tr>
<td>Head of ICT</td>
<td>107</td>
<td>44.4</td>
</tr>
<tr>
<td>Principal</td>
<td>53</td>
<td>22.0</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>1.2</td>
</tr>
<tr>
<td>Total</td>
<td>242</td>
<td>100.0</td>
</tr>
</tbody>
</table>
The distribution for gender was quite even between men and women, albeit with a slightly higher percentage of women (53%). However, if this is analyzed per position or school role, 70% of principals were men and 79% of teachers were women. Additionally, 43% of respondents were between 41 and 55 years of age and the majority had been at the school for more than 2 years. Finally, with regard to access and use of ICT, 97% answered that they used ICT on a daily basis, 97% that they had a computer at home and 90% that they had a wireless Internet connection.

**Perceptions of ICT ad the MCL as a school resource**

At the level of believes or perceptions of ICT, the great majority said that, in general, ICT have been well accepted and used as a resource to support new pedagogical practices at their school. In effect, the majority of respondents agreed or strongly agreed that ICT are important for their school (96.6%), that ICT has begun to be used for teaching and learning school subjects (94.7%), that all teachers within the school use ICT in their classes (72.5%) and that there is an institution-wide plan for the pedagogical use of ICT (86.3%).

With regard specifically to the MCL, 92.8% said that their school saw it as an opportunity to promote more innovative pedagogical practices, 82.6% as a way to motivate students (i.e. gain their interest and enthusiasm with the class lesson), 77.3% as a means of improving their students’ digital literacy levels, 70.1% as an opportunity to have increased ICT infrastructure for teachers and students, 68.8% as a way of supporting the Institutional Educational Project and 63.6% as a means of accelerating the pedagogical integration of ICT.

**Use of the MCL**
The great majority (90.5%) of respondents indicated that their school has been using the MCL for a year or more and in third grade this percentage rises to 95.6%, which was the target class level of the project. As shown in Table 3, the respondents said that the MCL was used with regular frequency (the most frequent answer being “often”, followed by “sometimes”) in mathematics and language, although more frequently in language than mathematics. If the answers ‘often’ and ‘always’ are added together, then 59.5% of respondents used the MCL in mathematics, while 70.7% used it in language. This use can be explained by considering that the aim of the project was to use the MCL in these two subjects, although the majority of respondents said that they were also used sometimes or often in other subjects such as natural science, history & social science and technology. It is interesting to notice that 33.1% reported never using the MCL for the technology subject, which can be partly explained by Enlaces’ strategy to teach technology in the ICT laboratory (Table 3).

Table 3

Frequency of Use of MCL per Subject

<table>
<thead>
<tr>
<th></th>
<th>Mathematics</th>
<th>Language Arts</th>
<th>Natural Science</th>
<th>History &amp; Social Science</th>
<th>Technology</th>
<th>Other subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>20.9</td>
<td>24.3</td>
<td>9.8</td>
<td>7.7</td>
<td>5.7</td>
<td>4.6</td>
</tr>
<tr>
<td>Often</td>
<td>38.6</td>
<td>46.4</td>
<td>30.8</td>
<td>31.0</td>
<td>21.6</td>
<td>17.3</td>
</tr>
<tr>
<td>Sometimes</td>
<td>37.0</td>
<td>27.4</td>
<td>43.3</td>
<td>42.7</td>
<td>39.5</td>
<td>46.9</td>
</tr>
<tr>
<td>Never</td>
<td>3.5</td>
<td>1.9</td>
<td>16.1</td>
<td>18.7</td>
<td>33.1</td>
<td>31.2</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The correlation analysis showed that the per-subject frequency of use of the MCL is not related to general beliefs or perceptions about ICT, nor the expectations that the schools had with regard to the Enlaces project. Also, there was no significant difference in
frequency of use between rural and urban schools, with the exception of Language, where urban schools used the MCL with greater frequency ($\chi^2(1,317)=13.00, p<0.05$).

With regard to the activities that the majority of respondents said that teachers performed ‘often’ or ‘always’ with the MCL, the main responses were exercising previously acquired concepts and skills, searching for information and motivating the students. Also, the majority said that teachers used the MCL sporadically (sometimes or never) to evaluate learning, carry out research projects, process and analyze data, give instruction-based classes and introduce contents (Table 4).

**Table 4**

<table>
<thead>
<tr>
<th>Types of Use of the MCL</th>
<th>Evaluate learning</th>
<th>Exercise contents</th>
<th>Research projects</th>
<th>Search for information</th>
<th>Process and analyze data</th>
<th>Give instruction-based classes</th>
<th>Introduce contents to be developed</th>
<th>Motivate students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>7.3</td>
<td>24.2</td>
<td>6.2</td>
<td>20.3</td>
<td>10.9</td>
<td>14.7</td>
<td>12.6</td>
<td>38.9</td>
</tr>
<tr>
<td>Often</td>
<td>21.6</td>
<td>43.5</td>
<td>16.7</td>
<td>31.9</td>
<td>24.4</td>
<td>29.7</td>
<td>32.5</td>
<td>37.3</td>
</tr>
<tr>
<td>Sometimes</td>
<td>55.3</td>
<td>30.2</td>
<td>44.9</td>
<td>34.0</td>
<td>42.0</td>
<td>44.7</td>
<td>46.8</td>
<td>22.9</td>
</tr>
<tr>
<td>Never</td>
<td>15.8</td>
<td>2.2</td>
<td>32.2</td>
<td>13.8</td>
<td>22.7</td>
<td>10.8</td>
<td>8.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

By comparing the types of use by rurality, urban and rural schools made different use of the MCL. Urban schools made greater use of the MCL for giving instruction-based classes, drilling contents and motivating the students, while rural schools used them
more to process and analyze data, evaluate learning and carry out research projects. Urban schools made significantly greater use of the MCL for exercising contents \( t(287)=2.09, p=0.03 \) and giving instruction-based classes \( t(281)=2.06, p=0.04 \). These data are interesting, as they suggest that use of the MCL in urban schools tends to be more ‘traditional’, focusing in teachers giving out contents to students. Instead, in rural schools the tendency seems to be using the technology to explore constructivist didactics more focused on promoting active involvement by the students in research activities and the construction of knowledge.

**School conditions for MCL use**

During the interview stage, two important conditions for using the MCL came up. One of them was that schools needed to have the administrative measures to allocate the necessary time and space for training and preparing classes. Another one was that teachers also had to have technical and pedagogical support in the classroom. Therefore, these two variables were deemed as essential for measuring the conditions for the use of the MCL.

In terms of administrative measures adopted by the schools, the most frequently cited measures, adopted by around three quarters of schools, were the following: appoint a professional to be responsible for the security and care of the MCL (79.6%), have a calendar, schedule or timetable for the use of the MCL (79.2%), set a minimum for the amount of hours’ use per subject (71.1%), and organize a time and space for training teachers so as to improve the use of the MCL in their subject (71.8%). Following these came initiatives related to appointing a professional to support the teachers during the teaching process using the computers (68.6%), allocating time to teachers for preparing computer-based lessons (62.1%) and leaving the use of the MCL up to each teacher’s own initiative (60.4%).
However, here the view of the teachers and the principals turned out to be statistically significantly different for several of these measures (Table 5), with the principal’s view being more positive than the teacher’s for every measure. Although in general principals’ perceptions were more positive than teachers’ perceptions, they turned to be statistically significant in those questions related to administrative measures and school conditions for MCL use. In the rest of the scales no statistical differences were observed.

### Table 5

**Teacher and Principal’s Perception of Administrative Measures for Use of the MCL at School**

<table>
<thead>
<tr>
<th>Position</th>
<th>Teacher (%)</th>
<th>Principal (%)</th>
<th>$X^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of each teacher’s own initiative</td>
<td>80.0%</td>
<td>48.6%</td>
<td>$X^2$=12.19, p=0.000</td>
<td></td>
</tr>
<tr>
<td>Allocate a minimum amount of time to the teacher for preparing computer-based lessons</td>
<td>45.7%</td>
<td>74.3%</td>
<td>$X^2$=9.76, p=0.002</td>
<td></td>
</tr>
<tr>
<td>Organize a time and space for training teachers so as to improve the use of the MCL in their subject</td>
<td>65.3%</td>
<td>85.3%</td>
<td>$X^2$=6.40, p=0.011</td>
<td></td>
</tr>
<tr>
<td>Appoint a professional to support the teachers during the teaching process using the computers</td>
<td>51.0%</td>
<td>75.4%</td>
<td>$X^2$=7.49, p=0.006</td>
<td></td>
</tr>
<tr>
<td>Appoint a professional to be responsible for the security and care of the MCL</td>
<td>72.9%</td>
<td>87.1%</td>
<td>$X^2$=3.80, p=0.051</td>
<td></td>
</tr>
</tbody>
</table>

With regard to pedagogical support, the general perception was that it was not very frequent. The majority said that the different school actors either never or only sometimes supported teachers, with the exception of the Head of ICT at the school, where the majority stated that this person often or always offered support (Table 6). With respect to technical support, the responses were very similar.

### Table 6
To analyze the aids and barriers of the strategy, the different participants were asked whether or not they agreed with the various statements shown in Table 7. As it can be observed, main barriers were technical and pedagogical support for using ICT during lessons and availability of time for teachers to prepare, develop and implement new activities using ICT. In line with the results reviewed in the above section about perceptions of ICT, the great majority felt that in general there is a willingness in their school to use technology. Additionally, the majority did not see student or teacher ability or teachers’ confidence in using ICT as barriers. Finally, an important majority believed that the infrastructure is adequate.

At the end of the survey, the respondents were asked to give an overall evaluation of the different stages of the MCL project. In line with the answers for the previous item, training and support were mainly rated ‘normal’, while implementation and quality of equipment were rated ‘good’. The evaluation by the users of the MCL was not related to the rurality of their school, i.e. there were no significant differences between the evaluation by users at urban schools and rural schools.

### Table 7

**Barriers for Using the MCL at Schools**

<table>
<thead>
<tr>
<th>Pedagogical support</th>
<th>Colleagues</th>
<th>Management</th>
<th>Head of ICT</th>
<th>Head of Curriculum/Instruction</th>
<th>External support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>14.2</td>
<td>15.5</td>
<td>42.4</td>
<td>21.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Often</td>
<td>30.4</td>
<td>17.7</td>
<td>22.5</td>
<td>25.7</td>
<td>17.9</td>
</tr>
<tr>
<td>Sometimes</td>
<td>43.4</td>
<td>35.2</td>
<td>27.8</td>
<td>33.7</td>
<td>46.0</td>
</tr>
<tr>
<td>Never</td>
<td>12.0</td>
<td>31.6</td>
<td>7.3</td>
<td>19.7</td>
<td>29.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
</tr>
<tr>
<td>Aids / Barriers</td>
<td>% Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>--------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICT are considered useful</td>
<td>99.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using ICT in teaching-learning is a goal</td>
<td>92.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrastructure for using ICT is adequate</td>
<td>79.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical support for teachers is sufficient</td>
<td>46.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedagogical support for teachers is sufficient</td>
<td>40.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers have the necessary ICT skills</td>
<td>54.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students have the necessary ICT skills</td>
<td>66.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers have the necessary confidence</td>
<td>63.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers have the necessary teaching skills</td>
<td>60.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers have enough time</td>
<td>32.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is an overload of projects</td>
<td>44.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The correlation analysis showed that the overall evaluation of the project had a weak correlation with the frequency of use of the MCL, while there was a moderate correlation with some of the factors related to teacher support and ICT confidence. In particular, there was a moderate correlation between the existence of adequate pedagogical and technical support and the presence of teachers within the establishment with a sufficient level of confidence for using the ICT (r=0.45, r=0.39 and r=0.37, respectively).

**Explanatory factors for use of the MCL**

From the Binary Logistic Regression two models were obtained based on the two dependent variables, which were deemed to be indicators of a more or less successful implementation. In the first model, where the dependent variable was the frequency of use of the MCL, six significant predictive factors (p<0.05) were found (Table 8). From this analysis it could be concluded that there was a greater possibility of an increased use of the MCL in schools where there was a perception that students had greater ICT skills, where there was better pedagogical support from colleagues, and more class
observations. These last three aspects are consistent with the per-item descriptive analysis, where the importance of teachers feeling supported in their use of the MCL was also evident. The other two aspects (better organization and having basic skills) appear to be relatively necessary conditions for any ICT strategy that is implemented in a school. Better technical support appeared to be a not statistically significant factor (p>0.05), although it contributed to the overall model significance.

**Table 8**

**Model for Frequency of Use of the MCL**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>B</th>
<th>B S.E.</th>
<th>Wald</th>
<th>df</th>
<th>P</th>
<th>$e^B$ (odds ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of student ICT skills</td>
<td>1.2</td>
<td>0.393</td>
<td>9.269</td>
<td>1</td>
<td>0.00</td>
<td>3.3</td>
</tr>
<tr>
<td>Existence of planning for MCL use</td>
<td>0.97</td>
<td>0.281</td>
<td>12.002</td>
<td>1</td>
<td>0.00</td>
<td>2.64</td>
</tr>
<tr>
<td>Pedagogical support for teachers from colleagues</td>
<td>0.78</td>
<td>0.344</td>
<td>5.117</td>
<td>1</td>
<td>0.02</td>
<td>2.17</td>
</tr>
<tr>
<td>Technical support for teachers using the MCL</td>
<td>0.64</td>
<td>0.341</td>
<td>3.503</td>
<td>1</td>
<td>0.06</td>
<td>1.89</td>
</tr>
<tr>
<td>Observation of teachers using the MCL</td>
<td>0.97</td>
<td>0.445</td>
<td>4.779</td>
<td>1</td>
<td>0.03</td>
<td>2.64</td>
</tr>
<tr>
<td>Pedagogical support for teachers from colleagues</td>
<td>0.78</td>
<td>0.344</td>
<td>5.117</td>
<td>1</td>
<td>0.02</td>
<td>2.17</td>
</tr>
<tr>
<td>Technical support for teachers using the MCL</td>
<td>0.64</td>
<td>0.341</td>
<td>3.503</td>
<td>1</td>
<td>0.06</td>
<td>1.89</td>
</tr>
<tr>
<td>Observation of teachers using the MCL</td>
<td>0.97</td>
<td>0.445</td>
<td>4.779</td>
<td>1</td>
<td>0.03</td>
<td>2.64</td>
</tr>
<tr>
<td>Person in charge gives Technical Support Network (TSN) training</td>
<td>-1.16</td>
<td>0.529</td>
<td>4.813</td>
<td>1</td>
<td>0.03</td>
<td>0.31</td>
</tr>
<tr>
<td>Using ICT to teach or learn is a goal of the establishment</td>
<td>-1.97</td>
<td>0.841</td>
<td>5.513</td>
<td>1</td>
<td>0.02</td>
<td>0.13</td>
</tr>
<tr>
<td>Constant</td>
<td>2.52</td>
<td>0.871</td>
<td>8.396</td>
<td>1</td>
<td>0.00</td>
<td>12.4</td>
</tr>
</tbody>
</table>

**Overall model evaluation**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-2Log Likelihood</td>
<td>117.95</td>
</tr>
<tr>
<td>Model Chi square</td>
<td>91.009</td>
</tr>
<tr>
<td>Cox &amp; Snell R square</td>
<td>0.452</td>
</tr>
<tr>
<td>Nagelkerke R square</td>
<td>0.604</td>
</tr>
</tbody>
</table>

The second model, where the dependent variable was diversity of types of use, seven significant predictive factors were found (p<0.05) (Table 9). With this analysis it was
evident that the variables of greatest weight were the presence of a calendar for use of the MCL, the existence of lesson planning, the fact that a professional is appointed to support teachers and support from colleagues. It can be concluded from this analysis that there is a greater probability that teachers will use the MCL in diverse teaching practices if in the school there is a calendar for its use, if there is a plan for integrating the MCL into the different subjects and if the teachers are supported by their colleagues and by a technical professional. As such, the involvement in lesson planning training by the school administration appeared to be a factor favoring the use of the MCL in both traditional and constructivist teaching practices. Although contributing to the overall model significance, lesson planning training given by the company which supplies the equipment appeared not to be a significant explanatory factor.

Table 9
Model for Diversity of Types of Use of the MCL

<table>
<thead>
<tr>
<th>Predictor</th>
<th>B</th>
<th>B S.E.</th>
<th>Wald</th>
<th>df</th>
<th>P</th>
<th>eB (odds ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of student ICT skills</td>
<td>0.577</td>
<td>0.249</td>
<td>5.365</td>
<td>1</td>
<td>0.02</td>
<td>1.781</td>
</tr>
<tr>
<td>Existence of planning</td>
<td>0.601</td>
<td>0.257</td>
<td>5.491</td>
<td>1</td>
<td>0.02</td>
<td>1.825</td>
</tr>
<tr>
<td>Have a calendar for MCL use</td>
<td>2.805</td>
<td>0.786</td>
<td>12.726</td>
<td>1</td>
<td>0.00</td>
<td>16.534</td>
</tr>
<tr>
<td>Offer specific digital resources for each subject</td>
<td>-1.547</td>
<td>0.622</td>
<td>6.177</td>
<td>1</td>
<td>0.01</td>
<td>0.213</td>
</tr>
<tr>
<td>Assign a professional to support the teachers (e.g. Technician)</td>
<td>1.492</td>
<td>0.512</td>
<td>8.497</td>
<td>1</td>
<td>0.00</td>
<td>4.444</td>
</tr>
<tr>
<td>Lesson plan training (Company)</td>
<td>1.897</td>
<td>1.097</td>
<td>2.99</td>
<td>1</td>
<td>0.08</td>
<td>6.665</td>
</tr>
<tr>
<td>Lesson plan training (Administration)</td>
<td>1.74</td>
<td>0.779</td>
<td>4.984</td>
<td>1</td>
<td>0.03</td>
<td>5.699</td>
</tr>
<tr>
<td>Frequency of pedagogical support for teachers by colleagues</td>
<td>1.365</td>
<td>0.37</td>
<td>13.593</td>
<td>1</td>
<td>0.00</td>
<td>3.915</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.231</td>
<td>0.92</td>
<td>5.882</td>
<td>1</td>
<td>0.02</td>
<td>0.107</td>
</tr>
</tbody>
</table>

Overall model evaluation

-2Log Likelihood 130.28  
Model Chi square 98.856  
Cox & Snell R square 0.449
Classroom Observations

Considering that the survey responses were based on the respondents’ perceptions of how the MCL had been working at their school, it was decided to observe some schools that reported a frequent use of the MCL. This analysis cannot be considered as representative of all of the schools that showed a greater use of the MCL. However, these observations do allow for a more in-depth investigation of the types of practices that are being carried out, as well as to learn more about the conditions in which they are implemented and the role played by the MCL in the process.

Frequency and diversity of use of the MCL within the school was used as a first selection criterion. Only schools that said they ‘always’ use the MCL in Language and Mathematics were chosen. In addition, half of the schools selected declared to use the MCL with more traditional teaching methods (e.g. exercising contents, giving instruction-based lessons) and half said that they made frequent use of the MCL for more constructivist activities (e.g. research projects, data analysis). Geographical location of the schools was used as a second selection criterion, due to time constrains. All schools selected were from Santiago (capital of Chile), which is located in the region with the highest concentration of schools that ‘always’ used the MCL (30.3%).

A total of 11 schools were visited by the observation team, of which five (four urban and one rural) used the MCL with more traditional methods and six (four urban and two rural) with more constructivist methods. In each school a 45-minute Language or Mathematics class was observed. The observation had been previously agreed with both the school and the teacher, meaning that the teacher could plan the use of the MCL. The observations were carried out by two members of the evaluation team following an observation guideline, which allowed them to record information regarding the integration of the MCL into the class lesson, how the teacher handled the technology,
the type of activity carried out using the MCL, as well as the student-teacher and student-student dynamics related to the use of the technology.

The analysis of the observations showed that in five of the eleven classes there were technical problems, making it difficult to carry out the activities and to integrate the MCL with the defined pedagogical objectives. In fact, in one case the technical problems made it impossible to develop the planned activity. It was also observed that the majority of teachers did not have the sufficient knowledge to deal with and solve these technical issues on their own.

In four of the eleven observed classes, the teachers had an assistant who offered technical support in how to manage the technology. Two of these cases reported in the survey a constructivist approach and the other two a traditional approach and two of them delivered a lesson in Mathematics and the other two in Language. Therefore having or not an assistant did not seem to be related with the contents or types of use of the technology. In one of these cases the assistant was the schools’ ICT coordinator that had planned in advance the class with the teacher, which allowed the teacher to concentrate in the pedagogical process and obtain a better control of the class. In the classes observed where this support did not exist, the occurrence of technical problems affected the normal development of the class, reducing the effective amount of class time by up to 30 minutes of the 90 minutes class. In two of the cases observed, the students had a high level of ability when it came to handling netbooks, being capable of identifying and resolving technical issues.

By comparing the schools which were identified as either more traditional or constructivist in terms of their use of the MCL, the main differences could be seen in the interaction between the students and the teacher. Even when students used the technology individually, the teachers in the more constructivist schools tended to encourage greater interaction between students and with the teacher.
Despite taking into consideration these differences in teaching methods between the schools, the observations showed that schools used the MCL mostly with the aim of motivating the students, and not to implement more innovative teaching practices by using the technology. In only one of the classes the teacher presented a less traditional teaching activity, using a play-based dynamic that required the students to play an active role and generated a different type of interaction between the students and with the teacher. This was the case where the assistant of the class was the ICT coordinator, which allowed for a better flow and continuity of the class. However, even in this case the activity could have been done without the computers, meaning that the technology supported the innovation but did not drive it.

In summary, the analysis of classroom observations indicates that, even in those schools in which the MCL program could be considered successful due to the reported frequency and type of use of the technology, the introduction of the MCL has not driven teaching practices that differ to traditional paper and pencil activities. In all of the classes that were observed, the MCL was used mainly as a resource to motivate the students and not as an essential tool for carrying out activities that would only be made possible by the use of technology. Moreover, the observed pedagogical activities were strongly affected by technical problems, and thus a frequent use of the MCL did not always imply an effective use from a learning perspective. The observations also showed that in schools in which the MCL is being used in less traditional activities, a greater level of interaction among students and the teacher is being fostered. However we do not know if the teacher followed this practice before the technology introduction.

**Conclusions and discussion**

The objective of this study was to learn how a new strategy of Mobile Computer Labs providing 1:1 technology in the classroom had been integrated into the teaching and learning process of Chilean third grade classrooms, identifying the most important
facilitators and barriers in this process during its first year of implementation. The following conclusions are based on the three main research questions of this study.

With respect to the first question, related to the way and extent to which teachers are using MCL in their teaching practices, it can be concluded that the technology has been used sporadically in Mathematics and Language, with greater frequency in Language than in Mathematics. With regard to the types of activity carried out, the most frequent tended to be exercising previously acquired knowledge and skills and searching for information. Also, more than two thirds of the respondents stated that their school always or often used the MCL to motivate their students. When analyzing the types of use according to rurality, it was observed that urban schools tended to use the MCL to carry out more traditional activities, while rural schools to do more constructivist activities, like developing more research projects. It is unclear as to what could explain this difference between rural and urban schools, but one possible hypothesis is that in rural areas oral culture takes precedence. In this culture, face-to-face communication and interaction between people play a central role and therefore it could be argued that constructivist methods are adopted more naturally as they promote collaboration and encourage students to play a more active role when interacting with their peers.

In relation to the second question regarding the aids and barriers for integrating the MCL into teaching practices, it was found that the barriers to using the MCL included lack of time for planning, project overload and little technical or pedagogical support. Consistently, the logistic regression analysis found that students’ ICT skills, planning activities and technical or pedagogical support all facilitated the use of the MCL in Mathematics and Language.

With regard to the third question of this study related to the human, technological and contextual school conditions related to the integration of MCL into teaching practices, first, in terms of the human factors or conditions, it was found that:
With respect to participants’ beliefs or perceptions, the results consistently showed that there was a willingness and acceptance amongst the different users of both ICT in general and of the MCL in particular. It was also found that the frequency of use in subjects had no correlation with beliefs and perceptions about ICT or general expectations for the project.

However, it was also found that the principals’ view was more positive than that of the teachers in relation to the conditions of training and support for integrating ICT into teaching practices. This is an important finding when considering that different views of reality between participants on the same project (specifically between those that run the project and those that implement it) can be an important cause of difficulty when implementing public policies and strategies. This is also relevant considering that other studies show the importance of a shared vision of the innovation for a successful implementation (Kirkland & Sutch, 2009; Law. Et.al, 2008; Fullan, 2001).

Second, in terms of the technological conditions, these were consistently positively evaluated. The respondents indicated that they valued the MCL as a resource and the availability of the technology in general was not considered an obstacle to its pedagogical integration.

Finally, with respect to the institutional or contextual conditions, the findings were that:

- As far as the administrative measures implemented in the schools, those related to making the MCL resource more readily available were more positively evaluated than those related to the organization of time and space for planning, teacher training and support.
- Nevertheless, the institutional conditions of pedagogical and technical support emerged as insufficient and an essential condition for integrating the MCL into teaching practices. Even more, the classroom observations showed that those teachers that had technical assistance during the class were able to achieve the defined pedagogical objectives of the class while those that did not have technical assistance during the class
failed to achieve these. The relevance of permanent technical and pedagogical support is consistent with other studies findings (Trucano, 2005; Jones, 2004; Cox et.al, 2004).

The above conclusions show that the measures taken until now by the MCL project have been insufficient and that teachers require much clearer and more systematic guidance and orientation in order to use the new resources. This is identified as being the main failure of the project and is in line with other studies that have found that the absence of teacher training and development of specific software severely limit the benefits of technology in the classroom (Chong et al., 2011; Karsenti & Collin, 2011; Severin & Capota, 2011). In future stages of this project, or similar projects, teachers cannot be left alone during the process of adoption and implementation of a new technological resource. The classroom observations clearly showed that having someone who supports the teacher before and during the class is an essential condition for a well-implemented activity with MCL. This suggests the need for teachers to plan and work collaboratively with others to integrate ICT into the pedagogical process. It is important to consider that new technological resources add complexity to the classroom and imply changes in teaching practices and culture that do not occur overnight and which require time and support in order to be adopted and understood by the participants. Therefore, only by generating adequate conditions under which the adoption process is developed, with at least time for preparation and planning, and well designed technical and pedagogical support, can we expect teachers to acquire the necessary skills and new resources to obtain significant effects on student learning.

Finally, some limitations of this study were that it was based on the perception of one schools’ representative that answered the survey and not over objective data. In fact, some differences between the perceptions of these representatives (depending in their role in the school) were observed, therefore to a certain extent the evaluation of the project could be determined by the role of the respondent. In addition, the classroom observations were performed within time constraints that did not allow for a complete in-depth study to give a more detailed description of the variables associated with a
more frequent and innovative use of MCL. Finally, this study was performed only after a year of implementation of the MCL project in Chile. It is important to continue following up this strategy considering previous limitations and the lessons obtained in this study.

Acknowledgements
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APPENDIX 2: DIFFERENCES IN VIEWS OF SCHOOL PRINCIPALS AND TEACHERS IN THE IMPLEMENTATION OF A NEW TECHNOLOGICAL PROPOSAL FOR THE CLASSROOM

Magdalena Claro, Miguel Nussbaum, Ximena López, Victoria Contardo

Abstract

This paper presents a study about the communion of views among school principals and teachers in regard to the adoption of a new technological proposal for the classroom, in order to understand how an innovation is interpreted and adopted by different actors within the school context. For this purpose, the implementation of a new technological proposal for classrooms in Chile was studied considering two research questions: (1) In what aspects and in what ways are the views of school principals and teachers similar or different in regard to a new technological proposal for the classroom?; and (2) Are there keys in the views of school principals and teachers that could help understand the difficulties in implementing a new technological proposal in the classroom? A mixed methodology was implemented in two stages. In the first stage, quantitative, a self-administered questionnaire (web-based) was used to study teachers’ and principals’ views about the adoption characteristics of the Mobile Computer Labs (MCL) project. In the second stage, qualitative, interviews were conducted at three schools in order to further elaborate on the views of each actor and identify, on the one hand, the areas of convergence and divergence among them and, on the other, certain keys in regard to the difficulties in implementing the strategy under study. In general terms, quantitative and qualitative data coincided in showing a greater convergence in the views of school teachers and principals in regard to the value given to ICT resources and general integration of ICTs for teaching, rather than the implementation process and the use of MCL in schools. More specifically, the divergence of opinions emerged related to the availability of school resources and conditions to learn how to use the new resources, as well as the responsibilities in the organization.
1. Introduction

Literature about school change has demonstrated that new strategies that pursue changes in teaching practice should consider the social and cultural context of the school organization (Hargreaves et al., 2001; Fullan & Stiegelbauer, 1991). This refers to topics related to the meaning and understanding of members of the school organization about the new strategy and the social relations it arouses. Specifically in regard to innovations involving Information and Communication Technologies (ICTs), Fullan & Stiegelbauer (1991) stress three core elements: (1) new materials, (2) new behavior/practices, and (3) new beliefs/understandings. Nevertheless, using new materials (curricular, technological, and others) only reflects the last end of innovation (Fullan & Smith, 1999). Far more complex, according to these authors, is for teachers to develop new skills, behaviors, and practices associated to change, and modify their beliefs and understandings in regard to innovation.

In the same sense, research shows that very different views about the reality among actors involved in one same project (especially between the leader and whoever implements the project) could be a relevant cause of the difficulty in successfully implementing public policy and strategies. In fact, the distance or proximity of views among these two actors is indicated in the literature as a fundamental factor for any school innovation. Kirkland & Sutch (2009) put forward that perception among actors in the system about the usefulness of innovation would appear as essential to its success as its true usefulness. This perception could be constructed, for example, on the basis of teachers’ beliefs and attitudes or on the basis of influences from school leaders on teachers, in turn these leaders being influenced by higher levels in the school system. Likewise, it is fundamental to have a shared understanding among system players (especially teachers and leaders) in regard to the distance between the innovation and
current teaching practices, and also in regard to the resources needed to implement the innovation (Kirkland & Sutch, 2009: 30).

Furthermore, literature about educational change points to school administrators or principals as vital agents for the creation of conditions for school reform to be successful (Fullan, 1991; Leithwood et al., 1999; Hargreaves, 2001). More specifically, evidence points to the leadership of principals as an important factor in the adoption of technology by teachers. Without the involvement of the principal, adoption of the technology tends to fail, albeit teachers receive plenty of training (Dawson, 2003, Scrimshaw, 2004; Law et al. 2008). Dawson (2003) poses that in the same way that teachers are asked to change some of their teaching behaviors, the principal should also be asked to adopt new behaviors in support of the new role of teachers. Consistently, Gómez & Salgado (2010) propose that the key function of a principal of putting forward a vision implies sharing and working with other members of the community, and giving meaning and direction to the process. The possibility for leaders to have a contagion effect on the community depends also on the support given to develop the skills required by everyone involved. In other words, the vision and understanding that the school leader may have of the role of ICTs for the curriculum should translate into concrete measures providing the space for teachers to learn how to effectively use ICTs in the classroom (Allan et al., 2003; Law et al., 2008). For example providing the necessary time and support for teachers to prepare in the use of technology, research digital materials for their classes, and become familiar with the hardware and software (Jones, 2004; Cox et al., 2004). In general, an atmosphere that supports innovation and the use of ICTs is encouraging for teachers to attempt new practices (Kirkland & Sutch, 2009). For this it is necessary to implement forms of professional planning and learning that are well-integrated (and not accessory) to the teaching process and where learning to teach becomes part of the teaching process itself (Lieberman, 1995; Hargreaves et al., 2001).

Considering these findings, research shows that a key difficulty in implementing new strategies with ICTs is that they tend to focus on adopting the technology, not paying
attention to the creation of appropriate conditions for the social and cultural learning
required by innovation (Hargreaves et al., 2001; Fullan & Smith, 1999). In this process,
the communion of views of the actors involved (their perceptions and beliefs) both in
regard to the new strategy to be adopted as well as the physical, human, and
organizational conditions required for implementation, are essential. To contribute to
understanding this difficulty, this paper proposes further elaborating on the divergence
and convergence of views of principals and of teachers about a new technological
proposal for classrooms in Chile, consisting of setting-up Mobile Computer Laboratories, which have so far had very limited use (XX et al., 2013).

Thus, the research questions are:

(1) In what aspects and in what ways are the views of principals and teachers similar or
different in regard to a new technological proposal for the classroom?

(2) Are there keys in the views of principals and teachers that help understand the
difficulties for implementing a new technological proposal for the classroom?

2. Methodology

The aim of the study is to learn about and compare the views of principals and teachers
about the implementation of a new Mobile Computer Laboratory (hereafter, MCL)
strategy developed as of 2009 in Chile. This intervention consisted in promoting the
development of new classroom practices by means of providing 1591 primary education
public schools with a cabinet containing notebooks to be used by each student in a third
grade class. The strategy also included a notebook per teacher, with software to control
the class and communicate with students and a wireless network technology (intranet)
for communication among computers within the classroom (Ministry of Education,
2009). Together with the technology there was website providing information about the
project and digital education resources in Mathematics and Spanish Language, to support class lessons.

The methodology of the study was mixed and was implemented in two stages.

2.1. Stage One: Survey

(1) In the first stage, quantitative, a self-administered questionnaire was used on-line to study the views about the characteristics of adopting the MCL project at the schools taking part in the initiative. A total of 565 schools were contacted in three successive calls. An e-mail with the URL to access the survey was sent to each school. Only one representative from the school could answer the survey (Teacher, Principal, Head of Curriculum and Instruction, or Head of ICT). The questionnaire was answered by a total of 242 schools, achieving a 75% response rate. Due to the non-response cases, it was necessary to use weightings to reconstruct the representativeness of the various segments according to their appropriate weight in the overall distribution. Weighting coefficients were calculated by dividing the expected number of responses by the actual number of questionnaires validly completed. In order to learn about the differences or similarities among the views of school principals and teachers about the project, a chi-squared analysis was conducted for the responses of these actors in regard to the main aspects consulted within the two major theme strands:

(1) Valuation and adoption of ICTs at the School, specifically their views about:
   (a) ICTs contribution in general; (b) MCL contribution in particular; and (c) Level of pedagogical adoption of ICTs in the school.

(2) Implementation and use of MCLs, specifically their views about: (a) Planning and organizing the use of MCL at the school; (b) Level of teacher preparation to make pedagogical use of MCLs; (c) Technical and pedagogical training of
teachers in the use of MCLs; and (d) Innovative practices and use of MCLs in the classroom.

2.2. Stage Two: Case Studies

2.2.1. Data collection and methodological analysis

In the second stage, qualitative, interviews were conducted at three schools in order to further elaborate on the views of each actor and identify, on the one hand, the areas of convergence and divergence among them, and on the other to identify keys related to the difficulties in implementing the MCL strategy in the classroom. For this purpose, on the basis of the information obtained in the questionnaire, a school was randomly selected among the schools that had answered they frequently used MCL, one school from among those that had answered they made medium or moderate use, and one school from among those that had answered they did not frequently use MCLs. Here it is important to consider that high, medium, or low are defined in relative terms with regard to the use reported by the surveyed schools. This criterion was used based on the hypotheses that the frequency in use reported by the school could be related to more or less convergence of views among principals and teachers. Subsequently, within each school, two key informers were interviewed: the principal and a teacher taking part in the project. The interviews were conducted on the basis of a single set of open questions that aimed to enquire about the views of these school actors in relation to the same topics asked about in the questionnaire they had previously answered.

The interviews were conducted at the school, and each actor was interviewed individually by a surveyor. The principals were interviewed in their offices, whereas the teachers were interviewed in a classroom. Three researchers took part in analyzing the interviews, in order to compare the information and triangulate the analysis. The process of analyzing the interviews was performed using the steps of the grounded theory (Corbin & Strauss, 2008). In a first stage the information from the interviews was
broken-down into units of meaning, which were coded and classified for each of the topics consulted. The information was coded by categories for each topic, which in turn were summarized to reach a single definition that expressed the content of various semantic contributions in three levels of the discourse of the interviewees:

1) A first level, relative to the general perception of each actor about the consulted topic.
2) A second level, relative to the school or out-of-school conditions that could be favoring or hindering the development of the consulted topic.
3) A third level, relative to those responsible inside or outside of the school for implementation of the consulted theme.

It is important to point out that in the first two consulted topics within the first theme strand, that aimed to learn about actors’ valuation of ICTs in general and the contribution of MCLs in particular, it was only relevant to analyze the first level of discourse about the general perception of the interviewees. Therefore neither the second nor third level of conditions were addressed.

In a second stage, the categories stemming from each topic in the three levels of discourse of each actor were compared by school, in order to identify the similarities and differences among the views of principals and teachers.

2.2.2. Presentation of the case studies

Low Use School: This school serves 381 nursery, primary, and science and humanities secondary education students, of which 80% come from families classified by the Ministry of Education as vulnerable. At the time of holding the interviews the school was being reconstructed, since the facilities were damaged with the earthquake that hit Chile in 2010. For two years the school operated in the facilities of another school in the same township, sharing the classrooms, which led to delays in implementing all projects,
including the MCL. According to the Ministry of Education classification, the school’s level of technology was *Elementary*, which implies basic infrastructure and precarious pedagogical use of technology. The person in charge of implementing the project, appointed by the school principal, is the Head of Curriculum and Instruction, who organizes and plans all MCL activities. One particularity of the school is that the person responsible for giving the classes is the Head of ICT, who has to agree the content and objectives of the classes with the teacher of each level using the MCL. In this way, the persons most involved in the school are the Head of Curriculum and Instruction –who supervises the academic objectives– and the Head of ICT, who gives the classes and trains almost exclusively in the area.

**Medium Use School:** This school serves 208 nursery and primary students, of which 75% come from families classified as vulnerable. Their level of technology is *Advanced* according to the Ministry of Education classification, which implies they have excellent technological infrastructure and pedagogical use is very frequent. At the time of the interviews, the school principal had been in the position for two years and had arrived once the MCL had already been implemented in the school. One of the aims proposed by the principal is to change the existing perception among the population that this is a bad school, by implementing projects that may level learning conditions and for students to adopt digital skills by frequently using technology in class. A culture favorable toward ICTs for teaching is promoted in the school, and this is expressed with posters on the walls in the computer room, encouraging the use of computers. The computer room is under the responsibility of a teacher who coordinates timetables and proposes class contents to teachers in each level using the MCLs. School premises are seen to be very clean and tidy, which contrasts with the outside surroundings.

**High Use School:** This school serves 639 nursery and primary students, of which 60% come from families classified as vulnerable. According to the Ministry of Education classification, the level of technology is *Advanced*. At the time of the visit, the school Principal and the Head of Curriculum and Instruction had been in their positions for two
years. The principal mentioned that many ICT projects had not been implemented on account of problems in the internal organization of the school. The interviewed teacher plans and gives the class without any support, and the school’s Head of ICT provides the mobile cart with computers on request. In general, there is a favorable culture toward ICTs.

3. Results

3.1. Stage One: Survey

3.1.1. Valuation of ICTs and MCLs for teaching

3.1.1.1. Contribution by ICTs and MCLs

As shown in Table 1, both teachers and principals said they agreed or very much agreed that ICTs were relevant in their schools (94.1% and 94.3% respectively). In addition, most teachers and principals said MCLs are an opportunity to improve digital literacy (74.5% and 74.3% respectively), to promote pedagogical innovation (92.2% and 88.6% respectively), and to motivate students (88.2% and 75.7% respectively). Finally, the great majority of both groups that answered the survey said they recommended other schools to adopt MCLs as an educational resource (94.1% and 97.1%, respectively).

Table 1: Percentage of teachers and principals that say they value ICTs and MCLs for teaching

<table>
<thead>
<tr>
<th></th>
<th>Teachers</th>
<th>Principals</th>
<th>X2</th>
<th>R2</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICTs are relevant for teaching</td>
<td>94.1</td>
<td>94.3</td>
<td></td>
<td>2.93</td>
<td>0.394</td>
</tr>
<tr>
<td>MCLs are an opportunity to improve digital literacy</td>
<td>74.5</td>
<td>74.3</td>
<td></td>
<td>0.001</td>
<td>0.978</td>
</tr>
</tbody>
</table>
MCLs are an opportunity to promote pedagogical innovation | 92.2 | 88.6 | R2=0.425
| p= 0.515 |

MCLs are an opportunity to motivate students | 88.2 | 75.7 | R2= 3.005
| P= 0.083 |

Would recommend adopting MCLs | 94.1 | 97.1 | R2=0.682
| p=0.409 |

| 4.1.1.2. Adopting ICTs for teaching |

In relation to adopting ICTs in general, as shown in Table 2, teachers and principals said they agreed or very much agreed that these resources are beginning to be used in teaching and learning of subjects (95.1% and 94.4% respectively).

Table 2: Percentage of teachers and principals that say they agree or very much agree ICTs are beginning to be used in teaching

<table>
<thead>
<tr>
<th>Agree or very much agree that ICTs are beginning to be used in teaching and learning of subjects</th>
<th>Teachers</th>
<th>Principals</th>
<th>X2</th>
</tr>
</thead>
</table>
| 95.1 | 94.4 | R2=1.52
| p=0.676 |

| 4.1.2. Implementing and using MCLs |

In relation to how MCLs have been implemented in schools, there are statistically significant differences among teachers and principals.

4.1.2.1. Planning and preparation for using MCLs
As can be seen in Table 3, a smaller percentage of teachers than principals say there is support for preparing classes (45.7% and 74.3% respectively), and that time is made for training on how to use the tool for their subject (65.3% and 85.3% respectively).

Table 3: Percentage of teachers and principals that say the following administrative measures exist in relation to MCLs in their school

<table>
<thead>
<tr>
<th>Role</th>
<th>Role</th>
<th>X²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigning minimum time for class planning with computers for teachers</td>
<td>Teachers</td>
<td>Principals</td>
</tr>
<tr>
<td></td>
<td>45.7%</td>
<td>74.3%</td>
</tr>
<tr>
<td>Organizing time for teacher training to improve use of the tool in their subject</td>
<td>65.3%</td>
<td>85.3%</td>
</tr>
</tbody>
</table>

4.1.2.3. Training for the use of MCLs

Second, as shown in Table 4, there are significant differences among the views of these two actors in relation to school technical and pedagogical support, and teachers also have a significantly more critical view than principals about the frequency with which this occurs. A 40% of teachers say they never receive pedagogical support from the principal, whereas only 10% of principals say the same thing. Likewise, 37.5% of teachers say the principal never observes MCL classes, in comparison to only 11.6% of the principals. A 14% of teachers say they always receive pedagogical support from the school Head of Curriculum and Instruction, whereas 37% of principals say the same thing. Finally, only 26.5% of teachers say they receive support from the Head of ICT, in comparison to 37% of principals.

Table 4: Percentage of teachers and principals that say the following practices always or never happen at the school
Finally, in relation to using and innovating practices with ICTs and MCLs, quantitative data on the one hand showed that albeit the majority of teachers and principals reported using ICTs and Internet in class to support subjects, there were statistically significant differences in views among them. Nevertheless, the views among principals and teachers in relation to the adoption of new practices with ICTs and MCLs were convergent in the sense that the great majority of both groups said their school was involved in the adoption of new pedagogical practices with MCL (94.1% and 98.55% respectively).

### Table 5: Percentage of teachers and principals that say MCLs are used in the classroom to innovate

<table>
<thead>
<tr>
<th></th>
<th>Teachers</th>
<th>Principals</th>
<th>X²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers in the school use MCLs</td>
<td>71%</td>
<td>88.4%</td>
<td>R²=8.120</td>
</tr>
</tbody>
</table>

### 4.1.2.3. Using and innovating with MCLs

Finally, in relation to using and innovating practices with ICTs and MCLs, quantitative data on the one hand showed that albeit the majority of teachers and principals reported using ICTs and Internet in class to support subjects, there were statistically significant differences in views among them. Nevertheless, the views among principals and teachers in relation to the adoption of new practices with ICTs and MCLs were convergent in the sense that the great majority of both groups said their school was involved in the adoption of new pedagogical practices with MCL (94.1% and 98.55% respectively).
### 3.2. Stage Two: Case Studies

The results of the previous section (3.1) showed there is significant convergence of opinions among principals and teachers in terms of valuing ICTs and MCLs for teaching, and saying that in general these resources are being adopted for the teaching and learning process, and that new pedagogical practice is being developed at the school. Nevertheless, when elaborating on the process of use and implementation, certain statistically significant differences appear between the views of the two school actors. To better understand these results, the views and beliefs of teachers and principals were further elaborated in a qualitative study consisting of three case studies.

#### 3.2.1. Valuation and adoption of ICTs for teaching

##### 3.2.1.1. Contribution by ICTs and MCLs

As appears in Table 6, there is convergence in the general perception about this topic among all actors, by saying that ICTs in general and MCLs in particular contribute to education by motivating students. In relation to the specific contribution by MCLs to learning, there is agreement among principals and teachers within each school. In the low use school, this is defined as an instrument to support the review of subject content. In the medium use school, they are attributed a role linked to learning subjects and the development of digital skills. Finally, in the high use school, the learning that occurs on
account of motivation is mentioned once again, as well as greater attention paid by students.

Table 6: Views of principals and teachers about the contribution by ICTs and MCLs to teaching

<table>
<thead>
<tr>
<th>Contribution by ICTs</th>
<th>Low Use School</th>
<th>Medium Use School</th>
<th>High Use School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal</td>
<td>Teacher</td>
<td>Principal</td>
<td>Principal</td>
</tr>
<tr>
<td>Student motivation</td>
<td>Student</td>
<td>Better</td>
<td>Student</td>
</tr>
<tr>
<td></td>
<td>motivation</td>
<td>outcomes in</td>
<td>motivation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>learning and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>motivation</td>
<td></td>
</tr>
<tr>
<td>Contribution by MCLs</td>
<td>Access to digital culture and review of content</td>
<td>Review of content</td>
<td>Significant learning and digital skills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subject</td>
<td>Significant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>learning and</td>
<td>learning and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>digital skills</td>
<td>motivation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motivation and</td>
<td>attention</td>
</tr>
</tbody>
</table>

3.2.1.2. Adoption of ICTs in teaching

As shown in Table 7, in the first level of general perception of the interviewees about the topic, convergence can be observed among views in the sense that principals and teachers say ICTs are being adopted to a greater or lesser extent in teaching.

In the second level, in regard to views about the conditions of ICT adoption in teaching, a convergence of views can also be observed in the sense that all mention conditions related to the adoption of new practices and resources linked to ICTs. It is interesting, however, that principals reflect a broader view of the organization, recognizing the
cultural changes implied by ICTs at the school, whereas teachers approach the topic from the viewpoint of the classroom, recognizing technical difficulties when using ICTs or the motivation inspired in students by the use of these resources.

Finally, in the third level, about the views of the *persons responsible* for the adoption of ICTs in teaching, a convergence of views can also be observed in the sense that all mention the teachers and almost all mention the school leaders. The only exception is the principal of the high use school who, as described in the section presenting the case studies (2.2.2), tends to not take responsibility for any topic, due to the conflict with the Municipality responsible for school administration.

Table 7: Views of principals and teachers about the adoption of ICTs and MCLs in teaching

<table>
<thead>
<tr>
<th>Low Use School</th>
<th>Medium Use School</th>
<th>High Use School</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principal</strong></td>
<td><strong>Teacher</strong></td>
<td><strong>Principal</strong></td>
</tr>
<tr>
<td><strong>Teacher</strong></td>
<td><strong>Principal</strong></td>
<td><strong>Teacher</strong></td>
</tr>
</tbody>
</table>

**General Perception:**

- **Low Use School:** Some teachers still do not adopt them
- **Medium Use School:** Almost all teachers use them, some still do not
- **High Use School:** All teachers use ICTs

**Conditions:**

- **Low Use School:** Cultural change of teachers
- **Medium Use School:** Change in school culture and processes
- **High Use School:** Change in teacher practices
3.2.2. Implementation and use of MCLs

3.2.2.1. Class planning

As shown in Table 8, in the first level of general perception of the topic, in the low use school as well as the medium use school, there is convergence of views among principals and teachers, albeit in different ways. In the low use school they say there is no time for formal planning, whereas in the medium use school there is. In the high use school there is a divergence of views in the sense that the principal says there is no planning and the teachers say there is.

In the second level about the conditions for planning, the view among principals and teachers at all three schools tend to be divergent. As can be seen in Table 8, these differences are related to their views about the existence or not of formal time for planning within school time.

Finally, in the third level about the people responsible for having time for formal planning, views also tend to be divergent by attributing this responsibility to different
persons or instances. It is interesting that no school leader takes personal responsibility for the topic.

Table 8: Views of principals and teachers about planning of classes with MCLs

<table>
<thead>
<tr>
<th>Low Use School</th>
<th>Medium Use School</th>
<th>High Use School</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principal</strong></td>
<td><strong>Teacher</strong></td>
<td><strong>Principal</strong></td>
</tr>
<tr>
<td><strong>General Perception:</strong></td>
<td><strong>General Perception:</strong></td>
<td><strong>General Perception:</strong></td>
</tr>
<tr>
<td>There is no formal planning</td>
<td>There is no formal planning</td>
<td>There is formal planning</td>
</tr>
<tr>
<td><strong>Conditions:</strong></td>
<td><strong>Conditions:</strong></td>
<td><strong>Conditions:</strong></td>
</tr>
<tr>
<td>Temporary problem in infrastructure</td>
<td>Permanent problem of time organization</td>
<td>Within school time</td>
</tr>
<tr>
<td><strong>Persons responsible:</strong></td>
<td><strong>Persons responsible:</strong></td>
<td><strong>Persons responsible:</strong></td>
</tr>
<tr>
<td>Infrastructure provided by the Ministry</td>
<td>School leaders</td>
<td>Teachers</td>
</tr>
</tbody>
</table>

3.2.2.2. Preparing teachers to use MCLs

As appears in Table 9, in the first level of general perceptions about preparing teachers to use MCLs, the views of principals and teachers are divergent in the three schools.
In the second level about the *conditions* of this preparation, specifically the quality or sufficiency of the training received by teachers, there is also a divergence of opinions among principals and teachers in the three schools. Both in the low use school as well as the medium use school, principals say that teachers are well trained, whereas the teachers say not. Consistent with the other topics, in the case of the high use school, views are inverted.

In the third level about the *persons responsible* for teacher preparation, the view of principals and teachers are also divergent and it is notable that principals do not take responsibility as persons in charge of leading the school. In the low and medium use schools both principals assign the responsibility to the teachers for their level of preparation (which they consider to be good) in the sense that it is their obligation to open their minds and take an active role in the quality of their work. On the other hand, the principal of the high use school (who considers the level of teacher preparation as insufficient), assigns full responsibility to the Ministry of Education.

**Table 9: Views of principals and teachers about the preparation for teachers to use MCLs**

<table>
<thead>
<tr>
<th>Low Use School</th>
<th>Medium Use School</th>
<th>High Use School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal</td>
<td>Teacher</td>
<td>Principal</td>
</tr>
<tr>
<td><strong>General Perception:</strong></td>
<td>Teachers are well prepared</td>
<td>General Perception: Teachers are not well prepared</td>
</tr>
<tr>
<td><strong>Conditions:</strong></td>
<td>Despite poor talks,</td>
<td>Conditions: Insufficient, superficial</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Low Use School</th>
<th>Medium Use School</th>
<th>High Use School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal</td>
<td>Teacher</td>
<td>Principal</td>
</tr>
<tr>
<td><strong>General Perception:</strong></td>
<td>Teachers are well prepared</td>
<td>General Perception: Teachers are not well prepared</td>
</tr>
<tr>
<td><strong>Conditions:</strong></td>
<td>Insufficient, superficial</td>
<td>Conditions: Sufficient training</td>
</tr>
</tbody>
</table>
and insufficient training

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>Ministry of Education</td>
<td>Teachers</td>
<td>Ministry of Education</td>
<td>ICT Coordinator</td>
</tr>
</tbody>
</table>

### 3.2.2.3. Training for using MCLs

As shown in Table 10, in the level of *general perceptions* about the organization of training for teachers in the use of MCLs, in the low use school the views of principals and teachers are convergent in pointing out there is informal training among teachers. In the medium and high use schools, on the other hand, views are divergent: in the medium use school views differ in regard to the formality of training and in the high use school there is divergence of opinions as to whether there is any training.

In the second level about the *conditions* of the organization in training for teachers, the views of principals and teachers are divergent in the three schools in the sense of explaining the reasons for the existence or not of formal training in totally different ways.

Finally, in the third level about the *persons responsible* for organizing the training, the views of principals and teachers are also divergent in the sense of attributing responsibilities to different positions or instances.

Table 10: Views of principals and teachers about the training of teachers for using MCLs
### 3.2.2.4. Using and innovating with MCLs

As shown in Table 11, in the level of general perceptions about the development of new uses and innovative practices with MCLs, the views of principals and teachers are divergent in the sense of being linked to different expectations in regard to the new...
technology: in the low use school the principal expects profound changes, whereas new strategies that vary the routine are sufficient for the teacher. In the medium use school the principal expects adoption of the new technology, whereas the teacher expects things will be done differently to motivate students. Finally, in the high use school there is convergence in expecting a change in practices (although not specifying in what sense) and whereas the principal believes this has not happened, the teacher believes it has—at least in his/her case.

In relation to the second level of the conditions for innovating, in the low use school and the medium use school, principals and teachers have divergent views related to the new practices that each expect will develop with the use of MCLs. In the high use school, on the other hand, principal and teacher agree in that to have innovation, practices should be shared, a matter that does not happen at their school.

Finally, in the third level about the persons responsible for the development of new uses and practices with MCLs, the views of principals and teachers are convergent in the low and medium use schools in saying the teacher, whereas in the high use school views are divergent in assigning inverted responsibilities (the principal to the teacher, and the teacher to the principal).

Table 11: Views of principals and teachers about the use and innovative practices in the classroom with MCLs

<table>
<thead>
<tr>
<th>Low Use School</th>
<th>Medium Use School</th>
<th>High Use School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal</td>
<td>Teacher</td>
<td>Principal</td>
</tr>
<tr>
<td>General Perception:</td>
<td>General Perception:</td>
<td>General Perception:</td>
</tr>
<tr>
<td>There has not been innovation,</td>
<td>There has been innovation in</td>
<td>There has been innovation in</td>
</tr>
</tbody>
</table>
for which profound change is needed the sense of new strategies that break routines the sense that the technology has been adopted doing different things to motivate practices I don’t know about the others

Conditions: Pedagogical change, in the way of using technological tools

<table>
<thead>
<tr>
<th>Conditions: Technological change, having different tools</th>
<th>Conditions: Teachers ready to adopt new technologies</th>
<th>Conditions: Teachers ready to do class differently</th>
<th>Conditions: No organization of instances for sharing new practices</th>
<th>Conditions: No organization of instances for sharing new practices</th>
</tr>
</thead>
</table>

Persons Responsible: Teachers

<table>
<thead>
<tr>
<th>Persons Responsible: Teachers</th>
<th>Persons Responsible: Teachers</th>
<th>Persons Responsible: Teachers</th>
<th>Persons Responsible: Teachers</th>
<th>Persons Responsible: Principal</th>
</tr>
</thead>
</table>

5. Discussion

In regard to the first research question, *in what aspects and in what ways are the views of school principals and teachers similar or different in regard to a new technological proposal for the classroom?* Table 12 provides a summary of the main quantitative and qualitative results about the convergence and divergence of views among school principals and teachers in the two consulted theme strands. As can be appreciated, in general terms, the quantitative and qualitative data coincided in showing a greater convergence of the views of teachers and principals in the first theme strand about the valuation and adoption of ICTs in teaching, than in the second theme strand about the process of implementing and using MCLs in schools. More specifically, with regard to
the first theme strand, both stages of the study showed a convergence of views in the themes related to the contribution by ICTs in general and MCLs in particular as a learning resource. The qualitative study also showed that valuation is linked above all to the motivation produced by these resources in students and their contribution as tools to support the review of subject content and the development of digital skills. Second, both stages of the study showed a convergence of views among principals and teachers in relation to the overall adoption of ICTs in teaching at their schools. Albeit the qualitative study showed that principals approached the topic from a broader viewpoint linked to the organization whereas teachers had a more specific perspective linked to the classroom, these were not contradictory.

In the second theme strand about the implementation and use of MCLs, on the other hand, greater differences became evident in the views of principals and teachers, both in the quantitative as well as the qualitative data. Quantitative data showed statistically significant differences in topics related to planning time, preparation and training of teachers in the use of MCLs. Qualitative data, for their part, showed the views of principals and teachers were in general divergent in relation to these topics, above all in terms of school or out-of-school conditions that could be favoring or hindering the development of the consulted theme and of the responsibilities inside or outside the school for its implementation. The only theme for which quantitative and qualitative data were contradictory was the use and innovation of practices in the classroom with MCLs. Whereas in the survey the great majority of teachers and principals coincided in reporting that new pedagogical practices with ICTs were being adopted at their schools, the qualitative data showed there were different definitions of innovation and therefore principals and teachers did not coincide in a concrete view of what they intended to achieve with the new resource in the classroom nor on how they expected to achieve this.

Table 12: Convergence (C) and divergence (D) among the views of principals and teachers – Summary of qualitative and quantitative results
## Quantitative Results

*p < 0.05

<table>
<thead>
<tr>
<th>Qualitative Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Use</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strand 1: Valuation and adoption of ICTs in teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contribution by ICTs and MCLs</strong></td>
</tr>
<tr>
<td>C*</td>
</tr>
<tr>
<td><strong>Adoption of ICTs in teaching</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strand 2: Implementation and use of MCLs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class planning</strong></td>
</tr>
<tr>
<td>D*</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

| **Preparation for using MCLs** | Discourse level |
| D* | 1. Perception | D | D | D |
| | 2. Conditions | D | D | D |
| | 3. Responsible | D | D | D |

| **MCL Coaching for using MCLs** | Discourse level |
| D* | 1. Perception | C | D | D |
| | 2. Conditions | D | D | D |
| | 3. Responsible | D | D | D |

| **Use and innovation with MCLs** | Discourse level |
| C* | 1. Perception | D | D | D |
| | 2. Conditions | D | D | C |
| | 3. Responsible | C | C | D |
In relation to the second research question, are there keys in the views of school principals and teachers raised in the qualitative study that could help understand the difficulties in implementing a new technological proposal for the classroom? The main results are provided below.

First, the view of the interviewees about the contribution by MCLs to learning was vague. More specifically, data showed that MCLs tended to be identified with ICTs in general, not visualizing a specific contribution associated to the possibility for students to have 1:1 access to technology in the classroom.

Second, the qualitative data showed school actors did not have a plan for resolving the difficulties found in adopting the new resource. The new resource had somehow “arrived” and had to be used, but they did not have a clear project for using the resource nor how to resolve difficulties in its implementation. In addition, through the interviews it was not possible to obtain concrete concepts associated to changes in practice that principals or teachers expected to see or produce by using MCLs in the classroom.

Third, consistent with the role of each actor, it was found that the principal had a broader approach to ICTs, related to their responsibility for managing the school organization as a whole, whereas the teacher had a more specific approach, linked to their responsibility for managing resources and learning in the classroom. Although this was to be expected, analysis of the interviews also showed that principals were not very involved in the process to implement and adopt new technology in the classroom. More specifically, they did not have concrete information about the type of activities carried out, the difficulties encountered, or the results obtained with students.

Fourth, in relation to responsibilities within schools for the various topics, nothing clearly defined or formalized was found. Neither was a specific role of leadership seen in the principal. It was found that in general there were no clear objectives in terms of
the use of MCLs, and when there were, the principal did not follow-up on the implementation and results.

Finally, no relation was found between the reported level of use of MCLs (High, Medium, and Low) in the survey and the characteristics of the views of the actors. This is probably because as seen in the analysis of the interviews, in practice, use of the resource in all three cases was not relevant and not very innovative in pedagogical terms. In this sense, the reported frequency of use would not be reflecting organizational characteristics with evidence of more or less shared views in terms of the pedagogical contributions in regard to the use of MCLs.

6. Conclusions

This research aimed to make a contribution to understanding the relevance of the communion of views among school principals and teachers in regard to the adoption of a new technological proposal in the classroom. The perspective adopted was to elaborate on the views of the two fundamental actors in school organization, such as the principal and the teacher, to understand how innovation is interpreted and adopted within the social and cultural context of the schools (Hargreaves et.al. 2001: 53).

Quantitative and qualitative data were consistent in showing a convergence of views among principals and teachers in relation to ICTs in general and MCLs in particular, being well adopted and representing a contribution to the teaching and learning process in the school organization. The divergence of opinions emerged rather at the level of available school conditions and resources to make the most of the new resource and the responsibilities within the organization. The only topic where qualitative data contradicted the quantitative data was in regard to innovation, where despite the fact that in the survey the majority of principals and teachers reported they were implementing new practices, important differences appeared in the qualitative study both in terms of
what they understood by new practices as well as their opinion as to whether this was or not happening at their school.

In addition, the qualitative study showed that despite teachers and principals had the same view about the value and general contribution of the new strategy with ICT, there were two fundamental problems: first, a vague notion among all interviewees about the specific contribution by the new resource, which translated into an absence of pedagogical intentionality when using the new resource. This is a relevant difficulty, since as observed by Kirkland & Sutch (2009) not properly understanding the usefulness of a new strategy or resource greatly limits the results of its implementation. Second, different views among principals and teachers about the existing conditions in the school to be able to appropriately implement the resource in the teaching and learning process, which reveals a fundamental problem already detected by Kirkland & Sutch (2009) in regard to the relevance of having a shared diagnosis about the distance between the innovation and current pedagogical practices and also about the required resources to achieve this innovation. In this sense, there was no project or plan to get the financial, human, and organizational resources to achieve the proposed changes.

Furthermore, the results of this study revealed the absence of leadership of principals, by showing their lack of knowledge about what happens on a day-to-day basis and the difficulties related to time for planning and learning in their schools. Additionally, principals did not take direct responsibility for the consulted topics. This shows another key problem already identified in previous studies, regarding the relevance of leadership by the principal for the successful implementation of new strategies, which should translate into the creation of appropriate conditions and having time for reflection and learning (Law et.al. 2008; Jones, 2004; Cox et.al. 2004; Allan et.al. 2003). This finding reveals a fundamental difficulty that partly explains the limited outcomes of the studied strategy.
The interviews in the three schools also showed the lack of time for reflection and the absence of an atmosphere and organization for learning in the schools. This was clear in what was said by the interviewees in relation to the absence of formal organization for planning classes, technical and pedagogical training, exchange of practices and innovations, among others. This was also shown by the way how they defined certain concepts, such as for example planning, which was understood as scheduling and not as pedagogical preparation of the classes, or how innovation was understood as doing things differently with technology, not specifying the meaning or the depth of the change. The same was reflected by the little specificity of the contribution attributed to MCLs to learning.

Finally, it would be interesting to do a similar study about the introduction of another type of change strategy, to verify if the pattern of views found among principals and teachers is repeated or is particular to the type of strategy studied.

References


Jones, Andrew (2004). *A review of the research literature on barriers to the uptake of ICT by teachers*. UK: Becta


### APPENDIX 3: MAIN CHARACTERISTICS OF THE DIGITAL SKILLS PILOT TEST

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Sub-dimension</th>
<th>Nº of Items</th>
<th>Type of Items</th>
<th>Description, examples of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>ICT fluency/skill in sourcing for information</td>
<td>14</td>
<td>Multiple choice</td>
<td>An example of a simple multiple choice item is a task where the student had to choose, among five alternatives, the best group of key words for searching certain information on the Internet; for example, the number of endangered animals around the world.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>An example of a more complex item is a task where the student had to visit and analyze five different web pages about a common theme (a wiki, blog, forum, electronic journal and a institutional web site) and then choose the best web page from where to obtain the definition of global warming.</td>
</tr>
<tr>
<td>ICT skills in processing information</td>
<td>14</td>
<td>Multiple choice and open questions</td>
<td></td>
<td>In the case of multiple-choice items, for example, the student had to read and analyze different kinds of information (graphs, tables, texts), and then to choose the best interpretation for the information among five alternatives. In other cases, the student had to choose the best image to represent the information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Open questions included summarizing information from a web page in the word processor; creating a graph in a spreadsheet; writing a paragraph to</td>
</tr>
<tr>
<td>Category</td>
<td>Skill Description</td>
<td>Hours</td>
<td>Question Type</td>
<td>Task Description</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>--------------------------------------------------------</td>
<td>-------</td>
<td>---------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Communication</td>
<td>ICT skills in effective communication</td>
<td>10</td>
<td>Multiple choice and open questions</td>
<td>In the case of multiple-choice items, the student had to choose the best way to communicate a message considering the purpose and recipient. For example, the student had to open and read five different draft emails, and then to send the one he or she considered best for writing to a university professor; or select the best answer for a question in an ecologic forum; or the best slide of a slideshow to explain to little children what is global warming. Open questions, for example, asked the student to write and send an email to invite to participate in an environmental campaign.</td>
</tr>
<tr>
<td></td>
<td>ICT skills in collaboration and virtual interactions</td>
<td>10</td>
<td>Multiple choice and open questions</td>
<td>In multiple-choice questions, the student had to choose the best procedure that a moderator of a forum should undertake in case one of the participants does not follow the rules; or the best paragraph that the moderator should use to invite people to actively participate in the forum. In other cases, the student had to choose the best digital media (web, blog, messenger, email, etc.) to share a certain type of information. In open questions, for example, the student had to write a question in a forum to obtain specific information.</td>
</tr>
<tr>
<td>Ethics and Social</td>
<td>Ability to evaluate ICT</td>
<td>8</td>
<td>Multiple choice and open questions</td>
<td>Here, for example, the student had to visit a web page that offered them to interpret a graph, among others.</td>
</tr>
<tr>
<td>Impact</td>
<td>responsible use</td>
<td>sign-in as a member of an ecologic organization, and then select from a list the reasons why the website may be unreliable to share information. In another item, the student had to choose the best advice for a virtual classmate that received an email from an unknown sender, communicating that he had won a prize.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to evaluate ICT social impact</td>
<td>1</td>
<td>Open question</td>
<td>Here the student had to elaborate a short essay in which she or he reflected about the implications of the Internet in society.</td>
<td></td>
</tr>
</tbody>
</table>